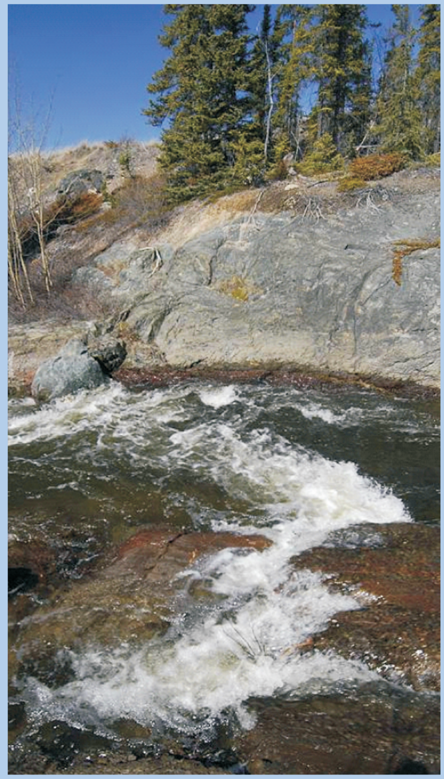
Giant Mine Remediation Project
Developer's Assessment Report



Submitted By:

Indian and Northern Affairs Canada | Affaires indiennes et du Nord Canada

Government of the Northwest Territories

EA0809-001

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Executive Summary

ES.1 INTRODUCTION

This document presents the Developer's Assessment Report (DAR) for the Giant Mine Remediation Project. Giant Mine is located in Yellowknife, Northwest Territories (NWT) about five kilometres north of the city centre (see Figure 1.1.1). The mine produced gold from 1948 until 1999, and ore for off-site processing from 2000 until 2004. After the owner of the mine went into receivership in 1999, Giant Mine was transferred to Indian and Northern Affairs Canada (INAC). INAC and the Government of the Northwest Territories (GNWT) continue to be responsible for the management of the site, including a variety of environmental concerns that need to be addressed.

Environmental Concerns

Gold in Giant Mine ore was associated with an arsenic-bearing mineral known as arsenopyrite. The process used to release the gold from the arsenopyrite led to the production of arsenic-rich gas as a by-product. From 1951 to 1999, operators of the mine captured this gas in the form of arsenic trioxide dust which was transferred to underground storage areas at the mine site. The dust is approximately 60% arsenic, which is hazardous to both people and the environment. Furthermore, the form of arsenic present in the dust is soluble, meaning that it could dissolve in any water that contacts the dust and could then be transported to nearby water bodies such as Baker Creek or Great Slave Lake.

Although arsenic trioxide dust is the main environmental concern at Giant Mine, other concerns include:

- The waste material from mine processing, called tailings, also contains arsenic. Most of the arsenic is in the form of arsenopyrite which is not as soluble as arsenic trioxide. Approximately 16 million tonnes of tailings are stored in four areas on surface, which together cover about ten percent of the site.
- Other areas have been contaminated with arsenic by emissions from the processing facilities, tailings spills, and use of mine rock for construction.
- There are over 100 buildings on the site that need to be removed, many of which are contaminated with arsenic and asbestos.
- There are eight open pits and 35 openings to the underground mine, all of which present safety hazards.

- Baker Creek flows through the site in a channel that has been heavily altered to accommodate mining, ore processing, and highway construction. The water and sediments of the creek are contaminated with arsenic.

ES.2 REMEDIATION PLAN

To address the concerns noted above, a proposal to protect human health, public safety and the environment was developed for the mine site. This proposal is called the Giant Mine Remediation Plan. The specific objectives of the Remediation Plan are to:

1. Manage the underground arsenic trioxide dust in a manner that will prevent 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 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; and

5. Restore Baker Creek to a condition that is as productive as possible.

The Remediation Plan has two phases: Site Remediation Phase and Long-term Operation and Maintenance Phase.

Site Remediation Phase

The activities for the Site Remediation Phase have been designed to address all of the concerns related to the Giant Mine Site and to meet the objectives of the Remediation Plan. As noted, the main environmental concern is the arsenic trioxide dust that is stored underground. This issue has been evaluated through many technical studies and consultation with the public. Several options have been considered; the preferred option is to maintain the arsenic dust and the rock around each underground storage area completely frozen. The techniques for accomplishing this are being examined through a detailed technical study.

The activities developed for the Site Remediation Phase are provided on Table ES.2.1. This table lists the components needing attention, the activities developed to address the concern, and the environmental benefits that will result. In addition to the benefits listed in the table, the implementation of the Project will create employment opportunities, especially for Aboriginals and other northerners, and will enhance business activity due to increased spending on goods and services.

Long-term Operation and Maintenance Phase

After the remediation activities are completed, the site will consist of a small area that will need to remain under active management, and a broader area that will be available for other uses. The actively managed area will allow for both maintenance of the ground freezing system and long-term treatment of contaminated minewater. An extensive monitoring program will also be in place.

Table ES.2.1 Proposed Remediation Activities and Corresponding Benefits

Component	Proposed Remediation Activity	Benefits
Arsenic trioxide dust storage areas	- Freeze in place through ground freezing ("frozen block" method); - Improve stability of storage areas; - Maintain ground freezing system.	- **Prevents release of soluble arsenic into groundwater around the mine;** - **Eliminates risk of water entering or dust escaping into lower mine workings;** - **Eliminates health and safety risks to members of the public**.
Other underground mine components	- Clean up and dispose of waste materials; - Seal mine openings.	- **Eliminates safety risks to wildlife and members of the public.**
Open pits	- Backfill B1 Pit and Brock Pit; - Place signs, fences and berms to control access to remaining pits.	- **Filling of B1 Pit allows for installation of freeze system and serves as a waste disposal site;** - **Public safety enhanced by restricting access to other pits through physical barriers.**
Waste rock	- Disposal of waste rock in B1 Pit.	- **Waste rock serves as backfill to allow for installation of freeze system.**
Tailings and sludge containment areas	- Re-contour and cover with rock and soil to promote drainage and potential revegetation.	- **Minimizes potential for contamination of groundwater;** - **Reduces the rate of arsenic release into mine workings;** - **Long-term improvement to air quality on site (e.g., dust reduction);** - **Improves visual quality of site;** - **Potential for future land uses following full remediation.**
Historic foreshore tailings	- Cover in place.	- **Limits erosion and potential release of arsenic to the water.**

Table ES.2.1 Proposed Remediation Activities and Corresponding Benefits (Cont'd)

Component	Proposed Remediation Activity	Benefits
Site water management	- Construct new water treatment plant; - Direct all contaminated water to the mine for collection and treatment; - Treat contaminated water and discharge to Great Slave Lake; - Manage treatment by-products on site.	- **Eliminates off-site migration of contaminants in groundwater;** - **Storage of contaminated water on surface no longer required;** - **Eliminates treated water discharge to Baker Creek;** - **Reduces the amount of arsenic discharged to Great Slave Lake.**
Baker Creek	- Divert portions of creek to reduce risk of flooding of underground workings; - Improve hydraulic performance; - Enhance physical habitat; - Managing contaminated sediments.	- **Reduces risk of flooding underground workings;** - **Improves aquatic habitat in Baker Creek.**
Quarries, borrow pits, and overburden piles	- Re-slope for improved drainage and stability; - Rehabilitate.	- **Reduces physical hazards;** - **Returns the site to more natural conditions.**
Contaminated soils	- Excavate and backfill into frozen zone in B1 Pit or treat on surface.	- **Improves quality of terrestrial habitat;** - **Allows future use of portions of the site for industrial, commercial, residential and recreational use.**
Buildings and infrastructure	- Remove all hazardous materials and demolish buildings; - Relocate portion of public highway to allow for remediation of the site.	- **Improves visual quality of site;** - **Reduces safety risks to the public and wildlife.**

ES.3 DEVELOPER'S ASSESSMENT REPORT

Environmental Assessment (EA) in the Mackenzie Valley is governed by the *Mackenzie Valley Resource Management Act* (MVRMA) which provides a legislative framework for the EA of proposed developments. In this case, the "development" is the remediation of the Giant Mine Site.

The Mackenzie Valley Land and Water Board (MVLWB) determined that it is unlikely that the proposed Remediation Plan would have a significant adverse effect on the environment or would cause public concern. Nonetheless, the City of Yellowknife referred the Project to an EA due to concerns about potential adverse environmental impacts within its municipal boundaries. In response to this referral, the Mackenzie Valley Environmental Impact Review Board (the Review Board) began its EA of the Project in April 2008. As proponents for the Remediation Project, INAC and the GNWT are responsible for undertaking the EA.

The EA is documented in the DAR (i.e., this report). The content of the DAR is based upon the Review Board's May 2009 *Terms of Reference* for the EA. It is also in accordance with the underlying principles and best practices of EA, and within the unique context of the Mackenzie Valley.

The DAR assesses the effects of both phases of the Remediation Plan; that is, the effects of the implementation of the Remediation Plan, and the effects of the on-going management during the Long-term Operation and Maintenance Phase.

Environmental Assessment Methodology

The assessment methodology follows the requirements of the Review Board's *Terms of Reference.* This methodology requires that the project works and activities be considered to determine how each one may interact with, and affect, the environment. This is done by establishing a geographic boundary and a timeframe for the Project; identifying applicable environmental components, such as surface water and air quality; and selecting the Valued Components (VCs) that represent important features of the environment as a focus of the EA study.

Project Works and Activities

Using input from the public and technical experts, the Review Board determined that the scope of the Project would include the key project works and activities as outlined on Table ES.2.1.

Geographic Boundary

The geographic boundary for assessing the environmental effects of the Remediation Plan includes a Site Study Area, a Local Study Area and a Regional Study Area. The Review Board established the following Site Study Area where the assessment is to be focussed:

- The lands encompassed by Reserve R662T;
- The land encompassed by the Giant Mine Townsite lease area (17889T), including the Great Slave Cruising Club;
- The section of shoreline of North Yellowknife Bay adjacent to the mine site where tailings have been historically deposited; and

The Local Study Area comprises the area immediately adjacent to the Site Study Area with focus on Yellowknife Bay downstream of Giant Mine. The communities of Yellowknife, N'dilo and Dettah are within the Local Study Area. The Regional Study Area is the North Slave Region of the NWT.

Timeframe

The Review Board established a timeframe of 25 years, consisting of:

- Fifteen years to complete the ground freezing and immobilization of contaminants (arsenic trioxide dust); and
- Ten years of subsequent monitoring activities to verify that the site has been stabilized.

The Review Board anticipates that upon completion of the Project (i.e., after 25 years), the appropriate regulatory authorities will be responsible for ensuring the site is stable and monitoring and follow-up activities are implemented.

Environmental Components

Baseline environmental conditions (i.e., the existing environment) were evaluated for each of the three study areas. The environmental components considered in the DAR were identified on the basis of likely interactions with the Project activities, as well as from past experience on similar projects and direction from the Review Board's *Terms of Reference*. The existing environment is described for the following components:

- *Surface Water Environment* – hydrology (surface water flow), surface water quality and sediment quality;

- *Geological and Hydrogeological Environment* - groundwater quality and flow, soil quality and permafrost;
- *Atmospheric Environment* – air quality and noise;
- *Aquatic Environment* – aquatic habitat and aquatic biota (plants and animals);
- *Terrestrial Environment* – terrestrial habitat and terrestrial biota (plants and animals);
- *Health* – non-human biota and humans;
- *Aboriginal Interests* – traditional land use, Aboriginal communities and Aboriginal heritage resources; and
- *Additional Community Interests* – land use, socio-economic conditions, transportation, and local resources.

Taking the baseline conditions into account, VCs were identified for each of the environmental components listed above and were the focus of the assessment of effects. Examples of VCs chosen for this Project are lake whitefish in Baker Creek and northern pike in Yellowknife Bay (Aquatic Environment); moose, grouse, peregrine falcon, willow (Terrestrial Environment); traditional harvesting and Aboriginal archaeological resources (Aboriginal Interests); and employment (Socio-economic Conditions).

ES.4 ASSESSMENT OF EFFECTS

Using the description of the project activities and the baseline information provided for each environmental component, all interactions between the project and the surrounding environment were screened to identify negative effects that might occur. In situations where potential negative effects were identified, different approaches to reduce or avoid the effects were selected. This is called mitigation. Effects remaining after mitigation are referred to as residual effects.

The proposed project actions and the environmental components were assessed in four ways:

1. Effects of the Project on the environment;
2. Effects of the environment on the Project;
3. Effects of accident and malfunctions; and
4. Cumulative effects.

Effects of the Project on the Environment

The fundamental objective of the Project is to prevent adverse effects that would occur if no remediation plan was undertaken. Therefore, most of the effects associated with the Project are positive and are beneficial to the environment and to the public. Benefits such as long-term improvement of soil, surface water, and sediment quality, immobilization of contaminants, as well as socio-economic opportunities, are expected. The key beneficial effects expected as a result of project implementation were summarized on Table ES.2.1.

Even though the long-term effects of the Project are beneficial to the environment and will result in a vast improvement to the existing situation, some site remediation activities may result in residual effects, even with the implementation of extensive mitigation measures. These include the following:

- Combustion and noise emissions from equipment and vehicles during on-site activities;
- Increase in suspended solids (dust) during earthmoving activities;
- Loss of aquatic habitat and increased turbidity during rehabilitation of Baker Creek;
- Release of existing contaminants to air or water during remediation of contaminated areas;
- Changes to existing surface water flow (hydrology) on site;
- Loss of some permafrost;
- Surface disturbances which can affect terrestrial habitat and biota;
- Erosion during removal of waste rock, etc.; and
- Potential loss of heritage buildings (community interests).

Using criteria such as magnitude (how much), duration (how long) and spatial extent (how far), the residual adverse effects were evaluated for significance; that is, whether the effect is minor (not significant) or significant. Based on this evaluation, it was concluded that with the identified mitigation measures in place, the residual adverse effects are considered to be minor and not significant, particularly in comparison to the benefits of the Project. Most of the residual effects are temporary and are restricted to the Site Remediation Phase.

The remediation activities will decrease but not completely eliminate arsenic releases from the site. For example, even after remediation, Baker Creek will continue to have concentrations of arsenic above background levels. Studies were undertaken to determine how much risk there would be to plants and animals, and to humans from all sources of arsenic. These studies are called ecological risk assessment and human health risk assessment, respectively.

Ecological risk assessment calculations show that there will continue to be a potential for adverse effects on bottom-feeding fish and terrestrial animals living in the Baker Creek area. Human health risk assessment calculations indicate that arsenic intakes by humans will remain within the range estimated for other Canadians, and that there will be little risk of adverse health effects. There may, however, need to be some restrictions on future activities at the site until monitoring programs can demonstrate that arsenic concentrations are within safe levels. For example, there may be a need to restrict the consumption of fish caught in Baker Creek.

Effects of the Environment on the Project

The evaluation of potential effects of the environment on the Project considered severe weather such as flooding, climate change and earthquakes.

Based on built-in design features of the Project, as well as procedures that would be in place to mitigate these environmental events, the DAR concluded that no significant adverse impacts on the Project are anticipated. A notable finding is that the proposed passive freeze system is predicted to withstand a "worst case" climate change scenario.

Effects of Accidents and Malfunctions

The EA also included an evaluation of effects that might occur under circumstances such as extreme weather, fires or human error and neglect. These effects were determined through an evaluation of potential accidents and malfunctions.

With appropriate design features, mitigation measures, and emergency response plans in place, the assessment concluded that significant adverse effects on the environment and human health from accidents and malfunctions are unlikely.

Cumulative Effects

The adverse residual effects from the Project were assessed to determine whether or not they have the potential to overlap in time and space (i.e. act cumulatively) with the effects of other projects and activities, either past, existing, or future within the study areas for the Project.

Several activities were identified as having potentially overlapping effects. They were primarily associated with other projects or activities located near the Giant Mine site, such as solid waste landfill operations and expansion, on-going quarry operations and the possible re-routing of Highway 4.

In all cases, the potential cumulative effects identified were found to be such that no additional mitigation measures would likely be necessary to protect the environment. None of the potential cumulative effects identified is expected to extend beyond the Site Remediation Phase.

ES.5 PUBLIC CONSULTATION PROGRAM

Aboriginal communities and the public will continue to be engaged in the design and implementation of the Remediation Project. The proponents have developed an Engagement and Consultation Plan that will guide INAC and the GNWT in consulting with and engaging Aboriginal Communities and the public throughout the balance of the EA process and implementation of the Remediation Project. As part of the comprehensive public consultation program, the Project Team will focus on the interests of Yellowknife, N'dilo and Dettah. An Aboriginal and Government Body is proposed to facilitate the incorporation of Aboriginal interests into the design and implementation of the Remediation Project.

Past engagement activities have included workshops, open houses, public sessions, mine tours and media information events. The main goals of these activities has been to inform the public of the conditions of the site, the options for long-term management of the arsenic trioxide dust, and to solicit input from the public on the options.

Future engagement and consultation activities will focus on the surface remediation of the site. The Project Team will work with communities to inform them of proposed site activities; respond to questions and concerns about them; and provide opportunities for the suggestions of communities to be considered in design processes.

Other communication initiatives include a website to provide current, accurate information on the Project, being available to various local and national media (television, radio, newspapers), and the creation of the Giant Mine Public Registry which gives the public access to technical information regarding the Project. In addition, the Project Office is open to the public and team members are available for answering questions in person, by phone or e-mail.

ES.6 MONITORING PROGRAM

The purpose of monitoring will be two-fold: to assist in determining if the environmental effects of the Project are as predicted; and to confirm that the proposed mitigation measures are effective, and thus to determine if new mitigation strategies are required.

Project implementation monitoring will be governed by an Environmental Monitoring and Evaluation Framework supported by a Long-term Environmental Monitoring Program. As part of the framework, INAC and the GNWT are committed to developing an Environmental Management System (EMS) that will be central to the ongoing monitoring and performance improvement of the Giant Mine Remediation Project. An audit protocol, including third-party auditing, and review process will be an integral part of the EMS. As the Project advances, and in response to monitoring results, Aboriginal communities and Yellowknife residents will continue to be engaged in the review of monitoring results and the identification of adaptive management approaches needed to address any environmental issues that are detected through the monitoring program.

The Giant Mine Remediation Project has been designed to minimize the potential for environmental effects associated with current site risks. While some risks can be eliminated, others (e.g., arsenic trioxide) will remain on site indefinitely and will require long-term management. To ensure the effectiveness of efforts to manage these risks, a Long-term Environmental Monitoring Program will be implemented. The program will evaluate both the physical performance of remediation infrastructure (e.g., frozen chambers, tailings covers) and environmental quality in the vicinity of the site.

The detailed plan for monitoring the site during and after implementation includes sampling and analysis of groundwater and surface water, air quality monitoring, environmental effects monitoring, and monitoring of ground temperatures within and around the frozen arsenic trioxide chambers and stopes. It also includes regular inspections of remaining pit walls, as well as the covers, ditches and spillways associated with the remediated tailings areas.

The monitoring will be sufficient to allow post-remediation to be compared to both predictions and licence requirements. Monitoring reports will be prepared and submitted to the MVLWB. Government agencies and co-management boards will continue in their capacity as environmental regulators of the Remediation Project (e.g., the MVLWB, Environment Canada, Department of Fisheries and Oceans, INAC, Government of Northwest Territories Environment and Natural Resources). These regulators will provide monitoring oversight to ensure that humans and the environment are protected from any significant adverse effects.

ES.7 CONCLUSION OF THE DAR

Based on the findings presented in the DAR, INAC and the GNWT have concluded that the Project is not likely to result in any significant adverse environmental effects.

The proponents are also of the opinion that the benefits of implementing the Project will outweigh any potential adverse effects. Moreover, such adverse effects are expected to be mainly temporary in nature, principally occurring during the Site Remediation Phase, whereas the beneficial aspects, particularly those associated with improvements to the land, air and water, are expected to endure for centuries.

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Glossary of Terms

Aboriginal heritage resources	Historical artefacts, archaeological features or sites associated with Aboriginal peoples.
Accident	An unplanned event that has the potential to result in adverse environmental or public health and safety consequences.
Acid base accounting	A screening procedure to determine the potential acid-neutralizing and acid-generating properties of minerals.
Acid rock drainage (ARD)	The outflow of acidic water from metal mines or coal mines that forms when certain minerals are exposed to air.
Adaptive Management	A management approach that involves monitoring the outcomes of a project and improving the way the project is managed on the basis of monitoring results.
Agronomic	Pertaining to agriculture.
Alluvial	Relating to alluvium, the sediment deposited in flowing water.
Amphipods	A small crustacean belonging to the order Amphipoda, such as the beach flea.
Angle of Internal Friction	A measure of the ability of a unit of rock or soil to withstand a shear stress.
Angle of Repose	The maximum angle at which a pile of unconsolidated material can remain stable.
Aquatic macrophyte	Aquatic plant large enough to be seen by the naked eye; may be submergent (grows underwater) or emergent (grows above the waterline).
Aquifer	A layer of underground rock or sand that stores and transports water.
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.
Asbestos	Fibrous mineral forms of magnesium silicate usually employed for its insulating and heat resisting properties; also a known carcinogen.
Attenuation	Reduction in mass or concentration of a compound in water over time or distance from its source due to naturally occurring processes such dispersion, dilution, or adsorption.
Atterberg Limits	Parameters related to the plasticity of a soil and used in estimating other engineering properties of a soil and in soil classification.
Basalt	A common extrusive volcanic rock.
Bathymetry	The measurement of the depth of water bodies.
Bedrock	Consolidated rock underlying the Earth's surface.
Benthos (Benthic organisms, Epibenthos)	Animals without backbones that live on river and lake bottoms.
Bioaccessibility	A measure of how available a chemical is to the biological processes of an organism. Synonymous with bioavailability.
Biota	All the plant and animal life within a particular area.
Borrow	Quarried construction materials (i.e. rock, gravel, sand). Synonymous with aggregate.
Bounding scenario	A situation that is likely to encompass the full range of potential adverse environmental effects associated with other similar scenarios.
Built environment	The part of the environment shaped by humans, including buildings, landscaping, roads, signs, trails, and utilities.
Bulkhead	A water-resistant seal used in a mine where a wall is constructed across an access point.

Glossary of Terms (Cont'd)

Bryophyte	Referring to small non-vascular land plants; includes hornworts, liverworts and mosses.
Calcine	The residual product from roasting sulphide concentrates.
Catchment	The natural boundary of the area where all surface water drains to a common point.
CCME	The Canadian Council of Ministers of the Environment. An intergovernmental forum in Canada for discussion and joint action on environmental issues. Develops environmental guidelines.
Climate normals	Average of climate data for an extended period. Canadian climate normals are based on stations with at least 15 years of data between 1971 and 2000.
Chironomids	A family of insects that are informally known as “non-biting midges” or “lake flies”.
Chlorinated organics	A class of chemicals that contain both carbon and chlorine atoms.
Chronic toxicity	A toxic effect which occurs after repeated or prolonged exposure.
Cold vapour technique	Analytical technique used to measure trace amounts of volatile heavy metals, particularly mercury.
Co-management	An arrangement where northern institutions of public government share administrative and regulatory responsibilities with government over the management of land, water and other natural resources.
Conductivity	The ability of a substance to conduct electric current; often used as an indirect measure of the salinity of the water.
Cone penetrometers test	An in-situ test used in geotechnical engineering applications to determine the density and compaction of soil and other materials.
Conveyance channel	A permanent waterway designed to convey storm water runoff.
Coolant	A medium, usually fluid, used to draw heat from an object.
Core need	When a household faces housing problems, such as suitability, adequacy, or cost. Or when the total household income is below the community Core Need Income Threshold.
Credible events	An event that has a reasonable probability of occurrence based on professional judgment in the context of project-specific conditions.
Crown pillar	The mass of bedrock overlying an underground excavation, such as a stope.
Cultural landscape	The physical and cultural environment associated with a heritage site.
Cumulative effects	Effects that are likely to result from a project in combination with the effects of other past, existing and reasonably foreseeable projects.
Cyanidation	A metallurgical technique for extracting gold from low-grade ore using cyanide solution.
Decant	To draw off the upper layer of liquid after the heaviest material (a solid or another liquid) has settled.
Demographic	A statistic characterizing human population, especially with regard to density and capacity for expansion or decline.
Density stratification	Differences in density throughout the water column typically caused by differences in temperature.
Discontinuous permafrost	Permafrost that only forms in isolated spots; often in areas with a northerly aspect or in wetlands.
Dissolved oxygen	Amount of oxygen dissolved in a given volume of water at a given temperature and atmospheric pressure.
Diversity	In the context of “species diversity,” meaning an expression of the number of number of species in an area and also their relative abundance.
Drawdown	The drop in the water table or level of water in the ground when water is being pumped from a well.
Drift	A near-horizontal passageway in a mine, typically following an ore body.

Glossary of Terms (Cont'd)

Dry Density	The density of a solid after it has been heated at high temperature to a dry condition.
Ecological Risk Assessment	The process of estimating the potential risk of contaminants to non-human biota under defined conditions.
Ecoregion	A part of an ecozone characterized by distinctive regional ecological factors, including climate, physiography, vegetation, soil, water and fauna.
Ecosystem	The combination of the biological community and the non-living environment.
Ecozone	An area at the earth's surface representative of large and very generalized ecological units characterized by various abiotic and biotic factors.
Effect	An observable and measurable response of a subject to an external source of disturbance; synonymous with "impact".
Effect Concentration	Concentration of a substance that causes a defined magnitude of response in a given system. For example the EC_{50} is the concentration that causes 50 % of maximal response.
Effluent	Liquid wastes that are discharged into the environment, such as treated industrial waste water or sewage.
Electrostatic precipitator	A particulate collection device that removes particles from a flowing gas using an electrostatic charge.
Employment participation rate	The percentage of persons, 15 years or older, who are in the labour force and are either employed or unemployed.
Endemic	Being unique to a particular geographic location.
Environmental Effects Monitoring	The repetitive measurement of environmental parameters to test specific hypotheses of the effects of human activity on the environment.
Ephemeroptera	An Order of insects dominated by a long aquatic larval stage relative to a very short adult life stage, some living for just one day.
Epilimnion	The layer of warm water at the surface of a thermally stratified lake.
Erosion	Detachment of soil particles by natural forces such as water, wind, ice, and gravity.
Ex situ	Meaning moved from its original place.
Fault	A volume of rock across which there has been significant displacement.
Fin rays	Soft or bony structures supporting fin membranes.
Flexural strength	Mechanical parameter for brittle material, defined as a material's ability to resist deformation under load.
Flocculent	A substance that is added to water to make particles clump together in order to achieve better filtration or recovery.
Fluvial	Relating to a stream or river.
Foliation	The set of layers visible in many metamorphic rocks as a result of the flattening and stretching of mineral grains during metamorphism.
Friable	The ability of a solid substance to be broken into smaller pieces with little effort.
Froth flotation	A method of concentrating ground ores using chemicals that cause the attachment of minerals to air bubbles, which are then skimmed off.
Gammarid	A common name describing a family of amphipods (shrimp-like crustaceans).
Geochemistry	The branch of chemistry relating to rocks and minerals.
Geomorphology	The branch of geology concerned with the characteristic, configuration and evolution of rocks and land forms.
Geotechnical engineering	The branch of engineering dealing with soil and bedrock, especially aspects related to the construction of foundations and earthworks.
Geotextile	Fabrics which are used in civil engineering applications for soil protection and reinforcement.
Grab sample	A sample collected at a specific time and specific location, used to determine

Glossary of Terms (Cont'd)

	the nature of the water for that specific time and location only.
Gross Domestic Product	The total market value of all final goods and services produced in a country in a given year, equal to total consumer, investment and government spending, plus the value of exports, minus the value of imports.
Guideline for Canadian Drinking Water Quality	National guidelines used to assess the suitability of water for human consumption.
HAZMAT	An abbreviation for "hazardous material", which are solids, liquids, or gases that can harm people, other living organisms, property, or the environment.
Hanging wall	The rock immediately overlying a mineral deposit.
Heat exchanger	A device designed to transfer heat between two physically separated fluids or mediums of different temperatures.
Heat flux	The flow of energy per unit of area per unit of time.
Hematite	The mineral form of iron oxide.
Human Health Risk Assessment	The process of estimating the potential risk of contaminants on a human population under defined conditions.
Hyalellids	A family of freshwater invertebrates of the genus "Hyalella".
Hydraulic conductivity	A measure of the ability of groundwater to flow through the subsurface environment.
Hydraulic gradient	The hydraulic gradient is the change in total head with a change in distance in a given direction yielding a maximum rate of decrease in head.
Hydrogeology	The branch of geology that deals with the distribution and movement of groundwater in the soil and rocks of the Earth's crust.
Hydrocarbons	A large class of organic compounds composed of hydrogen and carbon.
Hydrograph	The time record of the discharge of a stream, river or watershed outlet.
Hydrolysis	A chemical reaction where water reacts with a compound to produce other compounds.
Inductively Coupled Plasma – Mass Spectrometry (ICP-MS).	An analytic test used to determine the presence metals and certain non-metals at extremely low concentrations.
Inorganic	With few exceptions, any compound that does not contain carbon.
In situ	Meaning in its original position or place.
Invertebrate	Any animal without a spinal column.
Lacustrine	Referring to a lake environment.
Landfarming	A bioremediation process that uses bacteria and the application of soil amendments (i.e. fertilizer) to degrade contaminants in soil.
Latent heat	Heat absorbed or radiated during a change of phase at a constant temperature and pressure.
Leachate	Liquids that have percolated through soil and that carry substances in solution or suspension.
Leach extraction testing	A procedure to determine the properties of chemicals that may be washed from materials under natural precipitation conditions.
Lithic scatter	An archaeological site that consists of flakes and/or stone tools.
Lithology	The branch of geology concerned with the origin, formation, classification and mineral composition of rocks.
Littoral	Referring to the shallow shoreline of a lake.
Littoral zone	Shoreline area along water bodies that includes both terrestrial and aquatic habitat where emergent and submerged plant communities are found.
Mafic	Rocks, such as silicate minerals, magmas, and volcanic and intrusive igneous rocks.
Malfunction	The failure of a system or piece of equipment to function in the manner for which it was intended.
Mercury amalgamation	The use of mercury to extract gold through the creation of an alloy or

Glossary of Terms (Cont'd)

	amalgam.
Mesic	Pertaining to a habitat that has at least a moderate amount of moisture.
Mineralogy	The study of the chemistry, structure and physical properties of minerals.
Molar ratio	A comparison of the number of moles of one substance in a chemical equation.
Molluscs	Phylum of invertebrates having a soft unsegmented body, often enclosed in a shell.
Morphometrics	The study of the variation and change in the form of organisms.
Mowhi Gogha De Niitlee	The lands described by Chief Monfwi during the signing of Treaty 11 within which the Tlicho may exercise the rights established in the Tlicho Agreement.
Muck	Rock or ore that has been fragmented by blasting or excavation.
NP:AP ratio	The ratio of neutralization potential to acid generation potential in a mineral.
Oligochaetes	Subclass of the phylum Annelida that includes earthworms, as well as fresh water and marine worms.
Oligotrophic lake	A lake with low primary productivity due to limited nutrient availability.
Omnivorous	Referring to organisms that eat both animal and vegetable foods.
Organic	Any compound containing carbon (except carbon dioxide).
Otolith	A part of the inner ear of a fish that is required to maintain balance.
Outcrop	An exposure of bedrock at the Earth's surface.
Outfall	A pipe through which industrial facilities and wastewater treatment plants discharge effluent into a water body.
Overburden	Rock and soil that overlies an economic mineral deposit.
PCB (Polychlorinated Biphenyl)	Biphenyl-based compounds where hydrogen atoms have been substituted with chlorine. Considered a common and persistent organic pollutant.
Permafrost	Perennially frozen ground occurring wherever the temperature remains below zero degrees for several years.
Phytoplankton	Microscopic plants, such as algae, which are suspended in aquatic environments.
Piezometer	A small diameter observation well used to measure groundwater pressure.
Piezometric level	The level to which water will rise if a piezometer is installed.
Plant community	A collection of plants that live together on a relatively uniform area of land that is distinct from surrounding vegetation.
Plutonic	Pertaining to igneous rocks that are formed deep within the earth.
Polishing Pond	The last in a series of settling ponds through which effluent flows before being discharged into the natural environment.
Pore water	The water that fills the pores between the grains of sediment.
Porphyry	A variety of igneous rock consisting of large-grained crystals, such as feldspar or quartz.
Precipitate	A solid formed in a solution during a chemical reaction.
Probable Effects Levels	The level above which adverse effects are expected to occur frequently.
Primary productivity	The production of organic compounds from atmospheric or aquatic carbon dioxide, principally through the process of photosynthesis.
Probabilistic	Model where there are multiple possible outcomes, each having varying degrees of certainty or uncertainty of its occurrence.
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.
Proterozoic	A geological period from 2,500 to 544 million years ago that precedes the first abundant complex life on Earth.
Radionuclide	An unstable isotope of any chemical element that decays or disintegrates

Glossary of Terms (Cont'd)

	spontaneously, emitting radiation.
Raise	A vertical or inclined excavation that leads from one level, or drift, to another and may also extend to the surface.
Riparian	Related to the bank of a river, stream or other water body.
Rip-rap	Rock or other material used to armour shorelines, streambeds, bridge abutments, pilings and other shoreline structures against scouring from water or ice.
Refractory gold	A gold ore that is naturally resistant to recovery by standard milling and requires additional treatment processes.
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.
Return period	An estimate of the interval of time between events, such as an earthquake, flood or river discharge flow of a certain intensity or size.
Riffle	A shallow stretch of a river or stream where the current is above the average stream velocity and where the water forms small rippled waves as a result.
Rock mechanics	The study of the mechanical properties of rocks, which includes stress conditions around mine openings and the ability of rocks and underground structures to withstand these stresses.
Run-of-quarry	Large stones that have been blasted in a quarry and left untreated (i.e. requiring no further crushing).
Schist	A metamorphic rock with layered, flat minerals.
Sedge	Grass-like perennial plants that favour wet places.
Sedimentary rock	A form of rock made by the deposition and compression of small particles.
Seismic	Pertaining to earthquakes or earth vibration.
Sill	A flat mass of igneous rock between two layers of older sedimentary rock.
Sludge	A generic term for solids separated from suspension in a liquid.
Species at risk	Species designated as endangered, threatened, of special concern, or rare.
Specific gravity	The density of a substance relative to the density of water.
Spillway	A path designed to safely take overflow away.
Stope	Large underground open space or cavity left after ore has been mined out.
Structural geology	The branch of geology concerned with the deformation of rock bodies and the natural forces that caused the deformations.
Substrate	The material which comprises the bottom of a water body.
Swale	A low tract of land, especially one that is moist or marshy; often designed to manage water runoff, filter pollutants, and increase rainwater infiltration.
Taiga	The ecosystem considered to be a transition zone between the boreal forest and the tundra.
Tailings	The small-diameter waste material left over after the ore milling process.
Thermal conductivity	The measure of the ability of a medium to transfer heat.
Thermosyphon	A device that carries out passive heat exchange based on natural convection.
Total organic carbon	The amount of carbon bound in an organic compound; often used as an indicator of water quality.
Toxicity	The degree to which a substance is able to damage an exposed organism.
Toxicological reference values	An estimate (with uncertainty spanning perhaps an order of magnitude) exposure that is likely to be without an appreciable risk of deleterious effects.
Total suspended solids	A measurement of the concentration of particulate matter found in water.
Trichoptera	The Order of insects commonly known as caddisflies.

Glossary of Terms (Cont'd)

Turbidity	A cloudy condition in water due to suspended particles or organic matter.
Valued components	Physical, biological, cultural, and economic aspects of the environment that are considered to be important by society.
Viewshed	An area of land, water, or other environmental element that is visible to the human eye from a fixed vantage point.
Young-of-year	An animal younger than one year of age (i.e., born within the year).

List of Acronyms

ABP	Aboriginal Benefits Plans
AKDFN	Akaitcho Dene First Nations
BAT	Best Available Technology
CARD	Contaminants and Remediation Directorate
CCME	Canadian Council of Ministers of the Environment
CCCSN	Canadian Climate Change Scenarios Network
CEAA	Canadian Environmental Assessment Agency
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CSMWG	Contaminated Sites Management Working Group
CSP	Contaminated Site Program
CWQG-FAL	Canadian Water Quality Guidelines for Protection of Freshwater Aquatic Life
DAR	Developer's Assessment Report
DFO	Department of Fisheries and Oceans (Canada)
DIAND	Department of Indian Affairs and Northern Development
dw	Dry Weight
EA	Environmental Assessment
EC	Effects Concentration
ED	Environmental Division (of ENR)
EEM	Environmental Effects Monitoring
EHS	Environment, Health and Safety
EMEF	Environmental Monitoring and Evaluation Framework
EMP	Environmental Management Plan
EMS	Environmental Management System
ESP	Electrostatic Precipitator
FCSAP	Federal Contaminated Sites Action Plan
FOS	Freeze Optimization Study
GDP	Gross Domestic Product
GNWT	Government of the Northwest Territories
GYML	Giant Yellowknife Gold Mines Ltd.
HHERA	Human Health and Ecological Risk Assessment
IBA	Important Bird Area
ICP-MS	Inductively Coupled Plasma Mass Spectrometry
INAC	Indian and Northern Affairs Canada
IPCC	Intergovernmental Panel on Climate Change
IPRP	Independent Peer Review Panel
IR	Information Request
IRS	Intact Rock Strength
ISQG	Interim Sediment Quality Guidelines
ISCST3	Industrial Source Complex Short-Term
LOAEL	Lowest Observable Adverse Effects Levels
LSA	Local Study Area

List of Acronyms (Cont'd)

MACA	Municipal and Community Affairs (of the GNWT)
MGML	Miramar Giant Mine Limited
MHS	Mining Heritage Society
MMER	Metal Mining Effluent Regulation
MRBB	Mackenzie River Basin Board
MVLWB	Mackenzie Valley Land and Water Board
MVEIRB	Mackenzie Valley Environmental Impact Review Board
MVRMA	Mackenzie Valley Resource Management Act
NBCC	National Building Code of Canada
NO_2	Nitrogen Dioxide
NO_x	Nitrogen Oxides
NSMA	North Slave Métis Alliance
NTPC	Northwest Territories Power Corporation
NWT	Northwest Territories
PCB	Polychlorinated biphenyl
PEL	Probable Effects Level
PM	Particulate Matter
PM_{10}	Particulate Matter with a mean diameter less than 10 µm
$PM_{2.5}$	Particulate Matter with a mean diameter less than 2.5 µm
PMP	Probable Maximum Precipitation
PWGSC	Public Works and Government Services Canada
PWNHC	Prince of Wales Northern Heritage Centre
QA/QC	Quality Assurance/Quality Control
RQD	Rock Quality Designation
RSA	Regional Study Area
SARA	*Species at Risk Act* (Canada)
SDS	Sustainable Development Strategies
SENES	SENES Consultants Limited
SNP	Surveillance Network Program
SO_2	Sulphur dioxide
SOE	Status of the Environment
SRK	SRK Consulting Inc.
SSA	Site Study Area
TK	Traditional Knowledge
TOR	Terms of Reference
TRP	Tailings Retreatment Plant
TRV	Toxicological Reference Values
TSP	Total Suspended Particulate
TSS	Total Suspended Sediment
UBC	Under Baker Creek
UNESCO	United Nations Educational, Scientific and Cultural Organization
USEPA	United States Environmental Protection Agency
VC	Valued Component

List of Acronyms (Cont'd)

WSC	Water Survey of Canada
WTP	Water Treatment Plant
ww	Wet weight
YKDFN	Yellowknives Dene First Nation
YOY	Young of the year

1 Introduction and Overview

This document is the Developer's Assessment Report (DAR) prepared for the Giant Mine Remediation Project (the "Project") in Yellowknife, Northwest Territories (NWT). The Project is defined as the implementation of the Giant Mine Remediation Plan (the "Remediation Plan") which represents a proposal to stabilize the site, to isolate contaminants from the environment, and to establish safe site conditions that allow for the restoration of ecological processes.

1.1 Background

1.1.1 Project Location

Giant Mine is located approximately five kilometres (km) North of Yellowknife's city centre, as depicted in Figure 1.1.1. 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-3668T, now designated as Reserve R662T). Two impacted areas immediately outside of the lease area are also considered to be part of the site. They are the Giant Mine "Townsite", which was removed from the surface lease in 1999, and an area of historic tailings deposition along the shore of North Yellowknife Bay. The total area of these lands is 949 hectares (ha).

1.1.2 Key Environmental Concern

Gold in the ore from Giant Mine was associated with an arsenic-bearing mineral known as arsenopyrite. The roasting process used to liberate the gold from the arsenopyrite led to the production of arsenic-rich gas as a by-product. During the mine's first two years of operation (i.e., 1948-1950), arsenic was emitted directly into the atmosphere. The negative consequences of this practice were soon recognized and the mine operators developed processes to control the arsenic emissions. From 1951 to 1999 arsenic-rich gas from the roasting process was captured in the form of arsenic trioxide dust. Approximately 237,000 tonnes of the dust was collected and transferred into underground storage areas at the mine site.

Figure 1.1.1 Project Location and Surrounding Features

Arsenic trioxide, which is soluble in water, is hazardous to both people and the environment. If left unmanaged, the dust stored underground at Giant Mine would gradually dissolve and arsenic concentrations in groundwater would increase substantially. The contaminated groundwater would subsequently migrate into local water bodies downstream of the site, particularly Great Slave Lake. The arsenic trioxide dust stored underground, therefore, represents the primary environmental concern associated with Giant Mine and is the focus of the Remediation Plan.

1.1.3 Additional Concerns

While arsenic trioxide is the primary concern, there are other environmental issues associated with the site. Recovery of gold from the ore produced tailings that contain arsenic, mostly in the form of relatively stable arsenopyrite, but also in more soluble forms. Approximately 14 million tonnes of tailings are stored in four surface containment areas, which together cover 95 ha (i.e. about 12% of the total area encompassed by Giant Mine Lease Boundary). Surficial materials have also been contaminated with arsenic by emissions from the processing facilities, tailings spills, and use of mine rock for construction. Infrastructure remaining on the site includes more than 100 buildings, many of which are contaminated with arsenic and asbestos. Eight open pits and 35 openings to the underground mine also represent safety hazards. Baker Creek flows through the site in a channel that has been heavily altered to accommodate mining, ore processing, and highway construction, and both its water and sediments are contaminated with arsenic. The creek's current channel overlies mined out areas where long-term stability is a concern, prompting the need to consider re-alignment.

1.1.4 Project Proponents

Ownership of Giant Mine changed hands several times prior to its last owner, Royal Oak Mines Inc., which went into receivership in 1999. At that time, control of the property was transferred to the federal department of Indian and Northern Affairs Canada (INAC) which assumed responsibility for the site. In addition, as the administrator of the lands upon which Giant Mine is located, the Government of the Northwest Territories (GNWT) has also assumed responsibility for various aspects of the site. By virtue of their shared responsibilities, INAC and the GNWT are Co-Proponents[1] of the Giant Mine Remediation Plan. Additional details on the Proponents and their roles are provided in Section 1.4.

[1] For the purposes of this DAR, the terms "Proponent" and "Developer" are used interchangeably.

Federal-Territorial Cooperation

Given that the Giant Mine site is subject to the jurisdictional authority of both the territorial and federal governments, and that certain responsibilities rest with a specific party, it was recognized that an official agreement would be required to provide a framework in which the Remediation Project could be advanced. The federal and territorial governments entered into a Cooperation Agreement[2] regarding the Project on March 15, 2005. The Cooperation Agreement established that both parties would implement a care and maintenance plan for the site that protects human health, public safety and the environment. The Cooperation Agreement also established an Oversight Committee to provide direction and guidance on the following:

a. Finalizing an integrated (surface and underground) remediation plan;

b. Formulation of a single intergovernmental application for approval by regulators;

c. Ensuring that care and maintenance activities are undertaken;

d. Monitoring remediation activities at the site;

e. Preparing emergency response activities; and

f. Addressing any other matter that may arise in carrying out the terms of the Cooperation Agreement.

The Cooperation Agreement outlines the financial responsibilities of the federal and territorial governments relative to care and maintenance and the cost share for surface remediation. The federal government is also specified as being responsible for the management of arsenic trioxide stored underground at the site. The Cooperation Agreement does not transfer jurisdictional responsibilities that each party otherwise may have with respect to the site.

1.1.5 Environmental Assessment

On October 19, 2007, INAC and the GNWT applied to the Mackenzie Valley Land and Water Board (MVLWB) for a Water Licence (MV2007L1-0031) to implement the Giant Mine Remediation Plan. The application was subsequently referred to Environmental Assessment (EA) on April 7th, 2008, to be carried out by the Mackenzie Valley Environmental Impact Review Board (Review Board), in accordance with Section 5 of the *Mackenzie Valley Resource Management Act* (MVRMA). Details regarding the process that led to the referral are presented in Section 2.1.

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[2] A copy of the Cooperation Agreement was filed as Supporting Document Q1 of the Giant Mine Remediation Plan, and has been resubmitted within Appendix B of the DAR.

The DAR was developed based on the direction provided in the Review Board's *Terms of Reference for the Environmental Assessment of the Indian and Northern Affairs Canada Giant Mine Remediation Plan* (*Terms of Reference*). The purpose of the EA study, as documented in the DAR, is to identify and assess any likely adverse environmental effects that might be caused during the implementation of the Remediation Project. Where such effects have been identified, appropriate mitigation measures have been selected. To verify the predicted effects and confirm that mitigation measures are performing as intended, a framework to monitor the implementation of the Remediation Project has also been proposed.

1.2 Project Purpose, Objectives and Overview

1.2.1 Purpose and Objectives

In recognition of the contamination issues associated with the former Giant Mine, INAC has conducted a wide array of site characterization and remediation planning studies since 1999. The initial efforts were focused on developing a remediation strategy to address the underground arsenic trioxide. In 2004, after a comprehensive review of alternatives, INAC identified the Frozen Block method as its preferred option. Since then, INAC has continued to refine its understanding of how the implementation of the Frozen Block should proceed, in addition to directing its attention to other components of the mine site that require remediation. These efforts culminated with the finalization of a comprehensive Remediation Plan for the site in 2007.

The overall purpose of the Remediation Project is to enhance the ecological integrity of the environment such that there will be a safer, healthier and sustainable environment. Specifically, the objectives of the Remediation Project are to:

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

1.2.2 Project Overview

The Remediation Project (as described in the Remediation Plan) was developed based on the above-cited objectives, taking into consideration the findings of numerous scientific and engineering studies as well as input provided by external experts and members of the public. The

Remediation Project has been divided into a series of major components, as summarized in Table 1.2.1. A more detailed description of the Remediation Project components can be found in the Remediation Project Description (Chapter 6). The only exception is the monitoring program which is presented in Chapter 14.

Table 1.2.1 Key Physical Works and Activities for the Project

Remediation Component	Proposed Activity
Immobilization of arsenic trioxide through ground freezing	One or more freeze plants will be constructed. Freeze pipes around and below each arsenic trioxide chamber will be installed. Coolant will be pumped through the pipes to create a frozen shell around each of the arsenic trioxide chambers prior to saturation of the dust and further freezing to create the frozen blocks.
Remediation of remaining underground mine components	All underground equipment and infrastructure will be de-contaminated or removed. Surface openings to the mine are to be sealed where safety issues warrant.
Reclamation of open pits	B1 pit will be backfilled with surficial material (contaminated soil, waste rock, quarried rock or clean demolition fill) and covered in order to allow installation of freeze pipes. The remaining pits may be backfilled or will have physical barriers (berms or fences) constructed around their perimeters.
Disposal of waste rock	The limited amount of waste rock currently on site will be used to fill the B1 pit or used as backfill underground.
Capping of tailings containment areas	The surface of each tailings area will be regraded and ditches and spillways will be constructed to limit erosion and re-direct run off. Tailings containment areas will be covered by a layer of quarried rock followed by an upper layer of fine-grained soil. Subject to future consultations, the tailings covers may be revegetated.
Remediation of historic foreshore tailings	The existing geotextile and rip-rap cover below the lake surface will be extended to cover the tailings where they occur in the littoral zone.
Ongoing treatment of contaminated mine water	Minewater will continue to be treated prior to release to the environment. A new water treatment plant will be constructed and will operate on a year-round basis. Treated minewater will be discharged to Yellowknife Bay via an outfall and diffuser.
Rehabilitation of Baker Creek	Baker Creek will be diverted in certain reaches into a new channel away from the areas where it poses a risk of flooding to the underground workings. Other sections will be upgraded to reduce the risk of overtopping/flooding. Depending on specific circumstances, contaminated sediments in the creek may be excavated, covered or left undisturbed.
Excavation and disposal of contaminated surficial materials	Surficial materials contaminated with arsenic (which may also be contaminated with hydrocarbons) will be placed in the frozen zone of B1 pit. Soils contaminated with only hydrocarbons may be treated on site so that the soil can be reused. Surficial materials will be remediated to the GNWT criterion for industrial land use in Yellowknife.
Demolition and disposal of buildings and infrastructure	Buildings and surface infrastructure currently on the site will be demolished with the possible exception of several townsite buildings of interest/heritage value to the NWT Mine Heritage Society and/or the City of Yellowknife. Arsenic-contaminated materials will be removed and placed underground within a frozen zone. Stable non-hazardous demolition waste will be deposited in the B1 Pit, outside the frozen zone. Waste asbestos materials that are not contaminated with arsenic will be bagged and buried in tailings at the Northwest Pond.
Relocation of a small stretch of Highway 4 (the Ingraham Trail)	Approximately 1.5 km of the existing Highway 4 will be relocated to facilitate implementation of the Remediation Project.
Monitoring	A comprehensive monitoring program will be implemented that includes provision for monitoring groundwater and surface water (including Baker Creek and Yellowknife Bay), air quality, environmental effects, and ground temperatures within and around the frozen arsenic trioxide. The program will also include inspections of pit walls, tailings covers, ditches and spillways and other physical works.

1.3 Project Setting

The following briefly describes the general setting of the Project area. A detailed description of the existing environment is provided in Chapter 7.

1.3.1 Ecological Setting

The region surrounding Giant Mine is characterized by cool summers, very cold winters and low humidity. In general, the terrestrial habitat on and in the near vicinity of Giant Mine has been degraded by industrial impacts and proximity to urban development. However some wildlife habitat is available and non-resident species use the site as a travel corridor to more favourable environments.

The aquatic habitat of the Giant Mine site is dominated by Baker Creek, which runs through the Giant Mine lease area before entering Great Slave Lake on the western shoreline of Yellowknife Bay. The environmental quality of the creek has been adversely affected by historic mining operations, as evidenced by elevated arsenic concentrations in water and sediments, as well as lower benthos diversity. Nonetheless, the creek currently serves as habitat for a variety of fish species, muskrats and aquatic birds.

1.3.2 Land Interests

The Giant Mine site is within the boundaries of the City of Yellowknife and is situated on Commissioner's Land administered by the GNWT's Department of Municipal and Community Affairs (MACA). MACA established Reserve R662T in favour of INAC that covers the former lease area of Giant Mine to allow for the implementation of the Remediation Project. Subsurface mineral rights are under federal jurisdiction and were withdrawn by Order in Council SI/2005-55 on June 15, 2005.

The Giant Mine site falls within the Akaitcho Dene asserted territory and is in the near vicinity of the Yellowknives Dene First Nation (YKDFN) communities of N'dilo and Dettah. Giant Mine is also within the traditional land use area of the Tlicho, known as Mowhi Gogha De Niitlee, and it falls within the provisions of the Tlicho Agreement (2003).

1.4 The Project Team

The Giant Mine Remediation Project Team consists of INAC and the GNWT, supported by the federal department of Public Works and Government Services Canada (PWGSC). As indicated previously, INAC and the GNWT are Co-Proponents for the Project and are responsible for all the commitments made in the DAR. While the federal and territorial governments are ultimately responsible for the Giant Mine Remediation Project, its implementation will be conducted by private sector contractors procured through PWGSC.

In response to the Review Board's requirements outlined in Section 3.2.2 of its *Terms of Reference*, the following sections provide an overview of the Project Team's previous experience working on the remediation of industrial development sites in the NWT or other Northern environments.

1.4.1 INAC

INAC is responsible for the management of contaminated sites located on reserve lands (throughout Canada), on federal lands North of 60º, and on any other lands under the department's custodial responsibility. In addition to Giant Mine, INAC is responsible for a large portfolio of federal contaminated sites throughout Canada's North. The portfolio includes several major sites with significant environmental concerns (e.g., the former Colomac and Faro Mines) as well as hundreds of smaller sites with relatively minor environmental concerns.

To assist with the management of federal contaminated sites in the NWT, INAC established the Contaminants and Remediation Directorate (CARD) which is based in Yellowknife. CARD includes a staff of engineers, scientists and technical specialists that are responsible for leading the site assessment, remediation planning/implementation and long-term monitoring efforts necessary to manage INAC's portfolio of contaminated sites. The technical staff is supported by a pool of program and administrative personnel.

Under the general direction and guidance of the INAC/GNWT Oversight Committee and managed by INAC, the Giant Mine Remediation Project Office was established by CARD to focus on the Giant Mine Remediation Project. This group manages the joint interim office on behalf of the federal and territorial governments. Its focus is on both the long-term care and management of the arsenic trioxide stored underground, and the eventual remediation of the entire site. Staff dedicated to the group have a broad base of relevant technical expertise including: project management, contaminated sites remediation, mining operations and regulatory affairs.

Additional INAC Responsibilities

In addition to its role as Proponent, INAC has a number of responsibilities that relate directly to the Giant Mine Remediation Project. These include:

- As the federal Minister responsible for the MVRMA, the Minister of INAC will consider the recommendation of the Review Board with the other responsible ministers concerning the EA for the Remediation Project. Further details on the process by which this will occur are provided in Section 2.6;
- Any "Type A" water licences required for the implementation of the Remediation Project will require the approval of the Minister of INAC; and

- Inspection and enforcement of any regulatory authorizations issued under the MVRMA (e.g., water licences) will be the responsibility of inspectors within INAC.

INAC has additional responsibilities that are indirectly relevant to the Remediation Project. For example, the Minister of INAC is responsible for the *Indian Act* and related requirements (e.g., Crown Consultation, land claim negotiation). The department also has responsibilities to promote Northern economic development and capacity building.

INAC Contaminated Sites Management Structure and Experience

INAC has twenty years of experience assessing, remediating and monitoring contaminated sites in Canada's North. The department's experience working on the remediation of Northern industrial development sites began in 1990 with the launch of *Canada's Green Plan for a Healthy Environment*. A component of the Green Plan was the Action on Waste program which aimed to eliminate unsafe, hazardous and unsightly waste by:

- Cleaning up all known hazardous wastes;
- Identifying, assessing and remedying suspected hazardous sites;
- Cleaning up 21 abandoned Distant Early Warning (DEW) Line sites;
- Cleaning up wastes near communities; and
- Supporting local waste management strategies.

INAC completed many remediation projects under the Action on Waste Program including: the Horton River DEW Line site, the abandoned military installations at Iqaluit and Pearce Point and the Snag and Aishihik air bases in the Yukon. Many of these sites had reverted to INAC in the 1960s when they were no longer of use to their former operators, the Canadian military.

In 2003-2004 fiscal year, the federal government launched the Federal Contaminated Sites Action Plan (FCSAP), the details of which are presented in Section 1.7.3. At the end of the 2008-2009 fiscal year, the department had an inventory of 1,971 Northern contaminated sites within its FCSAP portfolio.[3] Of this total, there are 728 suspected contaminated sites that require assessment. The remaining sites (1,243) have either been assessed and do not require remediation or have had contamination confirmed and are undergoing detailed assessment, remediation or risk management planning. Within the NWT, INAC has a total of 671 contaminated sites in its inventory. Approximately half of these sites (326) are currently undergoing assessment, remediation or risk management. A wide array of environmental and physical concerns is

[3] With a total remediation cost of approximately $1.5 billion reported for contaminated sites as of March 31, 2008, INAC has the largest contaminated sites liability among all federal departments participating in FCSAP. The majority of this liability is associated with sites located north of 60^o.

associated with these sites including: mining residues (e.g., tailings and waste rock that have the potential to leach metals); hydrocarbon spills; chlorinated organics; radioactive materials; physical hazards and debris.

By the end of 2008-2009 fiscal year, INAC had remediated a total of 13 contaminated sites under FCSAP, the following five of which were completed that year:

- CAM-F Sarcpa Lake (Nunavut);
- FOX-C Ekalugad Fjord (Nunavut);
- Bar-D Atkinson Point (NWT);
- Port Radium Mine (NWT); and
- Discovery Mine (NWT).

INAC is forecasting the completion of the Johnson Point and North Inca sites (both located within the NWT) in 2009-2010.

1.4.2 GNWT

In light of its surface land responsibilities and its role as co-proponent, the GNWT has participated in the development of the Giant Mine Remediation Plan and will continue to be engaged in the long-term development of the site after remediation is complete. Key GNWT departments involved in reviewing and contributing to the Remediation Project include:

1. Environment and Natural Resources – Responsible territorial Minister under the MVRMA for:
   a) Environmental Protection, Wildlife Management and Forest Management - expert review advice and assistance;
   b) Environmental Assessment and Monitoring - coordinate GNWT input into the EA processes.
2. Municipal and Community Affairs – Commissioner's Land administration;
3. Industry, Tourism and Investment – economic and business development;
4. Health and Social Services – public health and safety;
5. Workers Compensation Board – worker health and safety; and
6. Department of Transportation – public transportation infrastructure.

Similar to their involvement in regulatory processes for other developments, GNWT experts have contributed specialized knowledge and expertise on key points throughout the development of the Giant Mine Remediation Plan and this DAR. This involvement has and will continue to be coordinated by the Environmental Division (ED) of the territorial Department of Environment and Natural Resources (ENR). Specifically, ED will assist INAC with the co-ordination of the environmental assessment and regulatory applications required to implement the Remediation Project. Through this process, the Environmental Assessment and Monitoring Section of ENR will serve as the window for coordination of GNWT departments.

GNWT Contaminated Sites Management Structure and Experience

Under the authority of the *NWT Environmental Protection Act*, ENR's Environment Division has a mandate to prevent the discharge of contaminants into the environment and minimize impacts when they do occur. The Environment Division's programs that are relevant to the Giant Mine Remediation Project include: spill contingency planning, response and clean up; contaminated site assessment and remediation; hazardous waste management and air quality.

The Environment Division has significant experience relevant to the Remediation Project. For example, ENR staff has been investigating spills in the NWT since the early 1970's and has overseen the remediation of more than 2,500 incidents, primarily in communities and along highway systems. The Environment Division has over 20 years' experience managing a range of hazardous waste and has developed a number of relevant guidelines for waste management, treatment and disposal.

With advances in scientific understanding, increasingly sophisticated approaches were needed to manage contaminated sites. In 1987, as a result of two major hydrocarbon-contaminated sites being identified, the Environment Division began developing petroleum hydrocarbon remediation criteria for residential and commercial/industrial sites. These criteria formed the basis for an *Environmental Guideline for Contaminated Site Remediation* that was adopted by the Minister of ENR in 1988 and subsequently updated in 2003.

In the late 1980's, the Environment Division worked directly with federal agencies and academic researchers on the DEW Line site assessment and remediation projects across the NWT. At the same time, the Division began reviewing Closure and Reclamation Plans for industrial projects in the mining and oil and gas industry, and provided technical advice to various regulatory boards and agencies.

The following points demonstrate the GNWT's experience and capacity in relation to the management of contaminated sites, with a particular emphasis on those aspects that are relevant to the Giant Mine Remediation Project:

- The Environment Division was a founding member and one of the principal participants in the Yellowknife Arsenic Soil Remediation Committee, a group responsible for the development of site-specific criteria for arsenic in soil in the Yellowknife area. The

Division co-chaired the committee and was a key participant in the completion of the project and development of the criteria.

- In 2002, ENR began undertaking environmental site assessments of ENR facilities around the NWT and implementing remediation where warranted. The Environment Division assisted with project management in the development of the project parameters, contract specifications and the approval of final reports.
- Since 1992, staff from the Environment Division have represented the GNWT on the Canadian Council of Ministers of the Environment (CCME) Soil Quality Guidelines Task Group and participated in the development of Canadian soil quality guidelines.
- Since 1975, the Environment Division has operated an air quality monitoring station in Yellowknife to measure ambient air quality, with a particular focus on the influence of roaster stack emissions from Giant Mine. To supplement the monitoring, two extensive snow core surveys were conducted to better understand impacts from these emissions.
- The Environment Division was an active member of the Miramar Con Abandonment and Reclamation Working Group since its inception. The group was responsible for reviewing the proposed *Con Mine Closure and Reclamation Plan* and providing recommendations to the MVLWB. The Division continues to monitor implementation of the Plan and facilitates updates for the former Working Group.

1.4.3 PWGSC

Under a multi-year services agreement with INAC, PWGSC is contributing project management, engineering, procurement and environmental services in the implementation of assessment and remediation of INAC's Northern contaminated sites. These services are provided through dedicated teams located in Yellowknife and Edmonton. Additional resources are allocated from other areas within PWGSC as required.

Although not a Proponent, PWGSC is playing an active role in the Giant Mine Remediation Project. Specific examples of responsibilities taken on by the federal department include:

1. Procurement Services – Developing and implementing procurement strategies for the various phases of the Project;
2. Detailed Engineering and Design – Managing the development of detailed designs and specifications to guide Project implementation; and
3. Contract and Project Management – Administering and managing a wide array of contracts with private consultants and contractors necessary to develop and implement the Remediation Project.

PWGSC Contaminated Sites Management Structure and Experience

PWGSC is actively involved in environmental remediation across Canada, including the North. Through the department's major role in property dispositions and acquisition, PWGSC has developed a broad-based knowledge of environmental issues and remediation practices. The department applies this knowledge as a contaminated sites custodian, a service provider to other departments and as expert support to FCSAP.

In addition to expertise in technical fields relevant to contaminated sites management, PWGSC plays a key role in providing project governance, the implementation of financial and environmental controls, risk management initiatives and project quality assurance on behalf of client departments. This includes the development of project management tools, the dissemination of information on innovative technologies and the development of risk management approaches. PWGSC also coordinates forecasts of project requirements and procurement opportunities to support linkages to other federal priorities. As a provider of environmental and project management services and results-oriented capacity for managing and delivering complex and high-value projects of national importance, PWGSC enables other government departments and agencies to deliver on their own core mandates.

Over the past 20 years, PWGSC has been active on hundreds of assessment and remediation projects across the North. Examples of Northern contaminated sites projects in which PWGSC has had an active role include virtually all of the sites within INAC's Northern portfolio (refer to Section 1.4.1 above). In addition to INAC, PWGSC has also assisted other federal departments with the assessment and remediation of Northern contaminated sites.

PWGSC is currently managing care and maintenance activities at the Giant Mine site, with services provided by a private sector contractor. A significant component of current care and maintenance activities involves the collection and treatment of contaminated minewater. Care of the site also includes carrying out remedial actions to address immediate physical risks to human health and the risk of significant engineering failure. In addition to its role at Giant Mine, PWGSC is actively involved in care and maintenance activities at the Faro Mine in the Yukon.

Work in the North that will be tendered through PWGSC over the next ten years is projected to exceed $700M. These expenditures will be primarily focused on abandoned mines, former military installations, exploration sites and high Arctic weather stations. PWGSC maintains communication with the environmental industry to ensure that they are aware of, and can build capacity in response to future demand arising from the need to remediate contaminated sites in the North.

1.4.4 Remediation Contractors

As the Project Team, INAC, the GNWT and PWGSC are collectively responsible for the design and implementation of the Giant Mine Remediation Project. While INAC has ultimate responsibility for the Remediation Project, the physical works and activities will be implemented by private sector Remediation Contractors operating under the direction of PWGSC.

As the Remediation Project advances towards implementation, PWGSC is developing contracting mechanisms appropriate to the scope of work to be performed. This will include procurement processes that promote Aboriginal and Northern employment and contracting, without compromising the overall effectiveness or cost of the Remediation Project. These mechanisms will also include provisions to monitor all commitments made by the Project Team that are to be implemented by Remediation Contractors.

1.5 Advisors to the Project

To promote the development of a Remediation Plan that is scientifically rigorous and defensible, the Project Team sought and incorporated the professional advice of consultants, government departments and independent experts. The following subsections describe the contaminated sites management experience of the advisors and their specific contributions to the Remediation Plan and DAR.

1.5.1 Technical Advisor

In 2000, INAC sought the assistance of a Technical Advisor to lead the evaluation of alternatives for managing the arsenic trioxide dust. After an international competition, a team led by SRK Consulting Inc (SRK) and SENES Consultants Limited (SENES) was selected in 2001. The role of the Technical Advisor, as defined by the initial scope of work, included:

- Providing expertise in "*mine waste geochemistry, mining reclamation, risk and environmental assessment, hydrogeology, rock mechanics, mining engineering, process engineering, materials management, geotechnical engineering, occupational health and safety, metallurgy, and arsenic materials as well as in mine-related project management experience of a scale and duration similar to the Giant Mine arsenic trioxide dust issue*"; and
- Acting as a "*neutral, broad-based advisor to the Department, recommending the implementation of more specific technical work, assisting INAC in the selection of subcontractors (as required), and providing direction to these subcontractors*".

SRK is an employee-owned, international company that provides engineering and consulting services on projects related to mining. SRK's Canadian practice was started in 1978, and it has a long track record in Northern mine closure projects. The SRK staff working on the Giant Mine

Remediation Project have completed mine closure projects at many sites in the NWT, Yukon, Nunavut, Northern Saskatchewan, Northern British Columbia, Alaska and overseas. SRK has been responsible for many of the technical studies required to characterize site conditions and led the development of the Remediation Plan. Major technical contributions were also made to the DAR.

SENES is a wholly Canadian-owned company that specializes in the fields of energy, nuclear, and environmental sciences. Since its inception in 1980, the company has participated in more than 5,000 projects around the globe, with a particular emphasis on the evaluation and management of environmental impacts from mining operations. SENES contributions to the Giant Mine Remediation Project have focused on water treatment, risk assessment and environmental assessment.

Specific examples of work conducted by SRK and SENES on other Northern sites include:

- *Faro Mine Complex Remediation Project (2004-2010 ongoing)* – SRK acted as technical advisor to the Interim Receiver for the Anvil Range Mining Complex during care and maintenance of the closed site and the development of options for final remediation. SRK also provided engineering support for many of the key closure components and was responsible for the preparation of the project description for submission to the Yukon Environmental and Socio-Economic Assessment Board. SENES' role in the Faro Project included human health and ecological risk assessment, and review of water management plans.
- *Colomac Mine Remediation Project (2000-2008)* – SRK assisted INAC in the development of a closure plan for the Colomac Mine site. SRK's role continued with additional site investigations and development of detailed designs and construction monitoring for major civil works. SRK also assessed the water balance and developed alternatives for contaminated water management. This work led to a highly successful "enhanced natural removal" in-situ water treatment scheme. SENES prepared human health and ecological risk assessments in support of the water management plan.
- *Port Radium, Great Bear Lake (2001-2010 ongoing)* – SENES conducted extensive environmental site investigations and risk assessments to characterize the human health and ecological risks associated with radionuclides, metals, petroleum hydrocarbons, designated substances and physical features at the former uranium mine. SENES developed a remediation action plan that was finalized in 2005 and implemented in 2007-2008 with SENES providing engineering drawings, contract documents and contract and construction supervision. SRK contributed to geotechnical and mine engineering components of the design. Long-term post-remediation monitoring was initiated by SENES in 2008 and continues to be carried out by the firm.

1.5.2 Other Government Departments

The Project Team has collaborated with other federal departments during the development of the Remediation Plan. Under the auspices of FCSAP, Environment Canada, the Department of Fisheries and Oceans Canada (DFO), and Health Canada have provided expert advice to INAC on topics such as site assessment, risk assessment and the evaluation of remedial option/risk management for the site. This collaboration has proven to be particularly important in the selection of remediation options for site components such as Baker Creek, where the various departments have played an important role in identifying ecological values and suggesting approaches to protect those values.

1.5.3 Independent Peer Review Panel

INAC brought together an Independent Peer Review Panel (IPRP) of nine recognized experts whose qualifications and experience collectively covered the fields relevant to the Remediation Plan. Membership of the IPRP included specialists nominated by communities and the local public. The names, qualifications and areas of expertise of the reviewers are as follows:

- Carroll O. (Chuck) Brawner, M.Sc., P.Eng, FCIMM, FCAE.: Specialist in tailings dam engineering, rock mechanics and mine stability;
- Laurie H. M. Chan, B.Sc., Ph.D.: Specialist in toxicology and human health risks, expert in Indigenous Peoples' nutritional and environmental issues;
- Larry Connell, B.Sc., P.Eng.: Specialist in water treatment, arsenic treatment and mine environmental assessment;
- Steve E. Hrudey, M.Sc., Ph.D., D.Sc.(Eng), FCAE,: Specialist in assessment of human exposure to arsenic and the assessment of health risk;
- Jean-Marie Konrad, M.Sc., Ph.D., FCAE.: Specialist in ground freezing, cold regions engineering and permafrost;
- Bob Leech, M.Eng.Sc., F.G.S.: Specialist in hydrogeology, specifically in groundwater flow and contaminant transport;
- M.A.J. (Fred) Matich, M.Sc., P.Eng.: Specialist in applied geotechnical engineering mine waste disposal;
- Craig Nowakowski, CPHI (C): Specialist in public and environmental health with Stanton Territorial Health Board; and
- Ken Raven, M.Sc., P.Eng.: Specialist in fractured rock hydrogeology, aqueous geochemistry, structural geology and conceptual hydrogeologic models.

The IPRP reviewed both the Report on Arsenic Trioxide Management Alternatives and the Giant Mine Remediation Plan and provided expert feedback to the Project Team. The role of the IPRP, as defined in its original scope, was to provide the following:

- An independent, technical review of the selection process and subsequent assessment of options considered for the long-term management, removal, secure storage or stabilization of the arsenic trioxide-bearing dust stored underground within Giant Mine;
- An assessment of any gaps in the data/information collected that are important in assessing the technical and economic feasibility of a long-term management alternative(s);
- Recommendations as to what additional information or data should be collected or developed to enhance public consultation and support development of a Project Description; and
- Recommendations as to which management alternatives are most likely to lead to a technically feasible, publicly supported and licenseable Project Description, given the current level of technology, information and understanding of public health, occupational risk and ecological risk.

In its review of the Giant Mine Remediation Plan, the IPRP made the follow conclusions:

1. It unanimously supported the approach described in the Remediation Plan and encouraged INAC to proceed with the plan into the regulatory approvals process.
2. It was of the opinion that the work produced by INAC and their Technical Advisor is of high quality, uses state of the art methodology and has adequately defined existing conditions at the Giant Mine site for purposes of developing the Remediation Plan at this stage. The IPRP further recognized that a detailed engineering phase would commence once the Project is approved.
3. It noted that the Remediation Plan as described will, in the long-term, provide protection of human and ecosystem health.
4. It noted that stability concerns within the mine may compromise the Remediation Plan if not dealt with in a timely fashion.
5. It provided a number of recommendations on specific items but noted they do not alter the basic conclusions regarding the viability of the Plan from a technical perspective.
6. It stated that the objective of integrating the original sub-surface and surface remediation plans for Giant Mine has been adequately achieved for present purposes of the proposed integrated Remediation Plan.

1.6 Community Involvement

Throughout their work on the Giant Mine Remediation Project and other contaminated sites, the Project Team has maintained a commitment to actively involve Northern communities in the process. This involvement has been achieved through community consultation and socio-economic opportunities, both of which are described briefly below.

1.6.1 Community Consultation

INAC and the GNWT are committed to engaging and communicating with Aboriginal and local residents regarding the management of contaminated sites in the North. This includes promoting Aboriginal, local and Northern participation and partnership in the identification, assessment, decision-making and remediation of contaminated sites. Details on communication and consultation processes for the Giant Mine Remediation Project are presented in Chapter 13.

1.6.2 Socio-Economic Opportunities

Through all of its contaminated sites projects, INAC strives to create positive social and economic impacts for the people in nearby communities. The range of benefits can include direct employment, support to local businesses through the procurement of goods and services, and training programs that help build the capacity of locals and provide opportunities to obtain future work based on the new skills developed.

In 2006, a Procurement Strategy was developed by INAC's Contaminated Sites Program. One of the objectives of the strategy is to maximize Northern and Aboriginal community, business, and individual participation and economic development opportunities. A Socio-Economic Benefits Strategy is also being developed to support this objective. In addition, INAC has developed an Aboriginal Benefits Strategy, which incorporates Aboriginal Benefits Plans (ABPs) as part of the overall competitive procurement process used to award remediation contracts. This has served as an effective mechanism for encouraging Aboriginal participation and economic benefits during INAC's efforts to remediate contaminated sites. Based on statistics compiled for 2006-2007, the following positive socio-economic performance was achieved by INAC's Contaminated Sites Program:

- *Employment:* Total reported employment was 1,055 people. Of this total, 65% were from the North and 42% were Northern Aboriginal people.
- *Workforce Training:* Eighteen sites reported providing training to over 400 employees. Of this total, 80% were Northerners and 65% were Northern Aboriginal people. A number of significant training initiatives were undertaken. To illustrate, the remediation project at the Colomac Mine was part of a Mine Training Society project that involved training several people involved in industrial trades. The Port Radium remediation project set aside over $100,000 to persons from Déline in order that they could participate

in the site's remediation. The Silver Bear remediation project hired several persons from Déline and helped to improve their skills through on-the-job training in areas relevant to the assessment and remediation of contaminated sites (e.g., environmental sampling and camp operations).

- *Purchase of Goods and Services:* Through work on twenty-four sites, 689 Northern suppliers benefitted from business opportunities. Of the total, 198 of the businesses were Northern Aboriginal suppliers. The total value of business from Northern suppliers was over $42 million, 63% of which was from Northern Aboriginal suppliers. In the case of the Colomac Remediation Project, goods and services provided by three Northern Aboriginal suppliers totalled over $19 million.

As described further in Section 6.13.4, these and other strategies will be used in the development of a project-specific procurement strategy for the implementation of the Giant Mine Remediation Plan.

1.7 Regulatory and Policy Considerations

1.7.1 Recent Status and Current Management

Immediately after INAC assumed control of Giant Mine in 1999, the department entered into an agreement by which Miramar Giant Mine Ltd. took control of the property. Under that agreement, Miramar continued to operate Giant Mine, with the gold ore shipped off site for processing at the Con Mine. Mining ceased in July 2004 and INAC again took control of the site one year later, after an orderly transition. INAC remains in overall control of the site with PWGSC carrying out day-to-day care and maintenance on its behalf through a private sector contractor (the Deton'Cho/Nuna Joint Venture).

Throughout its operational history that spanned more than 50 years, the environmental management of Giant Mine was regulated through various pieces of legislation. Most recently, the key regulatory instrument for environmental management was a Type A Water Licence (N1L2-0043) that expired on December 31, 2005. Since that time, INAC has operated under Section 39 of the *NWT Waters Act*. INAC has continued to manage water on the site consistent with the standards of the former Type A water licence. This includes:

- The water quality criteria and discharge parameters for treated minewater;
- The implementation of surface water monitoring, as specified by the Surveillance Network Program (SNP) for the site; and
- Monitoring of the potential effects on the aquatic environment, as determined through an Environmental Effects Monitoring (EEM) program.

In addition to complying with the former water licence, INAC's ongoing management practices at Giant Mine include:

Care and Maintenance

- Monitoring and maintenance of the mine in compliance with the *NWT Mine Health and Safety Act* and Regulations;
- Mine water management;
- Inspections, including operation, maintenance and surveillance of dams;
- Maintenance of mine water management systems (pumps, piping, flow meters etc.);
- Maintenance and seasonal operation of the Effluent Treatment Plant;
- Maintenance of mine ventilation and heating of ventilation air in winter months;
- Maintenance of "C" boiler heating plant and utilidor pipe boxes;
- Maintenance of mine equipment and "in use" infrastructure;
- Water supply and sewage;
- Dust suppression – tailings and roads;
- Maintenance of electrical systems;
- General housekeeping of the site including underground inspections;
- 365/24/7 site security;
- Snow removal and road maintenance; and
- Regular inspections of arsenic storage chamber bulkheads and other components of the mine.

Regulatory Compliance Monitoring

- Air monitoring using mini-vol and high-vol air samplers;
- Groundwater well readings and sampling;
- Minewater discharge sampling;
- Minewater and chamber seepage sampling;
- Lower Levels Mine flood water monitoring;
- Surveillance Network Program sampling;
- Water sampling/reporting for treated water including EEM component as necessary;
- Test thermosyphon readings;

- Arsenic chamber monitoring program (pressure/temperature) readings;
- Water quality sampling of standing water, ponds, seeps; and
- B-2 pit dam monitoring.

Immediate Risk Mitigation Activities

- Roaster Complex evaluations which include recommendations for work on the roaster flues to stabilize structures and contain the hazardous materials (2010/11);
- Baker Creek Reach 1&6 Culvert Highway 4 investigation for repairs (2010/11); and
- Ongoing Bulkhead Stabilization Program (approximately 3 bulkheads/year, 2010 -2013).

In addition to the above activities, INAC has commissioned and supported a wide array of environmental characterization studies, as described further in Chapter 7.

1.7.2 Key Environmental Legislation and Regulations

Due to the wide array of activities proposed as part of the Remediation Project, approximately 30 different types of authorizations are anticipated to be required from federal, territorial, municipal and co-management agencies. INAC will comply with all such requirements. Table 1.7.1 summarizes the key authorizations that are of interest from an EA perspective. A summary of the parent legislation and regulations for these authorizations is further discussed in this section. Section 6.13.2 provides a comprehensive listing of additional authorizations required for implementation (i.e., those that are not directly relevant to environmental management).

Table 1.7.1 Key Environmental Authorizations Required for Project Implementation

Authorization	Legislation	Activity	Permitting Agency
Water Licence	*Mackenzie Valley Resource Management Act, Northwest Territories Waters Act, Environmental Protection Act (NWT)*	Discharge of treated water, construction, spill contingency planning	Mackenzie Valley Land and Water Board
Fisheries Act Authorization	*Fisheries Act*	Placement of water treatment outfall[4]; modification and re-alignment of Baker Creek	Fisheries and Oceans Canada
Asbestos Licence	*Safety Act (Asbestos Safety Regulations)*	Handling of asbestos-contaminated material (i.e. decommissioning of mill and roaster complex)	Workers' Safety and Compensation Commission
Quarry Permit	*Commissioner's Land Act*	Obtaining borrow materials on Commissioner's land	Municipal and Community Affairs

[4] A final determination by DFO as to whether the placement of the water treatment outfall requires a Fisheries Act Authorization has not yet been made.

Mackenzie Valley Resource Management Act

The MVRMA established a network of co-management boards in the Mackenzie Valley which have jurisdiction over various aspects of environmental management, including land use planning, water and land use management and EA. For the Giant Mine Remediation Project, the MVLWB is the key regulator of land and water use. It was the application for a water licence to permit remediation activities (MV2007L8-0031) that resulted in the Remediation Project being referred to an EA.

Environmental assessment in the Mackenzie Valley is also governed through provisions of Part 5 of the MVRMA. The Review Board is the main instrument for conducting environmental assessment. The process by which the Review Board will make its decision is described in Section 2.6.

Northwest Territories Water Act

The *Northwest Territories Water Act* governs the review and issuance of water licences. The water licence required for the Remediation Project is to be issued by the MVLWB. The *Northwest Territories Water Act* makes distinctions among different intensities of water use; licences are issued accordingly by way of a Type A or Type B licence. The criteria that determine which type of licence will be required are outlined in the *Northwest Territories Water Regulations.* In the case of the Giant Mine Remediation Project, a Type A water licence will be required. The *Northwest Territories Water Act* requires that all Type A licences be approved by the Minister of INAC prior to issuance.

Fisheries Act

The Remediation Project will require authorization by DFO under subsection 35(2) of the federal *Fisheries Act* for those Project activities, such as the Baker Creek re-alignment, that may result in harmful alteration, disruption or destruction of fish habitat. The Remediation Project will also comply with other pertinent sections of the *Fisheries Act* including subsection 32, which prohibits the destruction of fish except as authorized by the Minister of DFO; and subsection 36(3), which prohibits the deposit of deleterious substances in water frequented by fish. The implementation of the Remediation Plan will adhere to direction provided by DFO in this regard.

Commissioner's Land Act

Commissioner's land is managed and administered by MACA through the legal authority of the *Commissioner's Land Act*. Two provisions of this Act are of particular relevance to the Remediation Project. The first is MACA's authority to set apart and reserve Commissioner's land for the public or other purposes. In the case of the Giant Mine Remediation Project, MACA established Reserve R662T to allow INAC full occupancy and unrestricted surface access to the site in order to carry out the Project. The *Commissioner's Land Act* also makes provisions for the issuance of quarrying permits on Commissioner's Lands and establishes the protocol by which quarry material may be acquired. Quarrying activities carried out for the purpose of the Project will adhere to those regulations.

NWT Mine Health and Safety Act

The *Mine Health and Safety Act* is the legislation that governs most aspects of the Remediation Project dealing with the physical welfare of workers. This includes aspects such as the provision of First Aid, emergency response and worker certification for underground activities. The Workers' Safety and Compensation Commission of the Northwest Territories and Nunavut (Commission) is the regulatory agency in charge of enforcing the *Mine Health and Safety Act*, as well as, but not limited to, the *Safety Act* and associated *Asbestos Safety Regulations*, the *Workers' Compensation Act* and the *Explosives Act*.

Mine Inspectors are appointed by the Commission to enforce the *Mine Health and Safety Act* and related regulations. Mine Inspectors have a broad suite of powers including the authority to enter a mine site at any time for the purpose of an inspection or investigation, the right to seize information, as well as the authority to order work stoppages. Relevant activities associated with Giant Mine Remediation Project will conform will all aspects of the legislation and will comply with all orders issued by mine inspectors regarding the safety and health of workers.

Storage Tank Systems for Petroleum Products and Allied Petroleum Products Regulations

The Remediation Project is anticipated to require the storage of large volumes of petroleum products on site. The petroleum products, mainly diesel fuel, will be held in aboveground storage tanks at a tank farm. The *Storage Tank Systems for Petroleum Products and Allied Petroleum Products Regulation*s applies to storage tank systems that are operated by the federal government, or are on federal Crown or Indian reserve lands.

Environmental Protection Act (NWT)

The *Environmental Protection Act* (NWT) provides broad provisions for the territorial Minister of Environment and Natural Resources (ENR) to develop, co-ordinate and administer policies, standards, guidelines and codes of practice relating to the preservation, protection or enhancement of the environment. For example, regulations that are applicable to the Project are the territorial *Spill Contingency Planning and Reporting Regulations* and the *Used Oil and Waste Fuel Management Regulations*. While there are no specific authorizations that are required under the Act for the Remediation Project, aspects of applicable regulations have been incorporated into the water licence application and the Remediation Plan. In the event of a spill occurring during Project implementation, the *NWT Environmental Protection Act* requires the party responsible for the discharge of a contaminant to clean up the site and repair any damage. ENR's regulatory role is to ensure that this happens and to intervene in cases where it does not.

The GNWT has also adopted a number of environmental guidelines under the *Environmental Protection Act* that are applicable to the Remediation Project and will be followed during implementation, including:

- Guideline for Ambient Air Quality Standards;
- Guideline for Dust Suppression;
- Guideline for the General Management of Hazardous Waste;
- Guideline for Industrial Waste Discharges;
- Guideline for Contaminated Site Remediation;
- Guideline on Ozone Depleting Substances and Halocarbon Alternatives;
- Guideline on Waste Antifreeze;
- Guideline on Waste Asbestos;
- Guideline on Waste Batteries;
- Guideline on Waste Lead and Lead Paint;
- Guideline on Waste Paint; and
- Guideline on Waste Solvents.

The GNWT also subscribes to the CCME's *Recommended Principles on Contaminated Sites Liability* (CCME 2006).

Additional Legislation and Regulation

While the laws and regulations summarized above are the primary mechanisms for environmental protection associated with the Remediation Project, numerous additional mechanisms will also apply. Selected examples include:

- *Migratory Birds Convention Act;*
- *Species at Risk Act [Federal];*
- *Species at Risk (NWT) Act;*
- *Canadian Environmental Protection Act;*
- *Transportation of Dangerous Goods Act; and*
- *Wildlife Act (NWT).*

1.7.3 Policies and Guidelines

In addition to the legislation and regulatory requirements noted above, the Giant Mine Remediation Project is being implemented within a framework of federal and territorial policies and guidelines. The most pertinent of these are as follows:

General Principles of Federal Contaminated Sites Management

INAC works within a broader management system for all Northern contaminated sites. This being the case, INAC has followed and will continue to follow a series of federal policies and guidance documents throughout the design and implementation of the Giant Mine Remediation Project. The policies and documents of particular importance include:

- A Federal Approach to Contaminated Sites prepared by the Contaminated Sites Management Working Group (CSMWG 2000);
- INAC Northern Affairs Program Contaminated Sites Management Policy (INAC 2002a); and
- Treasury Board Federal Contaminated Sites Management Policy (Treasury Board 2002).

Although the INAC Mine Site Reclamation Policy for the Northwest Territories (INAC 2002b) and the Mine Site Reclamation Guidelines for the Northwest Territories (INAC 2006b) were not intended for abandoned properties such as Giant Mine, some parts of the policy are generally applicable and have also been considered.

Taking into consideration the policies and documents noted above, the guiding principles applied to the Giant Mine Remediation Project are as follows:

- Meeting the overall INAC objective to contribute to a safer, healthier, sustainable environment for Aboriginal peoples and Northern residents by striving to preserve and enhance the ecological integrity of the environment (INAC 2002a);
- Taking immediate and reasonable action to protect the environment and the health and safety of persons (Treasury Board 2002);
- Meeting federal and INAC policy requirements and legal obligations regarding the management of contaminated sites (INAC 2002a);
- Ensuring sound environmental stewardship of federal real property by avoiding contamination and by managing contaminated sites in a consistent and systematic manner that recognizes the principle of risk management and results in the best value for the Canadian taxpayer (Treasury Board 2002);

- Providing a scientifically valid, risk management based framework for setting priorities, planning, implementing and reporting on the management of contaminated sites (INAC 2002a);
- Developing a Remediation Plan to be sufficiently flexible to allow adjustments as the remediation progresses, including the flexibility to adapt to new and improved technologies and methodologies (INAC 2002b); and
- Adopting solutions tailored to the Northern environment and peoples wherever possible (INAC 2006a – management framework).

Partnerships with First Nations

The following principles regarding partnerships with First Nations from the policy and guidance documents referenced above have also been incorporated into the Giant Mine Remediation Project:

- Promoting Aboriginal and Northern participation and partnership (INAC 2002a; INAC 2006b);
- Promoting respect and sharing of knowledge, experience and resources in partnerships/teamwork with clients and partners;
- Promoting the social and economic benefits that may accrue to First Nations and Northern communities (INAC 2002a);
- Planning, where appropriate, the scale and pace of remediation/risk management in keeping with Northern and Aboriginal capacity to be involved (INAC 2002a); and
- Incorporating economic opportunities, to the extent possible, for Northern and Aboriginal communities in the management and remediation of the site (INAC 2002a).

Federal Contaminated Sites Action Plan

In addition to the general principles described above, the federal government has developed a comprehensive framework to guide the management of federal contaminated sites. Beginning in 1995, the federal government recognized the need for an efficient and consistent approach to dealing with contaminated sites. As a result, the Contaminated Sites Management Working Group (CSMWG) was established to promote common approaches to management and remediation of contaminated sites. This working group now operates under FCSAP which serves as the framework under which the Giant Mine Remediation Project is being implemented. Details regarding INAC's work on contaminated sites under the FCSAP program were presented in Section 1.4.1.

FCSAP is a cost-shared program that helps federal custodians to address contaminated sites for which they are responsible. The primary objective of this program is to address the risks that federal contaminated sites pose to human health and the environment and to reduce the associated financial liability. The program has the complementary objectives of supporting other socio-economic outcomes, such as training and employment of Canadians and promotion of innovative technologies. Under FCSAP, each contaminated site progresses through a systematic procedure that leads from assessment through to remediation planning, remediation and eventually, long-term monitoring.

DFO Policy for the Management of Fish Habitat

The Remediation Project supports enhancement of fish habitat in Baker Creek; this aspect was guided by DFO's *Policy for the Management of Fish Habitat* which was implemented in 1986 to support the habitat provisions of the *Fisheries Act* and to help counter the negative impacts that development activities can have on fish habitat while promoting sustainable development. Specific goals of the policy include:

1. Conservation of existing habitats;
2. Restoration of damaged habitat; and
3. Development of new habitats.

Treasury Board Framework for Investment Planning – Assets and Acquired Services

The Policy on Investment Planning – Asset and Acquired Services replaced the Policy Framework for the Management of Assets and Acquired Services and its associated policy instruments effective December 10, 2009. This policy is a significant change in how the Government of Canada carries out its investment planning. The policy is implemented in conjunction with the Treasury Board Policy on the Management of Projects described below.

The objective of this policy is to contribute to the achievement of value for money and sound stewardship in government program delivery through effective investment planning. Effective investment planning should ensure a diligent and rational manner of resource allocation for both existing and new assets, and for acquired services, within departmental reference levels.

Effective investment planning ensures resources are allocated in a manner that clearly supports program outcomes and government priorities, and is characterized as being:

- Essential and responsive to government priorities and effective program delivery;
- Affordable, productive and financially sustainable;

- Reflective of an appropriate balance of risk, benefits and return between the Crown and third parties;
- Safe, secure and compliant with relevant laws, regulations and policies, and codes of conduct;
- Protective of Canadian heritage and the environment; and
- Reflective of departmental, portfolio, horizontal and government-wide perspective while taking into account strategic government-wide initiatives, as appropriate.

Treasury Board Policy on the Management of Projects

The objective of this policy is to ensure that the appropriate systems, processes and controls for managing projects are in place. The policy also supports the achievement of project and program outcomes while limiting the risk to stakeholders and taxpayers. The expected results of this policy, associated standards and directive are that:

- Projects achieve value for money;
- Sound stewardship of project funds is demonstrated;
- Accountability for project outcomes is transparent; and
- Outcomes are achieved within time and cost constraints.

INAC Environment, Health & Safety Policy – Contaminated Sites Program

INAC's *Environment, Health and Safety Policy* (EHS policy) for its Contaminated Site Program (CSP) provides direction in order to meet the requirements of the Canada Labour Code, applicable environmental regulations and policies, and related policies of the Treasury Board in the implementation of the CSP. The principal requirement of the Policy is to ensure that procedures are in place and implemented such that program activities are carried out in a manner that will not adversely impact staff, contractors, visitors, local communities, or the environment. Some of the key features of the Policy are the following:

- Senior managers are responsible for ensuring that all the requirements of the EHS policy are fully implemented;
- Managers and supervisors are responsible for ensuring that their employees are trained in safe work procedures and must ensure that employees follow these procedures and adhere to all related regulations;
- All personnel are required to support and comply with the EHS program, making safety, health and protection of the environment a part of their daily routine;

- All relevant territorial and federal laws, regulations and policies, including the requirements of INAC's CSP, are to be incorporated as minimum standards; and
- Pollution prevention practices and programs to achieve continuous improvement will be implemented as an ongoing requirement.

INAC Sustainable Development Strategy (2007-2010)

The 1995 amendments to the *Auditor General Act* included a requirement for the departments of the federal government to prepare Sustainable Development Strategies (SDS) and update them every three years. The Strategies provide a tool for departments to systematically consider the implementation of sustainable development into their policies, programs, legislation and operations. INAC has established eight sustainable development principles which have remained constant through the last four strategy iterations. They are the following:

1. Full consideration of economic viability, social implications, and cultural and environmental values in decision making and policy and program development;
2. Open, inclusive and accountable decision making;
3. Honouring treaty and fiduciary obligations, as well as land claim, self–government and international agreements;
4. Engagement of interested local communities and organizations when planning and implementing federal programs;
5. Respect for diverse cultures and traditional values, as well as the land and its diversity as the foundation for healthy communities;
6. Fair and equitable opportunities for First Nations, Inuit, Métis and Northern peoples to share in the benefits, risks and drawbacks of development;
7. Decisions based on the best available scientific, traditional and local knowledge; and
8. Efficient use of natural resources and minimization of pollution in INAC’s internal operations.

Given the department’s wide range of responsibilities, INAC’s current SDS identifies a number of objectives within its diverse mandate, including Objective 1.4, which calls for “*Sound environmental management practices in First Nation, Inuit and northern communities*”. Objective 1.4 specifically addresses INAC’s responsibility to clean up contaminated sites through the CSP. Table 1.7.2 depicts the sustainability framework that is to be considered to achieve Objective 1.4 with respect to contaminated sites under INAC’s responsibility.

Table 1.7.2 Sustainability Framework for Contaminated Sites under INAC Responsibility

Objective 1.4	**Sound environmental management practices in First Nation, Inuit and Northern communities.**	
INAC Mandate Area	**Clean-up of contaminated sites**	
Medium-term outcome	Reduce and eliminate, where possible, risks to human and environmental health and liabilities associated with contaminated sites.	
Short-term outcomes	Reduced number of contaminated sites and reduced departmental liability.	Increase number of contaminated sites remediated or in active remediation. Accurately quantify liabilities.
Targets	Reduce the number of contaminated sites south of 60. (March 2010)	Increase number of Northern contaminated sites in remediation phase or completed. (March 2010)
Activities	Regions to implement 5–year Contaminated Sites Management Plans. Regions to submit applications to FCSAP to leverage additional funding.	Contaminated Sites Management Plan approved in accordance with Treasury Board guidance. Develop and implement remediation/risk management strategies by site. Long–term monitoring.
Outputs	Approval of a 5–year National Contaminated Sites Management Plan. Approved funding from FCSAP.	Develop Contaminated Sites Management Plans, remediation plans, detailed work plans and quarterly reports.
Performance Measures	Regionally approved 5–year Contaminated Sites Management Plans. Regionally submitted FCSAP applications. A percentage decrease in Class 1 & Class 2 Contaminated Sites liabilities.	Contaminated Sites Management Plan approved. Absolute number of sites in remediation phase or completed.

1.7.4 Regulatory and Policy Influence on Project Design

The preceding sections summarized the wide array of regulatory (Section 1.7.2) and policy (Section 1.7.3) considerations that are applicable to the Giant Mine Remediation Project. In many respects, the Remediation Project is unique from other developments in that its primary goal is to mitigate potential risks to human health and the environment. For this reason, the previously described regulatory and policy considerations have formed the basis of the entire Remediation Project. Selected examples of how these requirements have influenced the design of the Remediation Project include:

- Environmental Protection - In the absence of ongoing care and maintenance and eventual remediation, there is a strong likelihood that releases to the environment would occur and result in contravention of key pieces of environmental legislation (e.g., the *MVRMA,* *NWT Waters Act, Fisheries Act, NWT Environmental Protection Act*). The Remediation Project has been designed specifically to avoid the potential for such contravention (i.e., to protect the environment).

- Protection of Human Health – While the primary goal of the Remediation Project is to mitigate adverse environmental consequences that could otherwise occur, a key consideration in the design of the Project has been the avoidance of potential occupational risks associated with its implementation. For example, when compared to other arsenic trioxide management alternatives, a major advantage of the frozen block method is the relatively lower risks to remediation workers. This approach is consistent with legislation such as the *NWT Mine Health and Safety Act*.
- Policy Considerations – As outlined in Section 1.7.3, a wide array of policies are applicable to the Remediation Project. The influence of these policies is reflected in numerous ways such as: i) taking immediate and reasonable action to protect the environment and the health and safety of persons (as per Treasury Board Federal Contaminated Sites Management Policy); ii) restoration of damaged habitat (as per DFO Policy for the Management of Fish Habitat); and iii) socio-economic benefits to Aboriginal, local and Northern residents (as per INAC's Northern Affairs Program Contaminated Sites Management Policy).

Based on the nature of the Remediation Project (i.e., an undertaking designed to avoid impacts to the environment and human health), regulatory and policy considerations are applicable to virtually all aspects of the Project.

2 Environmental Assessment Framework

The Environmental Assessment Framework is the broad suite of Review Board decisions and policies that have influenced the DAR's structure, tone and content. This chapter presents a summary of several EA milestone events including, among other things, the water licence application process that triggered the EA and the various activities that occurred during the EA start-up (e.g., issues scoping). Future steps in the EA process are also described, with particular reference to how information contained in the DAR will be handled in these subsequent steps.

The EA Framework also includes a description of how the DAR has been organized in response to the Review Board's *Terms of Reference*. Similarly, the chapter indicates how and where the DAR has complied with the *Terms of Reference*. The direction issued by the Review Board regarding the incorporation of Aboriginal traditional knowledge (TK) into the DAR is also responded to in this chapter.

2.1 Summary of the EA Process

Environmental assessment in the Mackenzie Valley is governed by Part 5 of the *Mackenzie Valley Resource Management Act* (MVRMA), which provides a legislative framework for the preliminary screening, EA and environmental impact review of proposed developments. The following subsections summarize the key milestones in the EA process to date for this Project.

2.1.1 Application to the Mackenzie Valley Land and Water Board

On October 19, 2007, INAC submitted an application for a water licence (MV2007L8-0031) to the MVLWB for the remediation of Giant Mine. The MVLWB deemed the application complete on October 26, 2007, and proceeded to initiate a preliminary screening of the proposed development[5]. On February 21, 2008, the MVLWB completed the preliminary screening and determined it was unlikely that the proposed development would have a significant adverse impact on the environment or would be a cause of public concern.

2.1.2 Referral to Environmental Assessment by City of Yellowknife

Notwithstanding the decision by the MVLWB, on March 31, 2008, the City of Yellowknife referred the Remediation Project to an EA pursuant to subsection 126(2) (d) of the MVRMA. In its letter of referral to the Review Board, the City of Yellowknife cited potential adverse

[5] While the MVRMA uses the term "development" to describe proposed projects, the current project is not a development in a conventional sense. The DAR's use of the term "Project" is intended to be consistent with the term development as understood in the MVRMA.

environmental effects within its municipal boundaries as its reason for the referral. In response to the referral, the Review Board commenced EA start-up activities on April 7, 2008, which included the creation of EA distribution lists and the opening of a public registry. The EA was assigned the file number EA0809-001 by the Review Board.

2.1.3 Review Board Scoping

Following the EA start-up, the Review Board commenced its scoping activities to identify and set priorities for relevant issues. On June 17, 2008, Review Board staff organized a day-long scoping session in Yellowknife to gather public input on the EA. In order to hear directly from the parties and interested members of the public, the Review Board subsequently held an issue scoping hearing on July 22 and 23, 2008. The following registered parties to the EA made presentations at the scoping hearing:

- The City of Yellowknife;
- Mr. Kevin O'Reilly;
- Mr. Bob Bromley;
- The Yellowknives Dene First Nation; and
- The North Slave Métis Alliance.

As an outcome of the scoping hearing, the Review Board issued ten Undertakings to some of the parties in order that the Review Board would have information available to it to assist in making a determination of the scope of the EA and the scope of the development.[6]

2.1.4 Review Board Decision on EA and Development Scope

In response to issues raised during the scoping activities, the Review Board issued its *Reasons for Decision* on December 19, 2008 regarding its decisions on the scope of development and scope of assessment for the EA. The Review Board's decisions on scoping were further defined in its *Terms of Reference for the Environmental Assessment of the Indian and Northern Affairs Canada Giant Mine Remediation Plan* that was issued on May 12, 2009. Both the *Terms of Reference* and an accompanying EA Work Plan were subject to public comment prior to finalization by the Review Board.

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[6] Information on the Undertakings can be found on the Review Board's web-site at the following address: http://www.reviewboard.ca/registry/project_detail.php?project_id=69&doc_stage=3

2.2 Scope of the Development Determination

In scoping a development, the Review Board must determine what physical works and activities are necessary for the "development" to occur so that they can be assessed. The Review Board uses the evaluation criteria of interdependence, linkage and proximity, as cited in its *Environmental Impact Assessment Guidelines* (Review Board 2004), to identify what physical works and activities are part of the development. Using these criteria, the Review Board determined that the scope of the development would include the following physical works and activities:

1) *Immobilization of arsenic trioxide through ground freezing (the frozen block method)*
2) *Ongoing treatment of contaminated water to remove arsenic, which includes:*
   - *Construction of a new water treatment plant*
   - *Treatment using additives to initiate the precipitation of arsenic from water*
   - *Storage of treated water and eventual discharge to Great Slave Lake*
   - *Storage of by-products of treatment*
3) *Removal of site infrastructure and materials, such as buildings, waste and contaminated materials*
4) *Capping of tailings areas*
5) *Removal of contaminated soils from mine site and tailings areas*[7]
6) *Rehabilitation of Baker Creek*
7) *Reclamation of open pits, some of which will be filled with site materials, some flooded due to changes in the water course of Baker Creek and some left open and bermed and/or fenced*
8) *Activities related to monitoring*
9) *Relocation of a small portion of the Ingraham Trail (Highway 4).*

The Project Team is in general agreement with the scope of the development as defined by the Review Board. The only exception relates to the potential for flooding of open pits (item 7). Arsenic concentrations in minewater are anticipated to remain elevated for many years to come (as described further in Chapter 6); hence, it was determined that it would be environmentally unacceptable to let the pits flood. The mine will, therefore, remain dewatered below the base of

[7] While this activity is identified in the TOR, it is better described as "Remediation of surficial materials". The rationale for this change includes: 1) management of contamination will not necessarily involve removal from the site and 2) "surficial material" is a broader category than soil and includes materials that have been placed on surface during the operation of the mine (e.g., waste rock). It should be clarified, however, that tailings located in the tailings areas are not classified as contaminated surficial materials.

all pits for the entire temporal scope of the EA and, as a consequence, the potential effects associated with the formation of pit lakes have not been evaluated by the EA. If INAC determines that the formation of pit lakes is desirable, both from an operational and ecological perspective, separate regulatory authorizations would need to be obtained.

2.2.1 Aspects Not Part of the Scope of Development

In its *Reasons for Decisions*, the Review Board also addressed the following issues that were raised during scoping activities but which it determined were not part of the scope of development:

Proposed Relocation of Ingraham Trail

In addition to the 1.5 km of Highway 4 (the Ingraham Trail) that requires relocation to complete the freezing of the arsenic trioxide dust, the GNWT's Department of Transportation is planning to relocate a larger portion of the highway. During scoping for the EA, several participants expressed the opinion that the proposed GNWT relocation should be considered part of the development. Following the receipt of correspondence from the GNWT, the Review Board concluded that the proposed highway relocation was not part of the scope of development for the following reasons:

- The Giant Mine remediation will take place regardless of the highway relocation;
- The Remediation Project will not create a circumstance that requires that the road be relocated (other than the small portion noted above); and
- The highway project is at an early and conceptual phase of development, with no feasibility studies completed, or proposed route selected.

Alternatives to Frozen Block Method

During the scoping activities, some participants requested that the rationale for choosing the frozen block method over other alternatives available to it, be considered in the EA. In its *Reasons for Decision*, the Review Board stated that it would not require a further analysis of alternatives to the frozen block method for the following reasons:

- The parties to the EA did not provide any new evidence which convinced the Review Board that the investigation of alternatives to the frozen block method should be initiated;
- The Review Board was of the opinion that the developer appeared to have already carried out a comprehensive review of alternative arsenic trioxide management methods;
- The Review Board agreed with the Project Team's assertion that the selected method was the best available choice; and

- The developer's technology selection had been influenced by advice provided by the Independent Peer Review Panel, as well as by public input.

Freeze Optimization Study

At the scoping hearing, the Project Team requested that the Review Board exclude its then proposed freeze optimization study from the scope of the development. The Review Board agreed to not scope the study into the EA based on the following:

- The Giant Mine's remediation is not dependent on the optimization study and will continue regardless of the study's result; and
- The two projects are not linked because in the hypothetical case that the frozen block method had been fully implemented, there would be no reason to conduct optimization studies after the fact.

2.3 Scope of the Environmental Assessment Determination

2.3.1 Geographic Scope of Assessment

The geographic scope of assessment is the spatial boundary that delineates where the assessment is to be focused. In its *Reasons for Decision* and *Terms of Reference*, the Review Board established the geographic scope for the Project to be consistent with the area described in INAC's water licence application to the MVLWB, which included the following:

- The lands encompassed by Reserve R662T (Giant Mine);
- The land encompassed by the Giant Mine Townsite lease area (17889T), including the Great Slave Cruising Club; and
- The section of shoreline at the North end of Yellowknife Bay adjacent to the mine site where tailings have been historically deposited.

The geographic scope of assessment corresponds to the "Site Study Area", as presented in Figure 3.4.1. Notwithstanding the above-cited generic geographic scope of assessment, the Review Board noted it would consider assessment boundaries appropriate to the valued component being considered.

2.3.2 Temporal Scope of Assessment

In establishing the temporal scope of assessment, the Review Board was of the opinion that, despite the Project's goal to minimize environmental risk at the mine site, some degree of risk, particularly from the underground arsenic trioxide will continue to exist indefinitely. The Review Board noted that predictions about future conditions are necessary in order to assess future potential environmental impacts; however, such predictions become more speculative and less certain as the timeline extends into the future. Acknowledging these limitations to its prediction-making ability, the Review Board established a temporal scope of assessment of 25 years, consisting of:

- The fifteen years required to complete the ground freezing and immobilization of contaminants; and
- Ten years of subsequent monitoring activities to verify that the site has been stabilized.

Following this 25-year period, the Review Board stated that it anticipates the responsibility to ensure that the site is stable and that monitoring and follow-up activities are implemented will be considered in the future by the relevant regulatory authorities.

2.3.3 Limitations to the Scope of Assessment

In its *Reasons for Decision*, the Review Board also determined that the following issues are not within the scope of the DAR.

Historic Dispersion of Arsenic Trioxide

During the scoping exercises, some participants suggested that the impacts due to the historic dispersion of arsenic trioxide beyond the Giant Mine site (Reserve R662T and lease area 17889T) be considered in the EA. The Review Board chose not to scope this issue into the EA as it recognized that the activities which led to the deposition of arsenic in locations away from the Giant Mine site are not related to activities proposed by INAC, nor are the effects of these historic activities a component of the Remediation Project.

Soil Remediation Standards

Concerns were voiced during the scoping exercises that the use of an industrial soil remediation standard (340 mg/kg arsenic) might preclude the full use of the site for residential and recreational purposes. In its *Reasons for Decision*, the Review Board observed that it was the land owner's responsibility to identify an acceptable remediation standard. Further, it was noted that the overall soil quality of the site will be improved and that the selection of the industrial remediation standard would not, in itself, have an adverse effect on the environment. On this basis, the Review Board determined that the selection of soil remediation standards was not within the Scope of Assessment.

Legacy Issues

During the scoping events, participants, especially representatives of the Yellowknives Dene First Nation (YKDFN), spoke about a variety of topics that could be collectively considered "Legacy Issues". Such issues are not only attributable to the historic impact of Giant Mine, but also include other mines that operated in the Yellowknife area, such as the Con Mine and the Burwash Mine. In discussing legacy issues, participants cited, among other things, the loss of harvesting sites, the lack of compensation for past effects, the anxiety provoked by fear of contamination, as well as illness and death attributed to contamination from the mines.

In its *Reasons for Decision,* the Review Board acknowledged the regrettable legacy of effects that may have occurred during the early years of gold mining in the Yellowknife region. Nevertheless, the Review Board determined that the Scope of Assessment for the Project should not include such effects as they are not attributable to the Remediation Project.

2.3.4 Key Lines of Inquiry

In response to public concerns voiced during the scoping phase of the assessment, the Review Board, in its *Terms of Reference*, identified the following two "Key Lines of Inquiry" that will require the most attention during the EA study and the most rigorous analysis and detail in the DAR:

1. Any issues related to arsenic trioxide (including its containment for an indefinite period underground and its contamination of the receiving environment); and
2. Questions related to monitoring and maintenance activities at Giant Mine after the active freezing stage.

Given the fundamental nature of these issues to the overall Project, the Key Lines of Inquiry are addressed throughout the DAR, but are the focus of particular sections which include:

- *Key Line of Inquiry #1* – Containment of Arsenic Trioxide: Chapter 6 – Remediation Project Description;
- *Key Line of Inquiry #1* – Potential for Environmental Contamination from Arsenic Trioxide: Chapter 8 – Assessment and Mitigation of Likely Environmental Effects; and
- *Key Line of Inquiry #2* – Monitoring and Maintenance: Chapter 14 – Environmental Monitoring and Evaluation Framework and Long-Term Environmental Monitoring.

2.4 Content and Organization of the Developer's Assessment Report

The DAR consolidates and summarizes all aspects of the EA. The document draws heavily from the numerous technical studies performed in support of the *Giant Mine Remediation Plan* as well as other reference material. The DAR is organized to present relevant information in a logical sequence that systematically describes the assessment of effects associated with the Remediation Project. The report is organized into the following 15 chapters:

1. Introduction and Overview;
2. Environmental Assessment Framework;

3. Environmental Assessment Methodology;
4. Site History;
5. Existing Site Description;
6. Remediation Project Description;
7. Description of the Existing Environment;
8. Assessment of Likely Environmental Effects and Mitigation;
9. Effects of the Environment on the Project;
10. Assessment of Accidents and Malfunctions;
11. Assessment of Cumulative Effects;
12. Significance of Residual Effects;
13. Consultation and Engagement;
14. Environmental Monitoring and Evaluation Framework and Long-Term Environmental Monitoring; and
15. Summary and Conclusions of the DAR.

2.5 Supporting Studies and Technical Documents

The Review Board's *Terms of Reference* directed that the DAR should be understandable as a stand-alone document and that supporting documents should be included only in appropriate circumstances. Therefore, the Project Team has endeavoured to present relevant information in a sufficiently clear manner for the general public to understand the Project and its potential environmental effects without having to refer to supporting documentation. However, the Project Team also recognizes that some parties, particularly technical reviewers, may be interested in additional details on specific issues that were not amenable to inclusion in the DAR. In this regard, the Project Team is of the opinion that the Remediation Plan and many of its Supporting Documents are integral parts of the DAR. Because of this, electronic copies of the Remediation Plan and its Supporting Documents have been respectively provided in Appendices A and B to the DAR. In addition, a number of site-specific technical studies have been completed since the finalization of the Remediation Plan in 2007. In situations where the Project Team considered these documents to be of potential interest to technical reviewers of the DAR, electronic copies of the documents have been provided in Appendix C. Table 2.5.1 provides a summary of the various documents that have been provided in Appendices A, B and C.

Table 2.5.1 Summary of Supporting Documents to the DAR

Appendix A – Giant Mine Remediation Plan	
Appendix B – Supporting Documents to the Giant Mine Remediation Plan	
A – Environmental Conditions	
A1	Impact of the Yellowknife Giant Gold Mine on the Yellowknives Dene: A Traditional Knowledge Report (YKDFN 2005)
A2	Baseline Study Reference List (KHS 2004)
A3	Ecological Investigations at Giant Mine (Jacques Whitford 2003)
A4	Biological Sampling at Baker Creek 2002 (Dillon Consulting Ltd. 2002)
A5	Biological Sampling at Baker Creek 2003 (Dillon Consulting Ltd. 2004)
A6	Baker Creek Fish Habitat & Rehabilitation Study for Abandonment and Restoration Planning (Dillon Consulting Ltd 1998)
A7	Fisheries: extracted from 2001 A&R Plan (Golder Associates Ltd. 2001d)
A8	Arsenic Concentration and Speciation in Fishes from Back Bay near Yellowknife, NT (DeRosemond 2004)
A9	Muskrat Sample Collection Program at Baker Creek (Golder Associates Ltd. 2004c)
A10	Giant Mine Migratory Bird Survey (Cygnus Environmental 2004)
A11	Air Quality Monitoring at Giant Mine Site, Yellowknife: A Baseline Study (SENES 2005)
B – Geochemical Characterization of Other Sources	
B1	Giant Mine Arsenic Trioxide Project – Structural Geology (SRK 2002b)
B2	Geochemistry of Mine Wastes, Giant Mine Site, Yellowknife, NT (Golder Associates Ltd. 2001a)
B3	Giant Mine – Underground Mine Water Chemistry (SRK 2005e)
B4	Summary of Routine SNP Monitoring Programs (SRK 2005i)
B5	Giant Mine – Surface Water Chemistry (SRK 2005f)
B6	Giant Mine – Geochemical Characterization of Other Sources (SRK 2005c)
C – Hydrogeology	
C1	Giant Mine Hydrogeology (SRK 2002c)
C2	Update to Supporting Document 2 (SRK 2004a)
C3	Groundwater Monitoring System Installation Report 2004 (SRK 2005j)
C4	Groundwater Monitoring System: November 2004 Monitoring Update (SRK 2004b)
C5	Groundwater Modelling: Model Design and Simulation Results (SRK 2005k)
C6	Groundwater Modelling Update – Giant Mine Remediation Project (SRK 2005l)
D – Arsenic Trioxide Dust Chambers and Stopes	
D1	Crown Pillar Stability Evaluation: Arsenic Trioxide Dust Storage Chambers and Stopes (SRK 2005b)
D2	Arsenic Trioxide Chamber Drilling and Testing Program 2004 (SRK 2005a)
E – Pit Stability	
E1	Site Wide Crown Pillar Stability Investigation (SRK 2006a)
E2	Pit Stability Review – Giant Mine (SRK 2005d)

Table 2.5.1 Summary of Supporting Documents to the DAR (Cont'd)

Appendix B – Supporting Documents to the Giant Mine Remediation Plan (Cont'd)	
F – Historic Foreshore Tailings	
F1	Review of Yellowknife Bay Tailings Environmental Assessments (SRK 2004c)
F2	Investigation of the Distribution of Historic Tailings in North Yellowknife Bay (Golder Associates Ltd. 2005a)
F3	The Potential for Geochemical and Microbial Remobilization of Arsenic from Sediments in Yellowknife Bay, Great Slave Lake: Progress Report 4 (Andrade *et al*. 2004)
G – Baker Creek	
G1	Giant Mine Flood Hydrology (SRK 2004d)
G2	Baker Creek Restoration Concepts (nhc 2005)
G3	Baker Creek and C1 Pit at Giant Mine (Golder Associates Ltd. 2004a)
H – Borrow Sources	
H1	Giant Mine Borrow Investigation (Golder Associates Ltd. 2004b)
H2	Air Photo Interpretation of Potential Borrow Areas North of Giant Mine (Golder Associates Ltd. 2004d)
H3	Summary of Potential Borrow Sources on Giant Mine Lease and in the Immediate Area (SRK 2005m)
I – Surface Contamination Investigation	
I1	Distribution of Arsenic in Surficial Materials: Giant Mine (Golder Associates Ltd. 2005b)
I2	Subsurface Environmental Investigation - Petroleum Hydrocarbon Assessment, Giant Mine, Yellowknife, N.W.T (Golder Associates Ltd. 2001c)
J – Ground Freezing	
J1	Conceptual Engineering for Ground Freezing (SRK 2006b)
K – Tailings and Sludge Remediation	
K1	Tailings and Sludge Containment Areas (SRK 2005g)
K2	Characterization of Soil and Groundwater in the Calcine and Mill Areas, Giant Mine (INAC and SRK 2004)
L – Water Treatment	
L1	Water Treatment Update (SENES 2005)
L2	Giant Mine Effluent Dilution Study (Hay & Co. 2005)
M – Supporting Calculations of Arsenic Release	
M1	Estimates of Flow and Arsenic Releases from Surface and Underground Sources (SRK 2005h)
N – Risk Assessment	
N1	Tier 2 Risk Assessment, Giant Mine Remediation Plan (SENES 2006)
P – Communications	
P1	Giant Mine Remediation Plan Public Consultation and Communications (INAC 2005)
Appendix C – Additional Supporting Documents	
Air Quality Monitoring at Giant Mine Site, Yellowknife: A Baseline Study (Volume 4 – 2007) (INAC 2008)	
As-built Report for Baker Creek Reach 4 Realignment Project (SRK 2007a)	
Baker Creek, Reach 4 Revegetation Report (Flat River Consulting 2007)	
Baker Creek, Results of Fish Monitoring in Reach 4, Spring 2008 (Golder Associates Ltd. 2009)	
Giant Mine Environmental Effects Monitoring Phase 2 Final Interpretative Report (Golder Associates Ltd. 2008)	
Groundwater and C-Shaft Monitoring: 2005-2006 Update Report (SRK 2007b)	

Table 2.5.1 Summary of Supporting Documents to the DAR (Cont'd)

Appendix C – Additional Supporting Documents (Cont'd)
Groundwater and C-Shaft Monitoring: 2007 Update Report (SRK 2009)
Groundwater and C-Shaft Monitoring: 2008 Update Report (SRK 2009a)
Record of Community Engagement During the Giant Mine Remediation Project EA – 2007 to Present (INAC 2010)
Seismic Studies Related to Tailings Dam Safety, Giant Mine (SRK 2008)
Tailings and Settling Pond Field Investigations, Giant Mine (SRK 2007c)

2.6 Timeline for the EA and Subsequent Regulatory Processes

Following the submission of the DAR, the Review Board will carry out a conformity check to identify any deficiencies that the DAR may have related to the information requirements of the *Terms of Reference*. Once the Review Board considers the DAR to be in conformity with the *Terms of Reference*, the DAR review will officially commence. As a consequence of the review, it is expected that the EA process will allow for two rounds of Information Requests (IRs), the first exclusive to the Review Board, and the second open to all registered parties to the EA. While it is anticipated that most IRs will be directed to the Project Team, other parties may be required to respond to issues raised. In addition, as part of the analytical phase of the EA, the *Workplan* makes provisions for "Roundtable Technical Meetings" to be held to permit interested parties to discuss issues identified by the Review Board. The final milestone of the analytical phase will involve the submission of technical reports by the registered parties, which are intended to summarize the reviewer's conclusions and to make recommendations to the Review Board.

It is currently assumed that the Review Board will convene public hearings to provide the registered parties and interested members of the public an opportunity to present evidence directly to the Review Board members. In the event that the Project Team or parties are unable to provide an immediate response to issues raised at the hearing(s), the Review Board may require a response by way of a filed submission or "undertaking". Following the closure of the public record for the EA, the Review Board will draft its *Report of Environmental Assessment*, which will make a decision, pursuant to section 128 of the MVRMA to either:

- Approve the Project;
- Approve the Project subject to the imposition of measures to prevent significant adverse impacts to the environment;
- Order an Environmental Impact Review based on its opinion that adverse impacts to the environment are likely;
- Order an Environmental Impact Review based on its opinion that the Project is likely to be a cause of significant public concern; or

- Reject the Project without an Environmental Impact Review.

After making its decision, the Review Board will issue its *Report of Environmental Assessment* to the Minister for INAC (also known as the "federal minister"), who will in turn distribute the report to any ministers who are responsible for issuing authorizations (the "responsible ministers") required to carry out the Project. The federal and responsible ministers will consider the report and decide by consensus whether:

- An environmental impact review of the proposal must be conducted;
- To accept or refer back to the Review Board recommendations of the report;
- After consultation with the Review Board, to modify recommendations of the report or to reject it and refer to environmental impact review; or,
- To refer the report for a joint review under the *Canadian Environmental Assessment Act.*

Upon approval of the Report of EA by the Minister of INAC, the Water Licensing process will resume. The Project Team will prepare a Consolidated Project Description (CPD) prior to resumption of the Water Licensing Process. The CPD will: a) incorporate changes to the Remediation Plan from the EA; b) clearly identify commitments made by all parties and how they will be implemented; and c) describe how the Project Team will account for and implement the mitigation measures recommended by the Review Board.

As the Project requires a Type "A" Water Licence, it is assumed that the MVLWB will conduct a public hearing during the regulatory phase. Prior to issuing Water Licence MV2007L1-0031, the Minister of INAC will approve the Licence.

2.7 Compliance with the EA Terms of Reference

The DAR has been prepared in accordance with the information required in sections 3.2 to 3.7 of the Review Board's *Terms of Reference*. As required in Item #2 of Section 3.2.1 of the *Terms of Reference*, a concordance table that cross references the items in the *Terms of Reference* with relevant sections of the DAR has been prepared as Table 2.7.1.

Table 2.7.1 DAR Compliance with the Terms of Reference

TOR Section	Requirement	Location(s) in DAR
3.2.1	**Summary**	
3.2.1 1.	Provide a non-technical summary of the DAR.	Summary
3.2.1 2.	Provide a concordance table that cross references the items in the ToR with relevant sections of the DAR.	This table
3.2.1 3.	Provide a summary table indicating for each subsequent section (3.2.4 through 3.7) whether scientific knowledge, traditional knowledge, or both, was used in the information collection and analysis.	2.8 (Approach to date) 13 (Future approaches for traditional knowledge collection)
3.2.2	**Developer**	
3.2.2 1.	A summary of previous experience of the Project Management Team working on the reclamation of industrial development sites in the NWT or other Northern environments	1.4
3.2.2 2.	A discussion describing the relationship between the developer and its contractors and subcontractors with details as to how the developer will ensure that the contractors and subcontractors will be responsible for, and honour commitments made by, the developer	1.4.4 6.13.1 6.13.4
3.2.2 3.	Any federal, territorial or municipal policy, directives, guidelines, standards or legislated requirements concerning environmental, sustainable development, community engagement or workplace health and safety standards that may have influenced the development design	1.7 (Environmental considerations) 6.13.2 (Additional authorizations)
3.2.2 4.	A description of the relationship between the Government of the NWT and the developer as it pertains to the development, including a description of respective duties and obligations of the two organizations	1.1.4 1.4
3.2.2 5.	A description of project feasibility including financial feasibility. Include discussion of funding certainty for the development and related monitoring	6.13.6
3.2.3	**Description of the Existing Environment**	
3.2.3	Description of the Existing Environment	Chapter 5 (Existing Site Description) Chapter 7 (Description of the Existing Environment)
3.2.3 a.	The presence of wild life at risk in the area and any important habitat	7.5.3 (Local) 7.5.4 (Site)
3.2.3 b.	Unique landforms, topography, or geology	7.7.1.2 (Giant mine pillow basalt)
3.2.3 c.	Heritage resources or areas of high potential heritage resources	7.6.6 (Aboriginal) 7.7.1 (Non-Aboriginal)
3.2.3 d.	Recreational or aesthetic values	7.7.1

Table 2.7.1 DAR Compliance with the Terms of Reference (Cont'd)

TOR Section	Requirement	Location(s) in DAR
3.2.3 e.	Areas that may be used for traditional harvesting of plants or animals or that may have cultural significance.	2.8
3.2.3 1.	Site hydrology, including surface water, groundwater and mine water	7.1.2 (Hydrology) 7.2.3 (Groundwater flow) 5.7.1 (Minewater)
3.2.3 2.	Modifications made to the site hydrology, which should clearly indicate where there are engineered disruptions of natural flow, such as dams or bank modifications, and where inputs to the hydrological system come from the mine	5.7.2.2 (Surface Runoff input from mine) 5.7.3 (Water Treatment and Discharge input from mine) 5.8 (Modifications to Baker Creek)
3.2.3 3.	Information on past and current water quality, quantity and flow regimes, with particular attention to Baker Creek	5.5 (Seepage from containment areas) 7.1.2 (Hydrology) 7.1.3 (Surface water quality) 7.2.3 (Groundwater flow) 7.2.4 (Groundwater quality)
3.2.3 4.	Aquatic organisms (especially fish) and aquatic habitat contained within the geographic area of the environmental assessment	7.4
3.2.3 5.	Vegetation and plant communities	7.4.3.2 (Aquatic) 7.5.4.1 (Terrestrial)
3.2.3 6.	Nature of sediments at the site, meaning the physical and chemical makeup of these sediments, including soils, sediment beds of rivers and lakes, tailings and waste impoundment areas and the shores and near shore areas of Great Slave Lake (Yellowknife Bay) that have been included in the geographic scope	7.1.4 (Sediment) 7.2.2.6; 7.2.5 (Soils) 5.4 (Waste Rock) 5.5 (Surface Tailings) 5.6 (Foreshore Tailings)
3.2.3 7.	Structural geology: specific consideration shall be given, but not limited, to faults, joint patterns, rock mass quality, ranges of conductivities and macroscopic transmissivity	7.2.2 (Structural geology) 7.2.2.4 (Macroscopic transmissivity) 7.2.3 (Conductivity)
3.2.3 8.	Terrain, bedrock geology, permafrost distribution, ground temperatures, active layer thickness, and seismicity, especially at locations where the developer proposes to freeze arsenic trioxide chambers	5.1.3 (Bedrock, temperature) 5.1.4; 5.2.5 (Stability of crown pillars) 7.2.2 (Bedrock, terrain, seismicity) 7.2.6 (Permafrost, ground temperatures, active layer thickness)
3.2.3 9.	On site infrastructure, including mine workings, overview of historic and recent boreholes and wells including sealing practices for abandoned boreholes and wells	5.1.3 (Arsenic mine workings) 5.1.4; 5.2.5 (Crown Pillars) 5.1.5 (Bulkheads) 5.2.1 (Other mine workings) 5.2.6 (Historic and recent boreholes) 6.2.9.1 (Recent FOS boreholes)

Table 2.7.1 DAR Compliance with the Terms of Reference (Cont'd)

TOR Section	Requirement	Location(s) in DAR
3.2.3 10.	Mine workings on site, including buildings, power lines, roads, fences and gates, and other associated infrastructure, also including: a) a description of the mine itself, including pits, underground tunnels, stopes, and vertical shafts; with particular attention paid to the arsenic storage chambers on site b) any equipment or infrastructure currently underground described in general terms, such as power lines or transportation infrastructure such as tracks and earth moving equipment, etc.	5.1 (Arsenic storage areas) 5.2 (Underground mine) 5.3 (Open pits) 5.5 (Containment areas) 5.9 (Quarries, borrow areas and overburden piles 5.11 (Buildings and infrastructure)
3.2.3 11.	Ambient air quality and climate history	7.3.2 (Climate) 7.3.3 (Ambient air quality)
3.2.3 12.	Historic and present past land usage, with the identification of traditional land use groups and areas of overlapping land usage	Chapter 4 (Site history) 7.6.4; 7.6.5.2; 7.6.5.3 (Aboriginal) 7.7.1.1 (Non-Aboriginal)
3.2.3 13.	Cultural and heritage resources, with the identification of the cultural groups who associate with these resources	7.6.6 (Aboriginal) 7.7.1.2 (Non-Aboriginal)
3.2.4	**Development Description**	
3.2.4 1.	The proposed physical footprint of the development, including all alterations and additions to the site, existing buildings, roads, fences, mine workings, power lines, water lines, etc.	6.1, Figure 6.1.4
3.2.4 2.	Description of the underground chambers and bulkheads currently being used to contain the arsenic trioxide dust, including an assessment of the structural integrity of each and proposed modifications	5.1.3 (Chambers) 5.1.4 (Crown pillars) 5.1.5 (Bulkheads) 6.2.4 (Stabilization)
3.2.4 3.	Overview of the frozen block method, including a non-technical description of the technology the developer proposes to use (freeze plants and thermosyphons)	6.2.3 (Overview) 6.2.5; 6.2.6; 6.2.7 (Additional details on specific elements of the frozen block method).
3.2.4 4.	A timeline that sets out the intended freezing sequence for the arsenic chambers and stopes, defines when the arsenic trioxide dust is considered frozen (i.e. safe for the environment), accounts for long term climate changes and differentiates between active and passive freezing	6.2.6 (Timeline) 6.2.7 (Active & passive) 6.2.8.2 (Climate change)
3.2.4 5.	Demolition plans and locations for buildings and other infrastructure, as well the identification of any structures that may be left intact with reasons provided	6.11.3 (Demolition) 6.11.4 & Figure 6.1.2 (Buildings intact) 6.11.5 & Figure 6.1.2 (Public highway)
3.2.4 6.	Description of the proposed waste management plan, including waste from building demolition, soil remediation, existing waste materials on site, contaminated mining equipment from underground and the surface and any other source for solid waste	6.12 (Waste disposal plan) 6.10 (Soil remediation waste)

Table 2.7.1 DAR Compliance with the Terms of Reference (Cont'd)

TOR Section	Requirement	Location(s) in DAR
3.2.4 7.	Location and ultimate disposition of open pits on the site. If the pits are to be filled, a description of the fill material and potential volumes, and if they are to be left empty, a description of any safety measures that will be installed such as berms or fences, and how these would be monitored and maintained	5.3 (Location) 6.4.3 (Disposition, fill, safety) 14.2.6 (Physical monitoring & maintenance)
3.2.4 8.	A detailed description of the proposed method(s) and location(s) of tailings disposal and/or containment, including a description of any technologies or materials that may be used, and any temporary or permanent measures to control fugitive dust from tailings disposal areas	6.6 6.7
3.2.4 9.	A detailed description of the proposed water treatment process, include the installation of new infrastructure, the proposed methodology, location and predicted quality of eventual discharge	6.8 (Site water management)
3.2.4 10.	The projected quantity of contaminated water that will be treated and discharged through the water treatment process on an annual basis, broken down by both season and by year	6.8.3 (Seasonal control) 6.8.5 (Short term vs long-term)
3.2.4 11.	The nature of the by-product (sludge) that will be generated through the water treatment process, including chemical makeup, projected quantity, and the proposed method for sludge disposal	6.8.5
3.2.4 12.	The proposed Baker Creek remediation activities, including: a. potential re-alignments b. diversion c. chanel and habitat enhancements d. options for management of contaminated sediments e. future improvements and contingencies for Baker Creek habitat restoration	6.9
3.2.4 13.	Estimated power requirements during the active freezing portion of the development, as well as any additional power requirements after the freezing is complete for any other purpose	6.2.5.4 6.8.5
3.2.4 14.	Estimated capital, operating, monitoring and maintenance costs (the latter presented by year for the life of the development) of the approval process	6.13.6
3.2.4 15.	The estimated lifespan of the development broken down into construction, active operations and ongoing maintenance; and monitoring	6.13.3 (Schedule)
3.2.4 16.	The number of person years of work associated with the development, broken down by life cycle stage	6.13.5
3.2.4 17.	The approval process for each development component, including all permits, licenses and authorizations, the regulatory agency in charge of each, and status	1.7 (Environmental considerations) 6.13.2 (Additional authorizations)

Table 2.7.1 DAR Compliance with the Terms of Reference (Cont'd)

TOR Section	Requirement	Location(s) in DAR
3.2.5	**Accidents and Malfunctions**	
3.2.5 1.	Analyze risks for this development, including components, systems, hazards, and failure modes.	10.3 (Identification of credible accidents and malfunctions) 10.4 (Screening) 10.6 (Assessment of Bounding Scenarios)
3.2.5 2.	Assess likelihoods and severity of each risk identified.	
3.2.5 3.	Describe all emergency response plans that will be in place during the execution of the proposed development, including a description of how the developer plans to communicate consequences and risks to the local population. (Note: Information requirements regarding potential accidents and malfunctions of the frozen block method are described in Section 3.3 - Arsenic Containment).	10.7
3.2.6	**Public Consultation**	
3.2.6 1.	For each consultation activity, identify dates and locations, participants in consultation activities, methods of consultation and discussion topics. Additionally, identify: a. All public methods used to identify, inform and solicit input from potentially affected parties b. All commitments and agreements made in response to issues raised by the public during these consultations, and how these commitments altered the planning of the proposed the development c. All issues that remain unresolved, and document any further efforts envisioned by the parties to resolve them	13.4, 13.5, 13.5.1, 13.10, 13.11, 13.13 13.4 (Consultation activities) 13.5 (Resulting commitments) 13.5.1(Summary of Feedback) 13.10 (Resolving Concerns) 13.11(Addressing Concerns with Implementation) 13.13 (Consultation and Engagement Plan)
3.2.6 2.	Identify any plans, strategies or commitments that the developer is contemplating to ensure that individuals or groups that may be affected by the development will continue to be consulted over the term of this environmental assessment and over the life of the project.	13.11, 13.12 13.11(Addressing Concerns with Implementation) 13.12 (Future Consultation Efforts) 13.12.1 (Environmental Monitoring and Evaluation) 13.12.2 (Aboriginal and Government Body) 12.12.3 (Traditional Knowledge Holders) 13.12.4 (Open Houses, Community Meetings, Workshops) 13.12.5 (Sharing Information Visually) 13.12.6 (Information Management) 13.12.7 (Tours of Giant Mine)
3.2.6 3.	Describe the membership and activities of the Giant Mine Community Alliance.	13.7 (Community Alliance)

Table 2.7.1 DAR Compliance with the Terms of Reference (Cont'd)

TOR Section	Requirement	Location(s) in DAR
3.2.6 4.	Discuss any efforts that the developer will be making to simplify the complex information contained within the development public registry and to more effectively communicate aspects of the development, including any efforts that will specifically address concerns that the developer may have heard from participants in previous consultation activities or during this environmental assessment.	13.8, 13.9, 13.12.5, 13.12.6 13.8 (Efforts to Simplify Information) 13.9 (Using Appropriate Media) 13.12.5 (Sharing Information Visually) 13.12.6 (Information Management)
3.2.6 5.	Discuss how the developer intends to engage with traditional knowledge holders in order to collect relevant information for the prediction of possible impacts, as well as the development of mitigation methods, adaptive management plans and monitoring program planning.	13.12.2, 13.12.3, 13.12.7 13.12.2 (Aboriginal and Government Body) 13.12.3 (Traditional Knowledge Holders) 13.12.7 (Tours of Giant Mine)
3.2.6 6.	Describe any plans the developer has to continue public consultation and involvement during implementation of the project and afterwards, with particular regard to reporting monitoring results and adaptive management and a description of how public complaints will be addressed and the dispute resolution process.	13.12.1 13.4 (Consultation activities) 13.8 (Efforts to Simplify Information) 13.13 (Consultation and Engagement Plan) Chapter 14
3.2.7	**Assessment Boundaries**	
	Describe the spatial and temporal boundaries of the assessment	3.4.1 (Spatial) 3.4.2 (Temporal)
3.3	**Arsenic Containment**	
3.3 1.	A detailed description of how the frozen block method will be done, including: a. A complete timeframe that encompasses the project from the start to the point where stability is reached and the arsenic is completely isolated from the surrounding environment b. With the best available information, a prediction of the amount of active freezing, the amount of passive freezing, power requirements, numbers and general locations of thermosyphons that will be necessary to achieve stability (referring here to a state where active management of the site is no longer necessary) c. An illustration of the stability of the proposed system for a duration of at least 100 years after converting the active freezing system into a passive system d. A description of the intended redundancies and factor of safety, in particular for the passive cooling system e. A description of the monitoring and maintenance requirements of the thermosyphons, the conditions that would require their replacement, and the expected frequency of replacement	a=6.2.6, b=6.2.5 & Figure 6.2.3, 6.2.7.2 c & d=6.2.8.2 e=6.2.9 & 14.2.6 f=6.2.5 g=6.2.6 (design criteria for freezing the block)

Table 2.7.1 DAR Compliance with the Terms of Reference (Cont'd)

TOR Section	Requirement	Location(s) in DAR
	f. A description of the method of installation of the infrastructure g. A description of the scenario whereby the developer would deem the project complete (that is that the remediation activities have sufficiently reduced or eliminated the arsenic contamination arising from the Giant Mine)	
3.3 2.	A detailed explanation on the saturation procedure of the arsenic trioxide dust before freezing and a demonstration that the frozen dust will be compact and ice saturated, (i.e. no loose cold regions and frozen bridges occur that could jeopardize the stability of the system)	6.2.6 (Step 2 – Wetting the Dust)
3.3 3.	A discussion of whether the frozen block method will protect the biophysical environment and the health and well-being of the human residents living nearby to the Giant Mine for as long as the contaminated materials persist at the site	8.9 (Human health and ecological risk assessment)
3.3 4.	A discussion of whether the developer contemplated a reconsideration of the frozen block method should a technological advance or change in the environment make it either necessary or advantageous to do so	6.2.2.4
3.3 5.	A discussion whether the developer contemplated assigning resources to make it possible to periodically review the questions posed above (s. 3.3 #5)	6.2.2
3.3 6.	A description of any opportunity costs for future underground arsenic management and treatment options associated with the proposed development in terms of futures foregone, including in-situ and ex-situ treatments	6.2.2
3.3 7.	An assessment of groundwater flows that will be adjacent to the arsenic chambers after the frozen block has been implemented, including a description of expected water quality and quantity, a comparison to current conditions, as well as an estimation of the influence of groundwater flow on the integrity and stability of the frozen block	6.2.8.1
3.3 8.	A discussion of the longevity (>30 years) of the proposed cooling system, which will include the following: a. a description of other instances of ground freezing technologies being used to isolate contaminants, a discussion of the challenges involved and of how successful each situation may have been b. identification of other instances of successful long-term application of passive cooling systems c. a discussion of the challenges involved, monitoring systems employed, maintenance efforts required, and why some systems had failed in the past d. contrast the expected duration of the hazard against the expected lifespan of each component of its containment system	6.2.8.3

Table 2.7.1 DAR Compliance with the Terms of Reference (Cont'd)

TOR Section	Requirement	Location(s) in DAR
3.3 9.	A prediction of the risks and effects of related to thaw. Include a discussion of the duration, risks and potential impacts if adaptive management required the frozen block to be intentionally thawed, and a discussion of risks and consequences of an accident or malfunction of the frozen block method. What response measures or plans would be in place to mitigate the effects of an accident? How would a failure of the frozen block impact the surrounding environment? This should include: a. A thorough analysis and discussion of diverse scenarios that may lead to partial or complete failure of the freezing system, and the risks associated with thawing for each scenario, including scenarios caused by external variables (such as prohibitive fuel costs, wildfires, warming of ground water, changes in the surface energy balance from ground water flow regimes influencing the ground surface vegetation, etc.) and internal engineering risks (such as crown pillar deformations, shearing of thermosyphons, stope collapses, etc.) b. A description of tolerable thresholds for arsenic trioxide releases for each phase of the development, which may be completed by identifying two or three additional higher threshold levels that correspond to partial failures of the system, each paired with an emergency response and communication plan c. A discussion of any policy or guidelines that would be followed in the case of an accident or malfunction d. Any emergency response plans that have been prepared or would be used in the case of an accident or malfunction of the development e. A discussion of how any information regarding an accident or malfunction or the risk of such an event would be communicated to the local population and how the developer plans to engage with local communities in regards to risk management	6.2.4, 6.2.8.2 6.2.8.4 6.2.8.5 10
3.3 10.	An account of how climate change predictions and observations affect the risk level in the long-term based on "best estimate" and "high estimate" scenarios, including discussion of risks in light of the current climate predictions as set out in the Fourth Assessment Report of the Intergovernmental Panel on Climate Change	6.2.8.2
3.3 11.	A description of potential effects of the frozen block on the additional remediation elements, including potential impacts on surface hydrology, tailings ponds consolidation and tailings covers	6.2.8.4 8.4.2
3.3 12.	A description of an adaptive management strategy that will use the information gathered during the initial freezing stages and refine the freezing system configuration, incorporating considerations such as freezing performance, site climate, and improved understanding of future climate trends	6.2.9

Table 2.7.1 DAR Compliance with the Terms of Reference (Cont'd)

TOR Section	Requirement	Location(s) in DAR
3.4.1	**Economy**	
3.4.1 1.	Provide an updated listing of all employment opportunities by skills category over the life of the development.	6.13.5
3.4.1 2.	Discuss the developer's strategies, plans or commitments with respect to maximizing the proportion of direct employees of the development that are NWT residents, aboriginal persons, and local residents.	1.6.2 6.13.4
3.4.1 3.	Identify any work that will be contracted out (as opposed to being conducted directly by the developer), the employment involved in those contracts, and the requirements that the developer will impose on contractors to maximize their use of northern and aboriginal contractors.	6.13.4
3.4.1 4.	Provide information on any barriers to employment for northern individuals or companies, either as direct employees or as contracted workers.	8.11.3
3.4.1 5.	Discuss any socio-economic impacts of the development that are more likely to be experienced by some groups than by others.	8.10 (Aboriginal) 8.11.3 (Non-Aboriginal)
3.4.1 6.	Identify any effects on local infrastructure and utility costs that may result from the development's demands on these facilities and services.	8.11
3.4.1 7.	Consider how any aspect of the development may affect present and future land uses in the area, including opportunity costs.	8.11
3.4.2	**Human Health and Safety**	
3.4.2 1.	Identification of all potential pathways for contaminant exposure for local residents	8.9
3.4.2 2.	An assessment of all risk to human health and impacts to quality of life related to exposure to arsenic trioxide, with consideration to chronic exposure as well as to short-term high level exposure that might result from a catastrophic malfunction of the development	8.9 (Chronic exposures) 10 (Accidents and malfunctions)
3.4.3	**Cultural Impacts**	
3.4.3 1.	How the implementation of the proposed development may affect land use at the Giant Mine site, with special consideration for traditional harvesting and other cultural land uses	8.10
3.4.3 2.	The type and nature of land uses (giving special consideration to traditional harvesting and other traditional activities of local aboriginal communities) that would be possible when the site is fully remediated (meaning the envisioned end point of active management) and how the permanent infrastructure and landforms contemplated by the development may affect these future activities (for example, if the site is more heavily used for recreation in the future, how will the open pits left on site affect local residents?)	6.1.2 (Post-remediation site conditions) 6.11.4 (Buildings remaining) 8.10.3 (Traditional harvesting and activities) 8.11.2 (Non-traditional land use)

Table 2.7.1 DAR Compliance with the Terms of Reference (Cont'd)

TOR Section	Requirement	Location(s) in DAR
3.5.1	**Water**	
3.5.1 1.	A listing of all applicable water resource permits, licenses, and authorizations that will be required from federal and territorial regulatory authorities, as well as all water quality requirements that may be mandatory or have been committed to previously by the developer	1.7
3.5.1 2.	A prediction of how a malfunction of the frozen block might affect contaminant levels in water both at the Giant Mine site and in the surrounding area, including Back Bay, Yellowknife Bay and Great Slave Lake. A timeline should be included.	6.2.8.2
3.5.1 3.	An examination of the potential effects of the proposed development on water quality, quantity and temperature throughout the potentially impacted area. Assessments of water quality should make use of applicable standards and guidelines. This analysis shall include, but not be limited to: a. A prediction of water quality, with special attention on arsenic levels, and how these levels may change through the lifespan of the project, the assessment of which should cover both inflows to the treatment process from i) mine water and ii) contaminated surface runoff and outflows from the treatment plant to the environment b. A prediction of water quantity in local water bodies, such as Baker Creek, including a description of peak and minimum flows, seasonal variations and water balance patterns and how these may change due to water treatment activities and other activities on site that may affect surface drainage patterns to other water bodies (such as realignment or diversion of Baker Creek or drainage channels) c. A prediction of water quality and quantity in new water bodies that may form in abandoned, unfilled open pits, highlighting potential sources of contamination that might have an effect on these water bodies.	6.8 (Prediction of post remediation water quality and quantities)* 8.4.2 (Hydrology effects of the Project) 8.4.3 (Surface water quality effects of the Project) 8.5.2 (Groundwater flow effects of the Project) 8.5.3 (Groundwater quality effects of the Project) * This is an activity of the Project that will result in positive effects relative to the baseline condition.
3.5.1 4.	Where permafrost exists at the Giant Mine, an analysis of potential impacts to the permafrost and its active layer from remediation activities	8.5.5
3.5.1 5.	An analysis of the effect of all remediation activities on ice formation, with particular attention to the impact of active freezing activities on normal seasonal freeze and thaw cycles in nearby water bodies	8.4.2
3.5.1 6.	An analysis of the short and long term effects of changes in surface water bodies and ground water flow on the frozen block and vice versa	6.2.8.1 (Groundwater) 6.8.7 (Surface water)

Table 2.7.1 DAR Compliance with the Terms of Reference (Cont'd)

TOR Section	Requirement	Location(s) in DAR
3.5.2	**Fish and Aquatic Habitat**	
3.5.2 1.	An description of fish and fish habitat present, and the various life stages that the proposed development may affect	7.1(Surface water environment baseline) 7.4 (Aquatic environment baseline) 8.4 (Surface water environment Project effects) 8.7 (Aquatic environment Project effects)
3.5.2 2.	A description of potential impacts to fish and fish habitat, including predicted habitat losses or gains from the proposed development	8.4 (Surface water environment Project effects) 8.7 (Aquatic environment Project effects)
3.5.2 3.	Site-specific mitigation measures proposed to reduce the predicted impacts to fish or fish habitat from the construction, operation or decommissioning of any development components	8.4 (Surface water environment Project effects) 8.7 (Aquatic environment Project effects)
3.5.2 4.	The production of a plan to offset residual impacts (such as a No Net Loss Plan and habitat creation)	8.7 The Project will enhance existing habitat (e.g., by reducing contaminant loads) and create new habitat (e.g., in the realigned Baker Creek). A No Net Loss Plan is not necessary due to the net positive effects of the Remediation Project.
3.5.2 5.	The potential downstream effects of arsenic contamination on aquatic organisms and their habitat considering both chronic exposure and also a scenario of a catastrophic failure leading to an abrupt and high level exposure	6.2.8.2 (Chain of events analysis) 8.7; 8.9 (Normal operations) 10 (Accidents and malfunctions)
3.5.2 6.	The potential impacts to fish and fish habitat in Baker Creek resulting from the development, including: a. the realignment or reconstruction of portions of the watercourse (specifically, construction activities that could affect surface drainage patterns and the hydrology of Baker Creek) b. any activities that could lead to the introduction of sediment (including contaminated sediments) into Baker Creek	8.4 (Surface water environment Project effects) 8.7 (Aquatic environment Project effects)
3.5.2 7.	The potential impacts to fish and fish habitat from any effects of the development on offshore migration or redistribution of existing tailings in north Yellowknife Bay	The Project will not affect the migration or redistribution of existing tailings in north Yellowknife Bay
3.5.2 8.	The potential impacts to fish and fish habitat associated with operation of the new water treatment plant, and proposed discharge of treated effluent into Yellowknife Bay (Great Slave Lake), including: a. The reduction of overall discharge or flow of Baker Creek which could lead to the potential for seasonal drying of portions of the creek, thereby reducing fish habitat	8.7.2.3 (Elimination of discharge to Baker Creek) 8.4.3.3 (Effects of outfall / diffuser construction on surface water quality) 8.4.3.3 (Effects of outfall / diffuser construction on sediment quality)

Table 2.7.1 DAR Compliance with the Terms of Reference (Cont'd)

TOR Section	Requirement	Location(s) in DAR
	b. The construction of the new discharge pipe and the discharge zone within Yellowknife Bay which could lead to the potential degradation of fish habitat	8.7.2.3 (Effects of outfall / diffuser construction on the aquatic environment)
3.5.2 9.	The potential impacts to fish and fish habitat in Baker Creek due to block freezing of arsenic trioxide dust in underground mine chambers, including discussions of any ice-damming in sections of Baker Creek that may result from active freezing and could lead to in extensions to the time period when the creek is frozen thereby reducing habitat utilization and access to spawning habitat for fish.	8.4.2
3.5.3	**Vegetation**	
3.5.3 1.	An overview of areas that will be revegetated, which should include a description of existing vegetation at those locations, a description of what seed mix or reclamation methods might be used and associated timelines	6.1.2 (Overview) 6.6 (Tailings covers) 7.4.3.2 (Baker Creek aquatic vegetation baseline) 7.5.4.1 (Terrestrial plant communities baseline) 7.5.4.2 (Contaminant concentrations in terrestrial vegetation baseline) The revegetation strategy for the site will be determined during the development of detailed designs for the tailings covers and other areas. The decision-making process will include the implementation of additional community consultations (particularly with Aboriginal groups) to determine preferred approaches to revegetation.
3.5.3 2.	Identification of any rare or "at risk" species	7.4.2.3 (Aquatic) 7.5.3.1 (Local terrestrial) 7.5.4 (Site terrestrial)
3.5.3 3.	The potential effects of the development on vegetation, with special attention to culturally significant species – as identified through traditional or community knowledge	8.7 (Aquatic) 8.8 (Terrestrial) Refer to Section 2.8 for an overview of traditional knowledge use by the Project.
3.5.3 4.	The potential effects of fugitive dust on vegetation and pathways for contamination of country food by ingestion of contaminated vegetation	8.6 (Air quality effects of particulate emissions) 8.9 (Pathway effects considered in the risk assessment)
3.5.3 5.	The potential effects of contaminated water on vegetation	8.4.3.3 (Effects on the Surface Water Environment and, by extension, receptors such as vegetation)

Table 2.7.1 DAR Compliance with the Terms of Reference (Cont'd)

TOR Section	Requirement	Location(s) in DAR
3.5.3 6.	The vulnerability of local plant communities to invasive species, and the likelihood that invasive species will be introduced by the proposed development	See response for TOR requirement 3.5.3.1
3.5.3 7.	A list of all mitigation required and committed to, to avoid significant impacts from the activities described above	8.6 (Atmospheric effects) 8.8 (Terrestrial environment effects)
3.5.3 8.	A conceptual plan for the adaptive management of effects on vegetation, including any monitoring programs, as well as reporting to regulators and potentially-affected communities	See response for TOR requirement 3.5.3.1. The revegetation strategy will be based on an adaptive management approach and will include provisions to report to regulators and potentially affected communities. The process will be guided by the approaches described in the following sections of the DAR: Chapter 13 (Communication and consultation) Chapter 14 (Monitoring and evaluation)
3.5.4	**Wildlife and Wildlife Habitat**	
3.5.4 1.	The rationale and methodology for the selection of species as valued components. Include species selected by the developer, and the following species (identified during issue scoping): a. Peregrine falcon (anatum subspecies) b. Black bear c. Moose d. Other fur-bearing mammals that frequent the area Analysis of each species shall include mapping the known distribution of each species, their likely and preferred range in the area, their habitat usage intensity broken down seasonally, migration corridors and any particularly important habitat sites.	The presence, abundance and distribution of species selected as valued components are described in: 7.4 (Aquatic Environment) 7.5 (Terrestrial Environment)
3.5.4 2.	The effects that each development component may have on wildlife and wildlife habitat valued components, which shall include: a. A description and quantification of all potential direct and indirect effects on habitat for each valued component b. Historic, current and expected wildlife use of potentially-contaminated water sources, and an assessment of the effects predicted from such activity c. Potential effects of contaminated fugitive dust on wildlife habitat d. Potential effects of altered water quality or quantity on health and distribution of animals, considering both steady long term exposure and short term higher level exposure resulting from a major malfunction of	7.4 (Aquatic habitat and biota baseline) 7.5 (Terrestrial habitat and biota baseline) 8.6 (Effects of fugitive dust emissions) 8.7 (Potential project effects on aquatic habitat and biota) 8.8 (Potential project effects on terrestrial habitat and biota) 8.9 (Effects of contaminant exposures on biota)

Table 2.7.1 DAR Compliance with the Terms of Reference (Cont'd)

TOR Section	Requirement	Location(s) in DAR
	the development e. Disturbance of wildlife, including blockages to movements, loss of effective habitat from disruption, and sensory disturbances from sources such as noise due to the development activities or results	
3.5.4 3.	The potential effects of the development operations on rare, threatened or endangered species including Peregrine falcon (anatum subspecies) and species listed by the Committee on the Status of Endangered Wildlife in Canada, including plans for monitoring species listed as "at risk" or "may be at risk" in the NWT General Status Ranks	8.8 (Potential Project effects on terrestrial valued components, including those identified as being rare, threatened or endangered (e.g. Peregrine falcon)) Chapter 14 (Monitoring)
3.5.4 4.	A conceptual wildlife management plan, including furbearers, migratory birds, waterfowl, hoofed mammals and large carnivores, in regards to ongoing monitoring of contaminant levels present in the ecosystem	Chapter 14 14.2.4 (Terrestrial and Environment Monitoring)
3.6	**Monitoring, Evaluation and Management**	
3.6 1.	A detailed description of the monitoring program proposed by the developer, including at a minimum a description of: a. A framework for effects monitoring, evaluation and management for all stages of the development b. Monitoring standards, methodologies and requirements for water quality, ground temperature, ecological effects and sediment contamination, and the effectiveness of mitigation and compensation measures c. Criteria for evaluating monitoring results, including triggers and thresholds for actions d. Internal management systems to ensure that results are properly assessed e. Plans for responding to unacceptable monitoring results through project management actions, and confidence in the adequacy of the management options available If. A description of any technology used in the implementation of the monitoring activities, and monitoring locations, frequency and duration g. A schedule of anticipated activities to implement the monitoring program h. Plans to periodically review of the efficacy of the proposed monitoring program and technologies used and a re-evaluation of the goals and benchmarks of the monitoring program i. Plans to engage with local communities in the development, implementation and review of monitoring activities j. The anticipated lifespan of active monitoring activities k. Anticipated redundancies in the monitoring program	Chapter 14 (Monitoring and Framework) 14.1 (Environmental Monitoring and Environmental Framework) 14.2 (Long-term Environmental Monitoring) a.=14.1 b.=14.2 c.= 14.2.2.3, 14.2.2.4, 14.2.3.2 d.= 14.1 e.= 14.1.3 f. = 14.2, 14.2.1 g.= 14.3 h.= 14.1.3, 14.2 i.=14.1.6,14.1.7 j.=14.2, Table 14.2.1 k.= Table 14.2.1, 14.3 l.= 14.2,14.3 n.=14.2,14.3

Table 2.7.1 DAR Compliance with the Terms of Reference (Cont'd)

TOR Section	Requirement	Location(s) in DAR
3.6 2.	An assessment of the ability of the monitoring program to adequately detect and identify small arsenic trioxide leakages from the frozen block	6.2.8.2 (Chain of events analysis) 14.2.2 (Mine water monitoring)
3.6 3.	An assessment of the ability of the monitoring program to adequately protect human health and safety and the integrity of the local ecosystem, with consideration given to the potential impact of a catastrophic malfunction	Chapter 14 Chapter 6 Chapter 10
3.7	**Cumulative Effects**	
3.7 1.	Identify the valued components to be considered in the cumulative effects assessment.	11.3.1; 11.3.2
3.7 2.	Describe all past, present and future human activities that may affect the same valued components as the development, or affect the implementation of the development. Provide a rationale for the choice of those activities.	11.3.4
3.7 3.	Identify and provide a rationale for the geographic and temporal scale that will be applied to the cumulative effects assessment of the valued components under consideration.	11.3.3
3.7 4.	Predict the cumulative effects of the human activities selected (in 2, above) on the valued components identified (in 1, above), including: a) A description of the predicted condition of the site following the development relative to baseline (1999) and natural background conditions b) A discussion of the approach and methodologies used to identify and assess cumulative effects c) Provide explicit documentation of the assumptions, models and information sources used, as well as information limitations and associated levels of uncertainty	a) Chapter 6 (Project description) b) 11.1 to 11.3 (Approach) c) 11.4 (Analysis – documentation of assumptions, information sources, limitations and uncertainty provided where appropriate)
3.7 5.	Provide a plan for the monitoring of cumulative effects and the adaptive management of the development's contribution to regional cumulative effects.	Chapter 14 14.2.8 (Cumulative Effect Monitoring)
4	**Deliverables**	
	A commitments table listing all mitigation measures the developer commits to employ as part of the DAR	Table 15.3.1

2.8 Use of Traditional Knowledge

Section 3.2.1 of the *Terms of Reference* requires that a summary be provided to demonstrate whether traditional knowledge and/or scientific knowledge were used in the information collection and analysis presented in the DAR. Due to the nature of the technical challenges associated with the Project, virtually all aspects of the Remediation Plan and much of the DAR have drawn heavily on scientific and engineering principles. Within this context, the current section does not focus on the use of scientific knowledge in the Remediation Plan. However, the emphasis of the current section is placed on the use of traditional knowledge.

In its processes, the Review Board gives Aboriginal traditional knowledge equal weight to scientific knowledge, when it has been made available. The Review Board's *Guidelines for Incorporating Traditional Knowledge in Environmental Impact Assessment* identifies the following three important elements of traditional knowledge that contribute to EA processes:

- Knowledge about the environment;
- Knowledge about the use and management of the environment; and
- Values about the environment.

The following examples demonstrate specific cases where the Project Team has attempted to secure traditional knowledge as an input to the Remediation Plan and the DAR:

- During the evaluation of options for the remediation of the arsenic trioxide chambers, Aboriginal communities were consulted to determine their values and preferences.
- To the extent possible, traditional knowledge was incorporated into the design and implementation of baseline studies that form the foundation of the Remediation Plan. In particular, consideration of traditional practices was integrated into human health and ecological risk assessments (e.g., collection and consumption of traditional foods).
- During the preparation of the Remediation Plan, in recognition of the importance of incorporating traditional knowledge into the Project, INAC financially supported the Yellowknives Dene First Nation (YKDFN) in the preparation of a traditional knowledge report entitled, *The Giant Gold Mine – Our Story: Impact of the Yellowknife Giant Gold Mine on the Yellowknives Dene - A Traditional Knowledge Report*. The report emphasized the YKDFN perspective on the historic relationship between the local Dene community and historic activities at Giant Mine.
- In the spring of 2010, the Project Team conducted a series of events to solicit community feedback on various aspects of the Remediation Project, including the Frozen Block Method, Surface Remediation and Environmental Quality. The events, which are described further in Chapter 13, were held in the Aboriginal communities of Dettah and

N'dilo (as well as Yellowknife). Information provided during those sessions has been incorporated into the DAR and will be incorporated into detailed remediation designs.

The activities cited above provide evidence of efforts that have been made to obtain and use traditional knowledge. Through this process, the Project Team has been able to gain a better understanding about how the land was valued prior to industrial development as a place to carry out traditional pursuits such as berry picking, fishing, trapping and hunting. To varying degrees, traditional knowledge, as defined by the three aforementioned elements was considered in the preparation of the DAR. In particular, traditional values about the environment have influenced and confirmed the guiding principles of the Remediation Plan.

To date, the nature of the technical challenges associated with Giant Mine required a focus on engineering solutions (e.g., the frozen block method). Planning is now sufficiently advanced to begin the detailed design phase for many elements of the Remediation Project. It is during this phase that the incorporation of traditional knowledge will have the greatest influence in determining the final environmental outcomes of the Remediation Project. Examples of areas where traditional knowledge will be solicited and considered as the Project moves forward include:

- Design of a revegetation strategy for the tailings areas;
- Ecological design of Baker Creek;
- Determining the most appropriate methods for controlling site access (e.g., open pits); and
- Detailed design, implementation and interpretation of monitoring strategies.

Going forward, the Project Team is committed to working with Aboriginal communities to encourage the incorporation of traditional knowledge into the Project through these and other approaches. This will be done with an understanding of the competing priorities that Aboriginal communities face. While the specific approaches that are ultimately used will be selected in partnership with Aboriginal communities, Chapters 13 and 14 present proposed frameworks through which this would occur.

3 Environmental Assessment Methodology

3.1 Introduction

The Giant Mine Remediation Project has been designed to improve and protect the environment from adverse effects that would otherwise occur. In this regard, the Remediation Project is being implemented to achieve an overall improvement in environmental quality (i.e., positive effects). While the Remediation Plan has been designed to optimize environmental quality, the EA of the Giant Mine Remediation Project is being conducted to identify and mitigate potential adverse environmental effects associated with the implementation of the Remediation Plan.

For clarity, the MVRMA defines an environmental effect[8] as:

> *"any effect on land, water, air or any other component of the environment, as well as on wildlife harvesting, and includes any effect on the social and cultural environment or on heritage resources."*

The methodology used to identify and assess the potential adverse effects of the Project on the environment is summarized in this chapter. The approach that was followed systematically evaluates how the various works and activities required to implement the Project may interact with, and potentially affect, one or more components of the environment. In situations where potentially adverse effects were identified, appropriate mitigation measures were selected to reduce or eliminate the effect. Any residual adverse effects with a reasonable potential of remaining after mitigation were evaluated to determine if they are likely to be significant.[9]

The general EA methodology for the evaluation of effects of the Project on the environment, as depicted in Figure 3.1.1, consisted of the following sequential steps:

1) Describing the site history and existing site conditions (risks) (Chapters 4 and 5);
2) Describing the proposed works and activities of the Project (Chapter 6);
3) Establishing the temporal and spatial boundaries for the EA (Section 3.4);
4) Characterizing the existing environment (Chapter 7);
5) Identifying Valued Components (Chapter 7);

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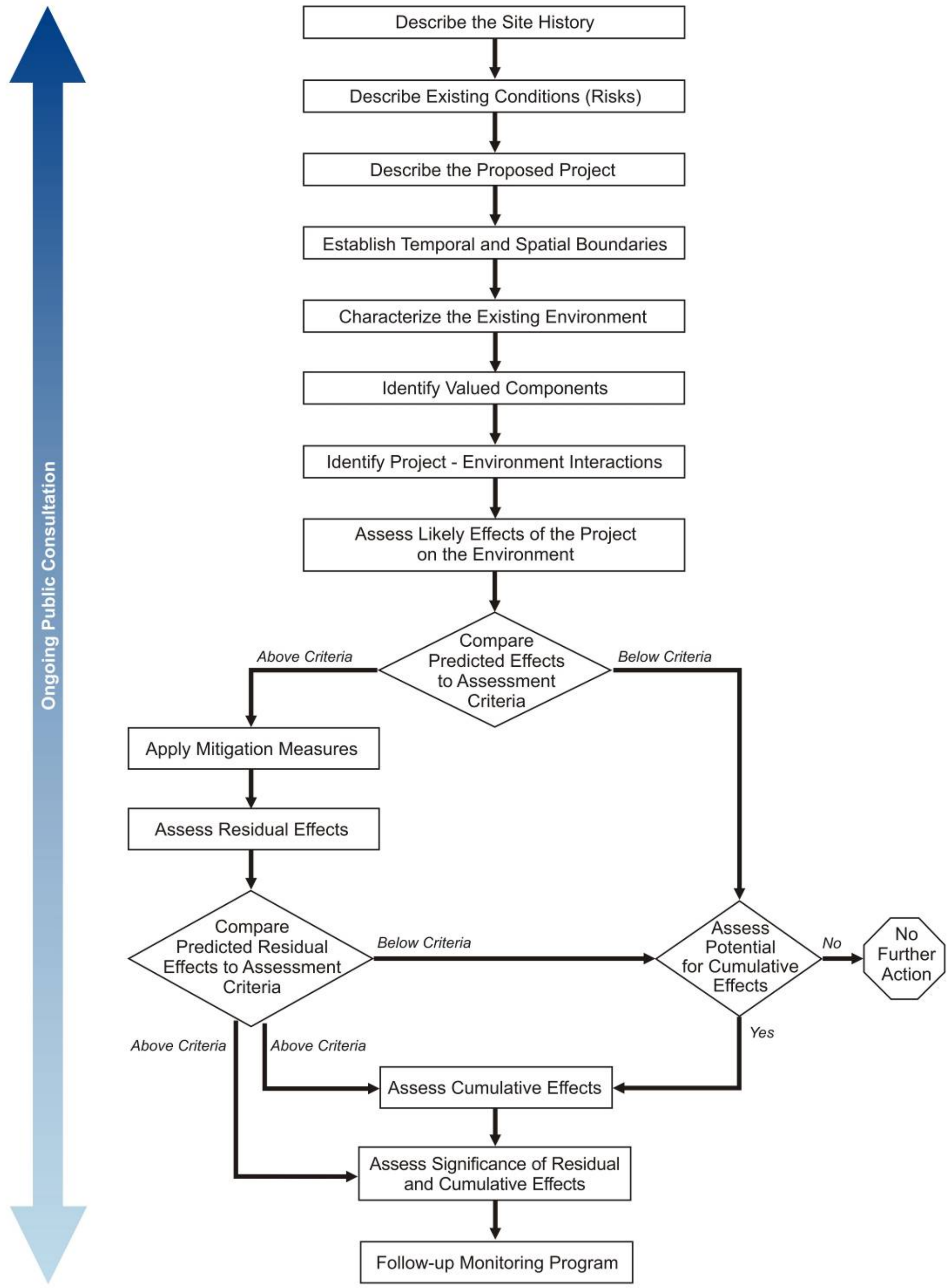
[8] The terms "effect" and "impact" are used interchangeably throughout this document.

[9] The determinations of "significance" presented in the DAR are the conclusions of the Project Team, which may vary with the conclusive determinations of significance that the Review Board will make when fulfilling its responsibilities under section 128 of the *Mackenzie Valley Resource Management Act*.

6) Identifying Project-environment interactions (Chapter 8);
7) Assessing likely effects of the Project on the environment (Chapter 8);
8) Identifying mitigation measures to reduce potential adverse effects (Chapter 8);
9) Identifying residual effects (Chapter 8);
10) Evaluating effects of the environment on the Project (Chapter 9);
11) Evaluating accidents and malfunctions (Chapter 10);
12) Evaluating cumulative effects (Chapter 11);
13) Determining the significance of residual effects (Chapter 12); and
14) Preparing a monitoring framework and long-term monitoring program to determine the effectiveness of mitigation measures and adaptive management (Chapter 14).

Further discussion of each of the EA methodology steps is presented in Sections 3.2 to 3.13. The application of this methodology for assessing the effects of the Project on the environment is described in detail in Chapter 8.

Figure 3.1.1 Environmental Assessment Methodology Framework



3.2 Description of the Site History and Existing Conditions (Site Risks)

EA studies generally begin with a description of the proposed project. However, the purpose of the Giant Mine Remediation Project is to mitigate risks that have developed over more than fifty years of industrial activity. To fully understand the proposed Project, it is necessary to understand the historic circumstances that contributed to the existing site conditions. The content of Chapter 4 addresses Giant Mine's history, starting from the pre-industrial period, to the mine's operational phase and eventual transfer of the mine to the government. Of particular relevance to the EA are the descriptions of the historic management of arsenic trioxide, tailings, and water treatment.

The contemporary site conditions and risks resulting from the past industrial activity are described in Chapter 5 which provides both a quantitative and qualitative description of the various physical components of Giant Mine. It is these "site risks" and the potential for adverse environmental effects that serve as justification for the implementation of the Remediation Project.

3.3 Describing the Proposed Project

Chapter 6 provides an overview of the Remediation Project that is required to address the current site risks identified in Chapter 5. This Project description is based on the Remediation Plan (as presented in Appendix A), and has been augmented with information requested by the Review Board in the *Terms of Reference* and advances in project design. The Remediation Project is divided into a series of physical works and/or activities, which are intended to address specific environmental and physical site risks. Components of the Remediation Project are described in sufficient detail to permit the subsequent identification of interactions between the Project and environment. In addition to describing those physical works and/or activities that will directly interact with the environment, Chapter 6 also provides details on implementation aspects of the Project. This includes information on the organizational, financial and strategic framework for carrying out the Project, permitting processes, resource requirements and activity scheduling. Although the monitoring program is an integral part of the overall Project implementation, given its particular importance as a Key Line of Inquiry, it has been placed in its own chapter (Chapter 14).

3.4 Establishing the Temporal and Spatial Boundaries for the Assessment

To facilitate the assessment of Project-environment interactions, it was necessary to establish relevant spatial and temporal boundaries within which potential effects of the Project will be confined. In its *Reasons for Decisions* and *Terms of Reference,* the Review Board set out the parameters of these boundaries, which the Project Team has adopted or modified as required in its effects assessment. The boundaries utilized in the DAR are described in the following sub-sections.

3.4.1 Spatial Boundaries

In selecting the spatial boundaries for the EA study, the Project Team has included all areas where there is a reasonable potential for the Project to result in measurable direct or indirect effects. These spatial boundaries have been divided into generic Site, Local and Regional Study Areas that collectively encompass all relevant components of the environment including people, land, water, air and other aspects of the environment. The generic EA study areas, which are described below, provide the spatial limits for assessing environmental effects. Where appropriate, the generic study areas have been modified for a particular environmental component to allow the full extent of likely effects to be considered.

Site Study Area

The Site Study Area (SSA) has been defined to encompass all areas within which activities directly associated with the Project are anticipated to occur. Broadly speaking, this includes the former lease area for Giant Mine (L-3668T) now known as Reserve R662T, as depicted in Figure 3.4.1. The adjacent Townsite (lease area 17889T) and the Cruising Club boat launch site are all located within the former lease area and are, therefore, considered part of the SSA. A section of shoreline where tailings were historically discharged to the North end of Yellowknife Bay of Great Slave Lake has also been incorporated into the SSA (i.e., the tailings "beach").

Local Study Area

The Local Study Area (LSA) comprises the environs immediately adjacent to the SSA, as shown in Figure 3.4.2. Due to potential interactions between the Giant Mine site and the aquatic environment, the LSA has been selected to focus on the downstream receiving environment of Yellowknife Bay. The communities of Yellowknife, N'dilo and Dettah are all situated within the LSA to take into consideration potential human health and socio-economic effects associated with the Project. The LSA has also been extended "upstream" of the SSA to include terrestrial habitats of species that may interact with the site.

Regional Study Area

The Regional Study Area (RSA) is defined as the area where there is at least some potential for measured direct, indirect and cumulative effects from the Project. While biophysical effects associated with the Remediation Project are not anticipated to extend beyond the LSA, there is a possibility that socio-economic effects will be experienced in other areas within the vicinity of the LSA (e.g., employment effects). On this basis, the North Slave Region of the NWT has been selected as the RSA for the Remediation Project, as depicted in Figure 3.4.3.

3.4.2 Temporal Boundaries

In broad terms, the temporal boundaries for the Project are defined by the duration of remediation and subsequent long-term care and maintenance activities. It is recognized that the developer's activities on site will continue in some form in perpetuity. However, the selection of temporal boundaries for the assessment of the Project's likely environmental effects has been framed by the Review Board's own determination on the temporal scope of assessment. As described in Section 2.3.2, the temporal scope assigned by the Review Board is a total 25 years consisting of:

- The 15 years required to complete the ground freezing and immobilization of contaminants; and
- Ten years of subsequent monitoring activities to verify that the site has been stabilized.

While the 25-year temporal boundary has been used throughout the DAR, longer time frames have been considered in a limited number of situations where the Review Board has requested it. Specifically, the *Terms of Reference* requested that the DAR include:

- A description of the stability of the proposed freeze system for a duration of at least 100 years after conversion from active to passive freezing; and
- A discussion of the longevity (>30 year) of the proposed cooling system.

Activities beyond the timeframe suggested by the Review Board will be considered in future processes when authorizations are required to continue care and maintenance operations at the Giant Mine site.

Figure 3.4.1 Site Study Area

Figure 3.4.2 Local Study Area

Figure 3.4.3 Regional Study Area

3.5 Characterizing the Existing Environment

The description of the existing environment, as presented in Chapter 7, defines the baseline conditions against which the identification and assessment of potential Project effects occur. A large body of information on baseline conditions exists from the operational phase of Giant Mine. Further, in its efforts to characterize baseline conditions and assist with the development of the Remediation Plan, INAC has commissioned numerous site characterization studies since the federal government assumed control of the site in 1999. While the description of the existing environment draws heavily on historic information from the operational period of the mine and more recent studies commissioned by INAC, additional information has also been sourced from publicly available information describing regional conditions (e.g., government reports).

The Review Board's broad interpretation of what constitutes the "environment" is reflected in the content of Chapter 7. Specifically, the baseline description is not limited to biophysical elements of the environment, but also gives consideration to the aspects of cultural and socio-economic environments that might be affected by the Project's implementation.

To facilitate the analysis of existing conditions and potential Project effects, the environment has been divided into a series of "components". The environmental components were identified on the basis of likely interactions with the Project, which was informed by the Project Team's past experience on similar projects, in addition to direction provided by the Review Board in the *Terms of Reference*. The following environmental components were adopted:

- Surface Water Environment;
- Geological and Hydrogeological Environment;
- Atmospheric Environment;
- Aquatic Environment;
- Terrestrial Environment;
- Aboriginal Interests; and
- Additional Community Interests.

In the *Terms of Reference*, the Review Board specified that the description of the baseline environment is to be as of the date when the federal government assumed responsibility for the site (i.e., 1999). The use of 1999 as a baseline year was modified in situations where subsequent characterization studies and/or modifications to the site have occurred since that time (e.g., realignment of Baker Creek Reach 4).

As indicated above, a large body of previous studies was used to develop the description of the existing environment. However, in relatively few situations, minor gaps required that additional studies be conducted to supplement the existing body of information on site conditions. These additional studies are discussed within the relevant sections of the description of the existing environment (i.e., Chapter 7).

3.6 Identifying Valued Components

To facilitate the assessment of environmental effects that might be caused by the Project, Valued Components (VCs) were selected for each of the environmental components listed in Section 3.5. The VCs selected for each environmental component are identified in Chapter 7.

VCs are most commonly thought of in terms of the aquatic and terrestrial environments, where ecosystem features, individual species, or important species may be identified as indicators. The term Valued Ecosystem Components (VECs) is often used to describe these valued components. Equivalent components also exist for the cultural and socio-economic environment (sometimes described as Valued Cultural and Heritage Components (VCHCs) and Valued Socio-economic Components (VSCs)). For simplicity, all are collectively referred to as VCs in the DAR.

The VCs used in the EA have been selected because they: i) are representative of the overall environment; and/or, ii) are measurable in terms of quantifiable and qualitative parameters of change in the components of the environment which they represent. Specifically, the criteria that influenced the selection of VCs included:

- Abundance in the study areas (SSA, LSA, RSA);
- Ecological importance (in the context of accepted scientific principles and the application of traditional knowledge);
- Data availability (sufficient information must be available to allow an appropriate evaluation of effects);
- Native species (those that have been well-established in the area over a long time period);
- Degree of exposure to potential stressors associated with the Project;
- Degree of sensitivity to potential stressors associated with the Project;
- Ecological and human health (the extent to which human health and the growth or sustainability of non-human biota may be affected);
- Socio-economic importance (value as a commercial, recreational or subsistence resource; inherent aesthetic value);
- Conservation status (the extent to which VCs may be specifically protected by law, designated as rare, threatened, or endangered);
- Traditional and current importance to Aboriginal persons; and

- Cultural and heritage importance to society.

In addition to the factors noted above, several VCs were also selected because they were identified in scoping sessions for the EA, as well as the Review Board's *Terms of Reference*.

3.7 Identifying Potential Project-Environment Interactions

The initial stages of the effects assessment required that Project activities with the potential to adversely interact with the environment be identified and characterized. Chapter 8 presents these potential linkages or interactions in a matrix format (Table 8.3.1) that considers both the active remediation and long-term care and maintenance phases of the Project. The matrix lists each of the major Project activities against the various environmental components under evaluation. Each Project activity was considered individually to determine whether there is a plausible mechanism for the Project to interact with the environment. The identification of plausible interactions was based on input from technical specialists with a comprehensive understanding of the Remediation Project and the environment within which it will occur.

3.8 Assessment of Likely Effects of the Project on the Environment

To determine whether any potential Project-environment interactions are likely to result in an adverse environmental effect, the Project Team determined whether such interactions would have the potential to result in a "measurable" change in the environment. For the purpose of the DAR, measurable changes were defined as being detectable and quantifiable when compared with existing (baseline) conditions. In addition to measureable changes in the environment, selected environmental components required the use of more qualitative indicators of change (e.g., Aboriginal interests which, in some cases, are a product of perception or values).

The assessment of effects involves determining whether predicted measureable changes to an environmental component are likely to result in an effect on the VCs associated with that component. To illustrate, a Project activity that results in noise emissions would only result in an adverse effect on the environment if noise-sensitive species were determined to be present. Similarly, a predicted change that is clearly trivial, negligible or indistinguishable from background conditions is not considered to be measurable and, therefore, will not cause a "likely effect". Those Project activities that are determined to have no measureable effect are screened from further consideration. Conversely, Project activities that are deemed likely to have a measureable effect are carried forward in the assessment process.

Wherever possible, potential effects on VCs are quantified by estimation/prediction of changes in assessment endpoints (e.g., concentration of arsenic in surface waters). Once the assessment of potential effects has been completed and such endpoints have been determined, the predicted effects are compared to assessment criteria. Where applicable, specific assessment criteria have been selected for each environmental component as the standard or benchmark to base a judgement on the likelihood of environmental effects (i.e., to evaluate whether a measurable change represents an environmental effect). Some assessment criteria have been adopted from formal environmental quality guidelines or regulations; for example, the GNWT's Ambient Air Quality Guidelines provided a benchmark against which predicted airborne dust levels caused by the Project were compared. In situations where regulatory criteria for a given environmental component do not exist (e.g., for socio-economic conditions), the Project Team developed evaluation criteria based upon its professional judgement. Even in these cases, quantitative evaluation criteria have been emphasized where possible. For example, the criterion used to evaluate the Project's potential effect on the availability of housing was determined by the Project Team to be the magnitude of Project-related changes in housing stock relative to baseline and/or projected conditions.

Predicted effects that do not exceed the threshold established in the evaluation criteria were not given further consideration during the assessment of Project effects but were considered in the cumulative effects assessment.

3.9 Identifying Mitigation Measures to Reduce Potential Adverse Effects

In broad terms, mitigation can be defined as the elimination, reduction or control of the adverse environmental effects of a project. Mitigation measures aim to prevent adverse effects from occurring and to keep those that do occur within an acceptable level. Whenever possible, mitigation measures that prevent effects from occurring are preferred. However, mitigation may also include measures that serve as restitution for any damage to the environment caused by adverse effects (e.g., replacement or restoration). Although mitigation measures are understood in the context of the MVRMA[10] to be those actions that address adverse effects, measures may also be selected that enhance the environmental and social benefits of a proposed development. In this sense, the entire Giant Mine Remediation Project can be viewed as a comprehensive mitigation measure to address existing environmental concerns and prevent additional adverse environmental effects that would otherwise occur if the site was abandoned.

For each of the potentially adverse environmental effects identified for the Project, measures deemed technically and economically feasible were selected to mitigate the anticipated effect. The proposed measures fell into one of two major categories:

> *Structural measures*: These include modifications in Project design and engineering practice, changes in the timing or location of an activity and industry codes of good practice. Certain measures are well established for particular types of activities proposed

[10] Ss 128(1)(b)(ii) of the MVRMA

as part of the Project. An example of this is the use of standard sediment control measures.

Non-structural measures: These include legal and policy instruments, training and capacity building, and economic incentives. Such types of measure are often useful in mitigating predicted effects to socio-economic VCs. An example is the use of procurement strategies that optimize business and employment opportunities as a means of offsetting adverse socio-economic effects that might be experienced by Aboriginal and Northern residents.

3.10 Identification of Residual Effects

All adverse effects that are anticipated to remain after mitigation are called residual effects. The assessment of residual effects was conducted based on the assumption that the selected mitigation measures will be effective in managing the effects they were designed to address. The process carried out effectively repeats that which was outlined in Section 3.8. Any residual effects that remained above applicable assessment criteria thresholds (e.g., benchmark or guideline values) were classified as having a potentially adverse effect on the environment. The significance of such effects was then evaluated according to the methodology described in Section 3.12.

3.11 Evaluation of Other Effects

While the DAR focuses on the evaluation of potential adverse effects that might be caused by the Remediation Project, it also includes an assessment of other effects. These include:

- Effects of the environment on the Project;
- Effects of accidents and malfunctions on the environment; and
- Cumulative effects of the Project when combined with the effects of other past, present and reasonably foreseeable developments.

In general, the approaches used to evaluate these effects share many procedural elements with the assessment of Project effects on the environment. However, as noted in the brief descriptions which follow, the methodologies used to evaluate these effects have several unique features.

Effects of the Environment on the Project

Natural hazards, existing conditions or trends in the environment that are reasonably likely to affect the Project were identified and considered in the DAR. Climate change, severe weather conditions and seismicity are examples of environmental phenomena that might exacerbate any predicted adverse Project-environment interactions, or otherwise prevent aspects of the Project from performing as proposed. A detailed description of the methodology used to evaluate effects of the environment on the Project is presented in Chapter 9.

Accidents and Malfunctions

The potential interactions between Project works and activities and the existing environment were also identified with respect to accidents and malfunctions. For the purpose of this assessment, *accidents* are defined as unplanned events that have the potential to result in adverse environmental effects. A *malfunction* is defined as the failure of a system or piece of equipment to function in the manner for which it was intended.

The focus of this aspect of the assessment is on those events that are considered credible in the context of the Project. It is not the intent of the EA to address all conceivable abnormal occurrences, but rather to address only those that have a reasonable probability of occurring and potential for significant adverse effects. Such events are screened to determine whether an environmental effect (consequence) would be possible and whether further assessment is required. Additional details on the methodology used to evaluate accidents and malfunctions are presented in Chapter 10.

Cumulative Effects

Cumulative effects are typically defined as being those biophysical, socio-cultural or economic residual effects that result from the proposed development in combination with other past, present or reasonably foreseeable future developments. The cumulative effects assessment focuses on the VCs that are potentially affected by each residual effect. A detailed description of the methodology used to evaluate cumulative effects is presented in Chapter 11.

3.12 Determining the significance of residual effects

The significance of anticipated residual effects can be defined using a number of criteria that are widely applied in EA processes. For the purposes of this assessment, the significance criteria have been listed under the headings 'primary criteria' or 'other criteria'. This distinction was made to highlight the fact that more weight is placed in this assessment on the magnitude, spatial extent and duration criteria than on the remaining criteria. The criteria selected for use in the DAR included:

Primary Criteria

Magnitude: A measure of the extent to which the effect exceeds baseline, reference criteria or guideline values, and its associated effect on VC function.

Spatial Extent: Refers to the area affected, and is categorized into three scales (site, local or regional).

Duration: The length of time for which the effect is anticipated to occur and the overall time frame during which the effect may occur (e.g., phases of the Project including the Remediation Phase and Long-Term Operation and Maintenance Phase).

Other Criteria

Frequency/Probability: The frequency and/or probability of the conditions or phenomena causing the effect are considered, as is the length of time between occurrences.

Reversibility: The reversibility of any effects must be considered, not only in terms of whether the effect is reversible, but also in terms of how much time and effort will be required for the affected environmental component to recover.

Ecological Importance: The importance of the environmental attribute or feature to ecosystem health and function.

Societal Value: The value of the environmental attribute or feature to society.

The significance criteria described above are applicable for the assessment of the effects of normal operations and cumulative effects. A similar but modified approach is applied in the assessment of significance for accidents and malfunctions (as described in Chapter 10).

Although efforts are made to quantify the significance of residual effects, professional judgment is also required. To standardize the judgments that were applied in these analyses, the Project Team used a rating system, with rankings of “high”, “medium”, and “low” against each significance criterion. Where any one of the primary criteria was rated as “low”, then the residual adverse effect was not considered to be significant. Where all three of the primary criteria were rated as “medium” or “high”, consideration of the other criteria was important in judging whether the residual adverse effect was “not significant” or “significant”.

After all significance criteria had been ranked, the Project Team assigned one of the two significance levels to each residual effect:

- *Minor adverse effect*: The residual adverse effect is minor or not significant and no further mitigation is considered necessary; or,
- *Significant adverse effect*: The residual adverse effect is significant and further or more effective mitigation is not considered feasible.

3.13 Monitoring Environmental Effects and Adaptive Management

The accuracy of any predicted adverse effects will be verified through a comprehensive monitoring program. This program, which is described in detail in Chapter 14, also includes provisions for the adaptive management of environmental effects through alteration of a particular work or activity, or the implementation of additional mitigation measures, if deemed necessary. The primary purpose of follow-up monitoring is to confirm the predictions of the EA, as well as to ensure that environmental quality is protected.

4 Site History

As indicated in Chapter 3, EA methodologies generally begin with a description of the proposed project. However, the purpose of the Giant Mine Remediation Project is to mitigate risks that have developed over more than fifty years of industrial activity. To fully understand the proposed Project, it is necessary to understand the historic circumstances that contributed to the existing site conditions. The content of the current chapter addresses Giant Mine's history, starting from the pre-industrial period, to the mine's operational phase and eventual transfer of the mine to the government.

4.1 Traditional Land Use

Before the development of mines and the settlement of what is now known as the City of Yellowknife, the land was used for centuries by various Aboriginal groups, including the forebears of the modern Akaitcho, Tlicho and Métis[11]. These people traveled 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 N'dilo.

Historically, Aboriginal 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. The caribou move into the region in the late fall and remain until early spring when they migrate north for the calving season. During the early winter to late spring, Aboriginal 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 Yellowknives Dene (YKDFN 2005) contains a high level overview of historic Dene use of the Giant Mine site and surrounding environments. The YKDFN has requested that the information presented in the report not be split up or taken out of context. To avoid that possibility, the information on traditional land use expressed in the report is not presented here. Instead, the reader is encouraged to review the entire Traditional Knowledge Report which is provided in Appendix B.[12] In addition to the information presented

[11] Additional details on current Aboriginal land use within the Study Areas is provided in Section 7.6.

[12] Much of the content from the Traditional Knowledge Report also formed part of the YKDFN presentation to the Review Board during the Scoping Session for the EA. Again, in response to requests that their information not be split up or taken out of context, the reader is requested to refer directly to the YKDFN presentation which can be found on the Public Registry for the EA.

in this report, during engagement events conducted in the spring of 2010, members of the YKDFN commented on traditional land use practices in the vicinity of Giant Mine prior to its development. For example, the west side of Yellowknife Bay (i.e., the lands on which Giant Mine is located) were used extensively for hunting, trapping and berry picking. Due to the important role of this area as wildlife habitat, Elders taught that the west side of the bay was not to be used to establish camps.

4.2 Early Exploration History

Many histories of the area state that gold colors were first discovered in the Great Slave Lake region in 1896, by miners on their way to the Klondike gold rush. Gold was found by prospectors in the area at least as early as 1900, but it was not until the 1930's, 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. It opened in 1933.

The Port Radium development stimulated mineral exploration throughout the North. The first non-native 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 wasn't long before gold discoveries were made in the immediate vicinity. Numerous claims were staked around Yellowknife in the 1930's, leading to the opening of the Con Mine in 1938, and the first large-scale gold production in the area. The development of Giant Mine commenced in 1945.

4.3 Industrial History

The following sections on the history of Giant Mine are based primarily on information obtained from a review of monthly operational reports to the company Board of Directors, which are stored in the archives of the Prince of Wales Northern Heritage Center. Additional information was obtained from published papers (Pitcher 1953; Grogan 1953; McDonald 1953; Mortimer and Tait 1959; Foster 1963), from Royal Oak Mines (1998a), and from selected correspondence in files located at Giant Mine.

Major milestones in the mine history are shown on a timeline in Figure 4.3.1. Figure 4.3.2 shows locations of the major site features referred to in the timeline.

4.3.1 Mine Ownership

The original 21 mineral claims on which Giant Mine is located were staked by Burwash Yellowknife Mines Ltd. 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. (GYML) 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.

Figure 4.3.1 Milestones in Site Development

Figure 4.3.2 Major Site Features

During the early 1940's, GYML and Frobisher Exploration Company Ltd. examined the possible geological relationship between the Con Mine and 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 GYML 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., controlled by Giant Resources Ltd. of Sydney, Australia, bought Giant Yellowknife Gold Mines. Pamour was subsequently bought out by Royal Oak Resources 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 Giant Mine until 1999 when it went into receivership. A court-appointed receiver transferred control of the property to INAC[13] in December 1999. Immediately, Miramar Giant Mine Ltd. (a subsidiary of Miramar Mining Corporation) purchased Giant Mine from INAC. Under the terms of the purchase agreement, INAC indemnified Miramar Giant Mine Ltd. for existing environmental liabilities at the site. Concurrently, the GNWT indemnified INAC for certain liabilities associated with the surface of the mine. Additionally, under the terms of a reclamation security agreement with INAC, Miramar Giant Mine Ltd. continued to operate the mine in environmental compliance. Until July 2004, Miramar Giant Mine Ltd. mined ore from the site on a greatly reduced scale. The ore was trucked to the Miramar Con Mine, located on the southern edge of Yellowknife. No further processing of ore took place at Giant Mine and the roaster did not operate after 1999.

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

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

[13] At the time of the transfer INAC was referred to as the Department of Indian Affairs and Northern Development (DIAND). To avoid confusion, the DAR consistently uses the current title of the department (i.e., INAC).

4.3.2 Mine Development

Underground mine development began in 1945 with the sinking of A-Shaft. A-Shaft 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 750 level. 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, including 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 methods 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 1970's. In order to keep the operations going while additional reserves were found, open pit mining began in 1974, with the excavation of A-1 pit, and continued through the 1970's with the development of the A-2, B-2 and B-1 pits. The B-1 pit, which lies close to several of the arsenic storage stopes, was worked from 1976 to 1978. Baker Creek was diverted in 1983 to allow the excavation of the C-1 pit. A total of eight pits were developed until open pit mining ceased in 1990 (further details are provided in Section 5.3.1). After that, ore was exclusively extracted from underground workings.

4.3.3 Ore Processing

Giant Mine ore has a complex mineralogy as described further in section 4.4. 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 Giant Mine was developed. An ore processing system was designed to concentrate the gold-bearing sulphide minerals using froth flotation, and then to roast the sulphide concentrate in preparation for cyanide leaching.

Ore processing operations began on May 12, 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 (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 tons per day to 700 tons per day. 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 (see Section 4.4.1 for further information on arsenic fume management).

Mill tonnage was increased again in 1958, to 1,000 tons per day. 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.

4.3.4 Tailings and Water Management

Tailings disposal began in 1948 with discharge of flotation tailings directly into North Yellowknife Bay. The tailings remaining from this disposal, on the shore and under shallow water, are known today as the Historic Foreshore Tailings. 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 1960's with Dams 2 and 3. Together these dams formed the North Pond, as well as the original tailings disposal area now underlying the Settling and Polishing Ponds. Construction of Dams 4 and 5 began in the late 1960's, closing off the south end of the area now known as the Central Pond. The dam and tailings pond locations are shown on Figure 4.3.2.

Records of dam construction in the 1950's and 1960's 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-1970's, 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 Northwest Pond was created by the construction of Dams 21 and 22 in 1987, to serve as an impoundment for tailings recovered from the North and Central Ponds and processed in the Tailings Retreatment Plant (TRP), as well as new tailings from conventional ore processing. 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 the B-1 Pit, in an area now covered with soil removed from the pit (see Figure 4.3.2). Most of the calcine was removed from the pond, but some calcine remains as described in section 5.5.4.

Control of arsenic in the mine effluent apparently began in 1957, when mine 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 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. 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.

Up until 1981, water pumped from the mine was discharged directly to Baker Creek near C-Shaft without treatment. Minewater was not used in the mill process, since the water quality had a negative effect on froth flotation recovery. A 1981 Water Licence requirement to treat minewater in the tailings effluent treatment plant led to the practice of 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 has been 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.

4.4 Arsenic Trioxide Management History

As mentioned in Section 4.3.3, most of the gold in Giant Mine ore is encased within larger grains of sulphide minerals, principally arsenopyrite and pyrite. 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. Major developments in the management of roaster off-gas and arsenic trioxide are summarized in Figure 4.3.1, and discussed in the following sub-sections.

4.4.1 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 the mine management to the conclusion that arsenic fume emissions needed to be controlled. For this purpose, an electrostatic precipitator (an "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 1000 tons per day, 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 ESP's operating in parallel, followed by a baghouse, was used until roasting operations ceased in 1999.

4.4.2 Arsenic Trioxide Dust Disposal

The scale of arsenic trioxide dust formation and the resulting problems were not anticipated during the initial development of the 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 July 21, 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 250 Level and from surface. From this drilling, it was determined that permafrost was present from above the 100 Level to below the 250 Level; that is, from 100 feet below surface to more than 250 feet below surface. Temperatures in two holes at the 250 Level were -0.5 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 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 and 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, INAC mining inspectors recognized that permafrost had receded in mine areas that were well ventilated. INAC 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. INAC 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. INAC 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, INAC questioned whether they would remain dry, if the permafrost in the surface bedrock and overburden became fragmented.

In an internal memorandum of May 1973, the Mining Inspector expressed concern regarding the potential for arsenic pollution from 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 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 drillholes.

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 for industrial emissions. With respect to arsenic trioxide management, the report recommended that underground storage of the arsenic trioxide dust at Giant Mine should continue, pursuant to requirements specified by the Mining Inspection Branch.

By the end of the 1970's, 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 1970's, 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 1980's, with the development of chamber 10, near C-Shaft, and later chambers 11 and 12 in a new area adjacent to the B2 Pit. A downturn in the arsenic trioxide market, and introduction of stricter waste disposal regulations in the USA in the mid-1980's, 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 was purified; this would require a new process. This option was actively pursued and investigated by the mine owner in the late 1980's, 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 1990's. Chamber 15 had not been commissioned by the time on-site ore processing ceased in October 1999, and remains empty.

Until the 1980's, 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 4.4.1, along with the year of their commissioning. The excavations are identified either as purpose-built chambers or mined-out stopes.

Table 4.4.1 Underground Arsenic Trioxide Dust Storage Excavations

Excavation Identification	Excavation Type	Year of Commissioning
B230	Chamber	1951
B233	Chamber	1952
B234	Chamber	1956
B235 / 236	Chambers	1958
B208	Stope	1962
B212 / 213 / 214	Stopes	1965
C212	Stope	1973
9	Chamber	1976
10	Chamber	1982
11	Chamber	1986
12	Chamber	1988
14	Chamber	1995
15	Chamber	Not used

4.5 Social and Economic Influence

Mining developments such as Giant, Con and others have had a profound influence on the growth and prosperity of Yellowknife and, arguably, the entire Northwest Territories. To illustrate, the initial establishment of Yellowknife in the late 1930's in what is now called "Old Town" was prompted by mining and exploration activity that was occurring throughout the region. In the decades that followed, mining continued to dominate the local economy, thereby providing the stimulus for population growth and the gradual development of the community and its infrastructure. In this regard, the initial establishment of roads, schools, hospitals, municipal services and other facilities in Yellowknife were directly attributable to Giant Mine and other mines in the area.

One measure of the historic relationship between Giant Mine and Yellowknife is the economic contribution of the mine. Throughout its operational life, the mine produced more than 7 million ounces of gold which, based on the average price of gold over the last decade (approximately $520 per ounce), would represent a cumulative revenue exceeding $3.5 billion in today's dollars. During the first 35 years of the mine's life, operating costs were, on average, approximately 62% of revenue (Bullen and Robb 2006). Much of this total would have been spent locally on payroll and for the procurement of goods and services required to support the mining operation. This, in turn, served to stimulate the broader development of the community as businesses and services were required to support the mining industry. Similarly, the importance of the mining economy in the development of Canada's North also factored into the decision to shift the territorial capital to Yellowknife in 1967.

Aside from its economic influence, mining played a critical role in determining the character of Yellowknife. As a "frontier outpost", the growing community attracted families and individuals who were drawn to the adventure of the North and the opportunities associated with the mining industry. These migrants played a major role in forming the community of Yellowknife that exists today. While the city's gold mines no longer operate, the mining industry continues to be an integral part of the community's heritage and future. The successful establishment of diamond mines in the NWT is attributable, in part, to the presence of the skilled work force and infrastructure established to support Giant and other mines.

Although Giant Mine was an important stimulus for economic and regional development, not all of the effects have been positive. Aside from the legacies of environmental contamination, the experience of local Aboriginal peoples with the mining industry has at times been difficult. The Traditional Knowledge Report prepared by the Yellowknives Dene (YKDFN 2005) contains an overview of the perspectives held by some Aboriginal people on their relationship with historic mining operations in the vicinity of Yellowknife. As indicated in Section 4.1, the entire YKDFN Traditional Knowledge Report, including their concerns regarding historic mining operations and environmental effects, is provided in Appendix B. In addition, similar sentiments were expressed during YKDFN community engagement sessions that were conducted during the spring of 2010. These sentiments are documented in the report titled "Giant Mine Remediation Plan – Summary of May 2010 Yellowknives Dene Engagements – Dettah and N'dilo" which was submitted to the public registry for the EA.

4.6 Recent Site Management

INAC and MGML

As discussed in Section 4.3.1, Miramar Giant Mine Limited (MGML) was responsible for the management of all site activities relating to ore production and environmental protection from the end of 1999 until June 2005. Ore production ceased in 2004, and the Deton'Cho/Nuna Joint Venture now provides care and maintenance under a contract with the federal government (through PWGSC). Routine environmental protection activities have included pumping water from the underground mine to the surface storage ponds, monitoring and maintaining the tailings dams, operating the water treatment system during the open water season, and monitoring environmental quality.

In addition to care and maintenance activities, numerous projects have been undertaken since 1999 to assess site conditions and secure the site. Projects conducted since 1999 include the disposal of lead-acid batteries, disposal of transformers containing PCB (polychlorinated biphenyl) fluids, disposal of waste oils and fuels, disposal of asbestos waste, secure storage of arsenic contaminated waste, disposal of non-hazardous waste, improvements to surface drainage, and demolition of fuel storage tanks and small buildings.

4.6.1 Studies of the Giant Mine Site

Since the bankruptcy of Royal Oak Mines in 1999, INAC has commissioned numerous studies of the mine site, either directly or through contractors and consultants. In 2000, INAC contracted the Technical Advisor to thoroughly evaluate possible alternatives for the management of the arsenic trioxide dust stored underground at the mine and to recommend a preferred alternative. After taking into account the recommendations by the Technical Advisor and an Independent Peer Review Panel, as well as public input gathered at workshops and other information sessions, INAC announced in February 2004 that it planned to proceed with the "Frozen Block" alternative for the management of the arsenic trioxide dust stored underground.

Once this decision had been made, it became clear that the existing Abandonment and Restoration Plan for the surface of the mine would have to be modified because of many interrelationships and linkages between surface and underground components of the mine. This led to the conclusion that it would be necessary to prepare an integrated plan describing both surface and underground remediation activities. The decision to prepare an integrated Giant Mine Remediation Plan was supported by a recommendation from the Independent Peer Review Panel.

In addition to the comprehensive studies on arsenic dust management options undertaken by the Technical Advisor, many other baseline environmental studies were completed to further quantify existing conditions. These studies are described in Chapter 7.

5 Existing Site Description

The current site conditions and risks resulting from the past industrial activity at Giant Mine are described in this chapter. The description is presented by site component as follows:

- Arsenic trioxide dust storage areas (Section 5.1);
- Other underground mine components (Section 5.2);
- Open pits (Section 5.3);
- Waste rock (Section 5.4);
- Tailings and sludge containment areas (Section 5.5);
- Historic foreshore tailings (Section 5.6);
- Site water management (Section 5.7);
- Baker creek (Section 5.8);
- Quarries, borrow areas and overburden piles (Section 5.9);
- Contaminated surficial materials (Section 5.10);
- Buildings and infrastructure (Section 5.11);
- Waste storage and disposal areas (Section 5.12); and
- Current site management (Section 5.13).

5.1 Arsenic Trioxide Dust Storage Areas

5.1.1 Dust Inventory

Arsenic trioxide dust has been stored underground at Giant Mine since 1951. As discussed in Section 4.4, the dust was collected in the baghouse and pneumatically placed in purpose-built chambers and mined-out stopes. The estimated inventory of arsenic trioxide dust stored in each of the chambers and stopes is shown in Table 5.1.1. These estimates were compiled by the mine operators throughout the period of dust production, from 1951 through 1999. The inventories of dust in chambers B230, B233 and B234, up to 1958, were estimated based on the chamber dimensions and the estimated bulk density of the dust. After 1958, dust production was calculated by the mine on a daily basis, using mass balance methods.

Table 5.1.1 Inventory of Arsenic Trioxide Dust Stored Underground at Giant Mine

Chamber / Stope	Dust Inventory (dry tonnes)	Primary Filling Period
B230	2,835	1951 to 1952
B233	11,426	1952 to 1956
B234	12,048	1956 to 1958
B235 / 236	32,945	1958 to 1962
B208	29,364	1962 to 1964
B212 / 213 / 214	59,289	1965 to 1973
C212	16,946	1973 to 1982
9	18,394	1976 to 1980
10	9,569	1982 to 1985
11	5,860	1986 to 1988
12	26,243	1988 to 1994
14	12,257	1995 to 1999
15	0 (empty)	Not applicable
Total	**237,176**	**1951 to 1999**

5.1.2 Dust Properties

5.1.2.1 Data Sources

The physical and chemical properties of the arsenic trioxide dust have been assessed in several studies conducted over the past twenty years. The most important of these studies are:

- Routine gold and arsenic assays by the mine staff;
- Sampling of underground dust and testing of geotechnical properties (Geocon 1981);
- Analysis of arsenic and gold content of Geocon (1981) samples (Giant Yellowknife Mines Ltd. 1982);
- Testing of flow properties of Geocon (1981) samples (Jenike & Johanson 1982);
- Chemical and particle size analyses of dust product from the baghouse (New Brunswick RPC 1988; Royal Oak Mines Inc. 1998a);
- Chemical properties and mineralogy of dust product from the baghouse and underground dust samples (CANMET 2000); and
- Physical and chemical properties of later baghouse dust production (Lakefield Research 2002).

A supplementary investigation was carried out in the winter of 2004 by drilling into selected chambers and stopes to measure *in situ* physical properties of the dust and collect and analyse samples of the older dust. Monitoring instrumentation, including vibrating wire piezometers to measure water levels, and resistance temperature detectors to measure temperature, were installed in each of the drillholes. Results from this program are presented in SRK (2005a), which includes reports on:

- The drilling, *in situ* testing and sample collection;
- Chemical analysis and physical testing of the arsenic trioxide dust samples (SGS Lakefield Research 2004);
- A mineralogical investigation of the arsenic trioxide dust samples (CANMET 2004a); and
- Laboratory measurements of the thermal properties of the dust (CANMET 2004b).

Additional studies commenced in 2009 as part of the Freeze Optimization Study to further evaluate dust properties. These studies are described in Section 6.2.9.

5.1.2.2 Physical Properties

Table 5.1.2 provides a summary of physical properties of arsenic trioxide dust based on studies conducted to date. The investigations did not recover undisturbed samples, although direct and indirect *in-situ* testing was performed. The recovered dust samples were tested for a wide range of parameters to characterize the physical, chemical and thermal properties. The *in-situ* testing provided some indication of the in-place density and strength of the material, through standard penetration tests and cone penetrometer testing. Moist zones were intersected in some of the 2004 drillholes, but the majority of the dust encountered was dry.

Table 5.1.2 Physical Properties of Arsenic Trioxide Dust

Property	1981 and 2002 Data	2004 Data	Best Estimate Values
Grain Size	92 – 97% <0.0045mm	72 - 98 % <0.0045mm	88.5% <0.0045mm
Dry Density (kg/mm^3)			Avg. = 1402 kg/m^3
Maximum	1107 - 1459 kg/m^3	1414 - 1726 kg/m^3	1726 kg/m^3
Minimum	636 - 891 kg/m^3	1333 - 1369 kg/m^3	654 kg/m^3
Specific Gravity	2.6 – 3.8 (avg. 3.17)	3.3 – 3.8 (avg. 3.48)	3.38
Atterberg Limits			
Liquid limit	inconclusive	25.0 – 41.7%	32 %
Plastic limit	19% - 24%	Non-plastic, 28.5% – 35.3%	30 %
Angle of Repose	46° - 58°	Not tested	46° - 58°
Angle of Internal Friction	33° - 35°	Not tested	33° - 35°
Hydraulic Conductivity (at 1150.1 kg/m^3)	7 x 10-7 m/s	Not tested	7 x 10-7 m/s
Thermal Conductivity		0.47 - 2.02 W/(mk)	0.47 - 2.02 W/(mk)
Frozen	0.093 W/(mk)		0.093 W/(mk)
Unfrozen	0.100 W/(mk)		0.100 W/(mk)
Freezing point of saturated solution	-0.7°C	Not tested	-0.7°C

5.1.2.3 Geochemical Properties

Arsenic and Gold Content

The arsenic trioxide dust was assayed for arsenic and gold on a routine basis, generally daily, throughout the dust production period, from 1951 through 1999. The weighted averages of these assays for the entire inventory of each chamber and stope are shown in Table 5.1.3. Although many samples of dust have also been chemically analyzed during the various studies conducted since 1981, the mine production assays provide the most reliable estimates of the arsenic and gold contents of the dust, since the estimated average for each chamber and stope is based on the assays of hundreds, or even thousands, of dust samples.

The roasting and gas cleaning circuits of the plant saw a number of changes during the early production period, the most important of which were changes to the "Cotrell" electrostatic precipitator circuits and the installation of a baghouse. The major changes affecting the quality of the arsenic trioxide dust were made in the period from 1958 through 1963, while the B235 and B236 chambers were being filled. The average production assays in Table 5.1.3 show much lower arsenic concentrations and higher gold concentrations in the dust produced before these changes were completed (refer to Table 5.1.1 for a summary of chamber fill dates). The estimated total inventory of gold in the dust is approximately 4.3 million grams, and about 60% of the gold is contained in the five oldest chambers, which hold 25% of the total dust inventory.

The average arsenic content of the dust produced after the major plant changes is generally above 65% (in units of arsenic by weight), which is equivalent to about 86% arsenic trioxide (in units of arsenic trioxide by weight). Loss of gold to the arsenic trioxide dust product was reduced to very low levels by the 1970's. The average gold content of the later dust production is actually less than the grade of ore being mined at the time. Other trace elements present in the dust are discussed in the following section.

Table 5.1.3 Arsenic and Gold Content of Arsenic Trioxide Dust

Chamber / Stope	Production Assays 1951-1999	
	Arsenic (%)	Gold (grams/tonne)
B230	45.3	24.8
B233	36.9	57.3
B234	36.1	80.0
B235 / 236	53.7	26.3
B208	65.7	12.1
B212 / 213 / 214	61.7	15.5
C212	65.6	5.9
9	67.5	4.3
10	66.8	4.6
11	67.4	4.8
12	65.9	5.9
14	65.5	5.5
Averages	60.1	18.1

Other Chemical Components

The drilling program conducted in 2004 provided an opportunity to sample dust produced over an extensive period of the mine history, from the 1950's through the 1970's, and to analyze the samples for a broad suite of chemical components. The results of these analyses are shown in Table 5.1.4. The data indicate that the material collected from chamber B233, the oldest dust, is distinctly different from the other materials. The oldest material has higher concentrations of all the elements measured, with the exception of arsenic and antimony. In particular, the silver, copper, iron, lead and zinc contents of the oldest dust are much higher than found in the dust produced later. These differences reflect the inefficiency of the plant during the 1950's in separating arsenic trioxide from other components of the dust produced by the roaster. The other components include iron and calcium arsenates, iron oxides and the common rock forming minerals chlorite, quartz and muscovite (CANMET 2000, 2004a).

The sample collected from chamber B235 has chemical characteristics that are similar to the material collected from the chambers and stopes that were filled later. This chamber was filled while major modifications were being made in the plant and the dust properties were changing, from 1958 through 1962. The chamber was also "topped up" with new dust in 1988. The analytical results suggest that the sample collected from B235 probably represents dust from later production.

Table 5.1.4 Results of Chemical Analyses of Arsenic Trioxide Dust Samples

Chamber / Stope	B233	B235	B208	B212	B214	C212	C212
Primary Filling Period	1952 to 1956	1958 to 1962	1962 to 1964	1965 to 1973	1965 to 1973	1973 to 1982	1973 to 1982
Sample ID	B233-P9	B235-P13	B208-1 Comp	B212-4 Comp	B214-1 Comp	C212-2 (140'-168')	C212-2 (168'-189')
Arsenic (%)	39.5	66.0	66.5	60.2	57.8	62.7	66.3
Aluminum (mg/kg)	19000	7700	4300	7300	12000	9300	6700
Antimony (mg/kg)	18000	3700	11000	17000	16000	2100	3600
Barium (mg/kg)	44	24	16	25	30	25	16
Beryllium (mg/kg)	<0.2	<0.2	<0.5	<0.5	<0.5	<0.2	<0.2
Bismuth (mg/kg)	<20	<20	<20	<20	<20	<20	<20
Cadmium (mg/kg)	<25	<25	<8	<8	<8	<25	<25
Calcium (mg/kg)	9300	2900	2300	3400	5300	6800	2300
Chromium (mg/kg)	71	20	16	22	36	30	23
Cobalt (mg/kg)	110	28	<25	26	43	22	28
Copper (mg/kg)	810	240	100	160	230	130	230
Iron (mg/kg)	150000	20000	18000	25000	42000	23000	21000
Lead (mg/kg)	4300	440	470	810	1200	240	550
Lithium (mg/kg)	<40	<40	<40	<40	<40	<40	<40
Magnesium (mg/kg)	5900	2900	1600	2200	3600	5500	500
Manganese (mg/kg)	300	100	74	85	130	170	88
Molybdenum (mg/kg)	<20	<20	<20	<20	<20	<20	<20
Nickel (mg/kg)	230	48	40	50	83	42	53
Phosphorous (mg/kg)	<100	<100	<100	<100	<100	<100	<100
Potassium (mg/kg)	5200	2000	1200	2200	3600	2600	1900
Selenium (mg/kg)	<60	<60	<60	<60	<60	<60	<60
Silver (mg/kg)	38	9	4	6	9	<2	6
Sodium (mg/kg)	960	600	230	370	560	270	230
Strontium (mg/kg)	14.0	5.8	3.2	6.0	9.4	8.1	5.7
Thallium (mg/kg)	<60	<60	<60	<60	<60	<60	<60
Tin (mg/kg)	<40	<40	<40	<40	<40	<40	<40
Titanium (mg/kg)	2000	610	160	310	330	840	510
Vanadium (mg/kg)	73	30	18	28	44	39	26
Yttrium (mg/kg)	2.1	1.0	0.7	1.0	1.6	0.9	0.9
Zinc (mg/kg)	2100	290	300	420	640	220	250
Grain Size µm (80%<)	45	10.4	36.8	18.4	15.2	55	51

Note: “Comp” refers to composite sample from different depths.
Other samples are from the depth range listed.
“<” less than detection limit

Arsenic Solubility

The water solubility of arsenic from several samples of arsenic trioxide dust, produced from the 1960’s through the 1990’s, was determined as part of a study conducted in 1999 (CANMET 2000). The tests were conducted at temperatures typical of the present minewater, the results of which are summarized in Table 5.1.5. Ranges identified in the table indicate the variability in arsenic solubility. This variability is believed to be correlated with the antimony content of the samples (samples with higher antimony content tend to show a lower arsenic solubility). Arsenic solubility also appears to be higher at higher temperatures. Since the temperature of minewater is expected to decrease as a result of reduced ventilation, the results reported in Table 5.1.5 provide a somewhat conservative estimate of solubility.

Table 5.1.5 Solubility of Arsenic from Arsenic Trioxide Dust

Solution Temperature	Soluble Arsenic Concentration (g/L)*
5° C	4.6 – 9.0
10° C	5.2 – 9.4

Data from Canmet 2000

* Note: The dissolved arsenic is expected to occur as arsenite (AsO_3) when it is first dissolved, but over time will oxidize to arsenate (AsO_4)

5.1.3 Storage Chambers and Stopes

5.1.3.1 Locations

The locations of the underground arsenic trioxide dust storage areas are shown in relation to surface features in the central mine area in Figure 5.1.1. As discussed in Section 4.4.2, the dust is stored in both purpose-built chambers and mined-out stopes. For ease of discussion, the chambers and stopes are often referred to as being in four areas, referred to as AR1, AR2, AR3 and AR4, which are also shown on Figure 5.1.1.

A total of ten purpose-built chambers and five mined-out stopes were used to store the dust, although the stopes B212, B213 and B214 are joined together and can be considered as one excavation. All of the chambers and stopes are located in the central area of the mine, close to the processing plant where the dust was produced. The chambers and stopes are relatively close to the surface, with most of the excavations extending from about 20 metres to about 75 metres below the ground surface (Table 5.1.6). All of the chambers and stopes are sealed by concrete bulkheads, which isolate the dust storage areas from the other mine workings.

Arsenic trioxide dust was distributed pneumatically through a series of pipes. Most of the pipes are still in place. As discussed in Section 6.2.4.3, distribution pipes containing arsenic trioxide dust on the first level in the AR2 area have been moved to a location inside the perimeter of future freeze holes. Many of the pipes contain residual arsenic trioxide dust; however some pipes are inaccessible and cannot be assessed. Distribution pipe locations are shown in Figure 5.1.2.

Figure 5.1.1 Dust Storage Chambers and Stopes

Figure 5.1.2 Location of Arsenic Distribution Pipes

Table 5.1.6 Approximate Chamber and Stope Dimensions

Identification		Excavation Type	Width (m)	Length (m)	Maximum Height (m)	Distance, Ground Surface to Top (m)	Excavation Volume (m^3)
AR3	B230	Chamber	9	23	21	67	2,800
	B233	Chamber	16	35	45	37	12,300
	B234	Chamber	12	35	46	36	12,000
	B235	Chamber	15	35	51	34	17,900
	B236	Chamber	14	35	47	39	15,200
	B208	Stope	24	200+	50	32	22,800
AR4	B212	Stope	31	52	57	31	25,700
	B213	Stope	31	17	39	31	9,400
	B214	Stope	31	28	25	31	12,400
AR2	C212	Stope	19	92	49	30	18,100
	9	Chamber	17	35	57	33	13,300
	10	Chamber	11	26	55	30	5,700
AR1	11	Chamber	16	38	23	25	9,800
	12	Chamber	15	70	36	23	25,500
	14	Chamber	14	125	24	23	12,000
	15	Chamber	15	60	30	26	27,000

5.1.3.2 Chamber and Stope Geometry

Summary dimensions of the chambers and stopes are provided in Table 5.1.6 and shown schematically in Figure 5.1.3 for stope B208. Three-dimensional views of the chambers and stopes are presented in Figures 5.1.4 to 5.1.8 at equivalent scales.

The chambers and stopes vary considerably in dimensions, shape and volume. The chambers, which were excavated for the purpose of storing arsenic dust, are generally rectangular shaped cavities with vertical walls. Figures 5.1.4 to 5.1.6 show the purpose-built chambers in areas AR1, AR2 and AR3 respectively.

In contrast, the stopes were originally excavated to follow the ore body and are quite irregular in shape. They are generally narrower than the chambers and have inclined walls. Figure 5.1.5 shows the mined-out C212 stope in areas AR2. Figures 5.1.7 and 5.1.8 show stopes B208 and B212, 213 and 214 in areas AR3 and AR4. The irregular nature of the stopes means that extensive access workings were developed to allow efficient removal of ore. As a result, there are numerous openings from the stopes into ore chutes, raises and drifts, most of which are expected to contain arsenic trioxide dust.

Figure 5.1.3 Schematic of Chamber and Stope Dimensions

Figure 5.1.4 3D View of AR1 Chambers

Figure 5.1.5 3D View of AR2 Chambers and Stopes

Figure 5.1.6 3D View of AR3 Chambers (without B208)

Figure 5.1.7 3D View of Stope B208

Figure 5.1.8 3D View of AR4 Stopes

5.1.3.3 Geology of the Storage Areas

Section 7.2 provides an overview of the bedrock geology of the site and details of the structural geology, including the spatial relationship of the arsenic storage areas to major faults. The major faults do not intersect any of the arsenic storage chambers or stopes, with the exception of Chamber 15, which is empty.

In the main ore zones, the rock is of two types, known as sericite schist and chlorite schist. The sericite schist rocks have particularly well-developed small scale fractures, possibly leading to increased hydraulic conductivity and stability problems. The chlorite schist appears to be more ductile, and therefore does not fracture as readily resulting in decreased hydraulic conductivity and improved stability.

The B212, B213 and B214 stopes occupy a hinge in a major fold in the sericite schists. The intensity of the fracturing and its horizontal orientation mean that this area is prone to instability, as evidenced by the presence of several wall failures. The rock surrounding the other stopes and chambers is generally either the less fractured chlorite schist or sericite schist with dominantly vertical fractures. These areas are expected to be more stable.

5.1.3.4 Water Levels

Water pressures in selected chambers and stopes are monitored by vibrating wire piezometers that were placed during the 2004 investigations. In stopes B208 and C212 the dust appears to be saturated towards the bottoms of the stopes. These findings correspond with the routine observations of water seepage from bulkheads below these stopes. In stopes B212 and B214, and in chamber B233, the dust is typically unsaturated at the depths to which the piezometers were installed. Variations in the depths of saturation occur, depending on the time of year and surface water conditions. Since 2001, monitoring of water pressure on the bulkheads below stope B208 has shown the pressure of a saturated zone, which has transiently increased during spring freshet periods.

5.1.3.5 Temperature

Temperatures in the dust and overlying bedrock and overburden are also being monitored using instruments installed in 2004. The monitoring to date has indicated a temperature range from -4 to +5°C, which is consistent with previous temperature monitoring in the immediate area.

5.1.4 Stability of Arsenic Trioxide Dust Storage Area Crown Pillars

The mass of bedrock overlying an underground excavation, such as a stope, is known as the crown pillar. Crown pillars can be a long-term concern if there is a potential for the rock to collapse, creating a new opening to the surface. The potential for collapse depends on the geometry of the crown pillar, the strength of the rock, and the support provided by any backfilled material inside the excavation.

The geotechnical stability of crown pillars above the arsenic chambers and stopes has been investigated in a series of studies. An initial review (SRK 2001a) found that all chambers have relatively thick crown pillars, and failures appear to be unlikely. However, the crown pillars above the stopes are not as thick, and their stability is a concern. In particular, the excavation of the B1 open pit adjacent to stopes B208 and B214 may have created areas where the crown pillars (and stope walls) are thin and fractured. The convoluted shapes of the stope walls could be a source of instability, because large slabs or wedges of rock on the upper "hanging walls" could collapse into the stored arsenic trioxide dust.

In contrast, the chamber walls, being more regular in shape and vertical, are likely to remain stable in the long-term. Access workings leading to the chambers are also generally stable structures, consisting of a small number of regularly spaced draw points at the base and a dust distribution drift across the top.

Supplementary investigations of suspect crown pillars were completed in 2003 and 2004. The complete results are presented in SRK (2005b) and the conclusions are summarized in Table 5.1.7 below.

Table 5.1.7 Crown Pillar Thickness and Likelihood of Failure for Arsenic Trioxide Storage Areas

Arsenic Trioxide filled Chamber or Stope	Minimum Thickness of Crown Pillars (m)		Likelihood of Failure
	Background Review	2004 Drill program	
B230	62		Very unlikely
B233	35		Very unlikely
B234	31		Very unlikely
B235	22	21	Very unlikely
B236	28	23.5	Very unlikely
B208	10	11.6	Possible
B212	7	10.4	Possible
B213	8	10.4	Possible
B214	7	7.0	Possible
C212	17	7.9	Very unlikely
9	19		Very unlikely
10	19		Very unlikely
11	19		Very unlikely
12	24		Very unlikely
14	25		Very unlikely
15	25		Very unlikely

Note: See SRK (2005b)

The crown pillars above stope B208 and the group of stopes B212, B213 and B214 were determined to be at risk of failure. The crown pillar above stope C212 was concluded to be unlikely to fail. However, any disturbance of the C212 crown pillar could have resulted in Baker Creek being funnelled directly into the stope. The subsequent relocation of Baker Creek away from stope C212 in 2006 has greatly reduced that risk.

Evaluation of the pillars around and below the arsenic chambers and stopes concluded that the pillar between the bottom of stope B208 and the partially backfilled stope B306 also has a "possible" likelihood of failure SRK (2005b).

5.1.5 Stability of Arsenic Trioxide Dust Storage Area Bulkheads

The chambers and stopes used to store the arsenic trioxide dust are secured by bulkheads. Mine records indicate that the bulkheads were designed to the engineering standards of the day; however, there are no as-built drawings on record to confirm the construction details. Bulkheads were constructed in all access workings leading to each chamber or stope. Upper bulkheads and access hatches generally served as dust injection points and/or provided access for monitoring the fill levels. Lower bulkheads either hold back the dust directly, or close off access to drifts or cross-cuts into which the dust could flow.

A total of 71 bulkheads were designed, but ten of these were either not built or were removed during subsequent mining operations, such as during the excavation of the B1 Pit. Consequently, 61 bulkheads remain in service, of which 26 are lower bulkheads. The bulkhead locations are shown in Figures 5.1.9 and 5.1.10. The long-term stability of these bulkheads is questionable and the short-term stability of some of them is also a source of concern. All of the accessible lower bulkheads have been the subject of recent investigations, including non-destructive testing (SRK 2001b; Klohn Crippen Consultants Ltd. 2002), and are included in regular inspections.

An updated version of the stability evaluation on lower bulkheads is summarized in Table 5.1.8. The table incorporates the findings of recent investigations and ongoing inspections.

Figure 5.1.9 Upper Bulkheads All Areas

Figure 5.1.10 Lower Bulkheads All Areas

Table 5.1.8 Evaluation of Stability for Lower Bulkheads

Current Bulkhead ID	Orientation of Bulkhead	Evidence of Seepage	Risk Rating	Comments
Area AR 3				
1	Vertical	No Access	Low	Any potential failures would be confined by bulkheads 13, 14, and 15
3	Vertical	No Access	Low	
5	Vertical	No Access	Low	
7	Vertical	Yes	Moderate	Seepage of water and, on one occasion, seepage of arsenic sludge. Concrete is competent
10	Horizontal	No	High	B208 stope has a dewatering system to prevent pressure build-up, however, bulkheads 11 and 12 are inaccessible. Failure would cause dust to enter underlying, partially backfilled stope B306
11	Horizontal	No Access	High	
12	Horizontal	No Access	High	
13	Vertical	Yes	Moderate	Bulkheads are at B208 stope, which has a dewatering system to prevent pressure build-up
15	Vertical	Yes	Moderate	
14	Vertical	Yes	Low	New supplementary bulkhead constructed immediately in front of the deteriorated one
Area AR 4				
32	Vertical	Minor	Moderate	Good condition, historically dry or very minor seepage
33	Vertical	No Access	Moderate	
34	Vertical	No Direct Access	Moderate	Historically dry or very minor seepage, as observed from a nearby safe vantage point
35	Vertical	No Access	Moderate	
36	Vertical	Yes	High	Inadequate flexural strength. Believed to be under significant head of water (~30 m). Failure would cause dust to block main access to AR2 and AR3 and release to lower workings
Area AR 2				
47	Vertical	No Access	Moderate	Adequate design strength but inaccessible for inspection
48	Vertical	No Access	High	Inaccessible and within the wet area influenced by Baker Creek
49	Horizontal	No Access	High	
50	Vertical	Yes	Moderate	Adequate strength
51	Vertical	Yes	Moderate	Adequate strength
56	Vertical	No Access	Low	
58	Vertical	Yes	Low	
Area AR 1				
64	Vertical	No	Low	Adequate strength
66	Vertical	Yes	Moderate	Adequate strength
68	Vertical	Yes	High	Inadequate flexural strength. Historic high seepage of water and arsenic sludge
70	Vertical	No	None	No arsenic dust in chamber 15

The bulkheads of particular concern are:

- Bulkheads 10, 11, and 12: These horizontal bulkheads are located above the partially filled stope B306. Failure of the bulkheads would lead to uncontrolled release of dust into the underlying workings. Bulkhead 10 is now accessible, but bulkheads 11 and 12 are not.
- Bulkhead 36: Year-round seepage has been observed from the north end of stopes B212, 213 and 214. Failure of Bulkhead 36 would lead to uncontrolled release of dust into the underlying workings.
- Bulkheads 48 and 49: The condition of these bulkheads is unknown. They are located under stope C212 and the former Baker Creek alignment known as the Mill Pond, and water draining from the Mill Pond could cause fluctuating pressures on the bulkheads.
- Bulkhead 68 has been observed to leak water and arsenic sludge every year since 2000.

A monitoring and maintenance program is conducted to reduce the risk of bulkhead failure. This program consists of:

- Regular visual inspections by a professional engineer of the accessible bulkheads;
- Pressure monitoring at Bulkheads 15, 32 and 58;
- Reinforcement of Bulkhead 14 with shotcrete in 2004;
- Pressure and temperature monitoring within chambers and stopes B208, B212, B214, B233 and C212;
- Operation and monitoring of a dewatering system hydraulically connected to stope B208;
- Operation of a water interception system in B1 pit to reduce inflows to stope B208;
- Seepage flow monitoring at Bulkheads 13, 14, 50, 51, 58 and 68; and
- Arsenic analysis from seepage at Bulkheads 14, 36, 50 and 68.

5.2 Other Underground Mine Components

The other underground mine workings form a network of connected voids, including horizontal drifts, inclined raises, vertical shafts, ramps, chutes and ore stopes. In addition, many thousands of exploration drill holes intersect the workings.

5.2.1 Tunnels and Vertical Shafts

A three-dimensional layout of the mine workings is shown in Figure 5.2.1. The arsenic storage chambers are also shown in order to illustrate their position relative to the main tunnel system.

Figure 5.2.1 3D Layout of the Mine Workings

5.2.2 Other Underground Arsenic Sources

In addition to the arsenic trioxide dust stored underground in chambers and stopes, there are other potential sources of arsenic that could affect the quality of minewater when the workings are flooded. These include large quantities of tailings and waste rock that were used to backfill mined out stopes, and lesser quantities of materials such as track ballast in the main drifts and cross-cuts, and fine-grained slimes that have accumulated in various areas of the mine. Mineralized wall rocks throughout the mine could be another arsenic source.

Backfilling of the mined-out stopes was carried out to:

- Maintain stability in the mine (i.e., prevent collapses that could undermine workings located above the abandoned stopes);
- Dispose of waste rock; and
- Dispose of mine tailings.

Backfill records and records of backfill “robbing” are incomplete, and it is not possible to safely inspect most of the older stopes to check backfill levels. Determining accurate estimates and locations of backfilled and remaining open void volumes is therefore difficult. Figure 5.2.2 illustrates the stopes and backfilled areas of the mine.

Backfilled tailings are distributed widely in the mine, from the C-Shaft north to the Supercrest area, and from surface down to the 1650 Level. A review of mine records confirmed that calcine tailings were combined with flotation tailings and used for backfill from 1956 to 1967. Tailings backfilling continued until 1978, using only flotation tailings. Approximately 2.3 million tonnes of underground tailings were accounted for in the mine records, about half of which were backfilled before 1967. Therefore it is reasonable to assume that about half of the backfilled tailings contain calcine.

Studies of the geochemical characteristics of backfilled tailings and other mine materials were conducted in 2001, 2002 and 2004. The data are summarized here and full analyses are presented in Golder (2001a) and SRK (2005c). Samples of the materials were collected for laboratory testing, which included mineralogical analyses, metal analyses, acid base accounting tests, and several tests designed to assess the potential for leaching of arsenic and metals from the materials.

Figure 5.2.2 Location of Backfilled Stopes

The 2001 to 2004 test results indicate that the backfilled tailings would not generate acidic drainage. Samples containing only flotation tailings had trace amounts of sulphides and low metal contents. Samples that also contained calcine tailings had somewhat higher amounts of sulphide and elevated metal levels. The leach extraction tests indicated that the flotation tailings release elevated concentrations of soluble arsenic and antimony. Although the samples containing calcine tailings released less arsenic and antimony, they released slightly elevated concentrations of cadmium, cobalt, copper, manganese, nickel and zinc. The calcine tailings contained large amounts of arsenic bearing iron oxide minerals, which have the potential to release arsenic if chemically reducing conditions develop after the mine is flooded.

Testing of the backfilled waste rock indicated that this material is unlikely to generate acidic drainage; however, the samples did contain variable amounts of sulphide and metals. Leach extraction tests indicated substantial amounts of soluble sulphate, and there were somewhat elevated metal concentrations in the leachate. Mineralogical tests indicate that iron oxides are only a minor constituent of the waste rock and, therefore, long-term release of arsenic is not expected to be a major concern. The wall rock and track ballast samples were similar in character to the waste rock.

Slime samples were found to contain iron oxides that strongly resemble the calcine observed in many of the backfilled tailings samples, suggesting that at least some of the slimes are comprised of tailings spilled in the mine access workings. The geochemical behaviour of this material is expected to be similar to the backfilled tailings containing calcine.

Additional laboratory testing of tailings backfill was conducted in 2004, using samples collected underground during the 2002 program. The objectives of the 2004 program were to conduct extraction tests on a larger number of samples than had previously been tested, to ensure that the samples adequately represented variability in the tailings backfill, and to include tests intended to simulate mildly reducing conditions that could develop in the underground mine when it is flooded. The test results are presented in SRK (2005c). The arsenic releases from both types of backfill samples, flotation tailings and calcine tailings, were generally consistent with the results of previous testing described above. The tests to simulate mildly reducing conditions did not successfully promote reducing conditions; however, they did provide further demonstration of the redox buffering capacity of the backfill, and of the limited potential for arsenic release under oxidizing conditions.

The results of the laboratory studies were used to estimate the arsenic concentrations that could arise when these materials are flooded, and the arsenic loads released to the minewater in the long-term. These estimates are discussed in detail in Section 5.7.1 and Section 6.8.

5.2.3 Underground Infrastructure and Equipment

The underground infrastructure includes all of the equipment and systems used to mine the rock and bring ore to the surface, while maintaining a safe working environment in the mine. This includes ore and waste rock handling systems, ventilation systems, mine dewatering systems, and distribution systems for fresh water, compressed air and electricity.

Most of the underground infrastructure is constructed of steel, wood and concrete, and presents no environmental concerns. However, environmental concerns may be associated with underground facilities in which hazardous materials were used or handled. These include workshops used to maintain mine equipment, storage areas for fuels, oils and explosive materials, and the electrical distribution system. The following sections describe this infrastructure and highlight potential remediation concerns.

5.2.3.1 Maintenance Shops

The mining equipment used underground has been powered by compressed air, electrical batteries, and diesel fuel. This equipment has been maintained in workshops located near major access points on most of the mine levels.

Scoop trams, jumbo drills and other diesel powered equipment have been maintained in five different shops located on the 575, 750, 1500 and 1650 Levels. Salvageable equipment in the shops on the 1500 and 1650 Levels has been removed and the remaining equipment drained of fuel and oil prior to the flooding of these Levels.

The active maintenance shops on and above the dewatered 750 Level may contain unused hazardous materials in storage, such as small quantities of diesel fuel, lubricating and hydraulic oils, greases, cylinders of compressed gases, solvents, and chemicals such as cleaners and additives. Hazardous waste materials stored in the shops include small quantities of used oils, oil absorbent materials, used solvents, and lead-acid batteries.

Maintenance shops for battery powered equipment are located close to C-Shaft on many of the mine levels, although only a few have been active recently. These shops may contain small supplies of sulphuric acid, as well as new and used lead-acid batteries.

5.2.3.2 Fuel and Oil Storage Areas

Two underground diesel storage facilities located on the 750 and 1500 Levels have been in recent use. These consist of single-walled steel tanks (4,500 litre capacity) standing inside concrete spill containment berms. Fuel has been trucked to these tanks from storage facilities on surface. The storage tank on the 1500 Level was drained and moved to surface in 2005, prior to flooding this level. Several other diesel storage facilities have been used underground in the past, but are now inactive. In most cases, these storage tanks have been moved to new locations underground or brought to surface.

Lubricating and hydraulic oils have been stored in dedicated facilities adjacent to the maintenance shops for diesel powered equipment. Drums of oil have been stored inside concrete spill containment berms at these facilities.

5.2.3.3 Explosives Storage Areas

Every active mining area underground had designated explosive storage facilities nearby, and there are numerous such facilities throughout the mine. These consist of fenced mine workings or caverns, fitted with shelves for storing explosives. Detonation explosives (blasting caps) have been stored separately from bulk explosives. Only a few of these facilities have been recently active, and could still contain explosive materials. Explosives have been removed from inactive storage areas, including those now flooded, as required by GNWT *Mine Health and Safety Act and Regulations*.

5.2.3.4 Electrical Systems

An active electrical substation is currently located on the 750 Level, where transformers reduce the voltage for electric powered equipment such as lights, ventilation fans, and pumps. The transformer at this location is of the dry type, and does not contain oil.

In the early 1990's, several transformers that contained polychlorinated biphenyl (PCB) bearing oils were removed from the mine and transported to a disposal facility in Alberta. Most of the underground PCB materials were removed from the site in this period. Since much of the remaining underground electrical system dates from the period when PCB compounds were extensively used, small electrical components may be expected to contain PCB's. For example, most of the lighting in the maintenance shops is provided by fluorescent strip lights. Depending on the date of installation, the light ballasts may contain small amounts of PCB compounds in solid forms.

5.2.4 Openings to Surface

A total of 35 openings from the underground workings to surface are currently open, sealed with temporary measures, or require inspection to determine if they are adequately sealed in accordance with GNWT regulations for design load. The locations, types and current status of these openings are shown in Figure 5.2.3.

Five of the openings are vertical shafts that were at one time used to lift workers and equipment in and out of the mine, or bring ore and waste rock to surface. Four of the shafts are now used only for ventilation or utility lines. C-Shaft remains in service. All of the shafts are currently open with access controlled by buildings and doors.

Figure 5.2.3 Locations of Underground Mine Openings to Surface

There are seven openings known as portals, leading to horizontal adits or inclined ramps. These provided access to the mine for workers and mobile equipment, and were also used to bring waste rock to surface. Most of the portals are located in the open pits and are currently secured with temporary measures, such as doors and gates, which are locked when not in use.

The remaining twenty-three openings are vertical or inclined raises. These were used for ventilation, ore and waste rock handling, arsenic trioxide dust distribution, and emergency access to surface. Many of these openings are currently secured with locked doors and gates, or temporarily sealed with wooden covers. Others are backfilled with waste rock and require further assessment to determine if the backfill is adequate as a permanent seal.

5.2.5 Other Crown Pillars

The status of crown pillars in the vicinity of arsenic trioxide storage areas was described in Section 5.1.4. In addition, a site wide crown pillar stability investigation (SRK 2006a) reviewed all crown pillars of non-arsenic trioxide storage stopes that are within 30 metres of the current ground surface (the locations of these crown pillars are shown in Figure 5.2.4). Of the 18 crown pillars that met these criteria, eleven were identified as requiring further evaluation in the form of three dimensional volume modelling and geotechnical analysis which would ultimately determine the requirement for additional backfill support for the crown pillars.

Table 5.2.1 summarizes the assessments of stability and failure consequences, and indentifies the eleven crown pillars where further assessment has been recommended. Follow-up work is ongoing to identify backfill options, costs and details of how backfilling would be implemented for specific areas of the underground.

The long-term stability of the crown pillars associated with the arsenic trioxide storage areas is discussed in Section 5.1.4 above. The stability of crown pillars intersected by the open pits is discussed in Section 5.3.2 below.

Table 5.2.1 Consequences and Stability Risk Level for Other Crown Pillars

Stope	Section	Consequence Level of Crown Pillar Area Instability	Stability Evaluation Risk Level	Further Evaluation Recommended
2-01	5200S – 5300S	Moderate	Moderate to High: Possible instability if weak ground conditions prevail and the crown pillar is not supported by backfill.	Build a 3D model of the stope and further verify that this stope is filled with backfill
3-70	7500N – 7750N	High, due to potential impact on Baker Creek	Low	Build a 3D model of the stope, re-verify the overburden thickness and further verify that this stope is filled with backfill
2-19	1925S – 2000S	Moderate	Low	No further evaluations required
2-18	1800S – 1900S	Moderate to High, due to potential impact on Baker Creek	Low	No further evaluations required
1-18	0 – 250S	Moderate	Moderate if not filled	Verify that all these areas are adequately filled
1-18 #1	00	Moderate	Moderate if not filled	As above
1-18 EB	00 – 50N	Moderate	Moderate if not filled	As above
1-18 EA	100N – 200N	Moderate	Moderate if not filled	As above
2-15	300N – 400N	Moderate	Low	None
2-06	500N – 550N	Moderate	Low	None
1-31	3075N – 3225N	Low	Unknown: Unable to evaluate.	Build a 3D model of the stope and pit excavation and further evaluate the stability for a number of likely stope fill scenarios.
1-26	3875N - 3975N	Moderate	Low	No further evaluations required
1-36	3525N – 3600N	Moderate	Low	No further evaluations required
1-37	3650N – 3700N	Moderate	Low	No further evaluations required
1-43	3775N – 3975N	Moderate	High: Likely long-term instability if: -the weaker ground conditions prevail, -high extraction resulting in small pillars, and there is no fill around the pillars.	Build 3D model of the stope and further evaluate the stope geometry, Assess the stability of pillars likely left behind and assess the overall stability
1-43 #1	3950N – 4000N	Moderate	As above	As above
1-43 #1 & Upper	4025N – 4075N	Moderate	As above	As above
1-43 lower	4125N – 4300N	Moderate	As above	As above

Figure 5.2.4 Location of Crown Pillars Outside of Arsenic Storage Areas

5.2.6 Boreholes

There are approximately 27,000 known historic exploration and production diamond drill holes on the Giant Mine site (drilled from surface and underground). The majority of the holes have diameters ranging from 60 mm to 76 mm (i.e., NQ and BQ core sizes) and there is no available information suggesting that any of them have been sealed. Figure 5.2.5 shows an example section illustrating the interconnections of surface and underground diamond drill holes with the underground workings and an open pit.

Recent groundwater studies have included both new holes drilled by diamond drill or auger, and rehabilitated exploration holes. Ten shallow (<15 m deep) wells and fourteen deep (~150 m deep) groundwater monitoring wells are currently in use. There is also a multi-port monitoring well in C-Shaft.

Two service holes located adjacent to B-Shaft provide electrical power and compressed air to the underground workings. Both holes have casing pipe extending to the 2nd Level.

In the AR1 arsenic storage area, several boreholes were drilled into the chambers in order to place arsenic trioxide dust into the chambers. Remnant casing pipes have been removed and the holes have been sealed with concrete.

Figure 5.2.5 Typical Cross Section Showing Interconnections of Drill Holes with Mine Workings

5.3 Open Pits

5.3.1 Dimensions and Access

The eight open pits are shown on Figure 5.3.1 and the physical dimensions are listed in Table 5.3.1. Pit depths and volumes have been calculated based on recently completed digital terrain mapping. The volumes listed in the table are to the "spill point" of each pit. The spill point is defined as the lowest section of the pit rim, where water would overflow if the pit was flooded.

Table 5.3.1 Open Pit Dimensions and Approximate Volumes

Pit	Length & Width (m)	Depth (m)	Mined Volume (m^3)
A1	319 x 136	50	766,000
A2	355 x 152	38	498,000
B1	193 x 148	35	327,000
B2	277 x 110	26	223,000
B3	170 x 65	11	40,000
B4	69 x 50	7	12,000
Brock	104 x 34	10	6,000
C1	276 x 127	28	395,000
Total:			**2,267,000**

Currently, it is possible to access the A1, A2, B1, B2, B3 and C1 pits by means of the existing access ramps. These ramps are not maintained, with the exception of those in the B2 and B3 pits, which are used for underground access via the UBC and 1-38 portals.

Figure 5.3.1 Site Plan Showing Outlines of Open Pits

5.3.2 Interaction with Underground Workings

Numerous intersections with mined-out stopes, drifts, and other openings (raises, etc) occur along the bottoms and sides of the pits. Some pits actually mined through underground openings as they were being excavated. Access adits were constructed in several of the pits in order to enter the first level of the mine without an additional ramp from surface. Currently, the only active adits are the UBC portal in the B2 Pit, and portal 1-38 in the B3 Pit.

All of the identified openings to the surface are discussed in Section 5.2.4. Further details on surface openings that are specific to the open pits are discussed in detail in SRK (2005d). The openings consist of intercepted raises, tunnels, man-ways, and purpose-built adits. Many of the smaller openings are currently either open or have been capped or blocked using engineered structures. The historic drifts and stopes that connect to the open pits are particularly important for remedial planning. A stability assessment of crown pillars underlying the open pit floors was undertaken in 2006 (SRK 2006a). These stopes were backfilled prior to open pit mining to provide for stable crown pillar conditions when excavating the pits, and would have been topped up if voids were detected when breakthrough occurred. They were not capped and, in some cases, backfill has been removed (e.g., stope C218 beneath C1 Pit).

There are areas of subsidence in the C1 pit where the pit bottom intersects several backfilled stopes. These are thought to have occurred due to water infiltrating from Baker Creek through a cut-off dam at the north end of the pit, or through the wall under the historic creek channel. Efforts were made to eliminate inflow from the creek in 2004. This work is described in Golder (2004a). Further discussion of the subsidence zones is provided in SRK (2005d).

5.3.3 Pit Walls and Stability Issues

The stability of the pit walls was investigated in 2001, with a review of data and site inspections (Golder 2001b). The investigation indicated that a thawed overburden in the northwest wall of the A1 Pit had experienced some sloughing, but no movement was observed in any of the other pit walls.

Access to the pit walls constitutes a hazard to the general public, especially due to the proximity to Yellowknife city limits and the adjacent highway. Currently, access to the pit walls is controlled by mine operations security.

Tension cracks are evident at some of the pit edges and within the pits, notably the A1, A2, B1 and C1 pits. Additionally, subsidence areas are occurring in the C1 Pit as described above. A subsidence area is also occurring in the B3 Pit above stope 1-31. These are being actively monitored and are discussed in detail in SRK (2005d).

The B2 Pit dyke was identified as a high failure consequence dam during a dam safety review carried out by BGC Engineering Inc in 2004. The dyke keeps water from Baker Creek out of B2 Pit where it could enter the underground mine via the UBC Ramp at the bottom of the pit. A geotechnical investigation program was carried out in the fall of 2007. The dyke developed an uncontrollable seepage in November 2007. As a risk mitigation measure to prevent possible flooding of the mine, a new structure, the B2 Dam, was constructed on the upstream side of the dyke. The dam is undergoing routine monitoring for settlement as well as temperature and moisture beneath the upstream face of the dam. Settlement appears to have tapered off since the dam was constructed.

Dam 1 above the B3 Pit has undergone geotechnical investigation as part of this assessment program. Similar to B2 Pit, excessive water entering B3 Pit would flow underground via a ramp at the bottom of the pit. Dam 1 is included in the annual site-wide dam inspection which is carried out by Golder Associates.

5.3.4 Pit Wall Geochemistry

Acid rock drainage potential in the pit wall rock was investigated by Royal Oak Mines (1994) and Golder (2001b). Test results showed that 85% of the samples collected were acid consuming. Given the large percentage of carbonate minerals within the ore zone lithology, any acid produced by discrete acid generating sections of rock with high sulphide concentration would be neutralized. Static leach testing also showed only limited potential for arsenic release from the wall rocks (Golder 2001b). Pit wall geochemistry is discussed in more detail in Golder (2001a).

5.3.5 Borrow Material in Open Pits

A large quantity of backfill material is located in the A1, A2, and C1 Pits, as listed in Table 5.3.2. Tension cracks and subsidence areas within the backfill are evident, and the material is not considered to be stable over the long-term (SRK 2005d).

Table 5.3.2 Backfill Material Currently in Pits

Pit	Estimated Volume of Backfill (m^3)		
	Till	Waste rock	Till & waste rock
A1			66,000
A2		29,500	
C1	123,500	58,500	
Total	123,500	88,000	66,000

5.4 Waste Rock

Most of the waste rock produced by open-pit mining, and brought to surface from the underground mine, was utilized as construction material in tailings dams and site roads. There are currently just three small waste rock piles immediately south of B2 pit, containing approximately 12,000 tonnes of rock.

The geochemical characteristics of the waste rock are discussed in detail by Golder (2001a) and summarized in Table 5.4.1. Analytical data show that the waste rock is non-acid generating, and the arsenic and metal content of the rock is relatively low. Leach extraction tests indicate that arsenic and metal concentrations in waste rock leachate are low.

Table 5.4.1 Summary of Waste Rock Geochemistry Characteristics

Parameter	Range in Solids (mg/kg)	Range in Leachate (mg/L)
NP:AP ratio	2.2 – 38.9	n/a
Arsenic	11 – 8,960	0.0077 – 0.11
Antimony	4 – 74	<0.2
Chromium	105 – 494	<0.01
Copper	54 – 276	<0.01 – 0.01
Nickel	54 – 117	<0.05
Lead	<2 – 82	<0.05
Zinc	66 – 238	<0.005 – 0.013

NP:AP = ratio of neutralization potential to acid generation potential
n/a = not applicable
Notes: Twenty three samples were analyzed for acid-base accounting (ABA) and metal content in solids
Eight samples were submitted for leachate extraction testing. Tests were conducted at 20:1 dilution

5.5 Tailings and Sludge Containment Areas

5.5.1 North, Central and South Ponds

5.5.1.1 Tailings Disposal

Approximately 9.5 million dry tonnes of tailings were originally deposited in the North, Central and South Ponds. From 1988 through 1990, 2.5 million tonnes of these tailings were reprocessed in the Tailings Retreatment Plant (TRP) and transferred to the Northwest Pond. Today, about 7 million tonnes of tailings remain in the North, Central and South Ponds. The tailings were deposited by a combination of sub-aqueous and sub-aerial methods. The tailings in these ponds cover a combined surface area of 51 hectares, with a maximum tailings thickness of about 22 metres in the Central Pond. The geochemical characteristics of the tailings are discussed in Section 5.5.5 below.

5.5.1.2 Containment Structures

The tailings are impounded by a series of dams. The design objectives for all of the dams were to contain tailings and to minimize seepage of pore water. Seepage collection systems were designed and constructed at all of the perimeter dams where seepage did occur.

Dams 1, 2 and 3 were the first tailings dams constructed, and together form the North Pond, as well as the original tailings disposal area now overlaid by the Settling and Polishing Ponds. The locations of these structures are shown in Figure 5.5.1. The original three dams consist of mine waste rock placed in stages on top of previously deposited tailings. Tailings were beached on the upstream sides of the dams, limiting seepage through the dams from the pond water accumulated upstream.

When Dams 1, 2 and 3 were raised in the 1970's, the rockfill was extended in the downstream direction and a sloped clay zone was constructed upstream. The raised sections of the dams incorporated a filter zone of sand and gravel between the clay and the downstream rockfill, and the clay core was extended onto the tailings beach to create a horizontal upstream clay blanket as an additional barrier to seepage through the lower sections of the dams. In the late 1980's the downstream toe and slope of Dam 2 was partially dismantled to supply clay materials for construction of the Northwest Pond dams. Some mine waste rock is currently stockpiled along the downstream toe.

Dams 4 and 5, which close off the south end of the Central Pond, were constructed above the rising tailings level so that, unlike the first three dams, the foundations do not include tailings. Dams 4 and 5 have zones of clay on the upstream side to reduce seepage through the structures.

Dam 6 is a simple rockfill structure separating the North and Central Ponds, and does not incorporate a low permeability zone. Dam 11, which forms the southern boundary of the South Pond, was designed as a water retaining dam. It has a rockfill downstream section, a central core of low permeability clay material, and a rock fill upstream shell. Sand and gravel filter zones are present upstream and downstream of the clay core. Tailings placed on the upstream side form a beach in front of the dam. A similar design configuration was later used for the dams of the Northwest Pond.

The dams that contain tailings and water in the North, Central and South Ponds have been inspected annually by a professional geotechnical engineer since 1979, to assess their performance and maintenance requirements. The performance and safety of these dams was reviewed in September 2004 (BGC 2004). The detailed review identified no immediate safety concerns, but made recommendations to assess dam performance in more detail, and improve operating, maintenance and surveillance procedures.

Figure 5.5.1 Original Tailings Containment Area

5.5.1.3 Dam Seepage

In the history of development of the North, Central and South Ponds, several of the dams have produced large volumes of seepage which passed either under the dams, or through the structures themselves. Today, seepage at Dams 2, 3 and 11 remains a water management concern.

Dam 2 is founded partly on tailings, which covered low lying ground between Dam 1 and the North Pond before the dam was built. In recent years, seepage from the North Pond to the Settling and Polishing Ponds has occasionally been evident from poor water quality in these ponds, with higher arsenic concentrations than found in the discharge from the Water Treatment Plant.[14] Because of this, an operating criterion is now applied, keeping the North Pond water level no more than 1.7 metres higher than the level of the Polishing Pond. This practice effectively controls the seepage through Dam 2 within acceptable limits.

Seepage through or under Dam 3 has been a concern in the past. Two small dams, known as 3C and 3D, were constructed to contain the seepage downstream of Dam 3 and allow it to be pumped back to the North Pond. In recent years, the North Pond water level has been kept low in relation to Dam 3 and seepage at this dam has been a relatively minor concern. A small volume of contaminated seepage water occasionally collects at Dam 3C, and is pumped back into the North Pond as required. Although it continues to be monitored, Dam 3D no longer collects enough seepage to warrant pumping.

Seepage emerges at the downstream toe of Dam 11, on the South Pond, and is contained by Dam 7. The contained water is pumped back into the South Pond, and the volume of seepage is monitored with a flow meter. The seepage flow rate has decreased since tailings discharge to the South Pond ceased in 1999. The annual average seepage flow rate is currently 3 to 5 m^3 per day, typically containing 1 to 3 mg/L arsenic.

5.5.1.4 Water Management

A decant pipeline is used to transfer water directly from the South Pond to the North Pond, because the storage capacity of the South Pond is limited. The total water storage capacity of the North Pond, to the maximum operating level, is about 160,000 m^3, and the maximum pond depth is 5 metres. The arsenic concentration in the North Pond water is typically between 7 and 11 mg/L.

[14] The term "Effluent Treatment Plant" has also been used to describe the existing Water Treatment Plant.

5.5.2 Northwest Pond

5.5.2.1 Tailings Disposal

About 6.5 million dry tonnes of tailings are stored in the Northwest Pond (Figure 5.5.2), of which 2.5 million tonnes were transferred from the original tailings containment area (i.e. the North, Central and South Ponds). The remainder of the tailings came from conventional mill production. Tailings slurry was discharged near the crests of the dams to form shallow beaches sloping toward a pond of supernatant water. The tailings cover an area of 44 hectares, to a maximum thickness of about 15 metres. The geochemical characteristics of the tailings are discussed in Section 5.5.5.

5.5.2.2 Containment Structures

The Northwest Pond is contained by Dams 21A, B, C and D, and Dams 22A and B (Figure 5.5.2). These dams were designed to meet water retention dam standards in accordance with the accepted practice at the time of construction in 1987. The dams are composed of rockfill, with a sloping core of silty clay keyed into bedrock or frozen soils in the foundation, forming a zone of low permeability to control seepage. The clay core is underlain by a two stage granular filter zone, and is protected by an upstream rockfill shell.

The tailings dams of the Northwest Pond have been inspected annually by a professional geotechnical engineer, as a requirement of the former water licence and the current care and maintenance contract. The dam safety review completed in 2004 (BGC 2004) recommended more detailed assessment of the dam performance, and improvements in operating, maintenance and surveillance procedures, as long as the dams continue to perform their current function. The review identified no immediate safety concerns.

5.5.2.3 Dam Seepage

Seepage from the dams on the Northwest Pond has been indicated historically by the results of water sampling outside the impoundment. Only Dam 22B has produced enough seepage to make containment practical (i.e., there is insufficient seepage from the other dams to warrant collection). A seepage containment and pumping system is located downstream of the dam. The seepage volume has been reduced in recent years, due to lower pond water levels and improvements in seepage management, although contaminated water continues to report to the collection system. This water is pumped back to the Northwest Pond, and the volume is monitored with a flow meter. The annual average flow rate is currently 7 to 9 m^3 per day, typically containing 1 to 3 mg/L arsenic.

Figure 5.5.2 Northwest Tailings Contaminant Area

5.5.2.4 Water Management

The Northwest Pond currently plays a major role in site water management. Water is pumped from the mine throughout the year and is stored in the pond before treatment and discharge to the environment. The Northwest Pond provides the majority of the capacity for storing contaminated water on site, holding about 900,000 m^3 to the maximum operating level, at a maximum pond depth of 5 metres. Arsenic concentrations in the pond water are typically around 15 mg/L, and can vary from 10 to 20 mg/L. The role played by the Northwest Pond in site water management is discussed further in Section 5.7.1.

5.5.2.5 Test Tailings Cover Plots

A study to determine the appropriate design of covers for the tailings is being conducted on the Northwest Pond. The study consists of four plots that have been constructed with specific layers of crushed rock, fine material and geotextile. The plots were constructed during the winter of 2007/08 and each cover an area of 32 m^3. Instrumentation was installed in the plots to gather temperature and moisture data. An array of survey beacons was installed on each plot to monitor movement. The study is expected to continue for at least one more year.

5.5.3 Settling and Polishing Ponds

The Settling and Polishing Ponds, which are shown in Figure 5.5.1, form part of the current water treatment system. The ponds have had this function since 1981 when the first comprehensive treatment of minewater began. Before this, the pond formed between Dam 1 and Dam 2 was initially used for tailings disposal, and later for clarifying tailings water decanted from the North Pond before its discharge to Baker Creek.

The area is divided into the Settling and Polishing Ponds by a rockfill dyke constructed on top of the previously deposited tailings. The dyke serves to retain sludge produced by the Water Treatment Plant in the Settling Pond, while allowing relatively clear water to seep into the Polishing Pond. Over the years of operation, some sludge has passed through the dyke and settled in the Polishing Pond, although the majority remains contained in the Settling Pond. The water quality in the Polishing Pond is normally within the limits specified for effluent discharge to the environment in the water licence, with total arsenic concentrations below 0.4 mg/L. The function of the Settling and Polishing Ponds in the water treatment system is described further in Section 5.7.3.

The volume of sludge currently stored in the Settling and Polishing Ponds has been estimated from measured changes in the pond bathymetry since sludge deposition began. The sludge volume is estimated to be between 250,000 and 450,000 m^3 (Golder 2004b).

During normal operation of the Water Treatment Plant, the Settling Pond is shallow and holds a relatively small volume of water. The Polishing Pond contains approximately 230,000 m^3 of water, with a maximum depth of approximately 9 metres.

5.5.4 Calcine Pond

The former calcine storage pond is located northwest of the B1 Pit, adjacent to Baker Creek. The pond was used to store roaster calcine before further treatment to recover the contained gold. Some of the material deposited in the pond proved difficult to treat for gold recovery and was left in place. The pond was eventually drained and the remaining calcine was covered over with soils excavated from the B1 Pit.

A physical and geochemical investigation of the former calcine pond was conducted in 2003 (INAC and SRK 2004). An auger drill was used to test the dimensions of the remaining calcine deposit, collect samples, and install groundwater monitoring wells. The volume of calcine was estimated to be 960 m^3, based on the thickness determined by drilling, and the lateral extent of the calcine pond indicated by historical aerial photographs. The investigation indicated that the remaining calcine deposit varies in thickness from 1 to 3 metres, and is covered with clay material varying from 1 to 11 metres thick. The calcine is also underlain by fine-grained soils. The geochemical characteristics of the calcine are described in Section 5.5.5.

5.5.5 Tailings, Sludge and Calcine Geochemistry

5.5.5.1 Tailings

The geochemical characteristics of the tailings and tailings pore water have been assessed in several studies. In 1994, near-surface tailings solids from the North, Central, South and Northwest Ponds were sampled for acid base accounting test work (Royal Oak Mines 1994). The results indicated relatively low total sulphur contents (less than 1%), and generally high net neutralization capacities. The study indicated that the tailings would not be expected to produce acidic drainage.

Further assessment of the tailings was conducted in 2001 (Golder 2001b). Near surface tailings were sampled throughout the North, Central and South Ponds, and from various depths in a borehole drilled in the Northwest Pond. Samples collected by Miramar Giant Mines Limited in 2000, from various depths in the North, Central and South Ponds, were also analyzed as part of the same study. The test work conducted on these samples included mineralogical analysis, acid-base accounting, whole rock geochemistry, and analysis of water soluble constituents.

The study found that the tailings consist principally of fine-grained material containing quartz and carbonate minerals, with a small proportion of sulphides, including arsenopyrite, which are generally not altered or oxidized. The roaster products, or calcines, are also abundant in most of the tailings samples. The soluble arsenic in the tailings is most likely associated with the calcine, in which arsenic likely occurs adsorbed onto hematite particles.

The 2001 study confirmed that the tailings in all of the impoundments are net acid consuming. The ratios of neutralizing potential to acid generating potential in the tailings samples generally decrease with depth, and sulphate is found in the near surface tailings, indicating that oxidation is occurring at the surface. Evidence of oxidation at surface was not found in areas where the tailings are typically covered by water throughout most of the year, such as the central part of the Northwest Pond.

The 2001 study indicated typical arsenic concentrations of about 2000 to 4000 mg/kg, with a few samples in the range of 5000 mg/kg. The test work indicated that only a small portion of the arsenic in solid form is water-soluble (average of 0.2% by weight), however the presence of dissolved arsenic in tailings pore water and potential additional release of soluble arsenic from solid forms could generate runoff or seepage from the tailings that exceeds effluent quality criteria.

5.5.5.2 Water Treatment Sludge

The chemical characteristics of the water treatment sludge were also assessed by Golder (2001b). Two samples of the sludge were collected for laboratory test work, one from the sludge deposit in the Settling Pond, the other from the Water Treatment Plant discharge. This work included analysis of major and trace constituents, and sequential leach extractions.

The arsenic contents of the two sludge samples were 1% and 4.2% (by weight), and the iron contents were 6% and 30% (by weight). The higher arsenic and iron contents were found in the material from the Water Treatment Plant discharge. The iron to arsenic molar ratios of 8 and 9 indicate that the arsenic is likely to be very effectively retained in the sludge.

The sequential leach extractions were designed to simulate exposure of the sludge to ambient conditions. The results indicated that a very small proportion of the arsenic in the sludge is water-soluble (up to 0.006% by weight).

Further field investigations of the sludge deposits were completed in 2006, including collection of physical and geochemical data (SRK 2007c). Three core samples, representing sludge deposited throughout the period of water treatment operations, were tested. The arsenic contents of the three samples were similar, with an average of 2.4% (by weight). The iron contents were also similar, with an average of 12.1%, and an average iron to arsenic molar ratio of 6.8. Pore water was extracted from the core samples and analyzed. The median concentration of arsenic in pore water was 0.25 mg/L. The solubility of arsenic and other constituents was assessed using a water leach extraction method. The average final arsenic concentration in the leachates was 0.26 mg/L.

5.5.5.3 Calcine

The chemical characteristics of roaster calcine located in the former storage pond adjacent to Baker Creek were assessed in 2003 (INAC and SRK 2004). The purpose of the study was to assess the potential for the release of arsenic or other contaminants from the calcine to the creek. Samples of the material were collected by drilling through the soils lying over the calcine deposit. Laboratory testing of the samples included analysis of metals, acid-base accounting and leach extraction tests. Groundwater monitoring wells were installed in the drill holes.

The study concluded that, although this material is a potential source of arsenic and antimony, the soluble concentrations of these elements are moderate, and seepage flows to Baker Creek are low due to the low permeability of the surrounding soils. The acid-base accounting indicates that the calcine is unlikely to be acid-generating, and that major changes to the chemistry in the future are unlikely. Therefore, the calcine is not considered a major source of current or future arsenic loadings to the creek.

5.6 Historic Foreshore Tailings

Mine production records indicate that approximately 300,000 tonnes of tailings were deposited on the foreshore of North Yellowknife Bay. About 35% of the tailings are on the "beach", with the remaining in Back Bay. Some of the submerged tailings have been dispersed along the western shore of North Yellowknife Bay by lake currents. Sediment sampling carried out in 2004 has defined of the extent of tailings dispersion in North Yellowknife Bay. More detailed information on the historic foreshore tailings is provided in Golder (2005a) and summarized in Section 7.1.4 (Sediment Quality) of this Report.

Remedial works have been done on the beached tailings in 2001. The beach was re-contoured to a 4:1 (horizontal to vertical) slope and covered with geotextile overlain with gravel and coarse rock to prevent further erosion of the tailings solids into North Yellowknife Bay. To minimize the amount of surface water flowing through the tailings, drainage ditches were constructed to direct drainage to North Yellowknife Bay along a pathway south of the beach.

The tailings have a very low potential to generate acidic drainage. The tailings solids have low concentrations of metals with the exception of arsenic, antimony, lead and zinc. Tailings pore water contains elevated concentrations of arsenic, antimony and zinc only.

Assessment of the submerged tailings indicates that arsenic concentrations in lake sediment pore water appear to be proportional to the arsenic concentrations in sediments and the amount of tailings in the lake sediment. Elevated arsenic concentrations were found in samples located near the mouth of Baker Creek and in North Yellowknife Bay near the historic tailings disposal site. However, of the arsenic load entering Yellowknife Bay from the historic foreshore tailings area, roughly 90% originates from surface sources (including the beached tailings). This figure was estimated from field data collected from groundwater wells installed in the beach area.

The water column above the submerged tailings meets the CCME water quality guidelines for protection of aquatic life. However, the submerged tailings have negatively affected the benthic invertebrate population of the surrounding area to a distance of approximately 500 m from the shore. The environmental implications of the submerged tailings are described further in Section 7.1.4.2.

5.7 Site Water Management

5.7.1 Underground Mine Water

The major sources of water entering the underground mine include runoff flowing into the open pits, seepage from Baker Creek, seepage from the tailings containment areas, infiltration through soils and bedrock in the mine area and inflow from groundwater into the underground mine workings. Of the tailings containment areas, the Northwest Pond is the principal source of seepage into the mine. Several of these sources are controlled by climatic conditions, and the total inflow to the mine varies greatly during the year.

All water entering the mine ultimately drains into the main dewatering systems located at the area known as Supercrest, in the northern part of the mine. Most of the water is handled by gravity flow through ditches in the main drifts, as well as the ramps, raises and drainage holes that connect the main drifts. In areas where drainage by gravity is not possible, small sumps and pumps transfer water to the gravity drainage system, where it is fed to the Supercrest area via the 750 Level pipe system. The underground drainage and dewatering systems are shown in Figure 5.7.1.

Drainage from the southern part of the mine includes major inflows originating from the A2, A1 and C1 Pits during the freshet and heavy rainfall periods. Drainage from the northern part of the mine includes a large inflow of water from the Northwest Pond, which flows throughout the year, and seepage from other areas that increases significantly during the freshet, and when the water level in Baker Creek is high. In the C Shaft area, flows from the ditches are directed through drainage holes and drainage pipes to the open shaft where it cascades down into the flooded mine below. At Supercrest, a portion of the seepage from the Northwest Pond drains directly into another dewatering sump on the 750 Level.

Flooding of the lower levels of the mine was initiated in July 2005, when the pumps on the 2000 Level at the bottom of the mine were shut down and removed. In 2007 the pumps on the 1300 Level were also shut down and removed. Currently, water is pumped from the 750 Level Supercrest sump directly to surface and is discharged into the Northwest Pond.

Before flooding of the lower mine levels commenced, the dewatering rate required to keep the mine dry was typically about 2,000 m^3 per day in winter, increasing to 4,000 m^3 or more during the freshet period. Since the mine water has reached the 750 Level the dewatering rates have been similar.

5.7.1.1 Minewater Quality

Monitoring of water flows and chemistry within the mine has been carried out in several programs since 1999. The objectives of the programs were to identify and characterize the principal sources of arsenic within the mine, and to develop water and arsenic balances for the mine water system. A detailed discussion of the mine water sampling programs and mine water chemistry is presented in SRK (2005e).

The results of the sampling programs indicate that the main sources of water entering the mine are direct infiltration of snowmelt and precipitation, infiltration from Baker Creek, and seepage from the Northwest Pond. Although deep saline groundwater enters the lower levels of the mine, the isotopic composition of mine water samples indicates that the majority of water comes from the surface.

As water percolates downwards through the mine, it interacts with the mine walls and surrounding bedrock. Water samples collected from boreholes and fractures at the extremities of the mine have relatively low arsenic concentrations, ranging from 0.018 to 0.063 mg/L. Interaction with the mine workings nearer the ore zones leads to further increases in arsenic concentrations, in the range of 0.5 mg/L.

Water that contacts the arsenic trioxide dust is characterized by very high arsenic and antimony concentrations, slightly acidic pH, and high magnesium, sulphate and ammonia concentrations. Arsenic concentrations in seeps close to dust-filled chambers are in the range of 4000 mg/L. The isotope data indicate that most of the seepage from the chambers originates from snowmelt and rainwater. However, a sample collected below chamber C212, which was under Baker Creek until the creek was diverted in 2006, was more characteristic of creek water.

Water from the tailings ponds and polishing pond also enters the mine via direct infiltration. The tailings seepage tends to have arsenic concentrations in the range of 4 to 6 mg/L, as well as elevated concentrations of sodium, chloride, ammonia and nitrate.

Some of the mine stopes are backfilled with waste rock and tailings, as described in Section 5.2.2. Seepage from stopes that are backfilled with tailings typically have arsenic concentrations ranging from 0.1 to 6.8 mg/L (with one outlier of 20 mg/L), while seepage from stopes that contain waste rock have arsenic concentrations ranging from 0.2 to 1.6 mg/L.

Figure 5.7.1 Current Underground Dewatering System

The deep groundwater is characterized by very high total dissolved salts content, and high calcium, sodium and chloride concentrations. The deep groundwater appears to make major contributions to the sodium/chloride released to the mine, but is a relatively minor source of arsenic.

Typical concentrations of arsenic in water from each of the above sources are summarized in Table 5.7.1.

Table 5.7.1 Arsenic Concentrations in Underground Water from Different Sources

Source	Arsenic Concentrations (mg/L)
Soils, Bedrock, and Mine Walls	0.05
Northwest Tailings Pond Seepage	7
Tailings Backfill	5
Waste Rock Backfill	1.5
Arsenic Chambers & Stopes	4000

Results of monthly sampling of the underground mine flows and underground water and load balances reflecting winter and freshet sampling are presented in SRK (2005e). The results indicate that flows of approximately 2400 m^3 per day, and arsenic loads of approximately 56 kilograms per day are discharged from the mine to the Northwest Tailings Pond. Approximately 90 to 95% of the arsenic enters the mine drainage system between C-Shaft and 1000 feet north of B-Shaft (1000 North), which is the area of the mine beneath the arsenic chambers. An additional 5 to 10% is from further north of the arsenic dust storage areas, and can be attributed primarily to seepage from the Northwest Tailings Pond. A negligible proportion of arsenic load originates from south of C Shaft.

The underground mine workings form a network of connected voids, including horizontal drifts, inclined raises, vertical shafts, ramps, chutes and ore stopes to a total depth of 610 metres below the surface. In addition, many thousands of exploration drill holes intersect the workings, creating an extensive drainage system for the rock in the mine area. Although the mine workings have been partially flooded, the continued dewatering of the mine draws groundwater towards the workings, thereby preventing the escape of contaminated mine water from the site.

5.7.2 Surface Water

5.7.2.1 Fresh Water, Grey Water and Sewage

Fresh water is currently used for sanitary and fire suppression purposes at the active mine buildings near C-Shaft, as well as for heating purposes at the active boilers. Historically, fresh water was also used at the Townsite for domestic and fire suppression purposes, but this system was shut down in 2005.

All of the fresh water used for boilers, fire suppression and sanitary purposes at the active mine buildings is potable water obtained from the City of Yellowknife, and is currently trucked to storage tanks on site. All waste water generated from surface uses, including grey water and sewage, is currently directed into the underground water management system through a pipe in the C-Shaft. The waste water joins the main mine dewatering line on the 750 Level and is eventually discharged into the Northwest Pond.

5.7.2.2 Control of Surface Runoff

Runoff into the open pits is controlled to reduce the volume of water that would require pumping from the mine and eventual treatment. For this purpose, three runoff diversion systems were constructed to collect and divert runoff around the A1 and A2 Pits (Figure 5.7.2). The A1 North diversion ditch collects runoff from the west of the A1 Pit and directs it into Baker Creek, to the northeast of the pit. The A2 North ditch collects runoff from the west of the A2 Pit, and discharges into Baker Creek north of the pit. The A2 South diversion system consists of a small dam on high ground south of the A2 Pit, and a plastic pipeline that carries water from the dam to the drainage system adjacent to Highway No. 4. Clean runoff is also collected in the C1 and B2 Pits, and is periodically pumped from the pits directly into Baker Creek. The water is sampled before and during pumping to confirm the arsenic concentration is below the discharge limits specified in the former Water Licence (0.5 mg/L arsenic) and the federal Metal Mining Effluent Regulation (MMER). Results of the pit water sampling are documented on site.

Surface runoff in the shallow valley just north of the Roaster Complex is typically contaminated with arsenic at concentrations above the former discharge limits, due to the high levels of soil contamination found in this area. In recent years, the contaminated runoff has been contained in a shallow sump at the bottom of the valley and pumped to the South Pond, for storage and eventual treatment. Contaminated runoff in the immediate area of the Mill complex is now collected in a series of ditches and sumps, and directed underground through C-Shaft.

Clean surface runoff from the radio tower hill is pumped from a sump and discharged into the drainage ditch on the south side of the C-dry parking lot.

Figure 5.7.2 Diversion Systems to Control Surface Run-off

5.7.2.3 Contaminated Water Storage

The tailings containment areas are used to store contaminated water on surface before it is treated. As discussed in Section 5.7.1, minewater is pumped from the 750 Level of the mine to the Northwest Pond throughout the year. Historically, minewater has also been pumped to the South Pond via C Shaft, during periods of high mine inflow in the spring and summer. Small volumes of water are also returned to the Northwest Pond from the seepage collection system at Dam 22B, and to the South Pond from Dam 11. Dam 3C seepage is pumped back into the North Pond.

Apart from pumped discharges from the mine and the dam seepage collection systems, the tailings ponds also receive inputs of water from direct precipitation and runoff. Losses of water from the ponds include diffuse seepage through and under the dams, seepage into the mine workings, and evaporation.

The former Water Licence required that a minimum of 0.5 metres of freeboard be maintained at the lowest water retaining structures in the tailings containment areas, to provide emergency water storage for extreme precipitation events, and to prevent overtopping of the dams due to wave action. Operating under these conditions, the maximum storage capacity of the Northwest Pond is approximately 900,000 m^3.

The South Pond has been almost completely filled with tailings, and little capacity remains for water storage. A decant pipeline carries water by gravity flow from the South Pond directly to the North Pond. The inlet to the pipeline lies just above the minimum tailings elevation, so that the pond is almost empty when the pipeline is drained. When the South Pond was accepting minewater discharge, a small pond developed to provide the hydraulic gradient required to push water through the pipeline to the North Pond. The pond volume was typically less than 20,000 m^3.

As discussed in Section 5.5.1.3, the level of the North Pond is controlled to minimize the potential for seepage of contaminated water into the adjacent Polishing Pond. The total capacity of the North Pond, to the maximum operating level, is approximately 160,000 m^3. However, the water reclaim system in use at the North Pond does not reach the deepest part of the pond and, as a result, only about 70,000 m^3 of the total pond capacity can be actively used.

5.7.3 Water Treatment and Discharge

Water is reclaimed from the Northwest pond and North Ponds for treatment in the Effluent Treatment Plant (ETP) during the open water season, usually from July through September. The ETP consists of a primary and secondary circuit. The primary circuit consists of three agitating tanks in series and is fully automated; under normal operating conditions only this circuit is operated. A backup or secondary circuit consists of three agitator tanks in series, with the middle tank bypassed and is operated manually. Influent water form the Northwest Pond and North Pond is normally blended to optimize reagent consumption.

A 60% solution of ferric sulphate is added to the influent water prior to entering the first agitator tank. The ferric iron combines with arsenic to form amorphous ferric arsenate precipitates. Arsenic species are also removed from solution by absorption on amorphous ferrihydrite (iron-hydroxide) precipitates.

Lime slurry is added to the first tank to neutralize the acid generated by hydrolysis of the iron and maintain optimal pH for arsenic precipitation. A polymeric flocculent is also added to increase the efficiency of solids settling. The overflow from the last of the three tanks in each circuit, containing water and precipitates, drains through a short pipeline to the north end of the Settling Pond. The lime slurry and flocculent solution are prepared from dry reagents in the ETP building next to the tanks. The ferric sulphate is received at the site as solution ready for addition to the circuit, and is stored in large tanks adjacent to and inside the ETP.

The Settling Pond provides quiescent conditions to allow precipitates to settle out of the water. The Settling Pond is separated from the downstream Polishing Pond by a permeable rock-fill dyke, which retains precipitates within the Settling Pond, while allowing the clarified water to seep through. Settling efficiency is greatly improved by the addition of flocculent in the ETP. Efficient settling within the pond reduces the build-up of precipitates on the upstream face of the dyke, thus reducing the hydraulic gradient required across the dyke to push water from the Settling Pond to the Polishing Pond. A larger hydraulic gradient would encourage the infiltration of precipitates to the Polishing Pond, which could result in unacceptably high concentrations of arsenic in the final effluent. The potential for this effect limits the maximum practical treatment rate to approximately 7,000 m^3 per day.

The Polishing Pond has a large capacity (230,000 m^3) and residence time of approximately one month. The pond provides the last opportunity for settling any precipitates carried over from the Settling Pond. The Polishing Pond also allows some mixing of the water, smoothing out variations in the water quality, and allowing brief ETP process upsets to occur without producing water that is unacceptable for discharge. In the event of more lengthy treatment problems, the large capacity of the basin also allows 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.

Final effluent is discharged through a siphon line from the south end of the Polishing Pond to a drainage ditch south of the B3 Pit. The treated water drains through a series of culverts under mine access roads and Highway 4 prior to discharging into Baker Creek (Baker Pond).

5.8 Baker Creek

The current and original alignment of Baker Creek is illustrated in Figure 5.8.1. For monitoring and remediation design purposes, Baker Creek is divided into a series of six reaches, defined by major changes in creek hydraulics or channel conditions within the mine lease area. Each reach boundary is defined in Figure 5.8.1 and described in Table 5.8.1 below. The hydrology, water quality, sediment quality, and aquatic life in Baker Creek are discussed in Chapter 7.

The construction of the open pits required extensive relocation of Baker Creek. Reach 1 was diverted to allow for the mining of A2 Pit. Reach 3 is a narrow bedrock confined diversion channel beside C1 Pit.

In 2006, Reach 4 was relocated into a new channel. The creek realignment was an emergency flood prevention measure taken to bypass the increasing uncontrolled flow of surface water that was flowing underground below Mill Pond.

Baker Creek is traversed by two structures that limit the natural behaviour of the system. Five structures were bypassed or removed during the Reach 4 realignment in 2006. These included old mine infrastructure, highways and mine road crossings, in-channel structures and debris.

Underground observations suggested that Baker Creek does not infiltrate into the underground mine across most of the site, although it is underlain by mine workings. The exception is at the north end of the C1 Pit where flow from the creek is observed to infiltrate the upper fill section into the pit during high water periods (i.e., during spring freshet and periods when ice blockage causes water levels to rise).

Figure 5.8.1 Baker Creek Current and Historical Alignments

Table 5.8.1 Description of Baker Creek Reaches

Reach	Description	Current Condition
1	Extends from marsh in Great Slave Lake to the channel north of A2 Pit; Bedrock overhangs the channel where it is confined to a narrow area between the A2 Pit and the Highway 4; The culvert crossing of Highway 4 is monitored and maintained to prevent icing and debris dams; The culvert can also be a barrier to fish migration at high flows and very low flows.	395 m total length bedrock and degraded channel
2	Straight reach most of which is physically undisturbed from historical mine activities; Large part of original riparian area is intact.	600 m total length impacted, natural channel
3	Extends from north end of C1 Pit downstream to upper end of Reach 2; Short alluvial section below bridge; The overhanging bedrock wall along the west side of the reach is prone to rock falls.	750 m total length bedrock channel
4	Extends upstream to weir next to B1 Pit and downstream to below the former location of the old bridge north of C1 Pit; original channel physically disturbed and modified by contaminated sediments	350 m total length man-made channel designed to provide conveyance and fish habitat features
5	Extends from the former location of the old weir to the outlet of Baker Creek; moderately disturbed by mining activity in stream bed and riparian areas.	425 m total length degraded backwater-type channel
6	Baker Pond, and in-filled pond at mouth of Trapper Creek; Pond bottom and shoreline contain mine tailings; Discharge point for effluent.	

5.9 Quarries, Borrow Areas and Overburden Piles

Construction activities on the site, such as the building tailings dams, roads and laydown areas, utilized mine development rock as much as possible. The Northwest Pond dams were constructed using material quarried from the current footprint of this facility. Consequently, there are few exposed quarries on the Giant Mine site. A clay and till borrow pit was opened south of the propane bulk storage facility during the construction of the Northwest Tailings Pond and is now filled with water. Two small quarries have been incorporated into the eastern side of the Northwest Pond and currently have exposed rock walls.

There are two overburden stockpiles on the site, located immediately north of A1 pit and immediately south of C1 pit. The material appears to be overburden stripped from the pit areas when they were opened in the 1970s and early 1980s. Seep samples collected from the stockpile north of A1 pit show that the overburden does not contribute arsenic to the surface water. Water quality data are provided in SRK (2005f).

5.10 Contaminated Surficial Materials

Surficial materials around the mine infrastructure show impacts of fifty years of industrial activity. Areas of contamination with arsenic and other metals (notably antimony, chromium, copper, lead, nickel, vanadium and zinc) as well as hydrocarbons have been delineated by detailed selective and random sampling across the site. The areas identified as contaminated and intended for excavation or treatment are shown in Figures 5.10.1 and 5.10.2. A detailed discussion of the investigation program and results is provided by Golder (2005b, 2001c) and the results are summarized below.

The contaminated materials found on the surface of the site generally consist of:

- "Contaminated soil" – Natural soil deposits or fill, other than waste rock or tailings, with arsenic and/or hydrocarbon contamination. In accordance with the objective set out in Section 6.1.2, only material that is above the NWT industrial land use remediation criterion (GNWT 2003) is included in the "contaminated soil" category herein.
- "Tailings" – Tailings that have been spilled or deposited outside of the impoundments, and containing arsenic dominantly in the form of arsenopyrite.
- "Waste rock" – Mine rock used as fill on surface and containing arsenic dominantly in the form of arsenopyrite.

It should be noted that the tailings impoundments, the historic foreshore tailings and contaminated sediments within Baker Creek are not indicated as contaminated areas on Figures 5.10.1 and 5.10.2. However, the materials in these areas do have elevated total arsenic concentrations. The physical and chemical characteristics of the tailings impoundments are described in Section 5.5. Section 7.1.4 discusses contaminated sediments.

Figure 5.10.1 Location and Concentration of Arsenic Contaminated Soils

Figure 5.10.2 Location of Hydrocarbon Contaminated Soils

5.10.1 Arsenic and Other Inorganic Materials

The primary contaminant of concern in soil at Giant Mine is arsenic. Areas of soil containing arsenic concentrations greater than the NWT industrial land use (IL) criteria of 340 mg/kg total arsenic were identified in nine areas of the mine site, which are shown on Figure 5.10.1. The figure presents the locations and results from samples collected during several investigations. These samples were analysed for total metals, as reported in Golder (2005b).

Total arsenic concentrations range as high as 25,500 mg/kg. The highest arsenic concentrations are found in the Mill and Roaster areas (Area 1) and in the area west of the Polishing Pond (Area 4). Selected samples were tested to determine how much of the arsenic is in a readily soluble form. The proportion of water soluble arsenic ranged from 0.4% to 58%, with the most soluble material located in the Mill and Roaster areas (Area 1). This is likely due to the presence of arsenic trioxide dust around the roaster, baghouse and emissions stack. Samples from Area 4 contain spilled tailings.

Arsenic concentrations in leachates from soils containing more than 340 mg/kg arsenic range from 0.7 mg/L to 231 mg/L. In soils containing less than 340 mg/kg arsenic, the arsenic concentration in leachates were less than or equal to 0.1 mg/L with one exception being at 7.3 mg/L.

Soil samples were also analysed for constituents other than arsenic. Antimony, chromium, copper, lead, nickel, vanadium and zinc concentrations in a small number of samples exceeded the NWT industrial land use criteria. Most metal exceedences occurred in the Mill and Roaster areas (Area 1). All exceedences of the industrial land use criteria for these other metals occurred concurrently with arsenic exceedences. Consequently, arsenic was selected as the indicator constituent to delineate contaminated areas. A notable exception is the possible lead contamination adjacent older buildings as described in subsequent Section 5.11.1.

The volume of contaminated material in each area was estimated and the results are summarized in Table 5.10.1 below. Details are given in Golder (2005b).

Table 5.10.1 Estimated Volumes of Material with Arsenic Above the NWT Industrial Level

Areas	Arsenic Contaminated Soil (m^3)	Tailings (m^3)	Waste Rock (m^3)	Total Estimated Volume Greater than 340 mg/kg Arsenic (m^3)
Area 1 – Mill and Roaster areas	170,000			170,000
Area 2 – West of Central TCA	4,800			4,800
Area 3 – West of TRP	200			200
Area 4 – West of Polishing Pond		110,000		110,000
Area 5 – Propane tank farm	2,000			2,000
Area 6 – Townsite			37,000	37,000
Area 7 – Townsite road			1,100	1,100
Area 8 – Dam 7 to Yellowknife Bay		2,300		2,300
Area 9 – East of Dam 3		800		800
Total	**177,000**	**113,100**	**38,100**	**328,200**

Note: Volumes have been rounded

5.10.2 Hydrocarbons

The potential for hydrocarbon contamination was evaluated in a separate investigation. Contamination by diesel fuel and/or fuel oil was identified in areas where fuel handling and bulk storage has taken place, as shown in Figure 5.10.2. No PCB contamination was detected in the fuel handling areas. The report detailing the hydrocarbon investigation is included in Golder (2001c).

The volume of hydrocarbon contaminated material is estimated to be 15,000 m^3. The areas of known hydrocarbon contamination generally fall within areas of high arsenic concentrations. Additional investigations will be required to determine the presence of contamination under existing tank foundations, concrete pads and drum storage areas that were inaccessible during the first investigation. It is likely the volume of hydrocarbon contaminated material will increase as a result of these investigations.

The potential for PCB contamination in soil at the surface electrical transformer sub-stations was evaluated in 2000 (Deton'Cho Environmental Alliance 2000a). The assessment did not reveal PCB concentrations in the soil exceeding the remediation criterion and recommended additional investigations at depth in sub-stations at the C-Shaft and B-Shaft complexes.

5.10.3 Contaminated Soil from the Freeze Optimization Study

Ongoing investigations at Giant Mine have included a Freeze Optimization Study (FOS), (described further in Section 6.2.9). Contaminated material excavated from the area of the FOS has been utilized in the construction of a causeway across the drained mill pond and stockpiled north of the Mobile Equipment Garage. The material consists mainly of mine waste rock that was determined to be contaminated by sampling during the course of excavation in 2009.

5.11 Buildings and Infrastructure

5.11.1 Buildings

The Giant Mine site has over 100 buildings, constructed in several phases of the mine history, using a variety of construction materials. The first buildings were constructed in the mid-1940's in the A Shaft area, to support underground exploration activity, and in the Townsite area to provide accommodation and recreation facilities for the miners. The buildings required for full-scale ore production and processing were constructed in the area of the B and C-Shafts in the late 1940's, and were subsequently improved and expanded through the 1950's and 1960's. The Water Treatment Plant was constructed in 1981, to comply with new effluent quality standards, and a new gold refinery was built in the same year. In the late 1980's, the Tailings Reprocessing Plant (TRP), Mobile Equipment Garage, and new C-Dry were built. The locations of the site buildings are shown in Figure 5.11.1 and 5.11.2.

The site buildings were inspected in 1998 (Royal Oak Mines 1998b). The purpose of the inspections was to visually identify the types and approximate amounts of hazardous materials associated with each building. The inspections identified asbestos containing materials, lead-based paints, and potential for PCB contaminated materials as remediation concerns. Asbestos containing materials identified included non-friable construction materials, such as the siding and roof shingles found on all of the older site buildings, and friable asbestos materials used for insulation. Large quantities of friable asbestos were found in the process buildings associated with the roaster and roaster-gas handling systems.

Most of the buildings have been painted on exterior and interior surfaces, and since lead was widely used in the manufacture of paints until about 1977, lead-based paints were probably used. Non lead-based paints have been applied over the original paint on most interior and some of the exterior surfaces. The original paint on many exterior surfaces is now peeling, cracked, or flaking, which could result in lead contamination of soils immediately adjacent to the older buildings.

In 2002, a survey of arsenic bearing materials located in the Mill and Roaster complexes was undertaken, including extensive sampling and analysis of process residues in various vessels and ducts (Northwest Consulting Limited 2003). Subsequently a demolition audit and inventory of hazardous materials was completed on the mill complex, main conveyor and TRP by AECOM (AECOM 2009).

All surfaces within the mill buildings and the TRP are coated with dust containing arsenic and cyanide. The 2002 survey identified approximately 700 tonnes of process residues containing greater than 10,000 mg/kg total arsenic, and likely to contain high levels of soluble arsenic. An additional 1,500 tonnes of process residues in the Mill and Roaster complexes may be expected to contain less than 10,000 mg/kg total arsenic. Further assessment of this material will be conducted to determine if it is suitable for disposal in the tailings ponds. The structures also have varying levels of asbestos and other hazardous building materials.

The buildings can be grouped into ten complexes, according to their function and location on the site. The ten complexes are listed in Table 5.11.1, along with the key hazardous material and remediation concerns associated with each complex.

Progressive remediation projects conducted since 1999 include the demolition of fuel storage tanks, utilidors and small buildings. Protocols were followed for asbestos training, removal methods and decontamination. Some asbestos building cladding accessible from the ground in the C Shaft area and utilidors containing asbestos were placed in sealed containers and buried in a landfill on site.

In 2009, the surface crusher and new surface rock breaker structures were dismantled during the preparation of the surface area above Chamber 10 for the Freeze Optimization Study. These are building numbers 116 and 100 on Figure 5.11.2.

Figure 5.11.1 Site Building Areas

Figure 5.11.2 Location of Buildings and Infrastructure

Table 5.11.1 Summary of Building Complexes and Associated Hazardous Material Concerns

Complex	Infrastructure	Hazardous Material Concerns		
		Asbestos-Containing Materials	Arsenic-Containing Materials	PCB Materials
Townsite	Residences, recreation hall, curling rink, freshwater pumphouse, domestic water pumphouse	Non-friable construction materials	None	Possible (small quantities of solid PCB materials)
A-Shaft Complex	A-Boiler, sewage lift station, core shed, transformer substation, old power house, hoist room, headframe, explosives magazine	Non-friable construction materials, friable insulation materials at A-Boiler	None	Possible (small quantities of solid PCB materials)
C-Shaft Complex	Main office, C-Dry, headframe, hoist room and compressor building, crusher building, machine shop, warehouses, pipe and steel racks, electrical shop, C-Boiler, Mine Equipment Garage, carpenter shop, planer shop, emergency powerhouse, conveyor gallery	Non-friable construction materials, friable insulation materials at C-Boiler	Small quantities of ore residue in crusher building, conveyor galleries	Possible (small quantities of solid PCB materials)
Mill Complex	Mill, refinery, reagent shed, office and laboratory complex	Non-friable construction materials	Large quantities of process residues	Possible (small quantities of solid PCB materials)
Roaster Complex	Roaster plant, kiln plant, carbon plant, Cottrell plant, baghouse, stack, arsenic trioxide silo, truck loading shed	Non-friable construction materials, large quantities of friable insulation materials	Large quantities of process residues, with high soluble arsenic contents	Possible (small quantities of solid PCB materials)
B-Shaft Ventilation Plant	Ventilation plant, propane tank, old compressor building	Non-friable construction materials	None	Unlikely
Tailings Retreatment Plant	Process plant, water tanks, thickener, leach tanks, warehouse, office trailers	Unlikely	Residual tailings	Unlikely
B3 Ventilation Plant	Ventilation plant, propane tank	Unlikely	None	Unlikely
Water Treatment Plant	Process control and reagent prep building, treatment tanks, reagent holding tanks	None	Small quantities of sludge residue	Unlikely
Akaitcho Complex	Headframe, core racks, compressor building, warehouse, recreation hall, bunkhouses	Non-friable construction materials	None	Possible (small quantities of solid PCB materials)
Pipe Systems	Utilidors housing pipe systems, from Townsite and A-Shaft complex to C-Shaft complex. Fresh water and steam heat supply, sewage disposal.	Non-friable pipe wrapping materials	None	None

5.11.2 Fuel Storage and Handling Systems

All above ground fuel and lubricant storage tanks that are no longer in use have been dismantled and are slated for removal from the site. The remaining above ground tanks are the fuel tanks for the C and C Dry Boiler heating plants and a mobile equipment diesel fuel tank located adjacent to C Boiler.

Underground storage tanks include heating oil tanks built into some of the buildings in the Townsite, and a gasoline tank adjacent to the main warehouse. The former are slated for removal with the buildings, and the latter is still in use.

As part of ongoing site Care and Maintenance, the tanks are assessed for compliance with the federal *Storage Tank Systems for Petroleum Products and Allied Petroleum Products Regulations*. Tanks previously not in compliance have been made compliant, dismantled or replaced with a compliant tank.

5.11.3 Electrical Distribution System

Fluids containing PCB compounds were banned for use in new electrical equipment manufactured after 1977. At one time, the Giant site had a large inventory of PCBs, but the majority of electrical equipment known or suspected to contain PCB fluids was removed from the site in 1993 and 1994, and transported to a disposal facility in Alberta (Royal Oak Mines 1998b).

An assessment of the potential for PCB fluids to remain at the site was conducted in 2000 (Deton’Cho Environmental Alliance 2000a). Eight unused transformers were identified as probably or possibly containing PCB fluids, and were removed from the site for disposal at a licensed facility. The assessment also included sampling and analysis of soils adjacent to all of the major electrical transformer stations, as described previously in Section 5.10.2. The sampling found evidence of limited PCB soil contamination at three of the sub-stations.

Another potential source of PCBs is fluorescent lighting ballasts manufactured before 1979. A large number of the site buildings contain fluorescent lighting systems manufactured in this period and may be expected to contain PCB compounds in solid materials. Small quantities of solid PCB compounds may be associated with other electrical components remaining at the site.

5.11.4 Power Lines

The main power line from the Northwest Territories Power Corporation (NTPC) that enters the site is 34.5 KV and enters the site from a two pole structure near the main mine entrance. The 34.5 KV line runs in a loop around the site and is transformed down at various substations on the site.

The 34.5 KV line runs to the number 5 substation where it is transformed down to 600 V. A 2.3 KV line runs underground via C-Shaft. There is also a substation at the C-Boiler where the 34.5 KV line is transformed down to 600 V.

The 34.5 KV line carries on northward where it branches off to the Freeze Optimization Study substation and is transformed down to 600 V. The line continues north to the B-Shaft where it is transformed down to 600 V and goes down the B Shaft. The line continues north where it branches to B3, it is transformed down to 4.16 KV that goes underground to Supercrest, and a 2.3 KV line that runs to the ETP where it is transformed down to 600 V. The 34.5 KV line continues north to the Akaitcho substation where it is transformed down to 600 V and 4.16 KV lines that go to the Akaitcho pumping system.

5.11.5 Roads, Fences and Gates

Roads on and passing through the Giant Mine site are shown on Figure 5.11.1, with further details on Figure 5.11.2. Highway 4 (the Ingraham Trail) and the Vee Lake Road run through the Giant Mine site along a 60 metre wide right of way. The highway, which is owned and operated by the GNWT, passes close to several key site components, such as Baker Creek, the A2 and C1 Pits, and the Roaster Complex. It also passes close to or directly above several of the underground arsenic trioxide storage chambers and stopes. Section 7.7.3 provides an overview of transportation activities within this area.

Other roads on the Giant Mine site are surfaced with mine crushed gravel. Where roads are adjacent to open pits, earth berms or fences have been installed to deter vehicles from entering the pit. For safety reasons, all of the Giant Mine site is closed to the public. This is indicated by signs posted along public access routes. Gates restricting access to authorized vehicles are installed at road entrances from the highway to Giant Mine. The main gate at the C-Dry parking lot and the crusher gate are remotely controlled. The remaining gates are kept closed with chains and locks to prevent unauthorized access. Entrances where gates are not practical have boulders placed across the road to prevent access. All access roads can be opened to allow vehicles into the property as required. Access to the Giant Mine Townsite within the City of Yellowknife Lease boundary is limited to the Great Slave Cruising Club and the mouth of Baker Creek.

Some areas on the mine pose a special hazard and fencing has been installed to prevent inadvertent access. The main types of hazardous areas include open pits, electrical installations, openings to underground and areas with elevated contaminant concentrations. The high walls adjacent open pits have fences to keep people and recreational vehicles away from steep slopes. All electrical substations are fenced as required by electrical code. Where the potential for public access exists, openings to underground have also been fenced. With regard to potential exposures to contaminants, the Roaster Complex area is fenced to keep people from inadvertently coming in contact with the arsenic trioxide dust that remains in and around the roaster building.

The location of the fences and berms described above are shown for four areas of concern on the mine property in Figure 5.11.3.

Figure 5.11.3 Location of Fences and Berms

5.12 Waste Storage and Disposal Areas

A number of equipment salvage and laydown areas are located across the site. For the purpose of this report, these areas are identified as waste storage sites. There are also several waste disposal sites. Eight principal waste storage and disposal areas have been identified. The following sections briefly describe these areas.

5.12.1 Area 1: A-Shaft Road

The mine road leading from the main site to the A-Shaft complex has been used as a waste storage or waste disposal site since the earliest years of operations. Redundant mining and processing equipment has been dumped on ground adjacent to the road over a distance of 300 metres. The majority of the waste is comprised of steel, and does not present any special hazards with respect to waste handling or disposal. In 2000, eight transformers suspected to contain PCB fluids were identified in this area and removed from the site for disposal. Small quantities of other hazardous materials could remain amongst the waste, including asbestos containing materials, and arsenic bearing process residues associated with equipment removed from the Roaster Complex.

5.12.2 Area 2: C-Shaft Area Yards

The storage yards east of the C-Shaft area have been used to store redundant equipment, including underground mining equipment and surface mobile equipment. Some of the clean waste has been collected and disposed at the current non-hazardous waste landfill (Area 8) in recent years, however, a large amount of waste remains in the storage yards. A large inventory of lead-acid batteries was collected from this area in 2000, and transported to lead recycling facilities off site (Deton'Cho Environmental Alliance 2000b). The majority of the remaining waste is non-hazardous, although small quantities of hazardous materials could remain in this area, such as hydrocarbon products associated with vehicles.

5.12.3 Area 3: South Pond Tire Dump

An inventory of used rubber tires is located in a flat area southwest of the South Pond.

5.12.4 Area 4: B1 Open Pit

The B1 Pit was designated as a disposal site for non-hazardous wastes in 1993, and was recognized as such by the GNWT (Royal Oak Mines 1998b). Some wastes, designated by the mine operator as non-hazardous, were placed near the bottom of the pit, and covered with waste rock and soil. Other waste was later placed on top of the fill, including underground and surface mobile equipment, piping, and tanks. No waste has been placed in this area since 1998 when it was recognized that the placement of waste in the pit could interfere with remediation measures for the arsenic trioxide dust stored in adjacent underground stopes.

5.12.5 Area 5: Central Pond Hazardous Waste Area

A disposal site for hazardous wastes is located on tailings in the northwest corner of the Central Pond, just below the Tailings Retreatment Plant. The wastes deposited there, which are partially buried in tailings, include asbestos containing materials attached to old equipment, and rusted steel drums that may contain asbestos and arsenic contaminated materials.

5.12.6 Area 6: Dam 1 Area

Waste is stored in several locations just east of Dam 1, south of the Polishing Pond. This includes non-hazardous steel waste (old equipment), as well as a large quantity of steel drums that originally contained hydrocarbon products. The drums are believed to be largely empty, although the presence of hydrocarbon staining in this area indicates that residues may remain in the drums.

5.12.7 Area 7: Northwest Pond Hazardous Waste Area

This area was designated by the mine operator for hazardous waste handling soon after the tailings pond was commissioned in 1987. Initially, the area was designated as a disposal site for wastes such as asbestos containing materials and arsenic contaminated materials. The arsenic contaminated materials included steel process equipment with arsenic scale, used bags from the arsenic trioxide baghouse, and personal protective equipment. The intent was to bury the waste with the deposition of tailings, as had previously been the practice for these types of waste. The waste materials were initially dumped at the site, without the intent of recovery for disposal elsewhere. At some point in the early 1990's, the function of the site changed from disposal to storage, after which, sealed drums of waste were placed upright on solid ground so that they could be easily recovered later.

From 2000 through 2004, a substantial clean up of this site was completed in several phases. Drums of waste that were not originally marked with the type of waste contained were opened and inspected. Several waste samples were collected and analysed. Drums containing arsenic contaminated materials (principally baghouse bags, clothing, and scale cleaned from process equipment), were placed in plastic over-pack containers, stacked on pallets at a new site nearby, and covered with plastic. Damaged and corroded drums containing arsenic contaminated materials were also collected and placed in over-pack containers.

Asbestos containing materials were also identified and collected in this process. An asbestos disposal landfill was created nearby by excavating a trench in dry tailings in the Northwest Pond, placing the waste in the trench, and backfilling it with tailings.

5.12.8 Area 8: Northwest Pond Non-Hazardous Waste Area

A disposal site for non-hazardous wastes has been operated at the north end of the Northwest tailings pond since the pond was commissioned in 1987. In the period of active tailings disposal, the waste was covered with tailings discharged from the Mill. In the years since tailings disposal ceased, a large amount of non-hazardous waste has been collected across the mine site and placed on the tailings in this area. This waste is routinely covered with waste rock. The waste typically disposed of in this area includes steel, wood, rubber, plastics and paper products. Scrap steel continues to be disposed of here.

5.13 Current Site Management

The Deton'Cho/Nuna Joint Venture provides care and maintenance of Giant Mine under contract to the federal government. Routine environmental protection activities have included pumping water from the underground mine to the surface storage ponds, monitoring and maintaining the tailings dams, operating the water treatment system and discharging treated water during the open water season, and monitoring environmental quality. Additional details regarding ongoing site management was presented in Section 1.7.1.

6 Remediation Project Description

6.1 Introduction

The "development" under consideration in the current EA is the remediation of the Giant Mine site. The site and its key features are shown in Figure 6.1.1. The proposed actions were first described in the Giant Mine Remediation Plan. During the EA scoping phase, the Review Board developed the *Terms of Reference* that requested further detail on some of the proposed activities. The *Terms of Reference* also specified that all relevant information should be made available within the DAR, rather than only by reference to previous documents.

This section therefore presents the proposed development. Some sections are very similar to analogous sections of the Giant Mine Remediation Plan. Others have been altered or expanded to address particular issues raised in the *Terms of Reference* or to be consistent with the current level of design.

6.1.1 Remediation Objectives

The specific objectives of the Remediation Project are to:

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

6.1.2 Summary of Post-Remediation Conditions

Figure 6.1.2 presents a conceptual view of the remediated site. Following implementation of the Remediation Project, the arsenic storage areas will be fully frozen and the freezing system converted to a passive system, such as thermosyphons, to maintain the frozen state indefinitely. A fence will be constructed around each of the arsenic trioxide storage areas and any associated infrastructure. The enclosed areas will remain under the control of INAC and the GNWT, as outlined in the INAC-GNWT Cooperation agreement referenced in Section 1.1.4.

Figure 6.1.1 Surface and Underground Site Components

Figure 6.1.2 Conceptual Post Remediation Site Conditions

Throughout the 25 year temporal scope considered in the EA, the water level in the mine will be maintained below the bottom of the open pits to prevent the formation of contaminated pit lakes (see Section 2.3.2 for further information on the temporal scope of the EA). Access to the open pits will be restricted by fencing or berms to ensure public safety. All openings to the underground, including those in the pits, will be permanently sealed where warranted by safety issues.

The induced hydraulic capture zone created by the continued drawdown of minewater will prevent the release of contaminated groundwater to the surrounding environment. Surface water from remediated areas (tailings ponds, etc.) that does not meet discharge criteria will be collected and directed into the minewater system for eventual treatment. A new Water Treatment Plant will be constructed and will be operated year-round, potentially in perpetuity. The discharge point for treated minewater will be moved from Baker Creek to Yellowknife Bay following the construction of a new outfall and diffuser.

Hazardous materials will be placed in engineered facilities and, with the exception of buildings that may be preserved for their heritage value, all existing structures will be removed. Soils exceeding industrial soil contamination criteria will be removed or covered with clean fill to make these areas suitable for industrial uses. Examples of possible uses include staging areas for winter roads, fuel storage, warehousing or light industry.

The tailings and sludge impoundments will be regraded and surfaced with covers to allow vegetation to establish and for the reclaimed areas to eventually be available for public use.[15] Examples of possible uses include the development of walking, skiing or interpretive trails. Sports fields could also be constructed on portions of the covered tailings. All quarries, borrow pits and waste disposal areas will be regraded and covered to promote drainage and revegetation in areas not consisting of exposed bedrock.

Various options for the remediation of Baker Creek are currently being developed with the input of government departments. The designs will also take into consideration input from Aboriginal and local residents that will be obtained through future consultation activities. The selected approach will physically stabilize the creek and improve both the quantity and quality of habitat. In this regard, the Remediation Project is expected to result in a gradual increase in numbers and diversity of fish, animals, wildfowl and native vegetation present in the drainage area of the creek. At the discretion of DFO, catch and release fishing could continue. Food fisheries may need to be discouraged, depending on the level of residual arsenic contamination.

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[15] The conceptual designs presented in the Remediation Plan and this DAR anticipate that areas such as the tailings and sludge impoundments will be vegetated following the placement of covers. This is consistent with the approach used in the vast majority of mine reclamation projects. However, alternate approaches will be considered during the preparation of detailed designs, subject to feedback received during future community consultation activities.

Decisions regarding future land use will be the responsibility of the land owner, the GNWT. However, several parties have expressed an interest in specific areas of the site and have identified plans for their use. Notably, the City of Yellowknife has established a vision for the development of portions of the Giant Mine site that it currently leases (i.e., the Giant Mine townsite and waterfront area surrounding the Cruising Club). The vision is presented in a land/water use plan prepared by the City of Yellowknife (2006) and includes several goals:

- Residential and commercial development;
- Community accessibility for recreation and tourism;
- Heritage preservation; and
- Natural preservation and environment.

Possible land uses identified by the City of Yellowknife include a UNESCO Geopark, retaining historically important buildings, enhanced mining heritage and recreational sailing uses, waterfront access for a public day use area and recreational use, ski-club trails, residential development and the protection of public viewpoints (City of Yellowknife 2006).

In addition to the vision established by the City of Yellowknife, the NWT Mining Heritage Society has expressed an interest in using parts of the Giant Mine site in the vicinity of A Shaft as a mine heritage centre, and the "Rec Hall" building in the former townsite as an exhibit hall (NWT Mining Heritage Society 2008).

6.2 Arsenic Trioxide Dust Storage Areas

6.2.1 Key Concerns

Current conditions in the arsenic trioxide dust storage areas are described in Section 5.1. The key issue associated with the dust is the potential for the release of arsenic, either from within the storage areas or from material that has already seeped out of the storage areas, during and following flooding of the mine.

A second and more immediate concern is the physical stability of the dust storage areas. Several of the bulkheads below the chambers and stopes have been identified as having moderate to high failure risks. There is a potential that arsenic trioxide dust would be released to the lower mine workings if one of the bulkheads were to fail, thereby complicating efforts to manage the effects associated with the dust. Failure of the crown pillars above some of the chambers and stopes is also a concern due to the potential for water to enter the arsenic trioxide storage areas and/or for dust to be released on surface.

6.2.2 Assessment of Alternatives

The selection of a method to manage the arsenic trioxide dust storage areas has been a long and careful process, involving dozens of scientific and engineering studies, as well as extensive consultation with local residents. The following paragraphs give a short overview of this process. A more detailed discussion of the many alternatives considered can be found in SRK (2002a) and IPRP (2003).

6.2.2.1 Technical Advisor Studies

In late 1999, when Royal Oak Mines Inc. went into receivership, INAC took on the task of developing a long-term management plan for the arsenic trioxide dust. This led to a decision to contract a "Technical Advisor" (see Section 1.5.1 for further details). During the period from January 2000 to December 2002, the Technical Advisor team:

- Compiled a detailed history of arsenic trioxide production and storage at Giant Mine;
- Reviewed all available information about the arsenic trioxide dust and the chambers and stopes in which it is stored;
- Carried out or directed investigations to further characterize the properties of the dust and the storage areas and to determine the current and possible future releases of arsenic to the receiving environment;
- Completed assessments of the ecological and human health risks associated with the current and possible future releases of arsenic;
- Assessed over 56 methods that were potentially applicable to the long-term management of the arsenic trioxide dust, and evaluated the feasibility, risk, and costs of four groups of alternatives;
- Prepared a comprehensive report, with 17 supporting technical documents, presenting the results of the initial evaluations (SRK 2001c);
- Carried out additional detailed evaluations of 12 specific alternatives selected on the basis of the technical merits and public response to the initial report;
- Prepared a second comprehensive report, including 19 supporting technical documents, to present results of the detailed evaluations (SRK 2002a); and
- Participated in three major public workshops, as well as presentations to interested community groups.

Results of the Technical Advisor's assessment of the risks associated with the arsenic trioxide dust and the management alternatives were presented in SRK (2002a). In brief, the risk assessment characterized possible human health and ecological risks associated with arsenic releases from the underground arsenic trioxide. After taking into account uncertainties in the assessment, the Technical Advisor concluded that 2,000 kg per year arsenic would be an appropriate target for the maximum arsenic releases from Giant Mine. That level of arsenic release would result in human health risks below the applicable thresholds and arsenic concentrations in North Yellowknife Bay at or below the CCME criterion for freshwater aquatic life (CCME 2007).

The 12 management alternatives considered included seven *in situ* alternatives that would keep the dust underground, and five *ex situ* alternatives that would take it to surface for disposal or re-processing. One of the *in situ* alternatives (Alternative C – deep disposal) and one of the *ex situ* alternatives (Alternative D – removal and surface disposal) were included as a result of requests from the public. The other *in situ* alternatives included three variants of perpetual water management and three variants of re-freezing the ground around the dust. The remaining *ex situ* alternatives included reprocessing of the dust to recover gold and high purity arsenic trioxide for sale outside the region, reprocessing of the dust to recover gold and stabilize the arsenic for local disposal and reprocessing to encapsulate the dust in either cement or bitumen for local disposal.

All 12 alternatives were initially evaluated to determine if they could meet the objective of keeping arsenic releases below 2,000 kg per year. Nine alternatives that were concluded to be capable of meeting that objective were then assessed on the basis of risks and costs. Three types of risk were considered: 1) the risk of arsenic release during implementation of the alternative; 2) the risk of arsenic release after the alternative was completed; and 3) the risk to worker health and safety. Cost estimates were developed for each alternative and included preparation and implementation costs as well as long-term monitoring and maintenance costs.

Table 6.2.1 summarizes the results of the second round of assessments. Alternatives A through C would keep the dust underground and therefore were classified as *in situ* alternatives. It was concluded that the best *in situ* alternative was Alternative B3, isolating the arsenic trioxide dust in its current location by creating a block of frozen dust and rock, monitoring in perpetuity and, if necessary, maintaining isolation by periodic refreezing. The water treatment alternatives, A1, A2 and A3, would require long-term operation of an active pumping and treatment system and, therefore, were considered to present higher risks of arsenic release over the long-term. Alternative C, mining the dust from its current locations and disposing it in new caverns at the base of the mine, was predicted to result in low long-term risks. However, it was determined that the worker health and safety risks associated with mining the dust would outweigh the slight reduction in long-term risks.

Alternatives D through G would require that the dust be brought to surface and were therefore considered *ex situ* alternatives. Alternative G1, comprising mining the dust, mixing it with cement, and storing it in a secure on-site landfill, was recommended as the best *ex situ* alternative. Alternative D, removing the dust and trucking it to a hazardous waste disposal site in Alberta, was concluded to present an unacceptable risk of arsenic release. Alternative F, mining the dust and re-processing it to recover gold and stabilize the arsenic, was considered to have a similar risk profile to Alternative G1. Given that the risks were similar, the Technical Advisor recommended the less costly method, G1, as the best *ex situ* alternative.

The Technical Advisor (SRK 2002a) noted that, in the public consultation carried out during the studies, some individuals had expressed reservations about options that would leave the dust in place, whereas others expressed concern about those that would bring the dust to surface. Therefore, the Technical Advisor recommended that both the best *in situ* alternative and the best *ex situ* alternative be carried through to the final round of public discussion.

Table 6.2.1 Summary of Alternatives Evaluated for the Remediation of Arsenic Trioxide Dust

Alternative	Risk of Arsenic Release		Worker Health & Safety Risk	Cost Range ($ Million)
	Short-term	Long-term		
A1. Water Treatment with Minimum Control	Low	High	Low	30-70
A2. Water Treatment with Drawdown	Low	Moderate	Low	80-110
A3. Water Treatment with Seepage Control	Low	Moderate	Low	80-120
B2. Frozen Shell	Very Low	Low	Low	90-110
B3. Frozen Block[c]	Very Low	Low	Low	90-120
C. Deep Disposal	Low	Very Low[b]	Moderate[b]	190-230
D. Removal & Surface Disposal	High	Very Low	Moderate	600-1000
F. Removal, Gold Recovery & Arsenic Stabilization	Moderate	Very Low	Moderate	400-500
G1. Removal & Cement Encapsulation[c]	Moderate	Low	Moderate	230-280

Notes:
(a) Alternatives B1, E and G2 were concluded to be infeasible and therefore were not further evaluated.
(b) Subsequent review by the IPRP (2003) concluded that the ratings shown here underestimate both the long-term risks and the worker health and safety risks associated with Alternative C.
(c) Alternatives B3 and G1 were concluded to be the best *in situ* and *ex situ* alternatives, respectively.

6.2.2.2 Independent Peer Review Panel Reviews

The Technical Advisor report (SRK 2002a) was comprehensively reviewed by the Independent Peer Review Panel (IPRP) consisting of nine of the country's top engineers and scientists in key disciplines that are relevant to the Project. In March 2003, the IPRP issued its report (IPRP 2003), which concluded:

"The IPRP considers that the December 2002 SRK Report is appropriate for the presently planned level of the studies (i.e. comparison and assessment of management alternatives). The IPRP agrees with SRK's selection of these two basic management alternatives."

6.2.2.3 Public Discussion of In Situ and Ex Situ Methods

The public discussion of the two alternatives recommended by the Technical Advisor began in January 2003 and included approximately twenty presentations to groups in Yellowknife, N'dilo, and Dettah. In addition, presentations were also made to the Community Alliance, a group of interested citizens, who act as a liaison between the local public and the Giant Mine Remediation

Project Team. The public discussion period culminated in a public workshop held in Yellowknife, May 26-27, 2003.

During the public discussion period, there were many expressions of concern about the *ex situ* alternative. These included statements from four Yellowknife Members of the Legislative Assembly and from GNWT staff rejecting the *ex situ* alternative. In contrast, while there were questions about, suggestions for improvements to, and requests for more study of the *in situ* alternative, direct opposition was limited.

In response to questions raised at a May 2003 workshop, both the IPRP and the Technical Advisor completed further reviews of Alternative C (deep disposal). Both reviews concluded that more detailed consideration only increased the preference for Alternatives B3 and G1, and that further consideration of Alternative C was not warranted. Table 6.2.2 summarizes the risks associated with the frozen block and deep disposal alternatives. The table clearly shows that the frozen block alternative is equal or superior to deep disposal in all categories. The difference is greatest in the implementation stage, where the frozen block alternative presents much lower worker health and safety risks than deep disposal. However, even in the long-term, when monitoring, contingencies and geological uncertainties are taken into account, the frozen block alternative is equal or superior to deep disposal.

Table 6.2.2 Summary Comparison of Risks and Uncertainties Associated with Frozen Block and Deep Disposal Alternatives

Project Phase and Risk/Uncertainty	Frozen Block	Deep Disposal
Preparation		
Selection of location	Not required	Difficult
Conventional worker safety risk	Lower	Slightly higher
Implementation		
Conventional worker safety risk	Lower	Higher
Worker health risk (due to arsenic exposure)	Much lower	Much higher
Risk of arsenic release to environment	Much lower	Higher
Post-Implementation		
Requirement for short-term pump & treat	Possibly required	Certainly required
Difficulty of short-term pump & treat	Lower	Moderately higher
Duration of short-term pump & treat	Uncertain	Uncertain
Long-term		
Difficulty of detecting failure of containment	Lower	Higher
Difficulty of contingency measures	Lower	Higher
Potential for immediate arsenic release in event of no care & maintenance	Very low	Very low
Potential for arsenic release after decades of no care & maintenance	Low	Low

After considering the public feedback and the follow-up studies, the Technical Advisor made the following recommendation to INAC:

"The in situ alternative recommended by the Technical Advisor, namely Alternative B3 – Ground Freezing as a Frozen Block, should be adopted as the preferred approach for managing the arsenic trioxide dust stored underground at Giant Mine. Elements of the alternative should be modified to take into account suggestions made by the general public, the Yellowknives Dene, and the GNWT. The modified alternative should be described within a Project Description that presents a complete plan for final closure and reclamation of the Giant Mine site, including surface works. The Project Description should then be submitted for formal environmental review, licensing and subsequent implementation."

6.2.2.4 Future Re-Consideration of Alternatives

The question of future re-consideration of alternatives for managing the arsenic trioxide dust was raised many times during the initial review process.

In theory, more attractive alternatives could present themselves in the future. However, INAC and the GNWT believe that the assessment of currently available alternatives has been exhaustive, and that the patterns that became apparent from that work show that it is unlikely that markedly superior alternatives will be identified. Specifically, the assessment included all currently available methods, even those in the early stages of research, and found nothing that had future promise. Furthermore, the assessed alternatives included examples of all conceivable classes of options. Where entire classes of options have been shown to be deficient, the conclusion will hold even if the future brings improvements in particular methods.

It should also be recognized that, once the proposed alternative is implemented, long-term risks will be reduced to levels such that it will be difficult to justify the costs and increased short-term risks associated with implementing a completely different alternative. In other words, the successful implementation of the frozen block method will significantly raise the thresholds by which any other alternative will be assessed.

For all of these reasons, INAC and GNWT view the frozen block method as the long-term solution for Giant Mine arsenic trioxide, rather than as a temporary measure. The Project Team remains open to improvements in the frozen block method, and will re-evaluate alternatives if technologies advance or if monitoring data indicate unforeseen emerging risks to the environment and/or humans. However, there is no intention of turning the proposed remediation into a long-term search for "something better".

6.2.3 Overview of Frozen Block Method

The general concept of the recommended "frozen block method" (Alternative B) is illustrated in Figure 6.2.1. Further details are provided in the following sections. The ground under and around the arsenic trioxide dust storage areas will be frozen first to create a "frozen shell" that will prevent any escape of arsenic. The interior of the frozen shell will then be flooded with water and cooled to create the "frozen block". Freezing of the flooded dust will take several years, primarily due to the latent heat released by the water as it changes to ice. The frozen conditions will be maintained over the long-term, and the large volume of ice in the frozen block will provide additional protection against thawing.

Several variants of the freezing method have been evaluated. The primary choice to be made was between "active freezing" and "passive freezing". Active freezing is accomplished by circulating a cold liquid through pipes installed in the ground. The term "active" is used because the method requires the input of power to cool the liquid and pump it through the pipes. The cooling normally takes place in a "freeze plant" constructed for the purpose. Active freezing is the most common method and has been in use to freeze the ground around tunnels and shafts for over 120 years. It has also been used to create frozen underground walls that prevent water from entering mines.

Passive freezing in this concept utilises a series of "thermosyphons", which are steel pipes that "syphon" heat from the ground and disperse it into cold air. In the typical installation each pipe is sealed and then filled with pressurized carbon dioxide, with the pressure adjusted so that the carbon dioxide forms a liquid at typical winter air temperatures and a gas at typical ground temperatures. The liquid carbon dioxide then flows downward into the underground portion of the pipe. Wherever the ground is warm, it causes the liquid carbon dioxide to heat up and transform into a gas. The carbon dioxide gas then rises up the pipe to the portion extending into the cold winter air, where it is cooled and transformed back to a liquid. A radiator added to the top of the pipe allows the heat released by condensing gas to be dissipated. The cycle repeats itself, effectively transferring heat from the warmer ground into the colder air. In areas where the winters are cold enough, the result is a complete freezing of the ground. The term "passive" is used because after the initial construction and charging of the thermosyphons, no additional energy is required.

Thermosyphons have been used for decades to maintain permafrost at shallow depths, and have recently been applied to create frozen walls around shallow contamination. The use of a thermosyphon to preserve and cool warm permafrost over the depths typical of the arsenic trioxide chambers and stopes has been tested at Giant Mine since 2002. The data collected thus far indicate that the thermosyphon is capable of developing frozen ground along its 100 m length and that it is performing as expected. After considering the advantages and disadvantages of each approach, it is apparent that the best option for freezing the arsenic chambers and stopes will be a combination of active and passive methods. Two combinations are being considered:

1. Using an active freezing system to freeze the ground followed by passive freezing to maintain frozen conditions over the long-term; and
2. Using a hybrid active-passive system, consisting of thermosyphons that can be connected to a freeze plant during the summer, to freeze the ground, and then switching the system to a fully passive operation over the long-term.

The active freezing approach has been used in very similar applications elsewhere and therefore has all the advantages of being a well-tested technology. On the other hand, use of a hybrid system has the potential to reduce power consumption and would simplify the subsequent conversion to a fully passive system. Advantages and disadvantages of the two approaches are being further investigated in the Freeze Optimization Study (FOS) that commenced in June 2009. Broader objectives of the FOS, including anticipated data collection, analysis and timelines, are presented in the following subsections, and summarized in Section 6.2.9.1.

6.2.4 Underground Stabilization

Implementation of the ground freezing is expected to take up to ten years. During this time, failure of the high risk bulkheads and crown pillars may pose a significant risk for arsenic release (as discussed further in Sections 5.1.4 and 5.1.5). The locations of the high risk bulkheads and crown pillars are shown in Figure 6.2.2.

6.2.4.1 Bulkheads

As described in further detail in Section 5.1.5, the chambers and stopes used to store the arsenic trioxide dust are secured by engineered bulkheads. The actual construction of the bulkheads, however, cannot be verified in most cases due to lack of as-built reports. Bulkheads were constructed in all access workings leading to each chamber or stope. A total of 61 bulkheads remain in service, with 26 potentially holding back dust directly. The long-term stability of these bulkheads is questionable and the short-term stability of some of them is also a source of concern. All of the accessible lower bulkheads have been the subject of investigations, including non-destructive testing, and are included in regular inspections as summarized previously in Table 5.1.8.

Measures to determine long-term stability and, where necessary, stabilize the bulkheads containing the arsenic dust are either in planning or have already been implemented. All bulkheads will be incorporated within the frozen zone around each chamber and stope.

Figure 6.2.1 Schematic of the Criteria for Ground Freezing

Figure 6.2.2 Location of High Short-Term Risk Bulkheads and Crown Pillars

6.2.4.2 Crown Pillars

Investigations to evaluate whether the chambers and stopes containing arsenic trioxide dust will remain stable while the final remediation plan is implemented have identified four “pillars” that are at risk of failure. The term “pillar” refers to rock that remains in place after mining has removed underlying, adjacent, or overlying material. Three of the four identified risk areas are “crown pillars” (i.e., rock left between the top of a mined out chamber or stope and the ground surface).

The risks associated with the crown pillar of stope C212 were reduced in 2006 by the relocation of Reach 4 of Baker Creek, which previously passed directly over the stope and would have quickly inundated the mine in the event of a failure. The pillar between the bottom of stope B208 and the underlying stope B306 is also considered at risk of failure. Work there has included the development of a new access drift that has allowed direct inspection and monitoring of the pillar, and will facilitate future backfilling of the void.

The crown pillars above stopes B208 and B212, B213 and B214 are also considered to be at risk of failure. Options to stabilize, cap and/or fence off the crown pillars were reviewed. It was concluded that capping and/or fencing would present unacceptable risks of arsenic dust release in the event of future crown pillar failures. The preferred option is to stabilize the ground by backfilling the voids between the crown pillars and the arsenic trioxide dust. Several materials are being considered for use as backfill, including coarse rock, cemented aggregate and foam cement. All are thought to be adequate to stabilize the crown pillars, but additional cost and constructability analyses are needed before a selection is made. Following freezing, all crown pillars will be supported by the frozen dust, ice, or fill placed prior to freezing.

6.2.4.3 Arsenic Distribution Pipes

In 2007, a procedure was developed to contain arsenic trioxide in pipelines on surface and underground. The surface pipes were transported to the Northwest Pond hazardous materials area for storage. The underground pipes were moved inside an area that would be frozen with the freeze program for the underground arsenic trioxide storage areas.

6.2.5 Freeze System Installation

6.2.5.1 Surface Preparation

To carry out the initial ground freezing, a series of freeze pipes will need to be installed around the perimeter and below the bottom of each arsenic trioxide chamber and stope. The perimeter freeze pipes will be installed from the surface. The surface expression of the freeze pipes in each of the four main areas is illustrated in Figure 6.2.3.

Figure 6.2.3 Surface Preparation for Freeze Pipe Installation

Area AR1 is located below a large bedrock outcrop east of the B2 Pit. A ramp will be constructed to provide access for the drill rig and related equipment, and for long-term monitoring and maintenance access. Depending on the drilling method selected and the related access requirements, further re-shaping of rough portions of the outcrop may be necessary.

Area AR2 is situated between Highway 4 (Ingraham Trail) and C-Shaft. Chamber 10 within Area AR2 is the target of the FOS, and the ground above it was modified in June 2009 as part of the study. Contaminated material was removed and replaced by imported crushed rock to provide a level working surface. The area overlying Stope C212 and adjacent to Chamber #9 will also require contaminated soil removal and/or soil cover and construction of a granular pad. As noted above, Reach 4 of Baker Creek passed over stope C212 in this area but was relocated in 2006. The former Mill Pond has been drained and will be partially backfilled with granular material to allow for the installation of the freeze pipes.

Area AR3 is between the Roaster Complex and the B1 Pit. Highway 4 passes over chambers B233 and B234. The installation of the freeze pipes will require the relocation of a 1.5 kilometre stretch of Highway 4 and demolition of buildings. Contaminated soil will be removed and/or covered. Minor regrading may also be needed to allow access for the drilling and freeze pipe installation.

Area AR4 underlies the north end of the B1 Pit. Backfilling of the pit, described further in Section 6.4.3, will provide access for drilling and freeze pipe installation.

6.2.5.2 Underground Preparation

All arsenic distribution pipes outside of the frozen blocks, as shown in Figures 6.2.4 to 6.2.7, will be dismantled and placed within a frozen block zone for long-term disposal. Any spills of arsenic dust that are encountered will be cleaned up and deposited in the nearest accessible arsenic chamber or stope.

All mine drifts leading to a frozen block zone will be plugged. Backfill plugs will also be installed wherever freeze pipes need to pass through open drifts or other voids. The plugs will provide a thermal connection to the walls of the drift or void, allowing the freeze wall to form without unfrozen gaps. A program to test methods for creating backfill plugs forms part of the FOS.

Installation of horizontal freeze pipes under the chambers and stopes will require the development of new access tunnels. All four areas will require underground development that will be connected to existing mine workings as shown in Figures 6.2.4 to 6.2.7.

Figure 6.2.4 Underground Access in Area AR1

Figure 6.2.5 Underground Access in Area AR2

Figure 6.2.6 Underground Access in Area AR3

Figure 6.2.7 Underground Access in Area AR4

The requirements for new underground access workings will be determined by the size and manoeuvrability of the underground drilling equipment, the equipment used for the installation of the freeze pipes and the equipment used to service the freezing system, all of which will be assessed as part of the FOS. The currently projected amount of underground development is summarized in Table 6.2.3, and is estimated to require the excavation of approximately 21,000 m^3 of rock from over 1,300 m of tunnel. The development rock will be used as clean backfill for other underground activities.

Table 6.2.3 Quantities for Underground Development

Area	Components	Volume (m^3)	Length (m)
Area 1	Drill drifts and access	6,500	446
Area 2	Drill drifts and access	5,980	374
Area 3	Drill drifts and access	6,340	396
Area 4	Drill drifts only (access drift included in Area 3)	2,260	142
	Total:	**21,080**	**1,358**

6.2.5.3 Freeze Pipe Installation

The current estimated total number and length of drill holes and freeze-pipes are summarized in Table 6.2.4. The estimates are based on an assumption of active freezing, with pipe spacing derived using thermal models that in turn rely on estimates of cooling rates and rock thermal properties. The FOS is expected to result in improvements to the parameter estimates, which could lead to changes in pipe spacing, drillhole numbers and total lengths. The changes are not expected to exceed 25% (increases or decreases) of the estimates provided in Table 6.2.4.

Table 6.2.4 Drilling and Pipe Summaries for Freeze Installation

	Surface Holes	U/G Holes	Surface Pipes (m)	U/G Pipes (m)
Area 1	180	63	11,139	1,970
Area 2	135	57	12,773	2,066
Area 3	206	57	18,673	2,560
Area 4	87	27	8,829	1,009
Total (with 15)	608	204	51,414	7,605

Note: Chamber 15 has been included in the installation requirements for AR1, although it currently does not contain any arsenic trioxide dust. Chamber 15 has been included as a contingency for storing other high-arsenic waste on site. Quantities do not include contingencies for possible extra drillholes and pipes needed at final engineering stage or for problems encountered during installation (drillhole deviation, etc.)

Surface drilling methods under investigation in the FOS include mud rotary, downhole hammer and coring. The downhole hammer method has so far provided the best combination of alignment accuracy and drilling efficiency. However, the other methods may need to be applied in particular cases where angled or directed holes are required. Underground drilling methods are also under consideration as part of the FOS which is using drillholes of 150 mm (6 inches) in diameter, in order to accommodate 100 mm (4-inch) active freeze pipes. Smaller diameter freeze pipes are also being tested and may allow drillhole diameters to be reduced.

Other details of the current estimates are provided in Table 6.2.5. In total, the current design calls for installation of nearly 900 freeze pipes for a cumulative length of about 65,000 m. Those numbers include an allowance for 10% re-drilling and replacement of pipes. The perimeter freezing system installed from surface represents 75% of the total pipes and 87% of the total drilling length. The bottom freezing system installed underground comprises the remainder.

The underground installation will also require the drilling from the surface of at least three holes for vertical coolant supply, return pipes and instrumentation cables.

Table 6.2.5 Compilation of Underground and Surface Drilling Quantities

	QUANTITIES	Quantity			Total Length of pipe (m)			Average Length of pipe (m)		
		Surface	Underground	Total	Surface	Underground	Total	Surface	Underground	Total
Area 1	11	34	12	46	1,924	373	2,297	56.6	31.1	49.9
	11 and 12	7	0	7	471	0	471	67.3	0.0	67.3
	12	51	19	70	3,343	658	4,001	65.5	34.6	57.2
	12 and 15	8	0	8	549	0	549	68.6	0.0	68.6
	14	30	15	45	1,630	420	2,050	54.3	28.0	45.6
	14 and 15	19	0	19	1,191	0	1,191	62.7	0.0	62.7
	15	31	17	48	2,031	519	2,550	65.5	30.5	53.1
Area 2	9 and 10	51	28	79	4,917	986	5,903	96.4	35.2	74.7
	9, 10 and C212	24	0	24	2,255	0	2,255	94.0	0.0	94.0
	C212	60	29	89	5,601	1,080	6,681	93.4	37.2	75.1
Area 3	B208	63	23	86	5,613	886	6,499	89.1	38.5	75.6
	B230	22	9	31	2,029	242	2,271	92.2	26.9	73.3
	B233	7	8	15	614	514	1,128	87.7	64.3	75.2
	B234	29	6	35	2,587	381	2,968	89.2	63.5	84.8
	B235 and B236	34	11	45	3,167	537	3,704	93.1	48.8	82.3
	B208 and B234	4	0	4	353	0	353	88.3	0.0	88.3
	B230 and B233	16	0	16	1,474	0	1,474	92.1	0.0	92.1
	B233 and B234	16	0	16	1,442	0	1,442	90.1	0.0	90.1
	B230, B233, B235 and B236	15	0	15	1,394	0	1,394	92.9	0.0	92.9
Area 4	B212, B213 and B214	87	27	114	8,829	1,009	9,838	101.5	37.4	86.3
	Subtotal:	608	204	812	51414	7605	59019			
	Re-drilled quantity (10%)	61	20	81	5141	761	5902	84.5	37.3	72.7
	Total:	669	224	893	56,555	8,366	64,921	AVERAGE		

6.2.5.4 Freeze Plant

If an active freezing system is selected, one or more freeze plants will be constructed. Each freeze plant will house the refrigeration units/compressors to cool the primary coolant, the heat exchangers between the primary and secondary coolants, the maintenance and storage areas, the control room and the power system. Based on current estimates of freezing rates, the plant or plants would require industrial grade power installations of up to 3.0 megawatts capacity. As is discussed further in Section 6.2.6, the peak power demand will be determined by the sequencing of freezing the chambers.

The currently preferred location for a single freeze plant is central to the four freezing areas, in close proximity to the new water treatment plant. Locating the two facilities together will simplify security requirements, and allow for the possibility of using waste heat from the freeze plant in the water treatment plant.

The design, construction, installation and commissioning of freeze plants are well understood processes. For example, the freeze plant at the McArthur River Mine in northern Saskatchewan is of a very similar size plant, and was constructed and continues to operate under similar conditions to those at Giant Mine.

A choice to use a hybrid freezing system could result in major changes to the freeze plant design. For example, a series of smaller plants, each located near one of the dust storage areas, could prove to be more cost effective than a single large plant. Similarly, if start-up of the hybrid systems can be timed for winter, the peak power demand for active freezing could also be reduced.

6.2.5.5 Coolant Distribution Piping

The cold “secondary coolant” coming out of the freeze plant will be routed to the freeze pipes via a series of supply lines. The distribution piping for a group of freeze pipes will be laid out with a common large-diameter header which will have successive reductions in pipe size as individual freeze-pipe take-offs are attached. The freeze pipes will tie into a common return header which will then lead back to the freeze plant.

Flow and pressure balance modelling, during the detailed design phase, will determine the pipe sizes. For example, in the FOS, the distribution piping is 250 mm (10-inch) diameter, with 102 mm (4-inches) of foam glass insulation and aluminum cladding. All surface piping will be laid out on pipe racks.

In an active freezing system, the coolant distribution piping will connect to a “top-hat” fitting on each freeze pipe. The fitting will direct inflowing coolant into an open-ended high density polyethylene (HDPE) tube that will extend to the bottom of each freeze pipe. The secondary coolant will then return up the annulus between the outer steel and inner HDPE tube, extracting heat from the ground in the process. The top of the annulus will be connected to the return header which will direct the secondary coolant to return lines and ultimately back to the freeze plant.

The secondary coolant will be required to be capable of operating at -40°C without crystallizing and without solidifying. This will allow the system to be operated without installing heat tracing to prevent freezing if flow within the system is stopped for more than a few hours. Several options for secondary coolant are under consideration. Historically, the most common secondary coolant has been brine, typically a strong solution of calcium or sodium chloride. Ethylene glycol and propylene glycol have also been used. The currently preferred secondary coolants are organic based, non-toxic and bio-degradable fluids specifically designed to provide effective cooling with minimal environmental risk. Several variants of heat transfer fluids are available under various trade names.

Hybrid systems may use a similar set of distribution pipes to deliver secondary coolant to the freeze pipes. However, in this case the secondary coolant would not travel down the pipes. Instead, it would enter a heat exchanger connected to the top of each thermosyphon. The heat exchanger would cool the carbon dioxide inside the thermosyphon. The liquid carbon dioxide would travel down into the ground, returning to the heat exchanger as a warmed gas. If the hybrid system were to include the options of multiple smaller freeze plants, distribution piping sizes would also be smaller.

An alternative hybrid system that is being tested in the FOS involves the delivery of primary coolant directly to the point of heat exchange with the carbon dioxide. The thermodynamic efficiency advantage offered by such a system is that it might provide a substantial reduction in power costs. Whether the savings are sufficient to warrant the additional complexity associated with transporting primary coolant outside of the freeze plant remains to be seen.

6.2.5.6 Instrumentation

Modern ground freezing systems are heavily instrumented to allow both control of the cooling process and immediate detection of leaks or other problems. The freeze plant designer typically incorporates a complete instrumentation and controls package within the plant itself. For example, instrumentation provided within the FOS system includes:

- Suction and discharge pressures and temperatures on the primary coolant loop;
- Suction and discharge pressures and temperatures on the secondary coolant loop;
- Coolant supply and return temperatures and flow rates;
- Coolant supply and return header by-pass loop flow rate;
- Coolant mixing/surge/storage tank levels;

- Freeze plant control room ambient temperatures;
- Freeze plant electrical power draw;
- Leak detection and alarms; and
- Other refrigeration related alarms (e.g., high/low level indicators, emergency switches, motor run indicators, controllers, etc.).

Similar instrumentation is anticipated to be incorporated into the final designs for the freeze system. Instrumentation on the coolant distribution and freeze pipes will include temperature, pressure and flow monitoring on both supply and return lines. These will allow the rate of heat extraction from each group of freeze pipes to be monitored and controlled, and any leakage of secondary coolant to be immediately detected. Several instrument types are being tested in the FOS. The exact numbers, locations and types of instruments for the freeze implementation will be determined in a later stage of design.

An additional set of instruments will be installed in drillholes located around the freeze pipes to monitor the progress of the cooling front into the surrounding rock and dust. In general, these will be temperature monitoring devices. Thermistors are currently thought to be the preferred choice, but thermocouples and resistance temperature devices are also being tested in the FOS. Water pressure sensors will also be included in monitoring strings inserted into the dust. Again, the numbers, locations and types of instruments will be determined at a later stage of design.

It is expected that all of the instruments will be connected to a data collection and storage system. Methods for handling the expected large volumes of monitoring data are also being tested in the FOS.

6.2.6 Initial Freeze

The freezing in each area will be accomplished in three steps:

1. Freezing the ground around and under each chamber and stope to create a completely frozen shell;
2. Wetting the dust and flooding the remaining void space within each frozen shell; and
3. Freezing the flooded zone to create each frozen block.

The most effective methods to accomplish each step remain under investigation, principally through the ongoing FOS. The discussion below focuses on the current concepts and estimates, but also describes other possibilities where uncertainties remain.

Step 1 Creating the Frozen Wall

The objective of the first step will be to create a frozen zone around each storage area that is wide enough to prevent any outflow of water or soluble arsenic trioxide when the chamber or stope is flooded. The current design criterion to reflect that objective is a ground temperature colder than -10°C over a distance of at least 10 m around and below each chamber and stope.

Table 6.2.6 shows an example freezing sequence for the case of a fully active freezing system. The principle behind this example sequence is to distribute the initiation of freezing so that about one-quarter of the freeze pipes would come on line in each year. Experience elsewhere shows that the initial months of ground freezing require the greatest power draw. Distributing the start-ups over time would minimize the overall peak power requirement. This sequencing would also allow the drilling of freeze holes and installation of freeze pipes to proceed in an orderly manner, just ahead of the piping and freeze system connections.

The one-year periods shown in Table 6.2.6 are optimal based on current estimates of drilling rates, power consumption and rock thermal properties. However, results of the FOS are required before those estimates can be confirmed or improved.

Table 6.2.6 Example Sequence for Initiation Using Active Freezing

Area	Chambers Stopes	Year 1	Year 2	Year 3	Year 4	Convert Active Freezing to Passive Freezing
AR1	#11					Year 6
	#12					
	#14					
	#15					
AR2	#9 & #10					Year 7
	C212					
AR3	B208					
	B230 & B233					Year 8
	B233 & B234					
	B235 & B236					
AR4	B212-213-214					Year 9

If a hybrid freezing system is selected, the freeze schedule could change. Peak heat removal during initiation of the freezing could be distributed between active freezing with the freeze plant during summer, and passive freezing using the thermosyphons during winter. That could conceivably shorten the total time needed to freeze the four areas. On the other hand, it is possible that hybrid systems will not be able to consistently reach the very low temperatures achievable with active systems. The consequence would be a requirement to modify the current freezing criteria, accept longer freezing times, or revert to active freezing methods.

Temperatures in the frozen wall around each chamber or stope will be monitored throughout the initial freezing to ensure that the design criteria are met prior to the next step, introducing additional water into the dust.

Step 2 Wetting the Dust

The objective of the second step will be to add water to the chambers and stopes, so it can be converted to ice in the next step. Complete and uniform saturation of the dust is not required; the "frozen block" concept only requires that a large mass of frozen water be developed somewhere within each chamber or stope. However, it would be desirable to distribute the water as much as possible throughout each chamber and stope prior to freezing.

The dust is thought to be quite open, with porosity estimated at up to 60%. The high porosity and the high latent heat of freezing water means that if water at even 1 or 2°C is added to the dust, it will infiltrate before it freezes. On the other hand, tests to date indicate that the dust has a relatively low hydraulic conductivity, estimated at $7x10^{-7}$ m/s. Based on these estimates, simply adding water to the surface of the dust and allowing it to infiltrate would be feasible but slow, taking up to several months in the larger chambers.

Other alternatives, involving more energetic blending of the dust with the water, are also under consideration. One method would involve lowering a high pressure nozzle into the dust through a borehole drilled from surface. Water would then be jetted into the dust, working from the base of the chamber or stope upwards to the top, and ultimately filling the available space with water. The equipment for this method exists and has been used in "borehole mining" of uranium, coal and kimberlite deposits. The water pressures in those cases are high enough to pulverize the target rock and allow it to be extracted from boreholes in the form of a slurry. The available energy would certainly be sufficient to distribute water through the relatively loose arsenic dust. Wetting methods remain in concept at this time and additional tests are planned as part of further design.

Step 3 Freezing the Block

The freezing systems required to develop the frozen block will continue to be operated until the water and dust within each chamber and stope reaches the target of -5°C. Modelling results presented in SRK (2006b) assumed active freezing for the first five years and passive freezing thereafter, and estimated that it would take up to ten years for all of the dust in the largest stopes to reach -5°C.

Table 6.2.7 provides a summary of estimated times to form the frozen shells and frozen blocks. The table also shows that the frozen block will continue to cool, and will eventually reach the same temperature as the frozen shell. However, the primary role of the frozen block is to provide a mass of frozen water that will resist any future increases in temperature. Thermodynamic considerations show that the most important component of that resistance would be the transition from about -1°C to just above 0°C (i.e., the point where the ice would have to be melted). Cooling of the block below that range provides little additional benefit. For that reason, the target of -5°C has been selected as the criterion for declaring the chambers and stopes to be adequately "frozen" and "safe for the environment".

Table 6.2.7 Estimated Times to Form Frozen Shell and Frozen Block with Five Years of Active or Hybrid Freezing and Passive Freezing Thereafter

	Predicted Total Time to Reach Stated Temperature (years)						
	Area 1	Area 2		Area 3			Area 4
	#12	#10	C212	B230	B233	B234	B212
Frozen shell at							
-1 °C	1.4	1.7	2.3	1.2	1.6	0.9	1.9
-5 °C	2.5	2.9	3.6	1.8	2.3	1.3	3.3
-10 °C	4.8	4.8	5.4	2.6	3.7	2.0	7.4
Frozen block at							
-1 °C	7.9	6.8	6.6	4.3	7.1	5.5	9.6
-5 °C	8.4	7.9	6.9	4.5	7.7	5.7	9.7
-10 °C	9.0	8.8	7.6	4.6	8.1	6.0	10.2

Results of the FOS will allow improved modelling of the freezing process. The target criterion of -5°C is not expected to change, but revisions to the modelling may indicate slower freezing rates. If rates are significantly slower than the current predictions, the active portion of the freezing period could be extended. This would allow overall freezing times to remain within the ranges shown in Table 6.2.7.

As noted under Step 1, a choice to use a hybrid system could either accelerate or slow down the initial freezing period. Since both the active and hybrid systems will rely on passive heat removal for the latter stages, a switch to hybrids is expected to have less effect on the overall freezing times shown in Table 6.2.7. Again, the timing of the transition from hybrid to fully passive could be adjusted to keep overall freezing times within the 10-year range.

6.2.7 Long-term Freeze Maintenance

6.2.7.1 Conversion to Passive Operation

The conversion of each portion of the freezing system from active or hybrid to fully passive will be timed to control the overall freezing times, as noted in the preceding section. The current concept is to continue with active or hybrid freezing through the formation of the 10 m wide freeze wall, and for about three years after the introduction of water into dust. The current modelling shows a progressive drop in heat extraction rates as the freezing zones expand. After about five years of active freezing (in total), heat extraction rates are predicted to be well within the capabilities of fully passive thermosyphons.

If active freezing is chosen for the initial freeze, the conversion will require either converting each vertical freeze pipe to a thermosyphon or installing thermosyphons within the decommissioned vertical freeze pipes. An initially hybrid system will be much easier to convert, as the active component would only need to be turned off and the carbon dioxide pressures within each pipe adjusted to optimize passive performance.

Conversion to passive operation will also require turning off the horizontal freeze pipes that will run under arsenic chambers and stopes. Thermal modelling presented in SRK (2006b) indicated that the vertical freezing pipes or thermosyphons would be more than capable of sustaining the bottom of the frozen blocks. Methods to convert the horizontal components to passive operation are being considered in the FOS as a means to save costs or add flexibility to the schedule only. The horizontal pipes are not needed to maintain freezing over the long-term.

6.2.7.2 Maintaining the Frozen Block

Over the long-term, the large mass of ice incorporated into each of the frozen blocks will act as a reservoir of cooling that will serve to maintain the frozen blocks. Any heat that does enter the blocks will be removed by the thermosyphons. There is no need for thermosyphons to be installed in the underground pipes, because the vertical system will extend deep enough to remove any heat from the bottom of the frozen blocks.

Thermal modelling presented in SRK (2006b) indicated that the vertical thermosyphons installed at 4 m spacing would continue to extract heat from the frozen blocks. Table 6.2.7 above shows the same result, with the blocks continuing to cool after the transition from active to passive cooling. The currently assumed 4 m spacing of thermosyphons would therefore be more than adequate to maintain cold temperatures over the long-term.

As noted above, results of the FOS will be assessed to confirm or improve the parameters used in the 2006 modelling. Options for changing the number and spacing of thermosyphons around each chamber and stope will be considered once those results are available and fully analyzed. However, the 2006 modelling indicates that an excess of cooling capacity will be available even if the spacing used for the initial freeze is maintained over the long-term.

6.2.8 Technical Risks

6.2.8.1 Influence of Groundwater

During Initial Freezing

Experience with ground freezing projects elsewhere has shown that groundwater is the most common source of problems. Groundwater flow carries heat and, if the flow is sufficiently large, it is not possible to freeze the ground. A local groundwater velocity in the range of 1 to 2 m per day is often cited as the flow rate at which active ground freezing becomes difficult. The most significant challenges occur when a freeze wall is developed within flowing groundwater. As the freezing shuts off part of the flowpath, it can increase flow velocities through the remaining unfrozen areas, making them difficult or impossible to freeze.

At Giant Mine, the initial freezing will therefore take place in rock that is well above the groundwater table. As discussed further in Section 6.8.3, the mine area is currently dewatered to the 750 Level, more than 100 m below the lowest portion of the freezing zones, and will continue to be dewatered to at least 20 m below the frozen blocks throughout the freezing period. The initial freezing will therefore take place in rock that has no groundwater flow.

The introduction of water into the dust during the wetting stage will create a potential for water to flow out of the frozen zones. That potential is the reason why the plans call for the first stage of freezing to create a complete frozen shell in the rock around each chamber and stope. The design criteria for the frozen wall, 10 m wide at -10°C, are highly conservative to minimize the chance of water escape. The plans for stabilizing bulkheads and creating backfill plugs in all of the affected mine drifts are intended to allow any potential weak points in the wall to become completely frozen.

Even with those measures in place, the addition of water to the chambers and stopes will need to be carefully monitored. Water addition rates and levels will be monitored within each chamber and stope, and any seepages into the surrounding drifts will be monitored. If there is an indication of water escaping the frozen zone, the wetting will be halted and the freezing time extended to allow any gaps in the frozen wall to be repaired. Although escape of water from a frozen zone is unlikely, any water that does escape will flow directly into the minewater capture zone and be treated.

Long-term

As discussed in Section 6.8.3, once monitoring establishes that all chambers and stopes are completely frozen, the mine dewatering system will be adjusted to allow the underground mine to flood to a level that is as high as possible, while preventing the formation of pit lakes. That level is expected to be just below the base of the A2 pit.

The resulting groundwater level will be at roughly 2/3 of the distance between the top and bottom of most of the arsenic chambers and stopes. Only one chamber (B230) will be completely submerged, and three (11, 12, and 14) will remain completely above the water table.

The groundwater modelling reported in SRK (2004a) indicates that the groundwater flow speeds in the region of the frozen blocks will be extremely low after water levels have been raised. The groundwater table is expected to be very flat across the entire mine areas, meaning that lateral movement of groundwater will be minimal. In addition, the large number of un-plugged underground drifts and other mine voids are expected to be the primary conduits for any flow that does occur. The plugged drifts and frozen zones around the arsenic trioxide dust will have overall hydraulic conductivities that are several orders of magnitude lower than the open drifts and voids located elsewhere in the mine. As a consequence, the frozen zones are not expected to experience any significant groundwater flow.

The mine flooding is expected to generate poor quality water. Most of the (non-arsenic dust) stopes that will be flooded contain tailings backfill that will release soluble arsenic. Groundwater quality around the frozen zones is also expected to be poor. The access drifts around the chambers and stopes contain significant amounts of tailings and mine muck, and some of them undoubtedly include arsenic trioxide dust residues from historical spills or escapes. However, the regional dewatering provided by the minewater withdrawal system will prevent any escape of contaminated groundwater. In addition, the minewater treatment system will be designed to accommodate the short duration of higher contamination that is anticipated to occur after the mine has been flooded. Section 6.8 provides more detail on site water management.

6.2.8.2 Thawing and Climate Change

Previous Simulations

SRK (2006b) presented simulations of long-term temperatures in the frozen blocks. Included were simulations of the highly unlikely scenario where all of the thermosyphons were suddenly made completely ineffective. Even in that scenario, it was predicted to take ten years before the arsenic dust warmed to -5°C, and between twenty and more than fifty years before the outer limit of the dust actually began to thaw.

Chain of Events Analysis

Before proceeding with this topic, it is worth reviewing all of the things that would have to go wrong before thawing would lead to a release of arsenic into the surrounding environment:

- The ineffectiveness of the thermosyphons would need to go unnoticed or unmitigated for at least the 20 year period noted above, or longer if some of the thermosyphons remain active.
- The temperature monitoring devices in the ground, which would provide a clear indication of warming long before the thaw reaches the dust, would need to be unnoticed or ignored.
- After 20 or more years of the above conditions, the dust at the top of some of the chambers would just be beginning to thaw. There would then be a potential for infiltrating precipitation to contact the dust and create dissolved arsenic. That potential would be far less than it is today, where all of the chambers and stopes are unfrozen and completely exposed to infiltration.

- Any arsenic that is dissolved would be transported downward into the mine, collected in the minewater system, and removed by the water treatment plant, just as it is today. Any significant increase in soluble arsenic reporting to the treatment plant would be noticeable both in influent analyses and in increases in water treatment costs.
- Assuming that none of the above elicits a response by the site operator and responsible authorities, the thawing would proceed. Thaw rates decline as the thawing front gets further from the ground surface. As a result, any further thawing into deeper parts of the dust would be even slower than the initial thawing discussed above.
- Again assuming no response, the thaw front would eventually reach the groundwater table. At that point arsenic would begin to dissolve into the surrounding groundwater and there would be significant increases in arsenic concentrations reporting to the minewater collection system. However, all contaminated water would still go to the water treatment plant where it would: (a) be immediately noticed and (b) be treated prior to discharge from the site.
- Again assuming no response, the above situation would continue indefinitely, with ever-increasing water treatment costs, but no uncontrolled release of arsenic into the surrounding environment.
- In order for any of the dissolved arsenic from the thaw zone to leave the site, the minewater collection system would also need to fail. Such a failure would be immediately noticeable as a significant change in flow to the water treatment plant. For this situation to be undetected, it is assumed that the water treatment plant would also need to fail or be inoperative.
- Under those highly unlikely conditions, the water table would begin to rise. This would be immediately noticeable in the water level monitoring wells. However, if the situation were to go unnoticed or unmitigated, the water table would reach the bottom of the pits. A pond would form in A2 pit first, and shortly thereafter in A1 pit. These ponds would continue to grow in size, and then be joined by additional ponds as each of the other pits begins to flood. The ponds in A2 and A1 pits would continue to grow, reaching 20-40 m in depth and 100 m or more in length. The formation of ponds within the pits would be readily apparent to even the most casual observer.
- Only if all of the above goes unnoticed or unmitigated, would the water level in the mine area eventually reach a point where either groundwater or surface water could flow outwards. That point would represent the first uncontrolled release of arsenic into the surrounding environment.
- Estimates of the rate of arsenic release are difficult to predict due to the wide array of variables involved. However, SRK (2002a) adopted an estimate of 16,000 kg per year for arsenic release from all of the chambers and stopes in a completely unfrozen and saturated condition. If only 15% of the arsenic trioxide chambers and stopes are thawed,

that value would reduce to about 2,000 kg/yr, which is the threshold at which long-term ecological risks are predicted to arise. Even at these levels, environmental effects would only manifest over the course of several years, and the immediate risks to human health would be minimal.

Previous reviews of the above chain of events have led to the conclusion that they would require a complete failure of operations, governance, and oversight. The fact that the whole process would be drawn out over decades, and many of the steps would be apparent to observers outside the site operator's team, means that all avenues of regulatory review and public protest would also have to have been rendered ineffective. This combination is conceivable only in the case of a complete breakdown of civil order. Such a breakdown would presumably entail more immediate risks to both the environment and human health.

Simplified Model of Climate Change and Heat Flux

The SRK (2006b) simulations incorporated the Intergovernmental Panel on Climate Change (IPCC 2001) "best estimate" of climate warming. More recent IPCC reports have presented slightly different estimates. For example, whereas the initial IPCC (2001) report predicted a 3°C increase in mean annual air temperatures around Yellowknife, a more recent IPCC (2007) "best estimate" translates into a 3.3°C increase. Those changes are well within the error bands of any inputs to the thermal modelling presented in SRK (2006b). Rather than repeating the earlier modelling of thawing, with slightly different climate inputs, a simplified model was developed. The simplified version has the advantage that it allows the sensitivity of predictions to both input assumptions and mitigation responses to be examined.

The simplified model considered only Chamber 12, which SRK (2006b) showed to be most sensitive to thawing due to its location in a prominent bedrock outcrop. Three climate conditions were simulated: current day, the IPCC (2007) "best estimate" of temperature increases, and the IPCC (2007) "worst case" estimate of temperature increases. The first portion of Table 6.2.8 shows the air temperatures associated with each climate condition.

To estimate the rate of heat flux into the chamber, it was assumed to be surrounded by a frozen zone held at -8°C, with a top surface of 3,000 m^2 and a side wall of 5,000 m^2 both exposed to thawing. The top of the frozen block was assumed to be 15 m below the ground surface, and the side wall an average of 25 m from the steep outcrop surface. The mean annual surface temperature was estimated from the climate parameters in the normal manner using a sinusoidal air temperature model and "n-factors" that relate air and ground surface temperatures. The freezing n-factor was assumed to be 0.8 and the thawing n-factor was assumed to be 2. The heat fluxes from the rock surfaces to the frozen block were then estimated using a linear heat conduction calculation, with an assumed thermal conductivity of 300 kJ/(m d °C).

The second part of Table 6.2.8 shows the results of the heat flux calculations. The heat flux of 14.2 kW predicted under the current climate increases progressively with each of the warming scenarios. The worst case heat flux of 21.8 kW is about 50% higher than current conditions. However, heat flux in the worst case is only 15% higher than the flux estimated for the IPCC best estimate, which is very similar to the case used in the SRK (2006b) analyses. The implication is that even the worst case predictions of climate warming would shorten the 20-50 year thaw times predicted by SRK (2006b) by only about 15%.

Table 6.2.8 Simplified Model of Thawing and Thermosyphon Performance

	Current Climate	IPCC Best Estimate	IPCC Worst Case
Climate inputs			
Winter temperature increase (°C)	-	5.4	9.6
Summer temperature increase (°C)	-	1.2	2.1
Mean Annual Air Temperature (°C)	-4.50	-1.20	1.35
Heat flux			
Mean Annual Surface Temperature (°C)	2.09	5.74	8.69
Heat flux into Chamber 12 frozen block (kW))	14.2	19.1	21.8
Change in predicted 20-year thawing time (years)	+ 5.1	-	-2.8
Thermosyphon heat removal			
Numbers of days of operation per year (days)	164	144	122
Average temperature in operating period (°C)	-19.5	-16.6	-13.8
Average wind speed (km/hr)	8	8	8
Heat removal by each thermosyphon (kW)	1.1	0.7	0.4
Theoretical number of thermosyphons required	13	27	52

Simplified Model and Thermosyphon Requirements

As noted in the preceding section, it is extremely unlikely that such thawing would occur or be allowed to proceed unabated. The first means of defence against thawing will be the thermosyphons. If all of the freeze pipes currently planned for Chamber 12 are converted for long-term use, the chamber will be surrounded by over 60 thermosyphons.

The ability of each thermosyphon to remove heat is primarily determined by the site climate. Three factors play a role. The thermosyphon only operates when air temperatures are lower than ground temperatures, so the duration of cold periods directly affects the total amount of heat that a thermosyphon can extract. The heat must be dissipated in the surrounding air, so the average air temperature during the thermosyphon's operating period plays a role. Finally, wind speed plays a role, as the thermosyphon radiator is better able to dissipate heat in stronger winds.

The third part of Table 6.2.8 shows how the predicted rate of heat extraction by a single thermosyphon would change under the global warming scenarios. In the current climate, each thermosyphon would be expected to remove heat at an annual average rate of 1.1 kW. The shorter cold period durations and warmer days predicted under the warming scenarios mean that each thermosyphon will be less effective. Under the worst case climate warming, the rate of heat removal by a thermosyphon is predicted to drop to about one-third of the current rate.

The last row of Table 6.2.8 shows the number of thermosyphons required to counteract the surface heat flux under each climate scenario. These numbers incorporate both the increased heat flux and the reduced thermosyphon effectiveness expected in warmer climates. The theoretical minimum number of thermosyphons increases from 13 in today's climate to 52 in the worst case of predicted future warming. The currently planned number of 60 thermosyphons would be adequate to keep Chamber 12 at -8°C even in the IPCC (2007) worst case scenario.

There are a number of simplifications involved in the above analysis. One is that the thermosyphons are assumed to be adequately distributed throughout the frozen block. Chamber 12 would not remain frozen if, for example, the theoretical minimum number of thermosyphons were all located at one end of the chamber. Another simplifying assumption is that the frozen block would need to remain at -8°C. Allowing the dust to reach higher temperatures would decrease the inwards heat flux and reduce the effect of climate change on thermosyphon effectiveness, leading to lower estimates of the minimum numbers of thermosyphons.

These limitations mean that the simplified model should not be relied upon for design, and there is no intention to cut back to the minimum numbers of thermosyphons shown in Table 6.2.8. However, the simplified model is quite adequate for illustrating several important points about the robustness of the proposed design. First, there will be a significant excess of thermosyphon "cooling power" under current climate conditions. Second, even after 100 years of sustained global warming, the currently assumed number of thermosyphons is likely to be adequate to counteract thawing. Third, in the event of higher than anticipated rates of global warming or lower than anticipated thermosyphon efficiency, the frozen block could be maintained by simply increasing the number of thermosyphons.

6.2.8.3 System Longevity - Other Instances of Ground Freezing Technologies

Final design, construction and operation of the Giant Mine freeze system are still several years away. The question of component longevity can only be addressed by considering the performance of similar systems elsewhere.

Active Freezing Systems

Ground freezing by active methods is a very well-established practice, dating back to the 1880's. A review prepared in 1995 listed over 400 active freezing projects, over twenty international conferences or symposia on ground freezing, and over 1000 published references (Harris 1995).

Probably the most relevant example of active freezing is the system used at the McArthur River mine in northern Saskatchewan. In that case, an active freezing system very similar to that proposed for Giant Mine is used to provide a “freeze curtain” to isolate the mine workings from an adjacent rock layer that contains high pressure groundwater. Today, ten years after its first operation, the freezing system at McArthur River continues to safely contain the pressurized groundwater and protect both staff and equipment working in the mine.

One incident that occurred at McArthur River in 2003 illustrates the risks associated with groundwater control. An exploration drift was mined too close to the pressurized aquifer, and in advance of the freeze wall. The inflow of water quickly flooded lower portions of the mine and forced a three-month shutdown. It was necessary to use concrete to plug the breach prior to re-freezing. To put this in perspective, it is worth noting that, because of the depth of the mine, water pressures against the McArthur River freeze curtain reach 5 MPa. This is ten times higher than any pressures that could develop during wetting of the arsenic dust at Giant Mine.

Hybrid Systems

Hybrid freezing systems are much less common than active freezing systems, but have been used to accelerate or create frozen ground at a number of sites. A relevant nearby example is the use of hybrid freezing below a dam at the Diavik Mine. The system successfully decreased the time needed for frozen ground to be formed, and thereby allowed earlier use of the dam.

Another example is the frozen ground barrier used to isolate subsurface radioactive contaminants at the Oak Ridge National Laboratory in Oak Ridge, Tennessee. The hybrid system in that case was installed, operated, and intensively monitored as part of a United States Department of Energy options analysis for containment of hazardous wastes. The system was deemed to be successful in meeting the hydraulic isolation objectives. It also demonstrates the effectiveness of hybrid systems in even very warm climates.

The test thermosyphon at Giant Mine was converted to hybrid operation in 2006. Initial performance was poorer than expected. It was subsequently determined that insufficient refrigeration capacity was provided. The refrigeration unit was upgraded in 2008 and the system is now reaching the expected lower temperatures.

Another type of problem was noted in the test hybrid thermosyphon in 2008. Gas pressures within the unit were observed to drop, indicating a slow leak of carbon dioxide gas. That problem had not been observed by the vendors in many years of similar applications, and was traced to insufficient sealing of a pressure monitoring apparatus that had been attached to the unit during the conversion to hybrid use. Normal operating thermosyphons are solid welded pipes with no weak points for gas escape.

Hybrid thermosyphons will be tested to evaluate their effectiveness. In particular, there are thermodynamic limitations on the temperatures that can be achieved with small diameter pipes. The ability to overcome these limitations is being tested in the FOS.

Passive Freezing Systems

Passive cooling by means of pressured heat exchange pipes was developed in Alaska in 1965 to preserve foundations in warm permafrost. Thermosyphons have since been used widely in Alaska, northern Canada and Russia to stabilize permafrost below buildings and roadways (Holubec 2008). The most extensive use is along the trans-Alaska pipeline where there are approximately 124,300 thermosyphons, installed during the 1970's (Sorensen *et al*. 2002). In Yellowknife, examples of thermosyphons can be seen in the Legislative Assembly parking lot and along 49th Street.

The malfunction of thermosyphons has been documented along the trans-Alaska pipeline (e.g. Sorensen *et al*. 2002). The early generation of thermosyphons were filled with anhydrous ammonia as the coolant[16]. In 1980, surveillance of the thermosyphons using infrared viewing equipment determined that many of the thermosyphons appeared to have "cold tops". This was found to be caused by a build up of non-condensable gases that form as breakdown products of anhydrous ammonia. The non-condensable gases blocked the upper portion of the radiator section and caused an overall reduction in performance of the thermosyphons. Infra-red surveys conducted in subsequent years showed that the level of blockage and number of thermosyphons blocked appeared to increase over time. A blockage level of 30% or more was set to identify thermosyphons that were candidates for repair. In 1991 the number of thermosyphons with over 30% blockage was reported at about 10% of the total.

A need to repair 10% of a system after 20 years of use would normally be considered very reasonable. This is especially the case where a very simple observation (with an infrared viewer) can identify a need for repair before an individual unit ceases to function. However, modern thermosyphons are not expected to suffer from this form of problem. The experience in Alaska is one reason why modern thermosyphons use inert carbon dioxide, which cannot degrade to form non-condensable gases, as the coolant.

In most applications prior to the year 2000, thermosyphons were used at relatively shallow depths. The experimental thermosyphon installed at Giant Mine in 2001 was intended to test whether the method would be effective at depths of 100 m. The results were positive, and the thermosyphon continued to perform well as a fully passive unit until it was converted to hybrid

[16] Carbon dioxide is currently the fluid of choice in thermosyphons used for ground freezing and in other passive geo-thermal heat recovery systems. It provides excellent heat transfer characteristics and in the event of an unlikely leak, it is environmentally neutral.

operation in 2006. Additional tests with deeper thermosyphons have since been carried out in Winnipeg, again with successful results.

6.2.8.4 Effects on Other Remediation Elements

Implementation of the freezing program will need to be carefully coordinated with other remediation activities. Contaminated soil will need to be moved prior to preparing surfaces above the chambers and stopes for freeze pipe installation. The B1 pit will need to be backfilled prior to beginning freezing of the underlying stopes B208 and B212-213-214. Demolition of the Roaster Complex will need to be timed to not interfere with surface work above chambers B230, B235 and B236, and the one and a half-kilometre section of Highway 4 will need to be relocated before surface work above Chambers B233 and B234 and Stope C212. Minewater levels will need to be monitored and reflooding of the underground coordinated with the freezing and wetting portions of the program.

All of the long-term thermosyphons may be within fenced areas, but the frozen zones are otherwise not expected to interfere with any other uses of the remediated site. Reach 4, the portion of Baker Creek that was passing over the future freeze area for stope C212, has already been relocated.

6.2.8.5 Intentional Thawing

The Project Team cannot conceive of any reason why it would be necessary to deliberately thaw the frozen zones. If it were for some reason necessary to temporarily enter one of the frozen chambers or stopes, mining could proceed through the frozen ground. The Project Team's broader position on significant future changes to the selected arsenic trioxide management option is stated in Section 6.2.2.

6.2.9 Monitoring and Adaptive Management

The Project Team recognizes that, while each component of the frozen block method is well proven in use elsewhere, the particular application and combinations needed at Giant Mine will present new challenges. Sufficient monitoring of each step and a guiding philosophy of adaptive management measures are therefore essential.

6.2.9.1 Freeze Optimization Study

The ongoing FOS is a first step in the monitoring and adaptive management process. Its objectives include:

- Providing a demonstration of ground freezing at a scale and level of complexity relevant to subsequent design.

- Collecting data needed to calibrate thermal and economic models of the full-scale program.
- Testing implementation methods, including methods to sample and test surficial contaminated soils (that will be removed from the project area), methods to drill and complete freeze pipe and instrumentation holes, methods for the remote repair/replacement of underground plugs and bulkheads, methods for active and hybrid active-passive ground freezing, and methods to transition from the initial active or hybrid freezing to long-term passive freezing systems.
- Developing methods to collect, store, manipulate and interpret performance monitoring data.
- Developing insights into project delivery methods and procurement issues.
- Identifying and examining “unknown unknowns” (i.e., topics that are relevant to the Project but have yet to be identified).

The FOS was initiated in 2009, and will include creating a frozen shell in and around arsenic storage Chamber 10 in area AR2. Chamber 10 is situated north of the mill crusher house and east of the No. 5 electrical substation. Access to the area is generally through the crusher gate. Freeze and instrument holes have been drilled around the chamber, with additional instrument holes drilled directly into the chamber. The locations of the FOS and surface drillholes are shown on Figures 6.2.8 and 6.2.9.

A perimeter of vertical boreholes has been drilled from surface to freeze the ground around the chamber. Some of the freeze holes have been cored to retrieve samples of the rock surrounding the chamber for thermal testing. Ground temperature will be monitored with sensors installed in some of the freeze holes, as well as instrumentation holes drilled specifically to monitor temperature. The underground portion of the FOS will include 17 horizontal freeze holes drilled beneath the chamber from the AR2 East freeze drift. The combined effect of the surface and underground freeze holes will be a zone of frozen ground surrounding the bottom and sides of the chamber. Temperature will be monitored in the ground under the chamber from three instrumentation holes also drilled from the AR2 East freeze drift.

Six service holes from surface to AR2 East drift are required. Four will be used to circulate the coolant from the freeze plant through the underground freeze holes. The others will be conduits for instrumentation cables and communications.

A summary of the FOS drilling is:

- Thirty-eight perimeter holes will be used to establish a wall of frozen ground around the chamber. The freezing will eventually advance into the chamber to freeze the dust stored inside.

- Twenty-two holes were drilled in rock around the chamber to monitor ground temperature.
- Nine holes were drilled to break through into the chamber where instrumentation will be installed in the dust to monitor temperature and water level. A profile of the dust stored in the chamber will be sampled from two of the holes.
- Several holes were re-drilled, sometimes twice, due to deviation outside the acceptable limit. As a result, five additional freeze holes and three additional instrumentation holes were drilled.
- Two additional holes were drilled specifically to retrieve core samples.
- Two holes will be a conduit for instrumentation cables from sensors in the underground portion of the freeze system.
- Four holes underground will serve as supply and return lines to circulate the freeze media for the horizontal freeze holes below the chamber.

Other work completed to date includes the removal of contaminated rock from the drilling area and the development of an underground drift to allow drilling below the bottom of Chamber 10.

Additional physical work relevant to the FOS that is expected to be completed by the fall of 2010 includes:

- Installation of a new power line and substation.
- Delivery and installation of a freezing plant.
- Installation of surface and underground coolant distribution pipes.
- Installation of active and hybrid freezing pipes in the surface drillholes.
- Underground drilling of horizontal freeze and instrumentation holes, and associated installations.

Results of the freeze optimization study are expected to become available in 2011, and will be used as input to the detailed engineering and design process.

6.2.9.2 Staging of Initial Freeze Program

Table 6.2.6 in Section 6.2.6 presents an example implementation schedule for the initial freeze program. The sequence shown in that table was selected to allow the simpler areas to be frozen first, so that any lessons could be learned prior to starting on the more complex areas. The selection of what is "simpler" could change as results of the FOS become available, but the principle of starting simple and moving to complex will be considered in future scheduling.

6.2.9.3 Monitoring Data Handling

Section 6.2.5 describes the types of monitoring instruments that will be installed during construction of the freezing system. Most of the underground components will be designed and installed with the intent that they will continue to provide data over the long-term. The primary instruments will include the following:

- A ground temperature monitoring system consisting of thermistors or thermocouples mounted on the freeze pipes and additional devices installed in independent drillholes.
- Water pressure measuring devices to monitor the pore pressure within the arsenic dust (during the wetting and freezing periods only).
- Devices for measuring ground movement in areas where stability is a concern.
- Monitoring of fluid temperatures, flowrates and pressures in active or hybrid system piping.
- Checks of gas pressure and monitoring of heat loss from the radiators of passive thermosyphons.

Further details will be defined once results of the FOS are available.

The volume of data produced by the instruments is expected to be massive, and development of methods to store, manipulate and interpret the data is a key element of the FOS. Key objectives in that regard include:

- Testing of sensors to measure ground temperatures and freezing system performance.
- Development and testing of a data capture system.
- Development and testing of a process control system.
- Development of a monitoring database.
- Development and testing of data interpretation models for each stage of the freezing.

A broader goal, to be addressed in the full-scale freezing, will be to develop data reduction and presentation tools that will allow the performance of the freezing system to be monitored, for example by internet connections to the site database.

6.2.9.4 Contingency Actions

The current level of design does not allow a contingency response to be assigned to each possible monitoring result. However, it is possible to list contingencies that would be available to the Project Team, depending on the nature of issues identified.

If monitoring indicates that the initial freezing process is not meeting design criteria, the available contingency measures are as follows:

- Investigate causes.
- Replace defective components.
- Extend the duration of active or hybrid freezing from surface.
- Install extra active or hybrid freeze pipes from surface along the initial alignment.
- Maintain active or hybrid freezing in the horizontal underground pipe system.
- Install additional freeze pipes at other locations (e.g. directly into the dust mass) to increase local freezing capacity.

If monitoring during the long-term passive freeze maintenance phase indicates unexpected warming in or around the frozen blocks, the available contingency measures will include:

- Investigate causes.
- Replace defective components.
- Modify the ground surface to reduce heat flux.
- Install shallow thermosyphons to counteract the surface heat flux.
- Install additional full-depth thermosyphons to counteract sideways or upwards heat flux.

The chain of events analysis presented in Section 6.2.8.2 above indicates that there would also be opportunities to apply contingencies to components of the long-term water management system.

Figure 6.2.8 Location of Freeze Optimization Study

Figure 6.2.9 Location of Drill Holes for Freeze Optimization Study

6.3 Other Underground Mine Components

6.3.1 Key Concerns

The underground of the mine has a large inventory of materials located outside the arsenic trioxide dust storage areas which contain arsenic, including tailings, waste rock, backfill in mined out stopes and the mine wall rocks. Flooding the mine workings will release arsenic from these materials into the water, making the minewater quality higher in arsenic concentration and unacceptable for discharge to the environment without treatment. Over time, the concentration of arsenic in the minewater is expected to decrease, as soluble arsenic is flushed from these materials and removed by the mine dewatering pumps and water treatment system. However, the concentration of arsenic in minewater is anticipated to remain elevated for an extended period. As a consequence, the minewater will continue to be contained and treated for the foreseeable future, well beyond the 25 year temporal scope for the EA.

Some of the underground infrastructure, such as the maintenance shops, fuel and oil storage areas, and explosives storage areas, contain materials that could contaminate the minewater when the underground workings are flooded.

The many openings into the underground workings from surface, including shafts, raises and portals present physical hazards to humans and wildlife through inadvertent or deliberate access. The measures currently in place to prevent unauthorized access are temporary and will deteriorate over time. Several openings are currently accessed through buildings that will eventually be demolished.

The following sections outline the methods proposed to address the above concerns.

6.3.2 Other Underground Arsenic Sources

Method Selection and Preferred Alternative

The ground freezing method described in Section 6.2 will effectively isolate the underground arsenic trioxide dust from the mine and groundwater by permanently freezing the dust storage chambers and stopes. There are no practical methods to remove or stabilize the other underground materials that contain significant, but much lower, concentrations of soluble arsenic. This is primarily because of the large volumes of these materials and their wide distribution throughout the mine. The only practical method to manage arsenic releases from most of these sources is to contain the contaminated water within the mine and treat it. This would be done by means of a long-term pumping system operated from surface using dewatering wells intercepting mine tunnels, and pumping the water to a treatment plant before it is discharged to the environment. Details of the proposed methods to collect and treat contaminated mine water are described in Section 6.8.

Clean-up and Isolation of Concentrated Sources

Measures to reduce the release of arsenic from some of the concentrated underground sources will be taken. For example, fine-grained materials in some areas located outside the proposed frozen zones are known or suspected to contain high levels of soluble arsenic, due to historical seepage from the dust storage areas. Where these materials are located in stable workings which can be safely accessed by workers and equipment (e.g., the main tunnels), heavily contaminated materials will be removed to a secure disposal site, to reduce the potential release of arsenic into the minewater.

Potential disposal sites include mine excavations that require backfill and that would be frozen, such as the empty spaces remaining within the frozen zones, the existing empty Chamber 15, a new purpose built chamber or a purpose-built shallow pit. The disposal options currently being evaluated and associated restrictions are described in greater detail Section 6.12.2.

6.3.3 Underground Infrastructure

Method Selection and Preferred Alternative

Contaminants other than arsenic that could be released from the underground infrastructure would be difficult to remove by the proposed water treatment system. Therefore, the preferred remediation method is to remove the sources of these contaminants before the mine is flooded.

Removal of Potential Contaminants

Materials to be removed from the mine will include hydrocarbon products located in the maintenance shops or designated hydrocarbon storage areas, and explosives. These materials will be brought to surface for disposal in accordance with procedures appropriate to the material type. The disposal could involve containment or stabilization on site, destruction on site, or disposal at an approved facility. Proposed methods for hazardous waste disposal are described further in Section 6.12. Hazardous materials were removed from all underground areas below the 750 Level prior to the commencement of flooding in April 2005. Hazardous materials from all other areas are being removed on an ongoing basis.

Since all of the underground electrical transformers are dry (i.e., not oil-filled) and do not contain PCB compounds, they would remain underground unless recovered for their salvage value. Small electrical components that are expected to contain small amounts of PCB bearing solid materials, such as light ballasts, will be removed from the mine for appropriate disposal at an approved facility.

Water in the flooded mine will be relatively low in oxygen and not acidic. Therefore, leaching of metals from abandoned equipment, such as the copper components of the electrical system, will not be a concern. Easily removable components, such as batteries, are being removed on an ongoing basis and recycled.

6.3.4 Openings to Surface

Method Selection and Preferred Alternative

The *Northwest Territories Mine Health and Safety Act* and Regulations specify that all underground openings to surface must be sealed before a mine is permanently closed. The appropriate method for permanently sealing a particular opening depends on the location, inclination, size and geometry of the opening, as well as the quality of rock around the opening. The selection of methods is primarily an engineering exercise to ensure that each opening is sealed in a manner that meets the regulations and achieves objectives for strength and durability. Examples of various types of seals that could be used at Giant are shown in Figure 6.3.1 and described below.

Sealing of Surface Openings

Mine openings to surface will be sealed with structures requiring minimal maintenance to remain stable and effective in the long-term. Each opening will be permanently sealed when it is of no further use for mine access or ventilation. While a particular mine opening still serves a purpose, access will be controlled with a lockable gate or door.

Most of the lateral openings, such as the portals located in the open pits, will be backfilled with broken rock. The depth of the plug, size of the rock, slopes of the rock faces and quality of compaction will ensure that the plug is physically stable in the long-term and discourage any future removal of the seal. Shallow access tunnels, such as the remaining DWC connector between the backfilled DWC opening and A1 Pit, will be filled or blasted down and regraded.

Sub-vertical openings, such as the raises and shafts, will be permanently sealed either by backfilling the excavation with broken rock, or by constructing a concrete cap over or inside the opening.

Several provincial jurisdictions in Canada provide detailed guidelines for the design of concrete caps. They specify that reinforced concrete caps overlying openings must be constructed directly on, or otherwise supported by sound bedrock surfaces around the opening. Cap design at Giant Mine has been adapted from the guideline recommended by the Ontario Ministry of Northern Development and Mines which exceeds the GNWT regulations for design load.

Figure 6.3.1 Typical Permanent Seals for Underground Mine Openings

The ground conditions would need to be inspected and assessed for competency as part of the cap design process. Where the bedrock around the opening is weak (e.g., due to heavy fracturing or weathering) a reinforced concrete bulkhead may have to be located some distance inside the opening, recessed into sound bedrock below the surface. These types of caps can be covered with soil and, since they are relatively impermeable, will normally be provided with a vent pipe to allow exchange of air between the mine workings and surface.

In some situations, where a small inclined mine opening is wider at the mouth than it is inside, a simple concrete plug, without steel reinforcement, could be installed. Depending on the required load capacity, additional shear resistance could be provided by installing steel dowels between the rock and the plug.

6.4 Open Pits

6.4.1 Key Concerns

Current conditions in the pits are described in Section 5.3. Long-term stability of the backfilled stopes located below some of the pits is a concern and the pit walls represent a physical hazard to people using the site in the future. Two other concerns are related to water management. If not controlled, water from the underground mine would form contaminated ponds within the pits. Baker Creek, if not controlled, could flow into the pits and into the underground mine.

6.4.2 Method Selection, Alternatives and Preferred Alternative

Open pits are one of several surface issues associated with Giant Mine. The assessment of remediation measures for the major surface issues at the site has largely been addressed through internal meetings of the Giant Mine Remediation Project Team and technical specialists. The surface remediation measures proposed in the Remediation Plan (as presented in the DAR) were also reviewed at a meeting with representatives of the GNWT. Specifically, a series of meetings in September 2003 and 2004 reviewed the remediation measures proposed in the previous Abandonment and Restoration Plan (Golder 2001b), listed other options, assessed several combinations of those options and identified those worthy of more detailed review.

The remediation options that were considered for the pits are:

- Backfilling and covering;
- Allowing flooding to form full depth pit lakes; and
- Partially backfilling and flooding to form shallow pit lakes or wetlands.

Backfilling and covering the pits would produce a surface that could allow a variety of future land uses. The main issue is the availability of backfill material. The available amount of clean backfill is very limited and is also in demand for other remediation activities. Two sources of material for backfilling the pits are the tailings and the contaminated soils from elsewhere on site. Both of these materials contain high levels of arsenic. Measures to limit release of that arsenic would need to be included in the backfill design.

Establishing pit lakes might provide additional aquatic habitat. However, the pits are connected to the underground mine workings. Therefore, any water allowed to accumulate in the pits would be contaminated for as long as the minewater itself was contaminated.

Partially backfilling all the pits could minimize the contact between the contaminated minewater and the shallow pit lakes or wetlands. However, any leakage through the backfill could result in Baker Creek drying up during low flow periods. The lack of sufficient clean backfill is also a problem for this option.

After consideration of these options, it was decided to proceed with a combination that makes use of the limited available backfill, reduces physical hazards associated with mine openings and pit walls and prevents the formation of contaminated pit lakes.

6.4.3 Specific Pit Remedial Works

The proposed disposition of each pit is summarized in Table 6.4.1 and a more detailed discussion is provided in the following sections.

Table 6.4.1 Summary of Open Pit Disposition

Pit	Disposition	Backfill	Safety Measures
A1	Remains open	no	Physical barrier around pit perimeter
A2	Remains open	no	Physical barrier around pit perimeter
B1	Backfilled	~330,000 m^3 Comprised of clean rock and contaminated soil	Security fence
B2	Remains open	no	Physical barrier around pit perimeter
B3	Maintained as surface runoff collection point	no	Physical barrier around pit perimeter
B4	Regrade pit slopes, cover and revegetate	no	None required
C1	Remains open	potentially	Physical barrier around pit perimeter
Brock	Backfilled	~6,000 m^3 Local clean material	None required

B1 Pit

The B1 Pit is partially above the B208 and B212-213-214 arsenic stopes and will need to be backfilled to allow installation of the required freeze pipes. The volume of backfill required to develop the drill platform for installation of freeze pipes is approximately 330,000 m^3. Before placing contaminated soil in B1 Pit, the voids between the crown pillars and the arsenic trioxide dust in this area are to be stabilized as described previously in Section 6.2.4.2. The backfill will be compacted to prevent differential settlement which could damage the freeze pipes, and to reduce hydraulic conductivity of the material.

This pit will be used to dispose of the contaminated soil and waste rock on site. The contaminated soil will be placed in a cell behind the freeze pipes and, as such, will be incorporated into the frozen zone. The volume of the B1 Pit that will be maintained at -5°C or lower is limited to approximately 60,000 m^3, as shown in Figure 6.4.1.

Contaminated soil will be excavated from other areas of the site (Section 5.10) and trucked to the pit. Where practical, contaminated soils will be segregated from waste rock or less contaminated soils, and incorporated within the frozen zone of the B1 Pit. An estimated 58,000 m^3 of contaminated soil (soil containing total arsenic above the industrial land use criterion (GNWT 2003)) would be disposed in this area. The rest of the pit will be backfilled with waste or quarry rock, stable non-hazardous demolition waste and other clean fill. Approximately 272,000 m^3 of clean fill will be required to cover the contaminated soil and completely backfill the pit. A cover similar to that proposed for the tailings will be constructed on the backfill to promote surface runoff (as described in Section 6.6).

A security fence will be placed around B1 Pit to restrict access to the freeze pipe system to authorized personnel only.

Other Pits

Pits A1, A2 and B2 will be left open and protected from inadvertent access. Accessible sections of the slopes or pit bottom where topsoil is located will be revegetated. A bulkhead and/or backfill will be placed in the UBC portal in the B2. Portals in the A1 and A2 pits will be secured using similar techniques (see Section 6.3.4). As described further in Section 6.8.3 pit lakes will not be allowed to form as long the mine water requires treatment for discharge.

As discussed further in Section 6.8.4, the B3 Pit will be used as the inflow point to the underground mine workings for surface runoff until these flows are acceptable for direct release to Baker Creek. At that time, the slopes of the pit will be pushed in to partially fill the excavation and revegetated. The northern rock wall will be left as is to form a natural escarpment. If the escarpment were to be considered a safety issue after sloping is completed, fencing would be installed as with other pits.

The walls of the B4 Pit will be regraded to shallower slopes using the available material currently at the location. The slopes will be covered with growth medium and revegetated. The absence of high rock walls makes revegetation of this pit feasible and the proximity to future public roads makes revegetation desirable.

Figure 6.4.1 Frozen Contaminated Soil Placed in B1 Pit

The C1 Pit will be left open. Partial backfilling of the pit to form a stable slope below the re-routed Baker Creek may be required, depending on the final alignments of the creek and Highway 4. Further investigations are ongoing as discussed in Section 6.9. Accessible portions of the slopes or pit bottom where topsoil is located will be revegetated.

The entrance adit in Brock Pit will be blocked. Crushed rock, soil and/or clean demolition debris will be used to backfill the pit.

Access to open pits will be controlled using an appropriate combination of signage, earthen berms, boulder impasses, and fencing. All openings to the underground will be sealed, as discussed in Section 6.3.4.

6.4.4 Contingencies and Adaptive Management

Differential settlement of backfill in the B1 Pit could cause damage to the top cover. This potential will be addressed in the site inspection and maintenance program. If significant settlement does occur, it would be remediated as part of the regular maintenance by means of regrading, or placement of additional material to maintain a free draining cover profile.

It may also be necessary to replace freeze pipes if the settlement causes damage. Long-term operating costs for the system have taken this contingency into account. Replacement pipes would be drilled and installed using standard drilling technology.

Stability of all remaining pit walls will be monitored and damage to berms or fences will be repaired.

6.5 Waste Rock

As discussed in Section 5.4, the only waste rock that is expected to remain on surface has been used in construction, primarily of roads, yards and tailings dams. The rock has been tested and is expected to maintain neutral drainage and to meet the water quality criteria for non-point discharges.

Sections of mine roads and yards will be excavated while retaining select sections to maintain access to the B1 pit area, the B3 pit area and the north side of the Northwest Pond. The remaining mine roads would not be required after closure activities have been completed. The current plan is to reclaim the roads for use as fill where significant volumes exist. Abandoned road sections that contain insignificant amounts of fill will be scarified and revegetated. Culverts will be removed and swales will be cut across the roads at appropriate intervals to facilitate surface water drainage.

Roads that will be reclaimed are shown in Figure 6.5.1. The selection could be modified to meet access requirements associated with future land uses.

Figure 6.5.1 Road Decommissioning

6.6 Tailings and Sludge

6.6.1 Key Concerns

Current conditions in the tailings and sludge containment areas are described in Section 5.5. The key concerns are seepage from Dams 3, 11 and 22B, surface overflow quality, dusting from the tailings surfaces and the potential for physical contact with the tailings by humans and wildlife. A summary of the remediation measures are presented here, while SRK (2005g) presents details of the remediation design concepts for these areas and includes appendices that compile the available engineering data on the tailings, the sludge and the containment structures.

6.6.2 Method Selection, Alternatives and Preferred Alternative

The selection of remediation methods for the tailings and sludge containment areas was driven by the objectives stated in Section 6.1.1, specifically minimizing public health and safety risks and minimizing the future release of contaminants to the surrounding environment. Exposed tailings present a potential for direct physical contact by people or wildlife. They also generate dust and allow runoff to become contaminated with arsenic as described in Section 5.5.5. To address these problems, the tailings will be covered. To facilitate covering and to prevent water ponding on the surface, regrading of sections of the tailings and construction of surface water run-off channels will be necessary.

Standard techniques will be used to construct the tailings covers and diversions. These will include sediment control measures to prevent sediment from spreading into Baker Creek, Trapper Creek and North Yellowknife Bay, both during construction and while vegetation is being established on the covers to provide long-term erosion control.

6.6.3 Dust Suppression

Current measures for controlling fugitive dust from tailings disposal areas involve spraying a product called Soil Sement, mixed with water, onto accessible areas of the tailings from a truck. This creates a hard crust on the surface of the tailings. The product is sprayed in the spring and when necessary during the summer months. Many areas that produce dusting problems cannot be reached due to the wet and soft nature of the tailings.

Methods to control dust formation during regrading of the tailings during remediation have not been finalized. A combination of wind breaks, watering and/or chemical stabilization techniques will be implemented. Potential environmental effects associated with this are discussed further in Section 8.6.

6.6.4 South, Central and North Pond Earthworks

The South, Central and North Pond surfaces will be regraded to direct runoff towards a new proposed spillway cut into the bedrock south of Dam 2.

The South Pond will require minimal regrading to enhance the existing slope towards the Central Pond. Natural ground projects into the South Pond at its north end. A ditch will be constructed through that area to direct flow into the Central Pond via a new proposed spillway between Dams 4A and 4B. The location of these ditches is shown in Figure 6.6.1.

The Central Pond also has a gradual slope towards the North Pond, with two gullies running in a southwest/northeast direction. The eastern gully is relatively shallow and will be regraded into a shallow swale with side slopes of 5 horizontal to 1 vertical (5H:1V). The west slope of the western gully would also be re-sloped to 5H:1V. The bottom grade of both gullies would be kept at close to the current levels and would direct surface overflow into spillways that will be cut through Dyke 6. The general arrangement at the Central Pond is shown in Figure 6.6.2.

The North Pond will cease to act as a water storage facility. The existing ponded water will be pumped, treated and discharged. The surface will be cut and filled to direct surface overflow towards a spillway that would be constructed around the south end of Dam 2. The outlet ditch invert will be at an elevation that will prevent water from pooling in the North Pond. The spillway will be constructed entirely in bedrock and will discharge approximately 100 m downstream, west of Dam 1. As long as the surface runoff water remains contaminated, outflow from the spillway will be directed to the B3 Pit portal, where it will enter the minewater treatment system. Once water quality meets discharge criteria, the runoff will be re-directed to Baker Creek. The location of the spillway is shown in Figure 6.6.3.

6.6.5 Northwest Pond Earthworks

Water currently stored in the Northwest Pond will be pumped, treated and discharged. The tailings surface will be cut and filled to direct runoff to the west where a spillway will be constructed through the bedrock outcrop between Dams 22A and 21D (Figure 6.6.4). Short-term discharge will be directed to a runoff collection sump and pumped to the Akaitcho shaft where it will enter the minewater collection system. Once water quality meets discharge criteria, the runoff will be re-directed to Baker Creek.

The Northwest Pond is also a potential location for non-hazardous waste. The disposal of non hazardous waste is described in Section 6.12.

Figure 6.6.1 South Pond Regrading and Water Management

Figure 6.6.2 Central Pond Regrading and Water Management

Figure 6.6.3 North Pond Regrading and Water Management

Figure 6.6.4 Northwest Pond Regrading and Water Management

6.6.6 Tailings Covers

The design concept proposes a two-layer cover, as shown in Figure 6.6.5:

- The bottom layer will serve three functions: (1) act as a robust physical barrier to prevent human or animal contact with tailings in the event that the overlying layer is evolved or damaged; (2) minimize upwards wicking of arsenic contamination through the cover; and (3) minimize the possibility of roots penetrating into the tailings.
- The upper layer will serve four functions: (1) act as a clean surface that will shed runoff; (2) allow vegetation to establish; (3) reduce infiltration; and (4) support future uses of the area.

To allow vegetation to establish, the upper layer should be a fine grained material of at least 30 cm in depth. However, using a variable depth of such material would allow for a wider range of vegetation species. Based on the amounts of fine-grained soils identified to date, it would be possible to cover all the tailings and sludge ponds with an average 70 cm depth.

A cost-benefit analysis will determine the optimum alternative among those currently under consideration for the bottom layer, including:

- 100 cm thick layer of run-of-quarry material (<100 cm in size);
- 30 cm to 60 cm thick layer of screened run-of-quarry material (<50 cm in size) with geotextile separation layers above and /or below; or
- 15 cm to 30 cm thick layer of crushed gravel (<2.5 cm in size) with geotextile separation layers above and/or below.

Depending on how the cover material is prepared, it may be necessary to include geotextile layers to prevent fine tailings from mixing upwards into the bottom layer, or fine material in the top layer from mixing downwards. Both of those effects would compromise the function of the bottom layer.

Tailings cover design is dependent on monitoring results from test plots as described in Section 5.5.2. The studies will provide a basis for determining the amount and type of run-of-quarry rock that will be required to accommodate potential settlement into the tailings and the requirements for phased construction. The final design will provide the specifications for all cover materials and depths and such details as access, monitoring, and sediment control during construction.

Figure 6.6.5 Tailings Cover Conceptual Design

There are several hills and existing quarry areas on the site that could produce the rock required for tailings cover material. Four locations closer to the tailings areas have been examined for their potential to produce sufficient rock at minimal cost as well as minimize the aesthetic effects of quarrying. Three sites are around the Northwest Pond, two of which have been quarried previously. A third option is to widen the spillway from the Northwest Pond (Fig.6.3.3). Once a tailings cover design has been selected, detailed quarry plans would need to be developed as a basis for optimizing the quarry operations. All quarry plans would meet the Northern Land Use Guidelines – Pits and Quarries.

Studies to select vegetation species and define seeding, planting and fertilization requirements are still needed and are part of ongoing work on the site. A detailed plan for additional revegtation studies is being developed. It is envisioned that a mix of non-invasive agronomic and native species will be used. This will minimize erosion in the short-term and allow revegetated areas to revert to a natural ecosystem in the long-term.

6.6.7 Settling and Polishing Ponds

Under the proposed remediation, the current settling and polishing ponds would not be required in the post-closure period. These facilities would be closed in place. The current concept, described in SRK (2005g), includes construction of a spillway through the bedrock outcrop south of Dam 1, and construction of a cover similar to that proposed for the tailings, as shown in Figure 6.6.6. To minimize settlement damage to the cover, it could be underlain with a filter cloth placed directly on the sludges. The option of using contaminated soils to consolidate the sludge is also under consideration.

There is an elevation difference between the solids in the settling pond and in the polishing pond. Further investigation is required to determine the long-term stability of the dyke that separates the two ponds. If necessary, the dyke will be buttressed.

The chemical stability of the sludge will be monitored. In the short-term, both the chemical conditions within the sludge and the water quality of any seeps will be monitored for signs of increased arsenic leaching. Monitoring wells will be installed within the sludge and underlying tailings to varying depths, allowing measurement of the saturated water level and collection of pore water samples for analysis. Seeps from the settling and polishing ponds would continue to be monitored in the long-term.

Figure 6.6.6 Sludge Cover Conceptual Design

6.6.8 Calcine Pond

As discussed in Section 5.5.4, the bulk of the calcine pond and its contents were removed several decades ago. What remains is a layer of calcine, approximately 1 m to 2 m thick, located about 1.4 m to 11 m below the ground surface. Monitoring suggests that the calcine is confined within the footprint of the old pond.

At present, the calcine layer is covered with fine-grained clayey silt material that is effectively isolating the calcine from the environment, as described in Section 5.5.4. It is currently proposed that the calcine material remain in place. Should it be determined during closure activities that the clayey silt overburden material is required elsewhere on the site or that remediation options selected for Baker Creek require it, the calcine layer could be excavated and disposed with other soils identified as contaminated.

6.6.9 Contingencies and Adaptive Management

It is anticipated that there will be a need for cover maintenance and repair. In the first years of construction, repairs of settled areas may be extensive. Access to soft tailings areas would be carried out either in the winter, or using additional fill or matting/geotextile to produce a workable surface over these areas if required.

The sediment control works built for cover construction will need to be maintained and operated until the vegetation is established and erosion is reduced to levels typical of natural areas. Strategies for handling runoff and seepage from the tailings areas are discussed in Section 6.8 and include provision for managing water quality.

6.7 Historic Foreshore Tailings

The key issue associated with the historic foreshore tailings is the potential for continued erosion of the beached tailings into Yellowknife Bay.

The proposed Remediation Plan is to further stabilize the beached tailings by extending the existing geotextile and rip-rap cover below the lake surface to cover the tailings where they occur in the littoral zone. This will minimize the potential of an erosion scarp developing due to wave action, as well as reduce migration of the tailings by lake currents and wave action. It would also likely stimulate benthic invertebrate production and create fish rearing feeding and spawning habitats. Remediation measures at the South and Central ponds are expected to reduce the amount of contaminated water that flows through the beached tailings, thereby reducing the loading of arsenic into Yellowknife Bay.

6.8 Site Water Management

6.8.1 Key Concerns

Minewater is expected to remain contaminated with arsenic at concentrations that are unacceptable for direct discharge, for an extended period after the ground freezing is completed. The length of this period cannot be predicted, but will certainly extend beyond the temporal scope of the EA. During this period, contaminated water will have to be contained within the mine workings and treated prior to discharge.

Remediation measures proposed for the tailings, involving regrading and covering, are expected to improve the quality of surface runoff and eventually allow direct discharge to the environment as described previously in Sections 6.6.4 and 6.6.5. The remediation activities are also expected to reduce the volume of contaminated sub-surface seepage from the tailings containment areas to low levels in the long-term. However, during an interim period after the covers are placed, runoff and dam seepage could require collection and treatment before discharge.

Water is currently treated and discharged only during the open water season, although contaminated water is generated throughout the year. This requires that a large volume of contaminated water be stored on site (currently about 0.5 million cubic metres). Water is currently stored in the Northwest Pond, which experiences a high rate of seepage into the mine workings below, making it an inefficient water storage location due to the continuous recirculation of contaminated water through the mine. Furthermore, there is a potential for humans and wildlife to be exposed to any contaminated water stored on surface.

Although two of the pits will be backfilled, six pits will remain open. Although not proposed as part of the Remediation Plan, if contaminated minewater were allowed to accumulate in the pits, this could present a hazard to humans and wildlife.

6.8.2 Method Selection, Alternatives and Preferred Alternative

The selection of a year-round versus seasonal water treatment schedule, and the requirement to store contaminated water on site, are the main issues affecting control of future water levels within the mine. Seasonal treatment, as currently practiced, requires the use of the Northwest Pond for storage capacity. For the reasons noted above, this pond is not a desirable long-term alternative for water storage. Other surface ponds are also unattractive as storage locations because of the potential for exposure of humans and wildlife to the contaminated water.

The alternative to surface storage is to store contaminated water in the underground mine workings. However, the combination of seasonal water treatment and underground storage would require large fluctuations in the minewater level during the year, repeatedly flooding and draining mine workings on several levels (approximately 100 metres). Large fluctuations in the water level are likely to increase the release of arsenic from sources such as tailings and waste rock backfill, and could even cause uncontrolled movement of backfill and ground stability problems.

Issues affecting the selection of water treatment and sludge disposal methods include the preferred location of the treatment system, the available technologies, and the schedule of water treatment and discharge location. Continued use of the existing treatment plant and sludge separation and disposal system was considered, and several alternative technologies were evaluated (SRK 2002a; SENES 2005). The optimum technology for this application is precipitation of arsenic with iron, separation and dewatering of the sludge by thickening and filtration, and disposal of the dewatered sludge in an engineered landfill.

The choice of treatment and discharge schedule, either seasonal or year-round, is closely related to the requirement to store water on site. Year-round treatment would reduce the range of fluctuations in minewater level, but would require year-round discharge of water to the environment. Discharge of treated water to Baker Creek, as currently practiced in summer only, would be very difficult in winter, whereas discharge to Yellowknife Bay would be possible year round. Eliminating the release of treated water to Baker Creek would also improve water quality in the creek and return it to natural flow cycles.

The desire to avoid using a contaminated pond on surface drives the decision towards storing water underground. Concerns about large fluctuations in the mine water level leads to the selection of year round treatment. Year-round treatment necessitates discharge to Yellowknife Bay, which also reduces impacts on Baker Creek.

6.8.3 Underground Water Management

The proposed storage of contaminated water underground requires that the deeper portions of the mine be flooded. The current water level is 10 metres below the 750 Level (at C-Shaft). During implementation of the Remediation Plan, it is proposed that the mine be flooded in stages (Figure 6.8.1). The first stage, while the freezing is in progress, will be to flood the mine to a safe distance below the bottom of the lowest arsenic stope. This is close to the 425 Level. Once the freezing is complete, the mine could be allowed to flood further, to a maximum level just below the bottom of the lowest open pit (i.e., A2 pit, just below the 100 Level).

Figure 6.8.1 Mine Reflooding Plan

During the summer and winter each year, the minewater will be gradually lowered from the maximum level to provide sufficient capacity to accommodate the peak inflows of the following freshet (i.e., spring melt and flows). Allowing for the risk of much larger than normal freshet inflows may require drawing water down as far as the 425 Level. Although the mine pumping and water treatment systems will be designed to handle a range of flow rates, the mine must be used to store significant amounts of water on a temporary basis each year, in order to smooth the flow through the water treatment system and avoid the need for storage of contaminated water on surface.

The current mine dewatering system uses pumps and other equipment that must be accessed from underground for maintenance and replacement. A new minewater pumping system will be installed for the implementation of ground freezing, consisting of multiple wells clustered together, each containing a pump. The wells would intersect the mine workings at one or more depths to allow full control of the water level at different stages of flooding. At least three wells will be needed to provide the required pumping capacity and redundancy. The pumping systems will be operated, maintained and replaced from surface and will not require access to the underground mine.

An entirely new water treatment plant is proposed, as described in Section 6.8.5. Final locations for the plant and wells have not been selected, but the preferred location is in the area of C-Shaft (Figure 6.8.2).

6.8.4 Surface Water Management

Measures to minimize flows of clean water into the mine will reduce the operating cost of the pumping and water treatment systems. One measure will be to maintain the existing three runoff diversion systems that currently reduce inflow to the A1 and A2 Pits, as long as water is being pumped from the mine. The diversion ditches are described in Section 5.7.2.2.

If runoff and seepage from the tailings containment areas is unacceptable for direct discharge, it will be directed underground for temporary storage and later treatment. Runoff from the South, Central and North Ponds, would be combined with runoff from the Settling and Polishing Pond area, and directed underground by gravity flow into the B3 Pit and the 1-38 Portal. Runoff within the catchment of the Northwest Pond would be collected in a small pool on the west side of the basin and pumped into the underground mine, either through the Akaitcho Shaft or a new drain hole drilled for that purpose, closer to the collection point.

Figure 6.8.2 Long-Term Mine Pumping System

6.8.5 Water Treatment and Sludge Disposal

Treatment Plant and Process

The new plant will process all site water requiring treatment before discharge, making the old water treatment system, including the settling and polishing ponds, redundant and ready for reclamation. Unlike the current system that involves storage of contaminated water on surface, water will be pumped directly from the mine to the new water treatment plant. The mine pumping systems will be automatically controlled to avoid interruptions or short-term fluctuations in flow rate that would affect the performance of the plant, as may be caused by electrical problems or equipment malfunctions.

The new water treatment plant will be designed to remove arsenic, the primary contaminant expected to be present in minewater and any surface water requiring treatment. Arsenic is the only constituent in present day site waters that exceeds *Metal Mining Effluent Regulations* limits. Figure 6.8.3 is a flowsheet illustrating a typical water treatment process for arsenic. Details provided in SENES (2005) can be summarized as follows:

- The oxidation state of arsenic in the minewater pumped to surface will be monitored and, if necessary, an oxidizing reagent will be added to oxidize the dissolved arsenic to the arsenate form (AsO_4^{3-}) needed for efficient precipitation with iron.
- A ferric iron reagent will then be added to the contaminated water, causing co-precipitation of arsenic with a ferric-oxyhydroxide phase.
- The pH of the water will be adjusted with an alkaline reagent to optimize this process. A flocculant will be added to gather fine particles of precipitate into larger clusters of particles, which will aid in the subsequent solid-liquid separation process.
- The precipitate will be settled out of the treated water in a thickener, generating sludge. The treated water from the thickener will be discharged to a holding system and the sludge will be dewatered to about 30 % solids using a pressure filter. The excess water from the pressure filter will be returned for additional treatment.
- The filtered sludge will be discharged to a storage silo, and then transported in batches to a sludge disposal facility (described later in this section).

In addition to arsenic, the treatment process will reduce the concentrations of other constituents in the water. These include antimony and some heavy metals. Antimony will co-precipitate with arsenic, while some heavy metals will have reduced solubility at the moderately elevated pH required for ferric-iron precipitation (from lime addition). Some metals such as zinc will also be adsorbed to iron hydroxide precipitates.

Figure 6.8.3 Water Treatment Flowsheet

The effluent from the treatment system will be discharged to a holding system from which effluent will be pumped through a newly constructed pipeline connected to an outfall diffuser in Yellowknife Bay. Effluent from the treatment system will be monitored continuously for conductivity, pH and turbidity, which will provide immediate feedback to the plant operators on the system performance. In addition, composite samples will be collected daily using an automated sampling device and submitted to a certified laboratory for chemical analysis including arsenic. Should plant upset conditions be detected, due to occasional plant equipment failures for example, the discharge from the effluent holding system will be immediately directed to underground storage until such time as plant performance is re-established. This approach to treatment system operation will afford maximum protection of the receiving environment and provide time for the plant operators to investigate and correct treatment plant performance.

The estimated quantity of contaminated water that will be treated and discharged through the treatment process on an average annual basis is 540,000 m^3 in the short-term (while the ground freezing is in progress) and 345,000 m^3 in the long-term (following ground freezing and tailings covering). The quantity of contaminated water to be treated will decrease as the water level in the mine rises and hydraulic gradients are reduced, thereby resulting in a reduced volume being pumped out to maintain the water level in the mine. The objective of using temporary water storage underground is to smooth the flow to the treatment plant, such that the annual volume requiring treatment will be processed at a reasonably consistent rate each month.

The precipitation part of the process used in the new treatment plant will be very similar to that of the existing plant, and the precipitation efficiency will also be similar (i.e., greater than 99% precipitation of arsenic). The new plant will use best available technology for the separation of precipitates from the treated water and, therefore, the final effluent quality is expected to be slightly better, on average, than achieved in the existing system. In this regard, it is anticipated that a long-term average total arsenic concentration of 0.2 mg/L is achievable; however, water treatment testing and preliminary plant design will be required to develop a precise estimate of the final effluent quality.

While it is intended that the system will be operated to optimize performance, the *Federal Metal Mining Effluent Regulations* (MMER) specify regulatory limits. These regulations stipulate a maximum monthly mean arsenic concentration of 0.5 mg/L, a maximum arsenic concentration on an individual composite sample of 0.75 mg/L and a maximum arsenic concentration on an individual grab sample of 1.00 mg/L.

Sludge Management

The quantity of water treatment sludge requiring disposal will decrease over time, as the concentration of arsenic in the minewater decreases, but is expected to remain great enough to require on-site disposal. In the short-term, this may be achieved by backfilling the sludge into mine voids that will subsequently be frozen, such as the voids above the arsenic trioxide stopes/chambers. The potential for underground disposal will be further assessed as the final remediation designs are prepared. After the underground arsenic dust is completely frozen, a small surface disposal facility for the sludge would be required. This would be an engineered landfill lined with synthetic and natural materials to prevent discharge of leachate from the sludge, and incorporating leachate monitoring and collection systems. The landfill would be completed as a series of separate cells, each of which would be covered when filled to capacity, with synthetic or natural materials, to minimize the infiltration of water.

The estimated quantity of sludge is 550 m^3/yr in the short-term (during implementation) and 30 m^3/yr in the long-term (following ground freezing and tailings covering) (SENES 2005). The sludge will be comprised 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 raw water.

Water Treatment Plant Power and Infrastructure Requirements

The estimated power requirement to operate the proposed water treatment plant is approximately 100 kW (2,400 kWh/day). New infrastructure required for the water treatment plant includes an access roadway, electrical power supply, sewage and grey water collection, process building, process equipment, treated water holding system, pumps, pipelines and fencing.

6.8.6 Outfall and Diffuser

Treated water that meets the discharge criteria will be pumped through a pipeline to a new outfall and diffuser located in Yellowknife Bay. The outfall is expected to be constructed using small diameter polyethylene plastic pipe placed directly on the lake bottom and anchored with weights, except in the section near the shoreline, which would be installed in an excavated trench or covered with rip rap within the ice scour zone. Three locations have been considered for the location of the diffuser: Location 1 is 8.5 m deep and 500 m offshore; Location 2 is 10 m deep and 1,500 m offshore; and, Location 3 is 10 m deep and 700 m offshore (Figure 6.8.4).

The objective of the diffuser design will be to achieve rapid and effective mixing of effluent with lake water and thus minimize the zone of influence on receiving water quality. In this regard, a minimum dilution ratio of 80:1 (i.e. 80 parts lake water mixed with 1 part effluent) was selected as an appropriate design objective.

Figure 6.8.5 shows a schematic of a typical multi-port diffuser design that would be capable of meeting the dilution requirement. The diffuser consists of a straight pipe section (manifold) at the end of the outfall line, to which are attached several smaller diameter pipe sections, consisting of a riser and a port, through which the effluent is discharged. The ports can be configured in a number of different ways. The outflow nozzles shown in Figure 6.8.5 are horizontally-oriented, but they could also be angled upward to direct flow away from the lake bottom if the potential disturbance of sediment is determined to be a concern. Alternatively, the nozzles could consist of holes drilled into the outfall diffuser manifold. Further investigation of alternative diffuser locations and the associated on-land and offshore pipeline alignments is still required. The design of the diffuser will be dependent on the results of these investigations.

The fate and transport of an outfall discharge is usually described in terms of near and far field processes, as shown schematically in Figure 6.8.6. The upper part of the figure illustrates the case where there are significant currents in the receiving water. The lower section of the figure demonstrates the case of negligible currents in the receiving waters.

The distinction between near and far fields is made because the length and time scales of the dominant mixing processes vary considerably in the receiving environment, but can be differentiated reasonably well into these two regions. The near field can also be referred to as the initial dilution zone or the initial mixing zone. In the near field, intense mixing quickly results in dilutions on the order of hundreds or more. This mixing is caused by turbulence generated by the discharge itself. The near field ends when the turbulence dissipates to levels similar to those in the ambient, marking the beginning of the far field, at which point the waste field is said to be established. The mixing zone may either be submerged or on the surface, depending on the strength of the ambient density stratification and ambient currents. The “trapping depth” is defined as the depth of the plume centreline at the point that the waste field is established (i.e., when the effluent makes the transition from the near-field dynamics to the far-field dynamics). In the top panel of Figure 6.8.6, the trapping depth is considerably below the surface, whereas, in the bottom panel, the trapping depth is essentially zero and the plume has surfaced. The near field processes are dominant only within a short distance from the diffuser and only for the first few minutes after the effluent is discharged. Beyond the near field, the established waste field is influenced by ambient currents and diffused by turbulence in the ambient waters in the far field. The far field processes occur over time scales of hours and distances of kilometres.

Modelling presented in Hay and Co. (2005) estimates centerline dilution, plume rise and plume diameter as the plume evolves from the end of the diffuser port until it is trapped or surfaces. The trapping depth is where the plume ceases to rise and become neutrally buoyant with respect to the ambient water. The horizontal distance to reach the trapping depth defines the initial mixing region. The modelling assumed a negligible ambient current velocity (i.e., natural currents and wind mixing in Yellowknife Bay were *not* factors in the dilution modelling, although both would be expected to increase the efficiency of dilution). For this study, the goals of 80:1 dilution were met by the diffuser alone (i.e., in the near-field zone), so there was no need to consider more complicated processes in the far-field.

Figure 6.8.4 Potential Future Locations of Treated Water Discharge

Figure 6.8.5 Diffuser Ports Schematic Diagram

Figure 6.8.6 Schematic Diagram of Submerged Outfall

For all of the cases evaluated (where season, diffuser location, diffuser configuration and effluent flow rate were varied), modelling shows that the effluent plume will not reach the water surface, but will be trapped under water at depths between 7.2 m and 10 m (i.e., within zero to 2.2 m vertical distance above the diffuser ports). The trapping depth depends on the location of the discharge and the seasonality, as well as the configuration of the diffuser. The horizontal distance to reach the trapping depth varies from 2 to 10 metres in the cases evaluated.

To summarize, the most efficient dilutions are observed in the greatest water depth (i.e., 10 m at Locations 2 or 3, versus 8.5 m at Location 1) and with a diffuser configuration that orientates the outfall ports at a 50 degree angle in the vertical, and has a smaller port diameter (0.031 m versus 0.035 m). Under these circumstances, the target dilution of 80:1 is achieved before reaching the trapping depth, in most cases, and occurs mostly within 10 m of the outfall diffuser. Based on a minimum design dilution ratio of 80:1 and a long-term average arsenic concentration of 0.2 mg/L (200 µg/L) in the treated effluent, the incremental increase in the arsenic level at the edge of the mixing zone would equal 0.0025 mg/L (2.5 µg/L). The dispersion analysis results indicated the 80:1 would be achieved within a lateral distance of 2 to 10 m of the diffuser head depending on ambient conditions in the lake. For an assumed short-term effluent arsenic level of 0.4 mg/L (400 µg/L), the incremental increase in the arsenic level at the edge of the zone would equal 0.005 mg/L (5 µg/L). The incremental arsenic levels reported above are additive to the baseline arsenic level of < 1 µg/L.

In summary, the results of the dispersion analysis discussed above showed that the Canadian water quality guideline for protection of freshwater aquatic life for arsenic of 5 µg/L (CCME 2007) and the Canadian drinking water quality guideline of 10 µg/L (Health Canada 2008) can be met within a short distance of the outfall on a consistent basis even under low current conditions that would be experienced in the winter months.

A preliminary underwater camera survey of potential fish habitat in the vicinity of the three outfall and diffuser locations was performed in 2009. The results of this study are described in Section 7.4. An engineering study of alternative on-land and offshore pipeline and diffuser installation methods will be completed, before the final design of the system is prepared.

6.8.7 Predicted Arsenic and Water Balance

The existing water and arsenic balance described in Section 5.7 and SRK (2005e) has been used to evaluate the arsenic release to surface and groundwater after implementation of the Remediation Plan. Estimates of the post-remediation arsenic release were made for seepage and runoff from residual surface sources (tailings areas, polishing and settling pond area, open pits and contaminated soils), surface sources that would result from water treatment activities (i.e., treatment plant sludges) and underground sources (arsenic chambers, tailings backfill, waste rock backfill, and bedrock and mine workings).

The estimates reflect long-term conditions, following completion of the remediation activities when arsenic concentrations in the surface runoff have reduced to levels that are acceptable for direct discharge. For the purpose of this assessment, it was assumed that partial dewatering of the mine is maintained at either the 425 Level or immediately below the base of the open pits at the 100 Level, and flows from the underground workings would continue to be treated.

A comparison of current and future flows and arsenic loading from the mine is provided in Table 6.8.1 and illustrated in Figure 6.8.7. The remediation activities are expected to reduce contributions from the water treatment plant to approximately 140 kg/year, contributions from the other remediated surface sources to Baker Creek to approximately 190 kg/year, and contributions in direct runoff to Yellowknife Bay to approximately 69 kg/year. In addition, the water treatment plant will discharge via a holding system, to Yellowknife Bay rather than Baker Creek. These changes result in a total reduction in loadings to Baker Creek from approximately 800 kg/year to 480 kg/year, and a decrease in loadings to Yellowknife Bay from approximately 910 kg/year to 690 kg/year. These predictions are based on an assumed arsenic concentration in runoff from surface sources and effluent from water treatment of 0.5 mg/L; however, as noted in Section 6.8.5, actual performance is expected to be better than this. Concentrations in surface runoff from all sources are expected to decrease gradually over time as readily soluble contaminants are flushed from the system. Therefore, further reductions in loading are likely to occur in the longer-term.

Table 6.8.1 Comparison of Current and Post-Remediation Arsenic Loadings to Baker Creek and Yellowknife Bay

Sources to Baker Creek	Average Annual Flow (m^3/yr)		Estimated Arsenic Release (kg/yr)	
	Current	Post-remediation	Current	Post-remediation
Baker Creek Upstream of Giant Mine	7,100,000	7,100,000	220	220
Tributaries from West of Giant Mine	850,000	850,000	67	67
Current Effluent Treatment Plant	750,000	Na	290	0
Runoff from Giant Mine Surface Facilities to Baker Creek	230,000	390,000	220	190
Total Inputs to Baker Creek	8,900,000	8,300,000	800	480
Direct Runoff to Yellowknife Bay	300,000	290,000	110	69
New Water Treatment Plant	na	370,000	na	140
Total Inputs to Yellowknife Bay*	9,200,000	9,000,000	910	690

Notes: Numbers may not add up due to rounding

* Average annual flow to Yellowknife Bay is reduced after remediation primarily as a result of the decrease in mine water requiring treatment.

na = not applicable

Figure 6.8.7 Estimated Post Remediation Arsenic Loadings

Contributions to Baker Creek from upstream of the mine and from tributaries to the west of Baker Creek are expected to remain at current levels of 220 kg/year and 67 kg/year respectively, and will be the most significant source of arsenic loading to Baker Creek after remediation. While these sources are also expected to diminish over time, it may take several decades and possibly hundreds of years before the arsenic is flushed from the system. Currently, there are no practical means of accelerating this process.

Remediation of the Northwest Pond, upgrades to surface runoff diversions and Baker Creek, and partial flooding of the workings will all result in a significant reduction in inflows to the mine. As a result, the amount of water that must be pumped from the mine and treated will be reduced from approximately 750,000 m^3/year, to 345,000 m^3/year, depending on the water level within the mine. The post-remediation flow was conservatively rounded up to 370,000 m^3/year (1,000 m^3/day) to estimate the rate of discharge from the water treatment plant.

Isolation of the arsenic chambers by ground freezing and removal of the Northwest Pond seepage will result in a substantial reduction in arsenic loadings reporting to the underground workings and ultimately to the treatment plant. Residual loadings in the underground workings would be on the order of 890 kg/year to 1,050 kg/year. The average arsenic concentration in the minewater is anticipated to be approximately 3 mg/L, reflecting inputs from the various backfill materials. It is assumed that this water would require treatment prior to release into the environment. However, the estimated arsenic concentration is strongly dependent on the quantity of water flowing through the backfill materials.

6.8.8 Contingencies and Adaptive Management

The water treatment plant will have the capacity for a range of influent flow rates and arsenic concentrations. The conceptual design described in SENES (2005) includes capacity for extremely wet climatic conditions, and sludge separation equipment capable of treating arsenic loads several times the estimated average load.

The mine water management system will be operated with a large contingency storage capacity in the mine, to manage extremely wet climatic conditions or pumping system malfunctions. In the event that this underground contingency storage was to be consumed, the minewater would begin to fill the open pits temporarily, but would not discharge to the environment.

In the event of a malfunction in the water treatment plant 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.

At some point in the future, the quality of the minewater could improve sufficiently to allow flooding of the pits with minewater and, eventually, direct discharge to the environment through a natural or engineered spill point. Small modifications to the pumping system would be required to control the mine water level and allow partial flooding of the pits, until direct discharge to the environment is acceptable. At that point, pumping and treatment could stop entirely. However, as indicated previously, this is not anticipated to occur within the 25 year temporal scope of the EA.

6.9 Baker Creek

6.9.1 Key Concerns

Baker Creek, which is described in Section 5.8, flows through the site in a channel that has been heavily altered to accommodate mining, ore processing and highway construction. The key concerns resulting from the alteration of the creek include:

- Water and sediment quality in Baker Creek are impacted by both historical spills, current discharges of treated effluent and offsite upstream inputs from the Marten Lake watershed.
- The current alignment of the creek includes many alterations and diversions that limit habitat development.
- The current channel is expected to be able to handle a 1 in 500 year storm event for most parts of the channel, but could be compromised by ice blockages or channel wall failure where it passes alongside the A2, B1, and C1 Pits. For storms greater than the 1 in 500 year event, inflow to a pit would be likely. Such an inflow could cause uncontrolled flooding of the mine and possibly release of arsenic to the environment.

6.9.2 Method Selection, Alternatives and Preferred Alternative

Several options for the long-term configuration of Baker Creek were examined in earlier studies (Dillon Consulting Ltd. 1998; Golder 2001d). Additional investigations on the capacity of the creek to support habitat are reviewed and a revised set of options is presented by nhc (2005). Remediation options were reviewed at the Baker Creek Remedial Design Options Workshop attended by representatives of INAC, PWGSC, DFO, Environment Canada (EC), the GNWT Department of Environment and Natural Resources (ENR), the GNWT Department of Transportation (DOT), Golder Associates and the Technical Advisor in September 2009. A second workshop was held in November 2009 to review the Giant Mine Risk Assessment Findings as they relate to the rehabilitation of Baker Creek with INAC, PWGSC, EC, DFO and the Technical Advisor.

The above studies and workshops considered the long-term future, when the site water quality is adequate to allow formation of pit lakes. However, as discussed in Section 6.8, water levels in the mine will be kept below the bottom of the deepest pit for many years, probably decades. Therefore, the Baker Creek remediation activities for this plan were selected to address the short-term concerns, but also maintain flexibility with the long-term options.

The option of rerouting Baker Creek around the mine site entirely was examined as part of the method selection analysis. However, this option was discounted due to the fact that the mine site catchments would continue to drain to the current channel and a creek would continue to exist, albeit with significantly reduced flow.

The selection of preferred alternatives requires additional assessment and consultation. However, the remedial approach described in the following section is provided as a representative example of a potential outcome for the final design of Baker Creek. Although modifications to individual design components are expected to occur, it is unlikely that there will be major deviations from the proposed approach.

6.9.3 Proposed Remedial Activities

The proposed Baker Creek remediation activities are shown in Figure 6.9.1. Clear preferences have emerged for Reaches 1, 3 and 4 as a result of the studies and workshops:

- The section of creek that flows past the A2 Pit (Reach 1) would be upgraded to decrease the risk of over topping and flooding the mine. Remedial works at the highway crossing would consist of upgrading the culvert or realigning the channel and building a bridge.
- The diversion around the west side of the C1 Pit (Reach 3) will be abandoned and a new channel constructed to the east of the pit along the current highway alignment.
- Reach 4 was relocated into a new channel in 2006. The weir at B shaft was removed and the creek was diverted away from Mill Pond, which overlies the C212 chamber. Ongoing studies indicate that the aquatic habitat is successfully being restored in the new alignment. There will be a need for changes at the south end of Reach 4 to accommodate the transition to the relocated Reach 3.

Figure 6.9.1 Baker Creek Remediation Options

The remaining reaches are physically stable and, therefore, do not require relocation on that basis. Contaminated sediments are present throughout the creek, but there is evidence that the reaches are biologically productive (as described further in Section 7.4). The extent and severity of effects to the existing aquatic life in the creek from the current contaminated sediments levels is unknown. Similarly, a final determination has yet to be made regarding whether removing and/or covering contaminated sediments will outweigh the disruptions to current biological functions. The feasibility of removing and/or covering contaminated sediments will also be a factor in evaluating the options. Additional studies are planned to assess these unknowns. Based on currently available information, the proposed approach for the management of contaminated sediments is as follows:

- Reach 2, running alongside Highway 4, is thought to be of limited biological value, except as a migration route between the lower reaches and the greatly improved habitat of Reach 4. Compared to Reach 5 and Reach 6, removal of contaminated sediments from Reach 2 is thought to be a low risk proposition. Some remediation options include:
  - Leave as is;
  - Enhancing the existing channel;
  - Enhance the existing channel and remove the contaminated sediments; and
  - Relocate to a new alignment.
- The Baker Pond area in Reach 6 contains tailings and contaminated natural sediments, but is also believed to be an important source of nutrients and food for fish in Reach 4. It may also play a significant role in moderating water temperatures in the early spring and contributing to the productivity of lower reaches. The excavation of contaminated sediments may disrupt some of these functions, possibly for many years until natural vegetation and habitats can be re-established. Depending on the results of further studies into the sediments, some of the remediation options include:
  - Isolate the tailings and contaminated sediments by capping, turn the area of exposed tailings at the north end of the pond into a wetland and keep Baker Pond a pond;
  - Cap the tailings and contaminated sediments and convert the area into a wetland with an isolated channel; and
  - Remove the tailings and contaminated sediments.
- Reach 5 may also contribute to the beneficial functions encountered in Reach 4 that are attributed to Reach 6. In addition, there are similar concerns about the value of removing contaminated sediments in Reach 5. Some remediation options for consideration include:
  - Leave as is;
  - Enhance wetland areas;

- o Remove contaminated sediments; and
- o Cover sediments in place.

A further complication is that, even after remediation, there will continue to be arsenic loadings to Baker Creek. Although arsenic levels will be much lower than current conditions, upstream sources of arsenic and residual releases from the site will have the potential to re-contaminate the sediments over the long-term.

Balancing the advantages and disadvantages of different approaches to Baker Creek remediation also involves questions of policy and local preferences. The Project Team has, therefore, initiated a process of consultation on plans for Baker Creek. As mentioned in Section 6.9.2, meetings were held with a number of government departments in September and November 2009 to seek feedback in this regard. In addition, as indicated in Chapter 13, future consultation activities will seek input on community preferences and input on the rehabilitation of the creek.

6.9.4 Contingencies and Adaptive Management

Geotechnical and permafrost investigations are needed along the length of proposed re-alignments of Reach 1, Reach 3, and the southern end of Reach 4. The alignments may need to be adapted based on the results.

If it is decided to remove contaminated sediments from Reaches 2, 5 or 6, a detailed series of excavation, sediment control and contaminant control plans will be required. Each of those will include contingencies to address specific environmental concerns that may arise during implementation. Restoration of the reaches after sediment removal may be a long and slow process. The current design philosophy, as evidenced in Reach 4, is to prepare a floodplain to confine the restored channel, but otherwise to let it migrate into a natural pattern. That approach will of necessity require adaptive management.

Additional changes to Baker Creek, including allowing the development of lakes in the pits, may be possible at some time in the future if water quality allows. This possibility is discussed in Section 6.8 and is many years, probably decades, into the future.

6.10 Contaminated Surficial Materials

The areas identified as having arsenic concentrations exceeding the industrial land use criterion will be excavated or covered with clean material. An exception is the spilled tailings that are already covered by the current alignment of Highway 4, which will be left in place. The proposed excavation limit for all areas will be set at 2 m or bedrock if shallower. Any materials found below this depth will be left in place and covered using clean fill. All surfaces will be regraded to promote surface runoff and inhibit subsurface migration. These areas will be delineated and identified on site maps to prevent accidental excavation of the contaminated material in the future.

As discussed in Section 6.4.3, contaminated soils will be backfilled into the B1 Pit within the frozen zone that will be created by freezing the underlying stopes. The soil will be placed in lifts and compacted to minimize volume requirements, permeability and future settlement. It is currently estimated that about 60,000 m^3 of the contaminated soil will fit into the frozen zone. The remaining 115,000 m^3 will be disposed in the tailings and/or sludge ponds.

Waste rock that contains total arsenic above the industrial land use criterion will be backfilled into the unfrozen section of the B1 Pit, with the remainder of the pit filled with clean material from other sources. The B1 Pit will then be capped with a soil cover, similar to that proposed for the tailings, to promote surface runoff and to provide a clean surface for revegetation.

Spilled tailings below the Polishing Pond will be excavated and placed in an existing tailings impoundment and covered along with the existing tailings. Any high arsenic material that is encountered will be placed either in the frozen section of the B1 Pit as compacted fill, or in an underground chamber.

As most of the areas with significant hydrocarbon contamination also have arsenic above the industrial guidelines, deposition of these soils within the frozen zone will remediate both types of contamination. Soils in the tank farm located just northeast of the A-Shaft are contaminated only with hydrocarbons. These soils could be bio-remediated in place or excavated and treated in an on-site landfarm facility or excavated and deposited within the frozen zone. The methods for the remediation of hydrocarbon contaminated soil will be chosen based, in part, on the volume and concentration of contamination encountered during remediation and the opportunity to reuse the soil once remediated (e.g., as a revegetation medium). PCB-contaminated soil will be excavated, handled and disposed of in accordance with the *Guideline for the General Management of Hazardous Waste in the NWT*.

All areas that have been stripped of contaminated surface materials will be contoured to promote positive drainage. Drainage pathways will be covered with at least 0.5 m of clean, fine-grained fill to provide a physical barrier and a revegetation medium.

6.11 Buildings and Infrastructure

6.11.1 Key Concerns

As discussed previously, many of the buildings on the site contain hazardous materials that could pose risks to site workers and the environment during building demolition. The demolition of buildings and collection of waste materials will also generate a large volume of non-hazardous waste requiring safe disposal. The current route of Highway 4 through the site presents an additional concern. The highway will need to be partially re-located to allow other remediation activities to proceed as proposed.

6.11.2 Method Selection, Alternatives and Preferred Alternative

The methods for the demolition of buildings and handling of waste will be chosen based on current industry best practices that meet local requirements for protecting the safety of site workers and the public, and protection of the environment. Specific methods will be selected at the time of contracting.

6.11.3 Building Demolition and Waste Handling

All of the site buildings without a continuing function will be demolished. The demolition of all of the buildings is expected to generate a total of approximately 90,000 m^3 of waste. The majority of the waste volume is expected to consist of non-hazardous construction materials and equipment, or materials that can be cleaned to remove contaminants and dust. Recycling of steel and other materials will be considered during the development of the Procurement Strategy as outlined in Section 6.13.4. As discussed in Section 6.4.3, stable non-hazardous demolition waste will be deposited in the B1 Pit, outside the frozen zone. The remaining non-hazardous demolition waste would be placed in a new facility constructed on the Northwest Pond or buried within the North Pond.

Hazardous materials removed from the buildings before demolition, or recovered from the demolition debris, will be handled and disposed according to industry best practices and GNWT regulations. Materials with high soluble arsenic will be disposed within a frozen zone. Options include Chamber 15, underground drifts or a purpose-built stope within a freeze zone. Waste asbestos materials that are not contaminated with arsenic would be bagged and buried in tailings at the Northwest Pond in a designated hazardous material (HAZMAT) area, as described in Section 6.12.1.

Other hazardous items would be packaged and shipped off-site to licensed facilities for disposal. Materials that would be disposed in this manner include painted items (lead contamination), oils, grease, chemicals and mercury containing light fixtures and possible small quantities of solid PCB materials as identified on Table 5.11.1 in the previous chapter.

Mill and Tailings Reprocessing Facility

A demolition audit and inventory of hazardous materials was completed on the mill complex, main conveyor and tailings reprocessing plant (TRP) (AECOM 2009). These facilities were audited for the type and volume of chemicals, oils, fuel products, processed ore, concrete, steel, equipment parts, wood, glass, batteries, compressed gases and other materials. The audit also identified any equipment with the potential to contain PCBs and mercury, as well as materials containing asbestos.

All surfaces within the mill buildings and the TRP are coated with dust containing arsenic and cyanide, although the arsenic speciation was not determined. The structures also have varying levels of asbestos and other hazardous building materials. As a result, building demolition would be done as a two phase process: decontamination followed by demolition.

Hazardous materials and potential contaminants will be removed from the buildings as much as possible to allow for safe demolition and disposal. Surplus chemicals, oils, asbestos-containing materials and other hazardous materials will be removed and disposed appropriately. However, some components, such as timbers and tanks, cannot be decontaminated without undermining the structural integrity of the buildings that house them. Therefore, decontamination of some building components will be limited prior to demolition.

Salvage of equipment and machinery was considered. However, given the contaminated dust covering all salvage, decontamination will be necessary prior to resale and packaging. The viability of salvaging equipment and machinery will be evaluated in further detail.

The arsenic and cyanide-containing dust that coats all surfaces, and the deteriorated condition of certain areas of the mill structure, make internal operations unsafe from a worker health and safety perspective. Therefore, the mill complex will be pulled down using external mechanical means only. To the extent possible, all demolition work will be conducted under dry conditions to prevent the generation of arsenic contaminated water and hydrogen cyanide gas from the dust within the buildings. Additional decontamination work would be done once the structure is down and material sorting begins.

Demolition of the TRP, while still having similar dust issues, would be more straight-forward. Removal of the facilities would likely be achieved using cranes, hydraulic equipment fitted with shears, and cutting torches.

Roaster Complex

An initial demolition assessment for the Giant Mine roaster complex was completed in 2009. The assessment established the approximate quantities of hazardous materials and how they might be containerized for transport to a disposal area to minimize risk to field personnel, the general public and the environment. The Roaster Complex consists of seven main structures (summarized previously in Table 5.11.1) containing a combination of arsenic trioxide dust, asbestos, equipment, vessels, piping and debris. The structures will be demolished using a combination of machinery and the controlled dropping of structures.

Potential emissions of arsenic trioxide dust from demolition will be contained. Examples of methods include: (1) maintaining negative pressure and exhaust air treatment with high efficiency particulate arrestor (HEPA) filters, and (2) applying an adhesive to potential sources of loose contamination to reduce emissions during demolition activities.

Based on preliminary planning, demolition debris that may contain arsenic trioxide is to be packaged in sealed containers. All asbestos materials will be saturated with water prior to removal. Asbestos waste (free of arsenic trioxide) will be double wrapped with polyethylene. Wash water will be collected and processed in the water treatment plant.

6.11.4 Buildings to Remain On Site

The City of Yellowknife has a 30 year lease option on the Giant Mine Town Site and has prepared a plan for development of part of this area (City of Yellowknife 2006). The plan describes four buildings which the City wishes to retain (houses 217, 168, 206 and 203 shown previously in Figure 5.11.2). The following discussion, excerpted from City of Yellowknife (2006), discusses these buildings and the reasons for retaining them.

> *A small portion of House No. 217 (10) dates back to the late-1930s and was used as a staff house during exploration. The building has had seven additions over the years. It is constructed on timber posts anchored into concrete foundations and is in excellent structural condition. This house was occupied by the mine manager and was considered to be a social center, often used for parties on the weekends and to entertain local dignitaries. It was last occupied in 2004. As per the historic use of this house dating from the 1930s and the role it played within the community, it is recommended that this house receive Heritage Designation.*
>
> *House No. 168 (11) was built in 1958. It is a cedar cabin with a 'Pan-Abobe' construction and built on a concrete foundation. It is in excellent structural condition. This three-bedroom house was used to accommodate VIPs and guests at the mine site. Later, it housed both single and summer student employees working at the Giant Mine. Like House No. 217 (10), it is recommended that this house receive Heritage Designation due to its role in the community and its current structural integrity.*

Figure 6.11.1 MWT Mining Heritage Society Interests at Giant Mine Townsite Area

House No. 206 (14) was built in 1951. It is constructed on timber posts anchored into concrete foundations and is in excellent structural condition. A portion of this house was used as a post office during the 1990s. It was last occupied in the 1990s. As this house was once used as a post office within the community and is currently structurally sound, it is recommended that this house receive Heritage Designation.

House No. 203 (19) was built in 1950 and an annex addition was constructed in 1963. It is built on timber posts anchored into concrete foundations and is in excellent structural condition. It was also a prefabricated structure from the Canol Project in Norman Wells. The basement crawl space has two children's bedrooms with very low ceilings. Former resident, Doug Stoodley, made many additions to the house and yard, including a brick fire pit and tree house in the back of the property, the bedrooms in the basement or crawl space and an interior fire place. This house was last occupied in the 1990s. Due to this house's history, dating back to the Canol Project in Norman Wells, as well as its structural integrity, it is recommended that it receive Heritage Designation.

The NWT Mining Heritage Society is also interested in property on the Giant Mine site. The Society is in the process of constructing a mining heritage centre located at the Giant Mine townsite and A-Shaft area and has been negotiating a small sub-lease with the City of Yellowknife to occupy the former "rec hall" which they wish to become the primary exhibit hall of the mining heritage centre (NWT MHS 2008). The Society also occupies a parcel of Commissioner's Land in the area of the A-shaft along the highway, owning the buildings (A-shaft headframe, powerhouse, hoist room and commissary) which were acquired in 2000-2001, and plans to seek title to this area as part of the future mining museum (NWT MHS 2008). The interests of the NWT Mining Heritage Society in the Giant Mine site are shown in Figure 6.11.1.

Discussions are ongoing with the City of Yellowknife and the NWT Mining Heritage Society regarding the transfer of liability associated with these buildings. Should the City of Yellowknife or the NWT Mining Heritage Society not assume the liability, the buildings will be demolished as outlined in the remediation plan. The final decision on retaining these buildings will be jointly made by INAC, the GNWT, the City of Yellowknife and the NWT Mining Heritage Society.

6.11.5 Relocation of Public Highway

A 1.5 km section of Highway 4 will need to be relocated to allow site remediation to proceed as proposed. The new highway alignment will avoid interference with surface facilities required for the ground freezing.

The GNWT Department of Transportation is also considering options for realigning a much longer section of Highway 4 to increase driver safety and highway standards. These options are outside the scope of the Giant Mine Remediation Project.

6.12 Waste Disposal

6.12.1 Non-Hazardous Waste

As discussed in Section 5.12, eight areas of miscellaneous waste are present on the site. These wastes will require safe and permanent disposal.

The selection of specific methods for waste disposal will generally be based on industry best practices and GNWT regulations. Recyclable materials such as scrap steel will be removed, if appropriate. Non-hazardous materials such as concrete rubble, wood products, asphalt, metals, plastics and insulation, will be moved for permanent disposal in new on-site facilities or the B1 Pit. During this process, the presence of hazardous materials in these areas will be assessed and segregated from the non-hazardous waste for disposal elsewhere.

A new primary disposal facility for non-hazardous waste will be created on the east side of the Northwest Pond, to accommodate waste from the demolition of buildings and infrastructure. The landfill will occupy an existing quarry and, to the extent possible, will be constructed to blend with the local topography. The waste will be placed on the tailings in small lifts, compacted to minimize subsidence and covered with broken rock to ensure that none of the waste remains exposed.

Depending on the demolition scheduling and regrading schedule of the North Pond, some non-hazardous waste may be permanently buried within an existing gully in the North Pond prior to regrading and covering.

Only demolition material that can be decontaminated of hazardous materials will be disposed in a non-hazardous waste facility. Equipment and machinery, if sufficiently decontaminated, may be sold for scrap steel, otherwise it will be disposed of in accordance with the GNWT regulations.

6.12.2 Hazardous Waste

Hazardous materials other than asbestos waste and arsenic trioxide contaminated waste will be handled and disposed in an approved facility in accordance with applicable regulations and guidelines.

Asbestos Waste

Asbestos waste not mixed with any other hazardous wastes, such as arsenic trioxide, will be disposed in a specially designated section of the Northwest Pond. The asbestos waste will be handled and disposed of in accordance with *GNWT Guideline for the Management of Waste Asbestos*.

Arsenic Trioxide Waste

Process residues 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.

It is estimated that 4,200 m^3 of arsenic trioxide dust/waste will be generated by demolition of the Roaster Complex. The current plan is to pack this material into sealed containers. The waste material will have a bulking factor of about 50%, requiring a total storage volume in sealed containers of about 6,300 m^3.

Several locations have been considered for disposal of the containers:

- Within Chamber 15;
- In the B1 pit backfill, within the zone to be frozen;
- In a new underground chamber that would be built as close as possible to the roaster area; and
- In a new pit or quarry located near to the roaster area and subsequently backfilled.

All of the options were concluded to be feasible. The Chamber 15 option would be complicated by the difficulty in packing the containers, and would leave a significant void that would need to be filled. The new underground or new pit or quarry options would all require additional disturbance and would create a new source that would need to be managed in perpetuity. Disposal within the backfill of the B1 Pit is complicated by the difficulty in avoiding placing the containers in locations which will be later drilled to install freeze pipes as shown on Figure 6.4.1. The selection of preferred alternatives requires additional assessment and this is currently ongoing.

6.13 Project Implementation

6.13.1 Organizational Framework

As indicated in Section 1.1.4, INAC and the GNWT executed a Cooperation Agreement on March 15, 2005 respecting the Giant Mine Remediation Project to co-ordinate the surface and underground remediation work. The agreement is specific to the Giant Mine Remediation Project and covers the care and maintenance of the mine site, the regulatory approvals of the remediation project, and the subsequent implementation. Under the terms of the Cooperation Agreement, an Oversight Committee shall, with the agreement of both parties, develop options and recommendations for a project implementation office to implement the approved Remediation Plan. The Oversight Committee will also provide general direction and guidance to the project implementation office once it is established.

The Giant Mine Project Office will provide direct oversight of the project implementation, and continue to act as the lead for regulatory affairs, communications, and consultation. A Technical Advisor will be retained by the Project Office to ensure that technical aspects of the detailed design and implementation conform to the general plans outlined in this document and in the Remediation Plan, and to any commitments made in subsequent approvals and licensing processes. The Independent Peer Review Panel established in 2002 will be continued and consulted as needed.

During the implementation phase, the Project Office will delegate certain duties and authorities to PWGSC. Specifically, it is expected that PWGSC will enter into contracts with and manage all of the detailed design, quality assurance, construction management and construction forces necessary to implement the work, and provide the required schedule, cost and contract management. The structuring of the design, construction management and construction forces has yet to be determined.

6.13.2 Approvals Process

The Project Team will seek all approvals needed to implement the work. Table 6.13.1 lists the permits, licences, leases, certificates, authorizations, approvals and agreements applicable to the Giant Mine Remediation Plan.

Table 6.13.1 Relevant Permits, Licences, Leases, Certificates, Authorizations, Approvals and Agreements

Potential Permits	Regulatory Authority
Annual Permit for Electrical Maintenance Work	*Electrical Protection Act* *Electrical permits issued by the GNWT Public Works and Services are only for the bunkhouses, cook houses and related residential facilities; all of the other electrical installations at a site are "permitted" by the Workers' Safety and Compensation Commission*
Application to Commence Shaft Sinking, Underground Development Work, or the Surface Stripping of an Open Pit for the Purpose of Production of Minerals	*Mine Health and Safety Act* *Chief Inspector of Mines, Workers' Safety and Compensation Commission* Applicable to underground development for the purpose of installing freeze system
Archaeologists Permit	*Northwest Territories Archaeological Sites Regulations* *GNWT Education Culture and Employment, Prince of Wales Northern Heritage Centre*
Blasting Certificate	*Mine Health and Safety Act* *Chief Inspector of Mines, Workers' Safety and Compensation Commission*
Explosives Use Permit	*Explosives Use Act Or Mine Health Safety Act* *Workers' Safety and Compensation Commission* Applicable if used under the *Explosive Use Act* (NWT) Not Applicable if used under *Mine Health and Safety Act* (NWT)
Fisheries Act Authorization	*Fisheries Act* *Department of Fisheries and Oceans*
Gas Installation Permit	*Gas Protection Act* *Electrical / Mechanical Safety Division, GNWT Department of Public Works and Services*
Installation Permit	*Boilers and Pressure Vessels Act* *Electrical / Mechanical Safety Division GNWT Department of Public Works and Services*
Magazine Licence	*Explosives Regulations Natural Resources Canada*
Permit for Wiring Installations	*Electrical Protection Act* *Electrical / Mechanical Safety Division, GNWT Department of Public Works and services*
Permit to Burn	*City of Yellowknife Emergency Response and Protection Services By-law* *Yellowknife Fire Division* *Forest Protection Act* *GNWT Forest Management Division, Department of Environment and Natural Resources*
Permit to Store Detonators	*Mine Health and Safety Act* *Chief Inspector of Mines, Workers' Safety and Compensation Commission*

Table 6.13.1 Relevant Permits, Licences, Leases, Certificates, Authorizations, Approvals and Agreements (Cont'd)

Potential Permits	Regulatory Authority
Quarry Permit	*Commissioner's Land Act* *Municipal and Community Affairs*
Scientific Research Licence	*Scientists Act* *NWT Aurora Research Institute*
Water Licence (Mackenzie Valley Region)	*Northwest Territories Waters Act* *Mackenzie Valley Land and Water Board*
Wildlife Research Permit	*Wildlife Act* *Wildlife Licenses and Permits Regulations GNWT Environment and Natural Resources*
Hot Work Permit	*Mine Health and Safety Act* *Chief Inspector of Mines, Workers' Safety and Compensation Commission*
Mine Hoist Permit	*Mine Health and Safety Act* *Chief Inspector of Mines, Workers' Safety and Compensation Commission*
Mine Hoist Certificate	*Mine Health and Safety Act* *Chief Inspector of Mines, Workers' Safety and Compensation Commission*
Hoist Operator's Certificate	*Mine Health and Safety Act* *Chief Inspector of Mines, Workers' Safety and Compensation Commission*
Shaft Conveyance Permit	*Mine Health and Safety Act* *Chief Inspector of Mines, Workers' Safety and Compensation Commission*
Rope Certificate/Test Certificate	*Mine Health and Safety Act* *Chief Inspector of Mines, Workers' Safety and Compensation Commission*
Underground Mine Rescue Certificate	*Mine Health and Safety Act* *Chief Inspector of Mines, Workers' Safety and Compensation Commission*
St. John Ambulance Standard First Aid Certificate Level I, Level II	*Mine Health and Safety Act* *Chief Inspector of Mines, Workers' Safety and Compensation Commission*
Canadian Red Cross Standard First Aid Certificate	*Mine Health and Safety Act* *Chief Inspector of Mines, Workers' Safety and Compensation Commission*
Canadian Red Cross Standard First Responder Certificate	*Mine Health and Safety Act* *Chief Inspector of Mines, Workers' Safety and Compensation Commission*
Asbestos Licence	*Canada Safety Act* *Consolidation of Asbestos Safety Regulations R-016-92*

6.13.3 Implementation Schedule

Figure 6.13.1 provides an overview of the implementation schedule for the remediation measures discussed herein. Subject to receipt of the approvals noted in the preceding section, the majority of the surface remediation activities will be completed within five years, with additional work and verification testing continuing until 2025 or later. Underground remediation, including installation and active operation of the freeze system is expected to take place over nine years. Surface work would occur concurrently but will be scheduled taking seasonal conditions into account.

6.13.4 Procurement Strategy

A long-term procurement strategy for the Giant Mine Remediation Project is being developed by the federal and territorial governments to maximize economic opportunities in a fiscally responsible manner. The Giant Mine Procurement Strategy will build upon the principles laid out in the Contaminated Sites Program procurement strategy identified in Section 1.6.2.

Through the previously described Cooperation Agreement, the Government of Canada (as represented by INAC) and the GNWT agree to coordinate the care and maintenance of the Giant Mine site and the implementation of the final Remediation Plan.

On behalf of the two proponents, and under the direction of INAC, PWGSC will provide procurement and project management services for the delivery of the Remediation Project. This is consistent with other successful remediation activities within the NWT, such as the Axe Point Military Site, Discovery Mine, Port Radium; and projects at the Colomac and Tundra Mines.

All procurement will be undertaken, and be consistent with, Canada's legal and policy requirements, as well as national and international trade agreements including:

- Applicable Land Claim Agreements;
- Treasury Board Contracting Policies;
- Agreement on Internal Trade;
- World Trade Agreements; and
- North American Free Trade Agreement.

These legislation and policies support national objectives such as industrial and regional development, aboriginal economic development, environmental and other approved socio-economic objectives.

Figure 6.13.1 Giant Mine Remediation Plan Implementation Schedule

Procurement Strategy

The procurement strategy will be developed based on the following goals from the Cooperation Agreement between the Government of Canada and the GNWT:

1. Finalize and implement an effective Care and Maintenance Plan;
2. Finalize and implement a Remediation Plan for the site that is cost effective;
3. Protect human health, public safety, and the environment;
4. Maximize territorial economic opportunities; and
5. Cooperate to achieve timely, efficient and cost effective processes based on accountability and performance.

The procurement strategy will include, but is not limited to the following content:

- Scope of Requirement;
- Strategic Analysis;
- Policy Impact;
- Stakeholder Expectations;
- Procurement Methodology;
- Communications Strategy;
- Timeframe;
- Tender Management;
- Risk and Mitigation;
- Contract Management;
- Reporting and Monitoring Arrangement;
- Transitional Issues;
- Asset Management; and
- Disposal Arrangements.

The procurement strategy will be developed to accommodate the various requirements of the four main phases of the Remediation Project which include:

1. Care & Maintenance;
2. Design;
3. Implementation; and
4. Post Remediation activities.

Care and Maintenance

Currently, care and maintenance of the site is being provided under a PWGSC managed contract with the Deton'Cho/Nuna Joint Venture (DCNJV). This contract is structured to undertake basic care and maintenance, with provisions for potential additional work and risk mitigation measures. The site is being maintained within regulatory compliance. Public health and safety, and the environment are protected under this contract.

Construction Manager Approach

It is anticipated that the majority of construction activities will be carried out through a Construction Manager (CM). The CM will be retained under a Government of Canada contract and be responsible for managing and subcontracting out smaller packages of remediation activities such as the freezing of the arsenic chambers, tailings covers, Baker Creek alignment, building demolition, hazardous materials disposal and contaminated soils disposal. These smaller packages provide greater opportunities for local and regional businesses in the NWT.

It is also anticipated that the care and maintenance function for the site will be assumed by the CM. Along with care and maintenance, the CM will be assigned full responsibility for the health and safety of the entire site, as prime contractor, throughout the duration of the Giant Mine Remediation Project.

Through the Government of Canada contract, the CM will be subject to the socio-economic commitments made by the proponent in the Environmental Assessment and Regulatory processes. Contracts placed through the CM will be let in an open, fair and competitive process and include all of the relevant commitments made by the Government of Canada. For example, contractors bidding on these smaller packages will be asked to demonstrate how they will provide training opportunities and employment to Aboriginal and northern companies and people. The procurement of these packages or projects will be closely monitored by PWGSC and the results reported to INAC and the GNWT to ensure commitments are honoured.

Overall Project Management of the CM contract will be the responsibility of PWGSC. PWGSC will be assisted in this role by a Project Management Consultant for the duration of implementation.

A long-term contract for Post-Remediation activities will also be required for the operation of the water treatment plant, maintenance of the freeze system and site security.

INAC, PWGSC and the GNWT have already begun meeting with affected Aboriginal governments and organizations to determine the most appropriate way to provide opportunities through training, employment and business opportunities. PWGSC will be holding workshops for Northern and Aboriginal businesses to enable them to learn about the opportunities associated with the Remediation Project and the contracting process.

The Procurement Strategy for the Remediation Project strives to ensure long-term economic opportunities for the people of the NWT. All aspects of the Remediation Project will be completed through open, fair and competitive contracts. The Project Team will work with NWT businesses and individuals to ensure they can fairly compete for opportunities associated with the Remediation Project.

It is anticipated that there will be no barriers for the participation of NWT residents and Aboriginal peoples in the Giant Mine Remediation Project.

6.13.5 Human Resource Requirements

Table 6.13.2 lists estimated numbers of person-hours to be involved in each implementation activity, and the expected time frame. As most of the activities are still in early stages of design, these estimates are very rough. Position types are also identified.

Table 6.13.3 lists the expected number and types of full-time equivalent positions that will continue over the long-term.

Table 6.13.2 Employment During Implementation Phase

Component	Person-Hours	Typical Positions
Remediation management	504,000	Project manager, civil engineer, mining engineer, quantity surveyor, technician, environmental superintendant, environmental monitor, trades supervisor, safety supervisor, planner, accountant, clerk
Baker Creek	144,000	Civil engineer, shift foreman, surveyor, rod man, heavy equipment operator, labourer, technician, mechanic, truck driver, surface driller/blaster, dozer operator
Buildings, hazardous waste & debris	136,000	Civil engineer, shift foreman, surveyor, rod man, technician, mechanic, electrician, millwright, heavy equipment operator, truck driver, labourer
Contaminated soils	117,000	Civil engineer, shift foreman, surveyor, rod man, mechanic, heavy equipment operator, technician, truck driver, labourer
Freeze system	762,000	Civil engineer, mining engineer, shift foreman, surveyor, rod man, heavy equipment operator, labourer, technician, truck driver, surface driller/blaster, drillers helper, journeyman pipe fitter, lead instrument technician, instrument technician, underground shift boss, underground miners, underground driller, underground rill helper, jumbo operator, LHD operator, underground safety, mechanics, electrician
Highway	30,000	Civil engineer, shift foreman, surveyor, rod man, mechanic, heavy equipment operator, technician, truck driver, labourer
Pits	27,000	Civil engineer, shift foreman, surveyor, rod man, heavy equipment operator, labourer, technician, truck driver, surface driller/blaster
Shafts & adits	9,000	Mining engineer, underground shift boss, underground miners, underground driller, underground drill helper, surveyor, rod man, jumbo operator, LHD operator, underground safety, mechanic, electrician
Tailings & sludge ponds	477,000	Civil engineer, shift foreman, surveyor, rod man, heavy equipment operator, labourer, technician, mechanic, truck driver, surface driller/blaster
Underground preparation	104,000	Mining engineer, underground shift boss, underground miners, underground safety, mechanic, electrician
Water management	186,000	Civil engineer, chemical engineer, mechanical engineer, electrical engineer, technician, trades foreman, electrician, carpenter, pipefitter, heavy equipment operator, labourer

Table 6.13.3 Estimated Full-Time Equivalent Positions During Long-term Operations & Maintenance

Component	Full-Time Equivalent Positions
Site manager	1
Environmental technician	1.5
Water treatment operators	4
Trades	0.5
Heavy equipment operator	1
Total	8

6.13.6 Financial Resource Requirements

Table 6.13.4 presents a summary of estimated costs for the implementation phase of the Remediation Project. Table 6.13.5 presents a summary of estimated annual costs over the long-term.

Funding for the Remediation Project is provided by the Federal Contaminated Sites Action Plan (FCSAP) which is transferred annually to INAC. The FCSAP program is administered through the FCSAP Secretariat at Environment Canada.

Treasury Board Approvals will be required for both the Effective Project Approval (implementation of the activities included in this assessment) and for the awarding of contracts above 40 Million dollars. Effective Project Approval will be sought by INAC, whereas approval for the awarding of contracts will be sought by PWGSC.

Table 6.13.4 Estimate of Total Costs – Implementation Phase

Component	Direct Cost	Indirect Cost	Contingency	Subtotals
Remediation Management	$ 65,657,339	$ 0	$ 9,848,601	$ 75,505,940
Care and Maintenance	$ 70,276,286	$ 0	$ 1,078,040	$ 71,354,326
Baker Creek	$ 10,444,509	$ 4,425,194	$ 3,717,426	$ 18,587,129
Buildings, Hazardous Waste and Debris Disposal	$ 13,398,988	$ 0	$ 6,699,494	$ 20,098,482
Contaminated Soils	$ 9,180,135	$ 3,136,990	$ 3,695,137	$ 16,012,262
Freeze System	$ 95,084,210	$ 27,536,273	$ 29,281,862	$ 151,902,345
Highway	$ 3,278,643	$ 1,427,047	$ 705,854	$ 5,411,544
Pits	$ 1,902,590	$ 924,978	$ 424,136	$ 3,251,704
Shafts and Adits	$ 680,374	$ 390,560	$ 160,640	$ 1,231,574
Tailings and Sludge Ponds	$ 42,608,281	$ 14,755,144	$ 5,601,504	$ 62,964,929
Sub-Surface Work	$ 8,967,055	$ 3,777,961	$ 2,549,004	$ 15,294,020
Water Management	$ 27,058,511	$ 4,706,893	$ 5,787,025	$ 37,552,429
Subtotals	$ 348,536,921	$ 61,081,040	$ 69,548,723	$ 479,166,684

Table 6.13.5 Estimated Annual Costs – Long-term Operations & Maintenance

Component	Average Annual Cost
Site management and monitoring	$260,000
Freeze system operation & maintenance	$360,000
Earthworks inspection & maintenance	90,000
Water management operation & maintenance	$1,200,000
Total	$1,910,000

7 Description of the Existing Environment

Based on existing site conditions (Chapter 5) and proposed project works and activities (Chapter 6), the description of the existing environment focuses on those aspects of the environment that have a potential to interact with the Giant Mine Remediation Project, both during the remediation phase and long-term operation and management. This environmental "baseline" (i.e., the environment as it is now) serves as the basis for determining incremental changes and likely environmental effects associated with the Remediation Project, as presented in Chapter 8.

Environmental studies have been carried out on and around Giant Mine for several decades. In particular, numerous physical and biological investigations have been conducted by INAC since becoming custodian of the site in 1999. When combined with the broader set of environmental studies conducted in the vicinity of Yellowknife, these investigations provide an excellent body of knowledge to describe baseline conditions relevant to the Remediation Project.

Consistent with the rest of the DAR, the description of baseline conditions has been organized according to environmental components. These environmental components were selected on the basis of likely interactions with the Remediation Project, as well as from past experience on similar projects. The environmental components and corresponding section headings for the description of the existing environment are as follows:

Section	Environmental Component
7.1	Surface Water Environment
7.2	Geological and Hydrogeological Environment
7.3	Atmospheric Environment
7.4	Aquatic Environment
7.5	Terrestrial Environment
7.6	Aboriginal Interests
7.7	Additional Community Interests

Depending on the environmental component under consideration, sub-components were selected to ensure analysis was conducted at an appropriate scale. For example, the description of the Surface Water Environment was separated into the following sub-components: hydrology, surface water quality and sediment quality. The baseline descriptions for each environmental component (or sub-component) are generally organized according to the study area boundaries defined in Section 3.4.1. Typically, baseline conditions across the Regional Study Area (RSA) are presented first, then the conditions in the Local Study Area (LSA) and finally, those in the Site Study Area (SSA). Through this tiered approach, conditions in the RSA provide context for the more localized conditions in the LSA and the SSA.

The description of each environmental component concludes with the selection of Valued Components (VCs) to be forwarded to the analysis of potential project effects, as presented in Chapter 8.

7.1 Surface Water Environment

7.1.1 Introduction

Water quality and sediment quality are key determinants of the health of aquatic ecosystems. The following sections provide a synopsis of surface water and sediment quality within areas that have the potential to be affected by the Giant Mine Remediation Project. These areas include the site itself and the downstream receiving environment of Great Slave Lake. An overview of site hydrology is also provided. Collectively, water quality, sediment quality and hydrology are considered to be part of the Surface Water Environment. On this basis, the sub-components of the Surface Water Environment are as follows:

- Hydrology;
- Surface Water Quality; and
- Sediment Quality.

The evaluation of the existing Surface Water Environment focuses on physical and chemical attributes. Biological components such as aquatic biota and habitat are discussed separately in Section 7.4.

As indicated previously, arsenic has been identified as a contaminant requiring particular attention when evaluating potential effects associated with the Remediation Project (Review Board 2009). In addition to arsenic, previous studies of Giant Mine and surrounding environments have identified other contaminants of potential concern. However, all of these contaminants were either: a) present at concentrations below levels that are likely to cause adverse effects, or b) in areas that are "co-contaminated" with arsenic. In the latter case, arsenic concentrations were consistently more elevated relative to applicable thresholds. As a consequence, remediation of arsenic contamination will also address other contaminants of potential concern. On this basis, the following sections focus primarily on arsenic concentrations in the Surface Water Environment.

7.1.2 Hydrology

As described in Chapter 6, the Remediation Project will result in changes to the hydrology of Baker Creek, which is located within the SSA. However, no changes to the hydrology of Great Slave Lake (i.e., the LSA) are anticipated. As a result, the following sections focus exclusively on the hydrology of the SSA. The generic SSA as described in Section 3.4.1 and shown on Figure 3.4.1 has been used without revision.

7.1.2.1 Site Study Area

The dominant hydrological feature in the SSA is Baker Creek (as presented in Figure 5.8.1). The creek, which originates upstream of Giant Mine, drains in a generally southward direction and discharges into Yellowknife Bay of Great Slave Lake. Overall, Giant Mine represents a relatively small portion of the total Baker Creek watershed. As a result, the natural hydrological response, stream flows and total runoff from Baker Creek are primarily a function of the watershed above the mine.

Baker Creek has a similar setting and characteristics to many other stream systems in the Northwest Territories. The suspended and bed loads of these systems are relatively low due to glaciation, weathering processes, terrain and the influence of lakes in the systems. Ice and freeze-thaw weathering processes dominate surface runoff, erosion, and fluvial processes. In Baker Creek, alluvial sediments are limited, and stream structure and features are relatively immobile. Stream flows are influenced by snow pack, lake storage deficit and summer precipitation.

As described in Section 5.8, large portions of Baker Creek have been disturbed throughout the mine site. Due to the influence of mine tailings and other factors, most of the channel structure and sediment composition has been affected through this area as well. Relocation, channelization and regrading during mining has converted broad run/riffle habitats interspersed with steeper riffle-pool areas to either ponded areas or confined channels with little structure. The existing channel is traversed by structures that either form a hydraulic control or limit the natural behaviour of the system. These include old mine infrastructure, mine road crossings, in-channel structures and debris, and crossings of Highway 4 (the Ingraham Trail).

The Baker Creek catchment has two distinctive features that control the stream's runoff response. First, the catchment has a very low relief, with an overall elevation range of about 157 m to 260 m. Second, storage in the upper catchment is provided by a number of lakes and wetland areas. The arid climate of the region also plays an important role in the character of Baker Creek's flows.

The hydrology of Baker Creek upstream of Giant Mine can be characterized with a high degree of accuracy because the Water Survey of Canada (WSC) has monitored the flow of this stream since 1968. The stream flow has been measured at two locations, the first of which was located just upstream of the confluence with Trapper Creek. In 1983, the station was moved about 3 km upstream to its current location at the outlet of Lower Martin Lake. The official estimates of drainage areas for the two locations are 126 and 121 square kilometres (km^2), respectively.

The WSC data from upstream of Giant Mine were used to characterize the low, average, and flood flows of Baker Creek. To improve the accuracy of the characterization, the two flow records were combined to create a single, longer record spanning more than 35 years. Owing to the small difference in their respective catchment areas, no adjustments were made to the flows of the original station before using them to extend the record of the current station. The long-term average flow is estimated to be approximately 0.215 cubic metres per second (m^3/s) or 6,800,000 m^3 per year, which is equivalent to an average annual yield of 56 millimetres (mm) when expressed as a depth of water (i.e., the average annual volume of runoff distributed evenly over the contributing catchment area). Thus, the average annual runoff generated by Baker Creek is only a small fraction (about 16.5%) of the total precipitation falling on the catchment.

There is some uncertainty in the official estimate of the drainage areas for the WSC stream flow gauging stations and for Baker Creek as a whole. This uncertainty arises because the available topographic maps for much of the catchment do not meet the minimum standard typical of mapping prepared by Natural Resources Canada. As part of a recent study, the catchment boundary of Baker Creek was delineated on available 1:50,000 maps. Different interpretations of where the drainage boundary should be placed suggested that the total catchment area for Baker Creek at its mouth falls in the range of 144 to 178 km^2. These uncertainties would change the estimates of unit runoff, but not substantively affect the estimated flood flows or low flows presented below.

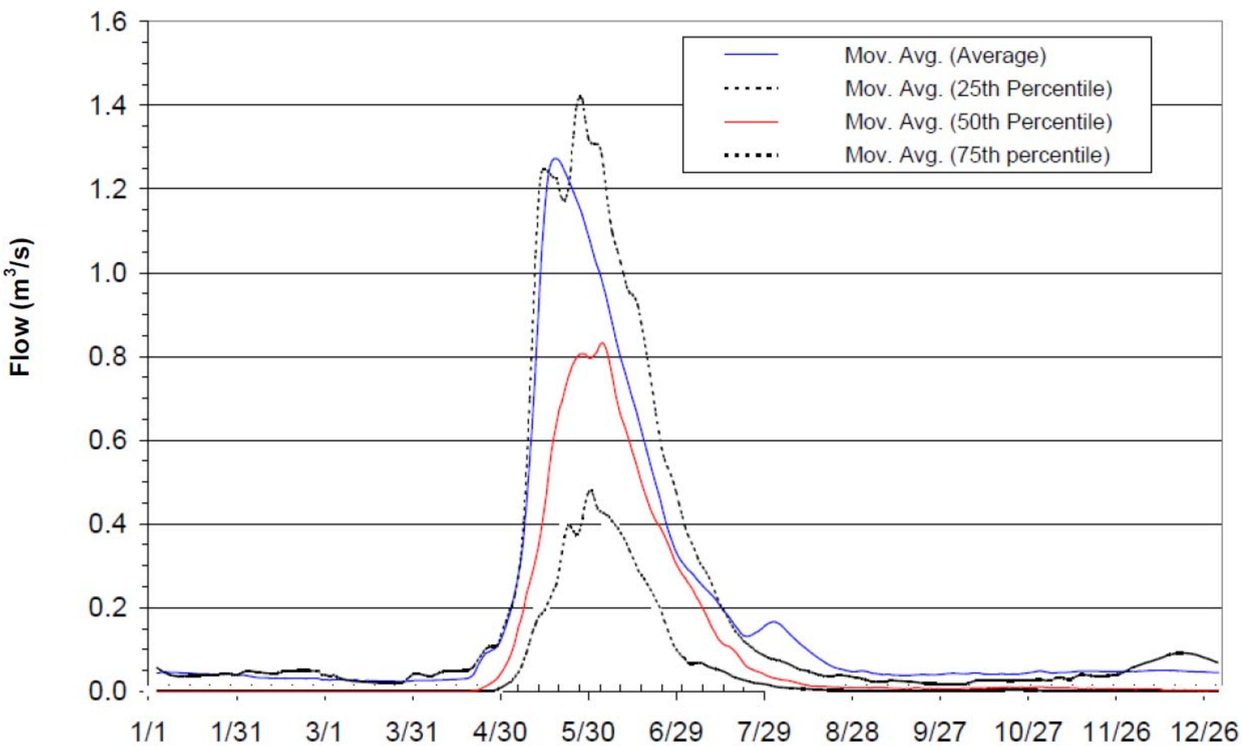
The largest recorded flood flow for Baker Creek at the WSC monitoring station is 8.5 m^3/s. This is equivalent to a unit discharge of 70 litres (L) per second per square kilometre of the watershed, which is very low on the scale of floods experienced elsewhere in Canada. The measured annual floods in Baker Creek were fitted to a theoretical frequency distribution to estimate instantaneous flood peaks for a range of return periods from 2 years to 200 years. Table 7.1.1 shows the results of this analysis. The relatively low flood flows can be attributed to the arid climate and the water storage available in the numerous lakes and wetlands in the catchment. Further information on the flood regime of the Baker Creek catchment is contained in SRK (2004d).

Table 7.1.1 Estimated Flood Flows for Baker Creek at the Outlet of Lower Martin Lake

Return Period (years)	Estimated Flood Discharge	
	(m^3/s)	$(L/s)/km^2$
2	1.3	11
10	3.8	32
50	8.3	69
100	11.3	93
200	15.2	126

As indicated in the average annual hydrograph for Baker Creek provided in Figure 7.1.1, flow within the creek drops to zero for some period in winter almost every year[17] In addition to low flow conditions during winter, Baker Creek can also dry up during the summer. The extended flow record for the creek was subjected to a frequency analysis to estimate summer low flows (June 1 to September 30) for a range of durations and return periods. The results, summarized in Table 7.1.2, indicate that flows within Baker Creek would be expected to decrease to very low levels (i.e., relative to peak flows) on a regular basis. However, under current conditions, the discharge of approximately 750,000 m^3 of treated minewater during the summer months prevents the possibility of the creek drying out.

Figure 7.1.1 Baker Creek Annual Average Hydrograph Upstream of the Giant Mine



[17] From the 29 complete years of data collected from the two upsteam gauging stations, winter flows fell to zero in 26 of the years.

Table 7.1.2 Estimated Summer Low Flows for Baker Creek at the Outlet of Lower Martin Lake (June 1 to September 30)

Return Period (years)	Duration (days)	Estimated Discharge (m^3/s)
2	1	0.003
	7	0.004
	30	0.007
	122	0.198
3	1	0.001
	7	0.001
	30	0.002
	122	0.125
5	1	0
	7	0
	30	0.001
	122	0.077
10	1	0
	7	0
	30	0
	122	0.044

7.1.3 Surface Water Quality

The generic LSA and SSA described in Section 3.4.1 have been used in the assessment of existing surface water quality. The assessment has not been extended to the RSA because potential adverse effects of the Remediation Project on water quality, if any, are not anticipated to occur beyond the LSA.

7.1.3.1 Water Quality Guidelines

As noted above, arsenic has been selected as the primary indicator of water quality for the Project. The Canadian Council of Ministers of the Environment (CCME) has established an arsenic concentration guideline for protection of freshwater aquatic life (FAL) based on the most arsenic-sensitive species of freshwater algae. Toxicity tests on the algae demonstrated growth inhibition at a concentration of 50 micrograms per litre (μg/L). The CCME subsequently multiplied this concentration by an application factor of 0.1 to yield the water quality guideline of 5.0 μg/L to protect freshwater aquatic life. In essence, the 5.0 μg/L guideline includes a 10 times factor of safety for the lowest effect levels in highly arsenic-sensitive aquatic species.

While the CCME freshwater arsenic guideline serves as an indicator of potential environmental degradation, it is fundamentally conservative and does not necessarily indicate that adverse effects are occurring within a given species of interest. Of particular importance, freshwater fish have demonstrated a lower sensitivity to arsenic than either invertebrates or algae. For example, as reported in SENES (2006), an effects concentration (EC) to 20% of the population of predator fish (e.g. northern pike, lake trout) was calculated to be 140 µg/L.[18] This serves to illustrate that site-specific conditions need to be considered when determining whether adverse effects to the environment are likely to occur. The potential for such effects to aquatic biota are considered in detail in Section 8.9.4.

With regard to human intake of arsenic in drinking water, the Guidelines for Canadian Drinking Water Quality have established the maximum acceptable concentration of arsenic in water as 10 µg/L (Federal-Provincial-Territorial Committee on Health and the Environment 2008). Similar to arsenic exposures for freshwater aquatic life, the potential for people to experience effects from elevated arsenic concentrations in water depends on a variety of additional factors, including arsenic exposures from other sources. The potential for such effects to humans is considered in detail in Section 8.9.5.

7.1.3.2 Local Study Area

Giant Mine is situated along the northeast shoreline of Yellowknife Bay on Great Slave Lake. Yellowknife Bay receives drainage from the Yellowknife River at its north end and extends approximately 18 km before opening into Great Slave Lake. As indicated in Section 7.1.2.1, the bay also receives drainage from Baker Creek which traverses the Giant Mine site.

To assist in determining potential environmental effects associated with Giant Mine, previous investigations have divided the LSA into smaller segments (e.g., SENES 2006). The segments, which are illustrated in Figure 7.1.2 and summarized in Table 7.1.3, are generally described as follows:

- Segment 1 - Referred to as “Back Bay”, the northern boundary of the segment is defined by the north tip of Latham Island. This segment includes the majority of the shoreline along the Giant Mine site and receives drainage from Baker Creek.
- Segment 2 - Encompasses input from the Yellowknife River and extends to the tip of Latham Island. In this assessment the segment is referred to as North Yellowknife Bay.
- Segment 3 - Encompasses the portion of Yellowknife Bay from the City of Yellowknife to Dettah. The segment is referred to in this assessment as South Yellowknife Bay.

[18] The calculated effects concentration was based on an acute effect (i.e., lethal concentration (LC)) to 50% of test species of 550 µg/L arsenic from a 28-day study on rainbow trout reported by Birge *et al*. (1979).

Figure 7.1.2 Segments of the Local Study Area for Water and Sediment

Table 7.1.3 Back Bay and Yellowknife Bay Physical Attributes

Characteristics	Units	Back Bay Segment 1	Yellowknife Bay	
			Segment 2	Segment 3
Surface Area	million m^2	2.51	5.30	12.73
Volume	million m^3	17.33	44.03	143.02
Mean Depth	m	6.9	8.3	11.2

A comprehensive summary of arsenic concentrations in surface waters on, and in, the vicinity of the Giant Mine site can be found in Appendix B of SENES (2006) which represents a compilation of more than 30 years of available arsenic data. Table 7.1.4, which is based largely on this data set, presents a statistical summary of arsenic concentrations for each segment within the LSA. It should be noted that current arsenic concentrations within the LSA are significantly lower than the mean concentrations reported in Table 7.1.4. For example, the most recent samples collected from Back Bay and North Yellowknife Bay in November 2009 had a mean arsenic concentration of 0.4 µg/L, well below the 5 µg/L CCME arsenic criterion for the protection of freshwater aquatic life.

Table 7.1.4 Measured Arsenic Levels in Surface Water (1973-2009)

	Total Arsenic Concentration (µg/L)			
	Great Slave Lake			Yellowknife River
	Back Bay	Yellowknife Bay - North	Yellowknife Bay - South	
# of Samples	54	29	35	8
Arithmetic Mean	28.1	9.5	16.9	0.26
Std. Dev.	104	19	89	0.07
Geometric Mean	3.8	3.1	1.3	0.25
Geom. Std. Dev.	6.3	4.6	3.8	1.4
Minimum	0.3	0.3	0.3	<0.3
Maximum	740	83	530	0.3

Notes: µg/L = micrograms per litre; Std. Dev. = standard deviation

As noted in the above table, arsenic concentrations in water collected from the Yellowknife River are much lower than within Back Bay and Yellowknife Bay. Elevated arsenic concentrations observed in Great Slave Lake are attributable in large part to releases during the historic operation of Giant Mine. For example, roaster emissions resulted in the deposition of arsenic in areas surrounding the mine which continue to be released to the aquatic environment. Similarly, discharge of untreated minewater during the initial mining period and the release of tailings to Back Bay during the early operational phase of the mine contributed arsenic loads to the water column and sediments. These historic releases, as well as current discharges from the site, serve as ongoing sources of arsenic input to the receiving waters of Great Slave Lake.

The trend in the arsenic levels in Back Bay and Yellowknife Bay over the past several decades is demonstrated in Table 7.1.5. The geometric mean values in all three water bodies clearly show a decreasing trend from the 1970's onwards. Most importantly, it is seen that the arsenic levels in Back Bay and Yellowknife Bay have fallen below water quality guidelines for protection of aquatic biota and drinking water supplies during the past two decades.

Table 7.1.5 Changes in Arsenic Levels in Surface Water Over Time

	Total Arsenic Concentration (μg/L)		
	Back Bay	**North Yellowknife Bay**	**South Yellowknife Bay**
Geometric Mean Concentration by Decade			
1970's	31.4	24.2	530
1980's	7.0	2.8	1.0
1990's	1.8	2.5	1.2
2000's	0.4	0.4	-

Note: Only one data point reported in South Yellowknife Bay in the 1970's.

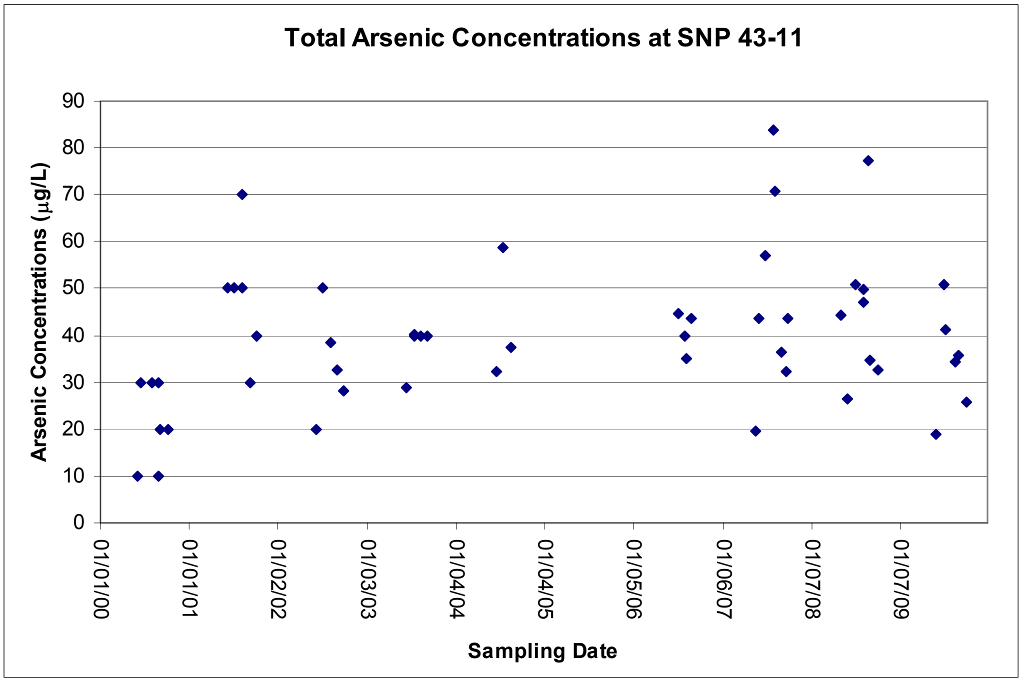
7.1.3.3 Site Study Area

Routine monitoring of surface flows and arsenic concentrations was carried out by Miramar Giant Mines Ltd. as part of the Surveillance Network Program (SNP) required by the site water licence. INAC has continued to implement the SNP which includes regular monitoring of stations upstream of the mine on Baker Creek, the outlet of Trapper Lake, Trapper Creek, the discharge from the underground mine to the Northwest Tailings Pond, the discharge from the water treatment plant, and the mouth of Baker Creek. A number of additional studies have also been implemented to assist in the characterization of water quality within the SSA. The following descriptions provide an overview of the findings from these studies. The locations of current (and future proposed) surface water sampling stations are identified in Chapter 14.

Upstream Water Quality

As shown in Figure 7.1.3, arsenic concentrations in Baker Creek immediately upstream of the mine area typically range from 20 to 60 μg/L. Detailed investigations have suggested that some portion of the arsenic present in the drainage area upstream of the mine may be attributed to weathering of bedrock that is variably enriched in arsenopyrite and contributes to the naturally high background arsenic levels in the area. However, arsenic concentrations upstream of the mine were higher than those in similar rock formations of the surrounding region, suggesting that some of the arsenic may be due to atmospheric deposition onto soils and sediments during the historical roasting operations at Giant Mine.

Figure 7.1.3 Arsenic in Water Concentrations from Baker Creek Upstream of Giant Mine



On-Site Water Quality

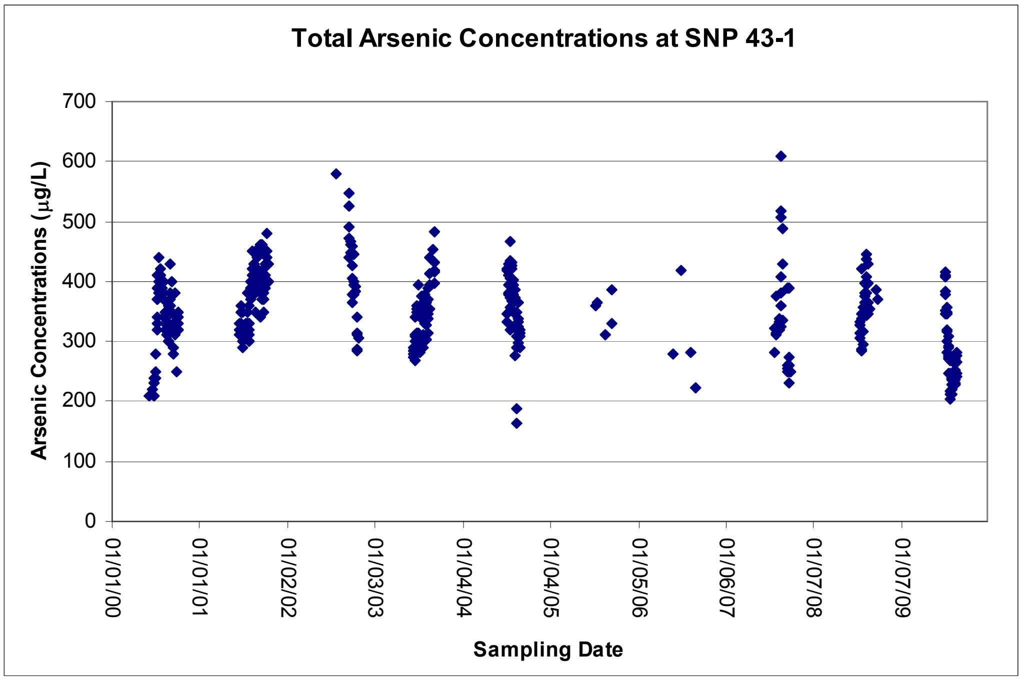
Trapper Creek is the largest tributary to Baker Creek in the vicinity of the mine, and enters Baker Creek just upstream of the water treatment plant discharge point. Trapper Creek is monitored at two locations: the outlet of Trapper Lake, and immediately upstream of Baker Creek. Monitoring at two locations is undertaken to measure the effects, if any, of seepage from the Northwest Pond on Trapper Creek water quality. Arsenic concentrations at both stations typically range from 50 to 200 µg/L, with average concentrations of approximately 100 µg/L.

Arsenic concentrations from the minewater treatment plant are monitored throughout the discharge period which typically runs for 13 to 14 weeks during the open-water season (based on data from 1992 to 2008).[19] Arsenic concentrations in the discharge from the water treatment plant are displayed in Figure 7.1.4. The long-term average arsenic concentration of the discharge is approximately 400 µg/L (the concentration has been trending downward for the past three years and is currently averaging closer to 300 µg/L). During the summer months, the discharge

[19] In recent years, the intiation of discharge has been delayed to allow for the out-migration of young-of the-year fish present in Baker Creek. The period of discharge has, therefore, been shortened to a maximum of approximately 10 weeks.

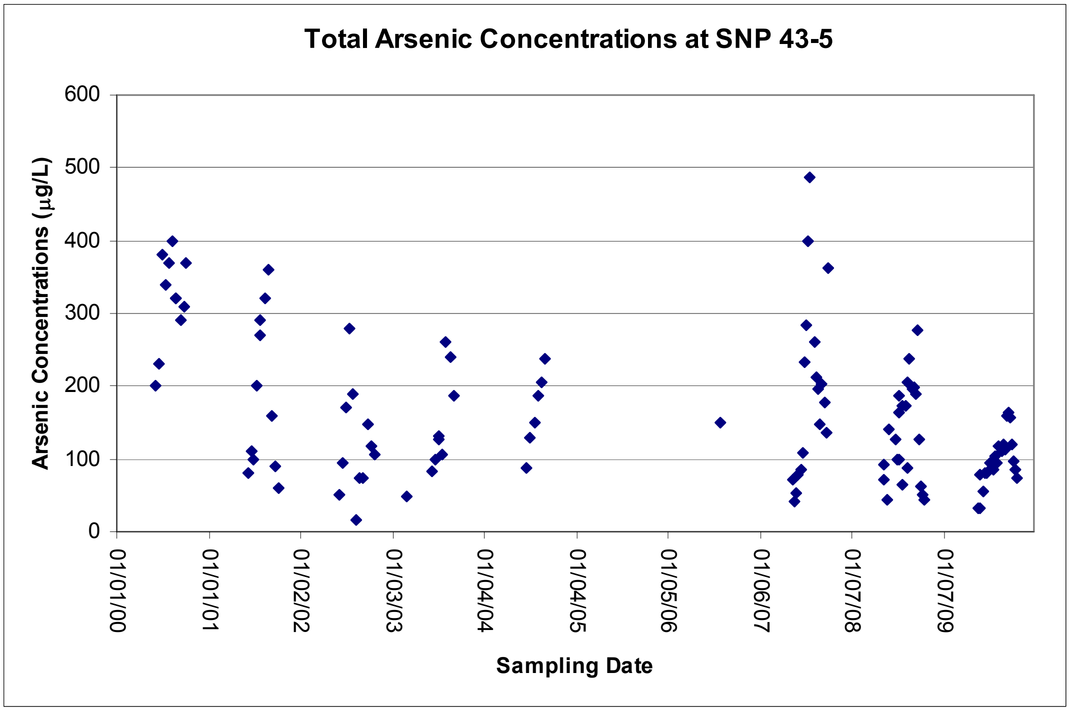
from the minewater treatment plant currently comprises a significant portion of the arsenic loading and volumetric flow of Baker Creek. For example, annual discharge volumes ranged from 255,000 to 1,828,000 m^3 between 1997 and 2006. On average, this represents an estimated flow rate of 0.13 m^3/s during the period of discharge. In contrast, the long-term average flow from upstream of the site is approximately 0.215 m^3/s.

Figure 7.1.4 Arsenic Concentrations in Treated Minewater



In addition to the loading associated with the minewater treatment plant, there is a progressive increase in arsenic concentrations as Baker Creek passes through the mine area. Data from the mouth of Baker Creek provide the most continuous record of downstream concentrations. The results, which are displayed in Figure 7.1.5, indicate there is a large difference in concentrations between samples collected during periods of treated water discharge and samples collected at other times of the year. During the discharge period, arsenic concentrations ranged from 60 to almost 500 µg/L, while during periods without discharge, arsenic concentrations ranged from 17 to 280 µg/L. Flow-weighted average arsenic concentrations for the discharge and non-discharge periods were 120 µg/L and 68 µg/L, respectively. The overall average concentration downstream of the mine was 94 µg/L.

Figure 7.1.5 Arsenic in Water Concentrations at the Discharge of Baker Creek to Great Slave Lake



Other surface water sampling programs have included detailed seepage surveys and additional sampling of Baker Creek and its tributaries upstream and to the west of the mine (SRK 2005f). Arsenic concentrations in seepage and runoff ranged from approximately 200 µg/L from undisturbed areas near the mine to as high as 68,000 µg/L in a water collection pond near the mill. However, most samples had arsenic concentrations of less than 1,000 µg/L.

The treated water discharge, plus runoff inputs from contaminated soils, tailings spills, and relatively undisturbed areas around the mine, account for essentially all of the arsenic loading observed at the mouth of Baker Creek. Creek sediments may also contribute to the arsenic concentration in the water of Baker Creek, but the sediment contribution is not distinguishable in the current data.

7.1.4 Sediment Quality

The generic LSA and SSA described in Section 3.4.1 have also been applied to sediment quality. The assessment has not been extended to the RSA because potential adverse effects of the Remediation Project are not anticipated to extend beyond the LSA.

Multiple investigations of sediment quality in the vicinity of Giant Mine have been conducted by numerous parties, particularly within the last decade. The most recent and comprehensive of the studies, which are summarized in the current section, include:

Local Study Area – A comprehensive investigation of the sediments and benthos of North Yellowknife Bay was conducted by Golder Associates in 2005 (Golder 2005a). The study, which was performed in a grid network emanating from the shoreline of the Giant Mine site, included sediment chemistry, grain size analysis and benthos.

Site Study Area – Sediment samples were collected and analyzed by Jacques Whitford in 2005 from Baker Creek at stations immediately upstream and within the SSA (Jacques 2006). The assessment evaluated the physical and geochemical properties of sediments at multiple depths throughout the study area.

7.1.4.1 Sediment Quality Guidelines

As with other environmental media, arsenic concentrations in sediments on, and in, the vicinity of Giant Mine are elevated relative to background concentrations. In addition to arsenic, elevated concentrations of other potential contaminants of concern including antimony, cadmium, chromium, copper, nickel, selenium and zinc have also been measured in local sediments. However, as indicated previously, areas with elevated concentrations of these metals coincide with arsenic concentrations that are more elevated relative to applicable criteria. As a consequence, arsenic has been selected as the primary contaminant of potential concern for sediments. While the discussions that follow focus on arsenic, additional information characterizing the sediment of the study areas is presented in the two documents referenced above.

Overall, the implementation of the Remediation Project is not anticipated to result in an increase of sediment contamination. To the contrary, the project will have a beneficial influence. In this regard, metals that currently have elevated concentrations in sediments are not appropriate indicators for efforts to identify adverse effects associated with the implementation of the Remediation Project. Nonetheless, the presence of these potential contaminants in sediments has influenced decision-making regarding the preferred remediation strategies for the site.

With regard to sediment quality guidelines, the CCME has developed guidelines to assist with the identification and characterization of potential effects. Two sets of guidelines are provided by the CCME (1999 and updates). The Interim Sediment Quality Guidelines (ISQGs) provide scientific benchmarks, or reference points, for evaluating the potential for observing adverse biological effects in aquatic systems. The Probable Effects Levels (PELs) define the levels above which adverse biological effects are expected to occur frequently. The guidelines are derived from the available toxicological information according to the formal protocols established by the CCME.

The ISQG and PEL criteria [i.e. ISQG = 5.9 µg/g dry weight (dw) and PEL = 17 µg/g (dw)] have been used to evaluate the quality of sediment samples collected from the Giant Mine site and the downstream receiving environment, as presented in the following sections.

7.1.4.2 Local Study Area

A variety of historic, current, and future activities have influenced, and will continue to influence the sediment quality of Yellowknife Bay. During the early operational phase of the mine, such activities included the direct deposition of approximately 300,000 tonnes of tailings to the foreshore of North Yellowknife Bay. The tailings deposited in the bay have been in place for over 50 years and have been subject to weathering, erosion and dispersion. About 35% of the tailings are on the beach, with the remaining tailings submerged in north Yellowknife Bay. Atmospheric emissions from the Roaster Complex and discharge of minewater (treated and untreated) to Baker Creek have also resulted in historic arsenic loadings to Back Bay and Yellowknife Bay. In addition to historic impacts, calculations indicate that, under current conditions, the total arsenic loading in Baker Creek is approximately 800 kg/year (SRK 2005e). Collectively, these historic and ongoing loadings are exerting an influence on the baseline sediment quality of Back Bay and Yellowknife Bay.

As noted above, Golder (2005a) is the most recent and comprehensive evaluation of sediments in North Yellowknife Bay. Five principal sources of information are provided by Golder, including: total and extractable arsenic and metal content of sediments; benthic invertebrate abundance and community composition (as described in Section 7.4); a geophysical survey of the beach area tailings; air photo interpretation of Back Bay and North Yellowknife Bay; and visual assessment of the sediment cores from the study area.

The distribution of total arsenic in sediments observed by Golder (2005a) is presented in Figure 7.1.6. The highest concentrations of arsenic were generally found along the western side of North Yellowknife Bay from the mouth of Baker Creek to the north of the historic tailings deposit, with concentrations generally decreasing with distance from this zone. Total arsenic concentrations ranged from 6.9 µg/g to 2250 µg/g, with a median of 171 µg/g (dry weight = dw). In contrast, the CCME guidelines for arsenic in sediment are: ISQG = 5.9 µg/g (dw) and PEL = 17 µg/g (dw). The measured arsenic concentrations were comparable to those observed during previous sampling events in Back Bay and Yellowknife Bay.

Figure 7.1.6 Arsenic Concentrations in North Yellowknife Bay Sediments

In addition to surface sediment sampling, Golder also collected samples from multiple sediment depths along one of the survey transects. The arsenic concentrations, which are summarized in Table 7.1.6, ranged from 10.8 µg/g to 1730 µg/g. At stations near the shore (i.e., 250 m and 500 m from shore) arsenic concentrations were generally similar at the three core depths examined. At stations farther than 500 m from shore, arsenic concentrations tended to decrease with core depth.

Table 7.1.6 Total Arsenic Concentrations for Selected Core Depths in Yellowknife Bay

Distance from shore (m)	Core Depth (cm)	Arsenic Concentration (µg/g)*
250	0-5	1570
	5-10	1410
	10-15	1730
500	0-5	387
	5-10	220
	10-15	554
750	0-5	69.2
	5-10	45.3
	10-15	15.8
1000	5-10	19.2
	10-15	13.8
1500	0-5	57.6
	5-10	39.8
	10-15	10.8

* Note: ISQG = 5.9 µg/g (dw); PEL = 17 µg/g (dw).

Taking in consideration the results noted above and the results of benthic community surveys, Golder concluded that arsenic contamination of Yellowknife Bay sediments has negatively affected the benthic invertebrate community along the western shore of the bay to a distance of approximately 500 m from the shore, generally within the area where arsenic concentrations in sediments were greater than 150 µg/g. Additional information regarding the effects of tailings on the Aquatic Environment is presented in Section 7.4.

Based on chemical, biological and visual evidence, Golder suggested that tailings have been transported from the historical tailings deposit along the western side of Yellowknife Bay toward the mouth of the Yellowknife River. In addition, based on results from previous investigations, it was concluded that tailings are also present south of the historical tailings deposit to the mouth of Baker Creek and possibly further south.

When interpreting the effects of elevated concentrations of potential contaminants, bioavailability is an important factor to consider. For example, arsenic can be present in a variety of forms, only some of which are mobile and/or potentially toxic. In addition to serving as a tool to evaluate bioavailability, sequential extraction tests can assist in determining the source of a contaminant. The Golder (2005a) study included sequential extraction tests on selected samples to assess whether the arsenic was associated with insoluble tailings solids or with other, more soluble arsenic phases. The extractable arsenic data suggest that arsenic occurs principally as sulphides within the historic tailings deposit, typical of tailings composition. Near the mouth of Baker Creek, a large proportion of the arsenic is adsorbed to the sediment. This form of arsenic may have been precipitated onto sediments from a dissolved source and, as such, may not be directly related to the presence of submerged tailings. Possible sources of dissolved arsenic include arsenic-rich pore water from contaminated sediments and treated minewater discharged through Baker Creek. The arsenic in all samples subjected to sequential extraction is considered to occur in a stable form, provided the current submerged and slightly oxidizing conditions are maintained.

Work published recently by Andrade *et al*. (2010) expands upon that of Golder (2005a) and provides important details on the redox conditions of arsenic in Yellowknife Bay sediments and pore waters at high resolution in the vertical direction. Sediment cores in Yellowknife Bay (approximately 1,000 m offshore) were analyzed every 0.5 cm from 0 to 5 cm sediment depth, every 1 cm from 6 to 11 cm depth and every 2 cm to 29 cm depth. Arsenic concentrations are lowest (less than 100 µg/g) at core depths of greater than 20 cm and at 2 to 4 cm depth. Arsenic concentrations are highest (up to 1,300 µg/g) at mid-core depths (5 to 15 cm), spiking sharply following opening of Giant Mine and decreasing following the implementation of later emissions controls. Arsenic concentrations are also high near the sediment surface, spiking sharply in the top 2 cm of the sediment cores with concentrations up to 1,100 µg/g. Using these sediment data and data from pore water samples, Andrade *et al*. (2010) showed that significant amounts of dissolved arsenic is diffusing both upwards and downwards away from the mid-core depths that are enriched in solid-phase arsenic. Almost all of the upwardly diffusing dissolved arsenic is then attenuated (captured) by an iron-manganese (hydr)oxide layer at the sediment surface. Andrade *et al*., (2010) also suggested that, to some extent, this thin oxic layer could be reductively-dissolved, releasing arsenic (and iron) to lake bottom waters as a result of the summer addition of organic matter to the sediment water interface. It was therefore suggested that preservation of this thin oxic arsenic scavenging zone is paramount in arsenic mitigation strategies for Yellowknife Bay.

7.1.4.3 Site Study Area

Jacques Whitford (2006) evaluated 18 sediment sampling stations within the Baker Creek watershed. The stations were selected to assess sediment conditions throughout the Giant Mine surface lease (i.e., the Site Study Area) and upstream of the mine. Sediment cores were collected at each sampling station for depth profiling, and pore water samples were collected from 12 of the stations. Sediment samples collected from Baker Creek were analyzed for physical, chemical, geotechnical and geochemical parameters (sequential extraction, gastric extraction, toxicity test, mineralogy, acid volatile sulphide and chromium reducible sulphide).

The measured total arsenic concentrations in Baker Creek sediments collected from different depths are illustrated in Figure 7.1.7. The concentrations, which ranged from 82.8 µg/g (dw) to 7,660 µg/g (dw), were most elevated (i.e., above 5,000 µg/g (dw)) in the vicinity of B1 Pit (station ST9) and between the A1 and C1 Pits (station ST5).

Sediments from Baker Pond had total arsenic concentrations in the range of a few hundred µg/g to over 3,500 µg/g (dw). The total arsenic concentrations were lower (<2,400 µg/g (dw)) in the Mill Pond Stations (ST6, ST7 and ST8) and Baker Creek downstream stations (ST1, ST2 and ST4). The total arsenic concentrations were observed to increase with depth at some locations (e.g., for stations ST3, ST5, ST9 and ST14).

Based on the results described above, concentrations of arsenic in Baker Creek sediments are well above applicable criteria. For example, the mean arsenic concentration in surficial sediments throughout the SSA was 2,020 µg/g (dw), as compared to the CCME's PEL of 17 µg/g (dw). Despite these elevated concentrations, sections of the creek are serving as viable fish habitat, as described in Section 7.4.

Sequential extraction tests on Baker Creek sediments determined that less than 5% of arsenic is present in forms that are environmentally available (Jacques 2006). Overall, this suggests that the majority of arsenic present in surficial sediments is tightly bound in the sediment matrix and will not be readily soluble for flux into the overlying water column. Despite this, total arsenic concentrations in many sediment samples are thousands of parts per million; therefore, even 5% available arsenic represents a significant source for arsenic remobilization and potential distribution down Baker Creek and into Yellowknife Bay (Jacques 2006).

Figure 7.1.7 Arsenic Concentrations in Baker Creek Sediments

7.1.5 Selection of Valued Components

A number of Valued Components (VCs) have been selected to assess potential effects of the Remediation Project on the Surface Water Environment. In addition to being of critical importance to the Surface Water Environment, some of the VCs are also relevant to other environmental components. For example, water quality and sediment quality are key variables in determining the health of the Aquatic Environment which is discussed in Section 7.4. Due to this "pathways" effect, some of the VCs presented in Table 7.1.7 also appear as VCs for other environmental components that are discussed in subsequent sections of this chapter.

Table 7.1.7 VCs for the Surface Water Environment

Sub-Component	VC	Rationale
Hydrology	Baker Creek	- Changes in flows within Baker Creek important for aquatic biota
Water Quality	Members of the Public	- Protection of human health - Recreational users potentially exposed to contaminants - Site drainage through Baker Creek and treated minewater discharge to Great Slave Lake
	Water quality (intrinsic value)	- identified as a key VC by the Review Board - Aboriginal groups and northerners value components of the environment for their intrinsic value - Species sensitive to contamination of water - Changes assessed as potential pathways to aquatic and terrestrial VCs, as well as human health
Sediment Quality	Sediment quality (intrinsic value)	- Aboriginal groups and northerners value components of the environment for their intrinsic value - Species sensitive to sedimentation and turbidity, as well as contamination associated with sediments - Changes assessed as potential pathways to aquatic VCs

7.2 Geological and Hydrogeological Environment

7.2.1 Introduction

The works and activities of the Remediation Project, as presented in Chapter 6, have been strongly influenced by the Geological and Hydrogeological Environment of the site. By extension, the implementation of the Remediation Project also has the potential to affect certain aspects of the Geological and Hydrogeological Environment. The following environmental sub-components are described for the existing geology and hydrogeology of the Giant Mine area:

- Hydrogeology – Groundwater Flow;
- Hydrogeology - Groundwater Quality;
- Geology – Soil Quality; and
- Geology – Permafrost.

Prior to describing the existing conditions for each of these environmental sub-components, an overview of the structural geology, geomorphology and seismicity of the Giant Mine site is warranted. Although the Remediation Project is not expected to affect these aspects of the environment, each has the potential to influence the nature of effects on other environmental components.

It should be noted that virtually all of the information presented in the following descriptions of the Geological and Hydrogeological Environment focus on conditions within the SSA. The generic SSA, as described in Section 3.4.1, has been used without modification. Geological and Hydrogeological conditions beyond this area are not presented due to the absence of interactions with the Remediation Project.

7.2.2 Structural Geology, Geomorphology and Seismicity

7.2.2.1 Bedrock Geology

Giant Mine lies within altered volcanic rocks of the north-trending Yellowknife Greenstone Belt. The volcanic rocks are bounded to the west by granodioritic plutonic rocks that are in fault contact, and bounded to the east by unconformably overlying sedimentary rocks along the shoreline of Yellowknife Bay. The main ore bodies of Giant Mine are hosted within a major brittle-ductile shear system that crosscuts the Kam Group of volcanic rocks that are dominated by vertical to sub-vertically dipping tholeiitic basalt flows. The flows occur as both pillowed and massive units and sub-volcanic sills and dykes that were emplaced approximately 2.7 Ga (billion years ago). Dacitic to rhyodacitic tuffs and flows are also present. Parts of the Kam Group are crosscut by gabbroic sills and calc-alkaline porphyries intruded at 2.68 Ga that are spatially associated with the gold bearing shear zones. The shear system is complex, with some shears up to 500 m wide and extending over 5 km in strike (Hubbard *et al*. 2006). Mineralization is related to fluid movement through the shear system (van Hees *et al*. 2006) and is thought to have occurred around 2.6 Ga (NWT Geoscience Office, personal communication, 2009). Within the ore zones, basaltic volcanic rocks are recrystallized to serecite schist and chlorite schist.

7.2.2.2 Structural Geology

The Giant Mine site is bounded by a series of major Proterozoic faults (West Bay, Akaitcho, Townsite, Rudolph, and 3-12; Figure 7.2.1). These faults offset the ore body and are, therefore, unrelated to ore emplacement. They are the most important structures in terms of hydrogeology and geotechnical properties. Geomorphological conditions at the site are also controlled to a degree by the fault system, with the West Bay Fault creating a steep cliff line along the west side of the property. However, minor structural features such as fracture sets or shear zones also play a role, and create weaker zones that are followed by local creeks and erosional features. The characteristics of each fault zone vary along strike and down dip.

The West Bay Fault is the major fault in the Yellowknife area and bounds the western edge of the Giant Mine site. It is typified by a relatively discrete, steep westerly dipping fault plane that often contains fault gouge (clayey, ground up rock) and mineral fill. The width of the fault varies from a relatively narrow zone (less than 0.15 m wide) in the southern part of the site, approximately 1 m thick mineralised zone near the Brock Pit in the middle of the property, up to several metres wide, hosting barren calcite-quartz-hematite mineralization at the northern end of the mine. Further north, outside the mine lease close to Ranney Hill, a fault zone greater than 10 m in width of cataclastic quartzhematite mineralization is exposed at ground surface. This variation in fault zone width is indicative of the variation of the fault characteristics across the property.

The Townsite Fault is located at the south end of the Giant Mine workings. The fault, which is visible underground on 425 Level in two different areas and on surface, is typified by a narrow (<5 cm wide), gouge filled, fault plane. The Rudolph Fault was intersected on the 1650 and 2000 mine levels and is observed to be a fairly discrete structure. The Akaitcho Fault bounds the Giant Mine site to the north-east. On surface, the Akaitcho Fault is a narrow (<10cm wide) gouge and mineral filled, fault plane.

None of the faults observed underground were reported to have significant (or measureable in most cases) water flowing from them. This observed low transmissivity correlates with detailed hydraulic testing done on site, and is discussed in more detail below.

The arsenic chambers and stopes reside in a volume of rock that is bounded by three of these major faults and another major fault named the Ole fault. Internally, this rock volume is relatively free of major structures, with the exception of the Ole fault that may intersect the empty Chamber #15. Away from the major structures, the rock contains a relatively high density of small scale structures, consisting of a cross-cutting network of minor shear zones (SRK 2002b).

Figure 7.2.1 Main Faults in the Vicinity of Giant Mine

While the arsenic-filled chambers and stopes away from the B2 Pit (UBC) area are not transected by any major faults, they are found in or adjacent to the main ore zones, which consist of highly strained sericitic schist. This rock type has been recognized as having a higher density of minor faults and fractures, and is typically less competent than the adjacent chlorite schists (SRK 2002b).

Most of the stopes and chambers occupy steeply-dipping sericite or chlorite schist and, thus, remain fairly stable. However, Stopes B212, B213 and B214 are located in the nose of a major fold developed in the sericite schist, and are, therefore, in a less stable environment. This instability has resulted in several hanging wall failures in this area (SRK 2002b).

7.2.2.3 Rock Mass Quality

The #9, 10, 12, 14, 15, B230, B233, B235 and B236 arsenic storage chambers are located in the more competent mafic volcanic rocks that are either massive or pillowed in structure. The mafic volcanics are generally of a "Good" rock mass rating (RMR 60 – 70), with a rock quality designation (RQD) range of 85 – 95% occasionally punctuated by lower RQD's related to fracture zones. The average intact rock strengths (IRS) are in the range of 75 – 125 mega Pascal (MPa). Weaker zones do occur within these units where there is a higher degree of foliation or increased levels of alteration.

The #11 chamber, and the C212, B208, B212, B213 and B214 stopes are hosted in sericite altered rock units within shear zones. These units are generally also of good rock mass rating, but in a number of areas the extent of shearing and alteration reduces the rock mass rating to fair (RMR 55 – 65). The RQD range can be very variable dependent on the level of shearing. The average RQD range is 80 – 90%, but with some weaker zones closer to 50%. The average IRS is 75 MPa which tends to be lower than the massive volcanics especially in areas of increased sericite alteration. In these areas the rock strengths can be as low as 35 – 40 MPa. Due to the development of strong foliation, rock strength and excavation stability are dependent on the orientation of that excavation relative to the prevailing foliation orientation.

7.2.2.4 Macroscopic Transmissivity

The potential influences of the structures on groundwater flow vary according to their scale of development. Major structures include those faults that are continuous over significant distances and intersect many other structures (SRK 2002b).

Where major faults have been observed underground, they were typically dry along most of their observed lengths. These observations have been supported by hydrogeological testing, which showed that the major faults behave as flow barriers, as opposed to conduits. The low transmissivities of the major faults are likely related to the nature of the fault fill, be it a fine fault gouge (i.e. clayey material comprised of mechanically and chemically degraded rock) or a later mineral infilling (e.g. carbonate, hematite or quartz). The development of each type of fill has been observed to vary significantly along the individual fault planes, such that permeability along the fault planes can be highly variable (SRK 2002b).

The exception to these low transmissivities may be the Ole fault which may intersect Chamber 15. Water seepage was observed from faults in Chamber 15 by mine geologists in 1997 (SRK 2002b). However, considerable work was done in this area to grout the inflows, and these were observed to essentially stop. Recent inspection of the chamber indicates that water is not pooling in the excavation, and drain holes drilled under the chamber are still flowing, but at a very low rate.

7.2.2.5 Surficial Geology and Topography

The Yellowknife area has been subjected to numerous periods of glaciation; however, it is the Laurentide ice sheet, which climaxed around 20,000 years ago that inscribed its signature on the landscape (Prest 1970; Aspler 1987). The area was probably one of net erosion during the Laurentide glaciation; hence, tills are rare and rock outcrops contain excellent erosional features. The ice retreated to the northeast 10,000 to 8,000 years ago and the Yellowknife area was exposed with sands and gravels being deposited in some of the deeper valleys (e.g. gravel pits around the Yellowknife airport). The area was then flooded as Great Bear Lake, Great Slave Lake and Lake Athabasca became one vast proglacial lake - Glacial Lake McConnell. Varved lacustrine silts and clays blanket a large portion of the Yellowknife area having been deposited in Glacial Lake McConnell (Aspler 1987). Water levels dropped to that of ancestral Great Slave Lake around 2,300-2,700 years ago (Craig 1965).

The Giant Mine site consists of undulating topography with extensive areas of exposed bedrock on the higher ground, and minor surficial deposits in low lying areas. The site contains a central valley through which Baker Creek flows. The ridges on either side of the creek are 10 to 20 m high and are controlled by bedrock outcrops. The mining activity in the Baker Creek Valley has altered the original topography and surficial geology of the area.

7.2.2.6 Soil Type

The Giant Mine site is typical of the Yellowknife area with bedrock outcrops covering approximately 75 % of the area. Silts and/or clays are also present in localized deposits in low lying areas between bedrock outcrops. 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. Gravels with a sand matrix were reported at Giant Mine in this position during excavation of the A-2 open pit and are thought to represent fluvial deposition following deglaciation (Aspler 1987). Some of the remainder of the site surface is now covered with crushed waste rock that was used on site as fill and road base. The characteristics of this “gravel” are described in Section 5.4 on Waste Rock.

The surface conditions vary considerably between the various locations above the arsenic-filled chambers and stopes, ranging from boggy to bedrock outcrops. Current conditions are generally dominated by either bedrock or fill material with the original vegetative cover and organic layer having generally been stripped. The surficial deposits that are present above some of the arsenic-filled chambers and stopes consist primarily of clay and silt with some sand and gravel. These deposits reach a thickness of 32 m in some areas.

7.2.2.7 Seismicity

Yellowknife and Giant Mine lie within the “stable craton” of central North America, which has too few earthquakes to reliably define earthquake hazards. Understanding of seismicity in the stable shield or core regions of continents has lead to revised seismic hazard values and the development of a “floor” level of seismic hazard which was incorporated into the 2005 edition of the National Building Code of Canada (NBCC). This increased understanding has lead to the assumption that a large earthquake could occur anywhere in Canada. More specifically, events exceeding magnitude 6.5 are thought possible anywhere in the Canadian Shield, albeit rarely. The probabilistic hazard values that have been adopted within NBCC (2005) correspond to a 1 in 2,475 year event (2% probability of exceedance in 50 years).

As a consequence of these changes to the NBCC, a new suite of seismic hazard values were developed for Yellowknife. Ground acceleration, which is a key design parameter for earthquake engineering, is a measure of how hard the earth shakes in a given geographic area. The median values for firm ground in Yellowknife indicate that the peak ground acceleration is 0.007g for the 1 in 100 year return period, 0.021g for the 1 in 475 year return period, 0.035g for the 1 in 1,000 year return period and 0.059g for the 1 in 2,475 year return period.

The real earthquake record in Yellowknife is dominated by events of magnitude 6 or less, at distances of greater than 60 km (G. Atkinson, in SRK 2008). The recent and historical earthquake record in the Yellowknife vicinity is shown in Table 7.2.1, Figure 7.2.2 and Figure 7.2.3. The event that would be representative of a 1 in 2,475-year earthquake in the Yellowknife area is of magnitude 5.8 at a distance of about 100 km (G. Atkinson, in SRK 2008).

Table 7.2.1 Largest Measured Earthquakes in the Yellowknife Region

Date	Magnitude	Longitude (West)	Latitude (North)
1924/10/17	5.0	118.00	60.00
1983/03/23	3.3	111.56	65.69
1990/03/30	3.5	116.63	60.39
1992/05/02	3.3	120.43	59.28
2001/11/28	4.5	113.66	64.96
2001/11/28	4.2	113.48	64.94
2001/11/28	3.9	113.67	64.91
2001/12/10	3.8	119.24	61.11
2007/02/02	3.4	119.98	65.25
2008/06/12	3.8	117.87	60.99

Note: Information from http://earthquakescanada.nrcan.gc.ca

Figure 7.2.2 Earthquakes with Magnitude 2.0 and Larger, 1980 to present

Figure 7.2.3 Historical Earthquakes Magnitude 5.0 and Larger

7.2.3 Groundwater Flow

Groundwater Monitoring System

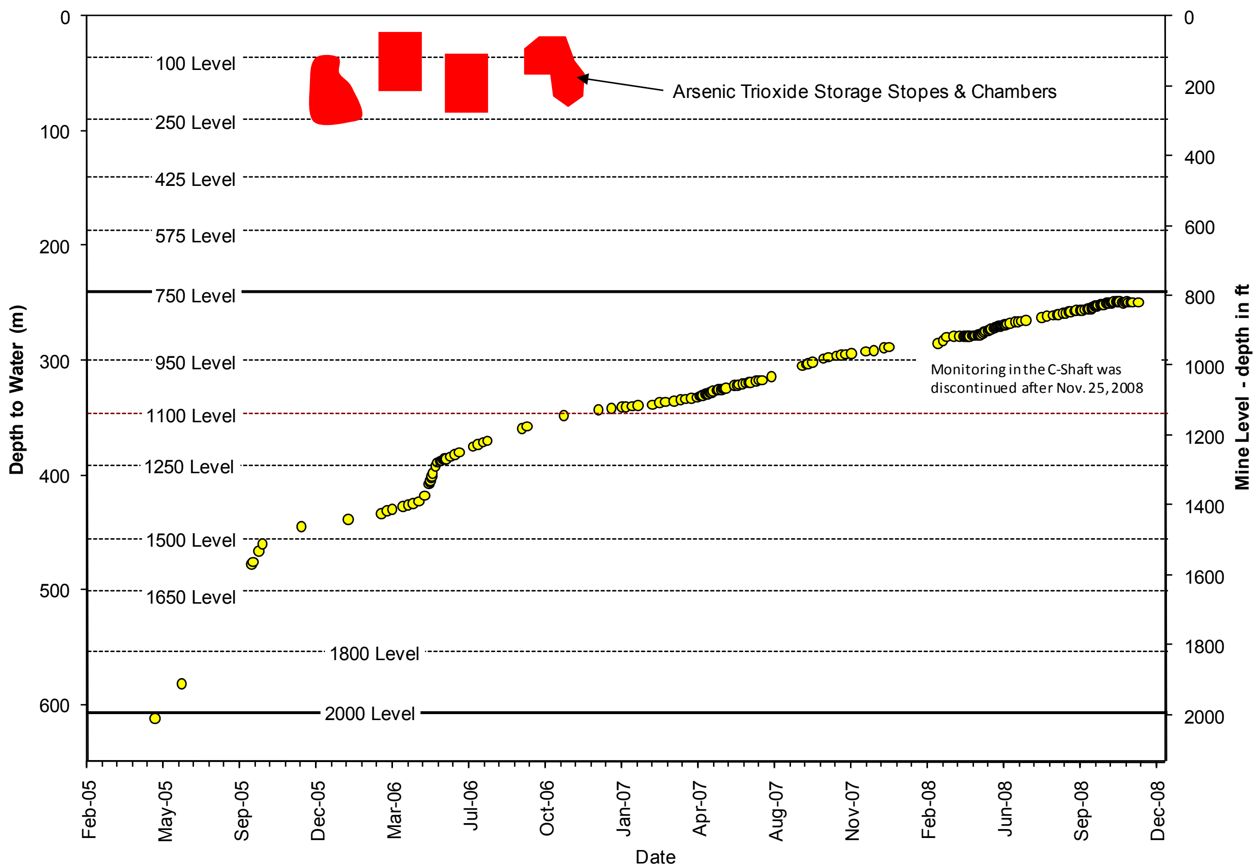
Groundwater chemistry and piezometric data are based on an extensive network of shallow and deep monitoring wells installed across the site (Figure 7.2.4), as well as samples collected in the underground workings where inflow has been isolated from direct vertical infiltration via mine workings from surface. Detailed discussions of the groundwater investigations carried out on the site were included as Supporting Documents C1 to C6 of the Giant Mine Remediation Plan.

The investigations to date have been used to delineate current groundwater flow conditions (as well as groundwater chemistry) in order to establish a benchmark for baseline conditions, and as a means of assessing the effectiveness of ongoing remedial works and changes in the hydrogeological regime, such as the recent reflooding of the mine to below the 750 Level.

The monitoring system was designed to collect data regarding hydrogeological conditions within the mine under partial and fully flooded conditions (partial reflooding was initiated in April 2005). Groundwater levels have not been observed to respond to the reflooding at this time because the maximum depth of the monitoring wells (~150m below ground surface) is higher than the water level in the mine (~230m below ground surface), as illustrated in Figure 7.2.5.

Figure 7.2.4 Groundwater Monitoring System Location Map

Figure 7.2.5 Groundwater Levels in the Reflooding Mine



Conceptual Hydrogeological Model

Due to the water level of the current partially dewatered mine, the underground workings continue to act as a hydraulic sink for the immediate area. Groundwater gradients on the site are, therefore, directed towards the underground mine, capturing local surface infiltration and flow within the mine. Subsequently, any arsenic in the underground mine is contained, as the only mechanism for groundwater to leave the mine is through the underground dewatering and water treatment system.

The current understanding of the hydrogeological system at the site includes the following:

- The regional pattern of groundwater flow follows the generally flat topography eastwards towards Great Slave Lake;
- The bedrock surrounding the mine has a relatively low hydraulic conductivity, based on available test data and the low pumping rates that have been observed in the minewater management system;

- The mine is relatively dry now and there is no record in the mine history of encountering natural high inflow zones;
- The West Bay Fault acts as a local barrier to groundwater flow in the southern and northern parts of the site, but appears to be more permeable in the area where Baker Creek crosses the fault;
- The pumping of water out of the mine has lowered the local water table and completely changed groundwater flows near the mine. Deep groundwater between the lake and the mine is flowing towards the mine workings;
- Water that infiltrates through the ground surface anywhere within the vicinity of the site enters the mine workings; therefore, it is captured by the mine dewatering system;
- Shallow groundwater (less than 10 to 20m deep) on the eastern perimeter of the site may be flowing towards the lake; and
- No arsenic has escaped the underground workings through groundwater flow.

To date, strong correlations between groundwater flow and rock type have not been identified. Variations in the hydraulic conductivity of the rock mass appear to be controlled by faults and fractures rather than by the different rock types and their boundaries.

The larger faults in the mine area (e.g., West Bay, Townsite, and Akaitcho) have the potential to markedly influence groundwater flow patterns and, as a result, have been the focus of several hydrogeological investigations. Multilevel monitoring systems have been installed through the West Bay (two areas), Townsite and Rudolph Faults as part of the groundwater monitoring system (SRK 2002a and SRK 2005j). Drill holes for monitoring well installations through the West Bay, Townsite, and Rudolph Faults provided detailed geological information from core samples. Geological structures were found to be narrow zones, or multiple planes. At several locations, piezometric levels near the West Bay and Townsite faults were found to be higher on the side of the fault away from the mine. This suggests that the faults are acting as flow barriers within these areas. At other locations along the West Bay Fault under Baker Creek as well as the Rudolph Fault, monitoring data suggests that the faults do not act as perpendicular barriers or preferential longitudinal flow paths.

A detailed inspection of faults intersecting accessible parts of the mine was also carried out in February 2004, when infiltration of surface water was expected to be at a minimum. Observations made at the time showed that little to no water was entering the mine along the structural features and, in general, all mine tunnels on the exterior edges of the mine, where groundwater inflow would be intercepted, were very dry. This supports the view that the hydrogeological conditions at Giant Mine are characterized by very low conductivity rock, and that flow through the system is expected to be very slow.

Groundwater Numerical Model

Groundwater monitoring data from the site were integrated into a mine-scale numerical model. The model, which is used to test the conceptual flow model of the site and future reflood scenarios as part of the planning process, is discussed in detail in SRK (2005d). Updates to the model are also described in SRK (2005e) which incorporates data from the enhanced groundwater monitoring system installed in August 2004.

The mine-scale numerical model was designed to illustrate groundwater flow patterns in the mine workings and surrounding bedrock. As described above, the simulated groundwater movement is towards the mine. The model has been calibrated to available data, but as the mine is currently dewatered, it is not possible to calibrate the model for fully reflooded conditions. The model will be updated based on changes in observed water levels as the mine is allowed to reflood during the implementation of the Remediation Project. However, as indicated previously, water levels will be maintained significantly below the local static water level until such time that minewater monitoring indicates it is suitable for release to the environment without treatment. As a consequence, the mine will continue to act as a groundwater sink for many decades.

7.2.4 Groundwater Quality

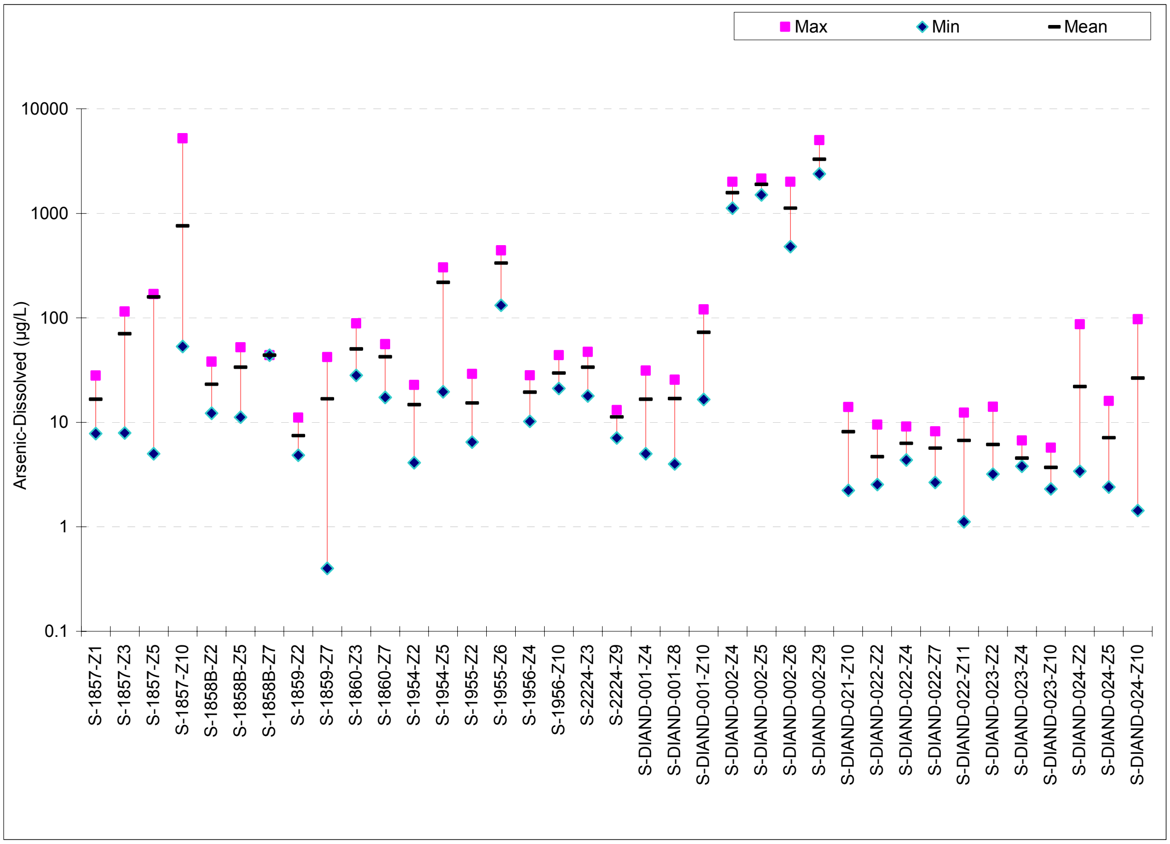
7.2.4.1 Groundwater Quality Guidelines

Although laboratory analyses of other contaminants of potential concern have been part of the groundwater monitoring program, arsenic has been selected as the primary indicator of groundwater quality for the Project. There are currently no regulatory criteria (guidelines) covering groundwater chemistry in the Northwest Territories or the rest of Canada. Therefore, all groundwater data collected to date has been assessed, but it is not possible to report on the chemical quality with respect to criteria performance requirements.

7.2.4.2 Arsenic Concentration in Groundwater

A detailed review of groundwater quality in the bedrock surrounding the mine is given in SRK (2004b), the results of which are illustrated in Figure 7.2.6. Groundwater quality monitoring to date shows elevated arsenic content in the groundwater when compared to other Canadian Shield groundwater geochemistry. However, arsenic concentrations in groundwater are much lower than minewater concentrations, which are described in Section 5.7.1. As the groundwater is moving towards the dewatered mine, the source of the arsenic is either the mineralized bedrock or infiltration from surface sources.

Figure 7.2.6 Arsenic Concentrations in Groundwater



7.2.5 Soil Quality

Surficial materials around the mine infrastructure show the effects of fifty years of industrial activity. These materials, which include natural soils, tailings and mine rock, are present variously across the site. An estimated 328,000 m^3 of material contaminated with arsenic at levels that exceed the 340 mg/kg GNWT criterion for industrial land use have been delineated on the site. Areas of hydrocarbon contamination are also present, but largely overlap the arsenic-contaminated areas. The contaminated surface soils were described in detail in Section 5.10 and are not repeated herein.

7.2.6 Permafrost

Permafrost is defined as soil or rock that remains below 0°C throughout the year, and forms when the ground cools sufficiently in winter to produce a layer of frozen ground that persists throughout the summer (Wolfe 1998). Yellowknife (and Giant Mine) is in the discontinuous permafrost zone, at the transition between widespread permafrost (underlies 50 to 90 % of the land area) and sporadic permafrost (underlies 10 to 50 % of the land area) (Wolfe 1998). Permafrost in the Yellowknife area postdates the withdrawal of Glacial Lake McConnell and has undergone a complex history of growth and decay during climatic fluctuations in the last 4,000 years (Aspler 1987). Permafrost occurrence in Yellowknife is highly variable. It dominates in areas where organic material accumulates such as in peat bogs, it is widespread where silts and clays dominate, is sporadic to absent in sands and gravels, and absent near bedrock exposures that act as a heat source (Aspler 1987).

As a general rule, maximum permafrost depth increases with increasing distance from exposed rock, reflecting distance from the heat source and also an increase in the thickness of surficial deposits (or overburden) away from bedrock. Overburden thickness also shows a direct relationship with permafrost thickness, serving to insulate and preserve permafrost not in equilibrium with present conditions (Aspler 1987).

The maximum depth of permafrost in the Yellowknife area was measured at Giant Mine in the B shaft area at 85 m, at a site where the overburden is 18 m thick (Bateman 1949). Similar observations were made at the mill where permafrost was reported down to 82 m (McDonald 1953). Espley (1969) reported that no permafrost was found in the upper levels of the B3 area that mostly consisted of bedrock, but that the arsenic dust chambers that were constructed above 76 m were at that time located within permafrost. This level of permafrost is thought to be a relic from a previous glaciation and the base of the permafrost is slowly regressing under warmer surface conditions (Aspler 1987).

It is clear that the permafrost at Giant Mine is warm, since the ground temperature remains near 0°C even where permafrost is present. It is also apparent that the permafrost recedes when the surface conditions are disturbed. 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 disposal stopes or chambers (Noel *et al*. 2003). A subsurface investigation (Geocon 1981) penetrated selected underground chambers and stopes to assess the possibility of extracting arsenic dust for resale. The study reported encountering a permafrost zone above three of the chambers. In 2006, when work was conducted on Reach 4 of Baker Creek, permafrost and ground ice was observed in areas to the east of the AR1 arsenic storage chambers.

Beginning in 1994, ground temperatures were measured in drill holes at several locations in the areas containing arsenic chambers. These temperature-monitoring holes had thermistor probes installed to depths up to 122 m below the surface with temperature measurements taken between 1994 and 2002. Permafrost was not encountered in any of the holes (Noel *et al*. 2003). A hole just south of chambers 14 and 15 (area AR1) had mean annual temperatures from +1°C at 110 m to +3°C at surface. The mean annual temperature range over the same depth in a hole near the B1 pit (area AR3) was 0 to +1°C. A temperature-depth profile at this location indicated that permafrost likely extended to a depth of approximately 30 m below surface prior to mining activities (Noel *et al*. 2003).

An experimental thermosyphon was installed north of the B1 pit (area AR4) in 2002. Permafrost was encountered down to about 25 m depth at this location; temperature measurements suggest a mean annual ground surface temperature of -0.5°C (SRK 2006b).

Further boreholes were instrumented in 2004 with temperature probes installed above and within arsenic chambers and stopes B212, B214 (area AR4), B208, B233 (area AR3) and C212 (area AR2) to depths of between 40 m and 70 m (SRK 2005a). These boreholes encountered permafrost within area AR3 at stope B208 (to a depth of about 50 m), and in area AR4 above the top of stopes B212-B214 (marginal permafrost) (SRK 2006b).

Temperature data from all instrumented holes within and around the arsenic chambers, from the period 1996 to 2005, from ground surface to 122 m depth, range from -1.3°C (in B208) to +4.9°C (in B214), with most of the values located between -0.5°C and +3°C. The range narrows to 0°C to +2°C at a depth of 75 m to 122 m (SRK 2006b).

Historic observations and recent ground temperature measurements show that mining activities have caused a major disturbance to the thermal regime that existed at the site. The disturbance is likely a combination of underground activities that introduced heat, and changes to the ground surface that removed insulating layers of overburden and increased the surface area of exposed bedrock that acts as a heat source.

Active Layer Thickness

The portion of the ground at the surface, above the permafrost layer, that rises above 0°C during the summer is termed the active layer (Wolfe 1998). With regard to the areas where arsenic chambers exist, permafrost is currently thought to occur in the vicinity of AR3, and AR4. AR1 is overlain by an exposed rocky knoll, and is not expected to have permafrost overlying the arsenic trioxide chambers. As noted above, permafrost in AR3 was encountered in the B1 pit and above Stope B208, and in AR4 at the experimental thermosyphon site, and above stopes B212-B214. In these areas, the active layer thickness is considered to be approximately 0.5 to 2.0 m, depending on the surface conditions. Areas with vegetative cover will typically have a thinner active layer than exposed areas that absorb more heat in the summer.

7.2.7 Selection of Valued Components

The VCs selected to evaluate potential adverse effects of the Remediation Project on the Geological and Hydrogeological Environment are presented in Table 7.2.2.

Table 7.2.2 VCs for the Geological and Hydrogeological Environment

Sub-Component	VC	Rationale
Groundwater Flow	None identified	- No specific VCs identified, since likely environmental effects are represented as changes to groundwater flow. Changes assessed regarding role as pathways to aquatic and terrestrial environments. No such pathways exist due to the continued draw down of the mine
Groundwater Quality	Member of the public	- Aboriginal groups and Northerners value components of the environment for their intrinsic value - Changes to groundwater quality assessed with respect to possible roles in providing pathways and mechanisms for effects on aquatic and terrestrial environments and on human health
	Groundwater quality (intrinsic value)	
Soil Quality	Member of the public	- Aboriginal groups and Northerners value components of the environment for their intrinsic value - Changes to soil quality assessed with respect to possible roles in providing pathways and mechanisms for effects on aquatic and terrestrial environments and on human health
	Soil quality (intrinsic value)	
Permafrost	Extent of permafrost	- Interacts with other components of the environment (e.g., Surface Water Environment, Terrestrial Environment)

7.3 Atmospheric Environment

7.3.1 Introduction

The following sections provide a synopsis of the existing Atmospheric Environment within areas that have the potential to be affected by the Giant Mine Remediation Project. The descriptions of the existing Atmospheric Environment have been separated into the following sub-components:

- Air Quality; and
- Noise Environment.

Prior to describing the existing conditions for each of these environmental sub-components, an overview of the climate characteristics is presented as it is a key component of the environment which influences not only the design of the Remediation Project, but also its potential effects.

7.3.2 Climate Characteristics

The climate of the North Slave region is characterized by its cool summers, very cold winters and low humidity. The Yellowknife area has an excellent record of climate data from the meteorological station at the Yellowknife Airport (1943 to present). The observations recorded at the station have been integral for understanding the region's climate characteristics and trends.

7.3.2.1 Precipitation and Evaporation

The area surrounding Yellowknife is one of the drier regions of Canada, with a mean annual precipitation of 281 millimetres (1971 to 2000)[20]. During the same period, the average annual rainfall was 165 millimetres, and the recorded mean annual snowfall water equivalent was 116 millimetres. The maximum rainfall event recorded over a 24-hour period occurred on August 15, 1973 when 83 millimetres fell.

Lake evaporation studies were carried out from 1994 to 2002 at Pocket Lake, which lies inside the Giant surface lease boundary. The results of this work indicate an average annual lake evaporation rate of about 415 millimetres, with annual values ranging from 361 to 460 millimetres during the study period (Reid 2001).

[20] Unless indicated otherwise, the climate data presented here has been sourced from Environment Canada's National Climate Data and Information Archive, as summarized in *Canadian Climate Normals, Yellowknife Station 'A', 1971 to 2000.*

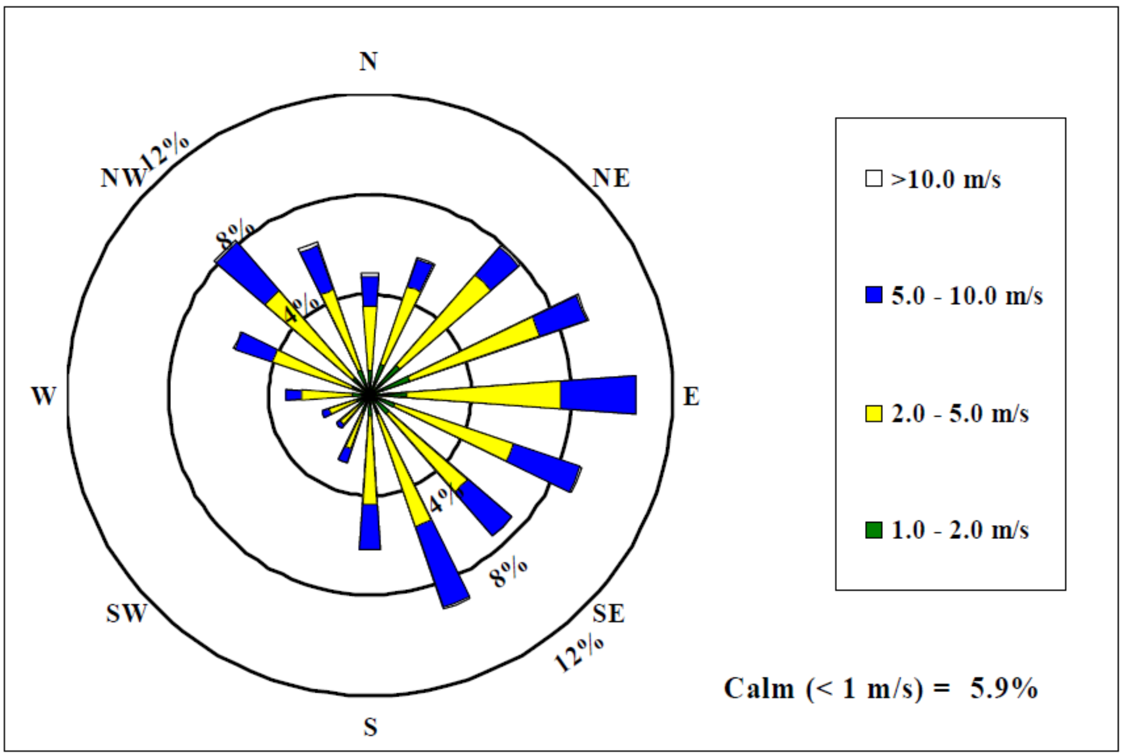
7.3.2.2 Temperature

Yellowknife's estimated mean annual air temperature is -4.5 degrees Celsius (ºC) with a range from a minimum of -51ºC (January 31, 1947) to a maximum of 32ºC (July 16, 1989). July is the hottest month with an average maximum temperature of 21.1ºC and January the coldest with an average minimum of -30.9ºC. Winters are also characterized by extreme wind chill with an average of more than 100 days per year having a wind chill of -30ºC or colder. The coldest wind-chill temperature on record is -64ºC (January 29, 1971).

7.3.2.3 Wind and Wind Direction

The average wind speed recorded at the Yellowknife airport between 1971 and 2000 was 14 kilometres per hour (km/hr). Yellowknife's monthly average wind speed varies little during the year with a range from 13 to 16 km/hr. North-westerly winds are most frequent during the winter and early spring, south-easterly winds dominate the summer months and easterly winds are frequent in the fall. Extreme wind events are rare compared to many other Canadian cities, with only an average of 1.6 days/year where winds reach speeds over 53 km/hr. Figure 7.3.1 illustrates the average wind speeds and percent frequencies by direction for the Yellowknife Airport Meteorological Station (INAC 2008).

Figure 7.3.1 Windrose for Yellowknife Airport



Note: Arrows denote the direction wind blows from.

7.3.2.4 Historic Climate Trends

An analysis of weather data recorded at the Yellowknife airport between 1958 and 2005 has revealed the following trends in climatic conditions (GNWT 2009a):

- An increase in the mean annual temperature of 2.2ºC;
- An increase in the mean winter temperatures of 3.9ºC;
- An increase in the mean spring temperatures of 2.0ºC;
- An increase in the mean summer temperature of 0.6ºC; and
- An increase in the mean fall temperature of 2.2ºC.

The following trends in precipitation were also identified for the same monitoring period:

- A decrease of 7.5 mm in the average winter precipitation;
- An increase of 5.3 mm in the average spring precipitation;
- An increase of 13.8 mm in average summer precipitation; and
- A decrease of 20.4 mm in average fall precipitation.

7.3.3 Ambient Air Quality

7.3.3.1 Air Quality Indicators and Standards

Based on current conditions at the site and the nature of activities during remediation, suspended particulate matter, arsenic and combustion emissions have been selected as the most appropriate air quality indicators for the Project. The rationale for the selection of these indicators is presented in Table 7.3.1, followed by descriptions of each indicator.

Table 7.3.1 Rationale for Air Quality Indicators

Key Indicators	Rationale
Particulate Matter	- Primary air quality contributor to local human health - Emitted from local sources* - Monitored by the GNWT in Yellowknife and INAC at various locations on the Giant Mine site
Arsenic	- Primary contaminant of concern associated with Giant Mine and within the surrounding environment* - Potential human health, terrestrial environment and aquatic environment effects - Monitored by the GNWT in Yellowknife and INAC at various locations on Giant Mine site
Sulphur Dioxide and Nitrogen Oxides	- Emitted and measured locally* - Potential local health and ecosystem effects - Can be transported from long-range sources - Chemically converted in the atmosphere to acid rain - Monitored by the GNWT in Yellowknife.

* Existing air quality in the area surrounding Giant Mine is a combination of emissions from sources in the general Yellowknife area. The modelling assessment undertaken in Section 8.6.2 predicts and adds the incremental air quality effects of the project to baseline conditions.

Particulate Matter

Airborne particulate matter is made up of microscopic solid (i.e., dust) and liquid particles that remain suspended in the air for varying lengths of time. The particles are predominantly from sources such as windblown dust (e.g., from wind erosion of exposed surfaces and vehicle disturbances) and combustion emissions (e.g., forest fires and internal combustion engines). The size of the particles varies from 0.005 to 100 micrometer or microns (µm) in diameter. The various sizes are generally subdivided into several distinct categories. These include total suspended particulate matter (TSP) consisting of all particles with a mean diameter less than 30 µm, inhalable particulate matter (PM10) with a mean diameter less than 10 µm, and fine particulate ($PM_{2.5}$) with a mean diameter less than 2.5 µm.

Particles belonging to the $PM_{2.5}$ and PM_{10} fractions pose a health concern because they are easily inhalable and can penetrate deep within the respiratory system. Through this process, particulate matter can aggravate asthma and other respiratory disorders. Adverse effects can also occur when particulate matter settles on plant surfaces and soils. In addition to physical effects, the particles also serve as a contaminant pathway. For example, in the case of Giant Mine, the arsenic content of particulate matter is an important human health and environmental consideration.

Sulphur Dioxide and Nitrogen Oxides

Sulphur dioxide (SO_2) can have adverse effects on human health, is toxic to vegetation and is a precursor of acid rain causing acidification of natural ecosystems. The low abundance of vegetation in many areas on the Giant Mine site is attributable, in part, to historic SO_2 emissions from the roaster. In large urban areas, elevated SO_2 concentrations have also been linked to an increase in respiratory hospital admissions as well as increases in cardiac and respiratory mortality.

Nitrogen oxides (NO_X) are toxic to plants and nitrogen dioxide (NO_2) can cause breathing difficulties in humans. They are also one of the main precursors of ground level ozone, which can affect breathing and damage vegetation. Deposition of oxidized nitrogen causes acidification and eutrophication of surface water bodies.

Air Quality Standards

Under the *NWT Environmental Protection Act,* the GNWT has adopted a number of concentration limits as ambient air quality standards (Table 7.3.2). The GNWT standards are used in the assessment of air quality monitoring data as well as for determining the acceptability of emissions from proposed and existing developments. Where GNWT standards are not available for a particular pollutant, limits established in other jurisdictions are typically considered. This is the case for airborne arsenic, where the Ontario Ministry of the Environment's Ambient Air Quality Criterion of 0.3 $\mu g/m^3$ (24-hour average) has been used by the GNWT as a benchmark in its air quality reporting. The GNWT has not adopted a standard for PM_{10}, but several Canadian jurisdictions, including British Columbia and Ontario, have adopted a PM_{10} concentration of 50 $\mu g/m^3$ that has also been considered by the territorial government.

Table 7.3.2 Ambient Air Quality Standards

Parameter and Standard	GNWT Ambient Air Quality Standards ($\mu g/m^3$)	Canadian National Ambient Air Quality Objectives	
		Maximum Desirable Concentration ($\mu g/m^3$)	Maximum Acceptable Concentration ($\mu g/m^3$)
Sulphur Dioxide (SO_2)			
1-hour average	450	450	900
24-hour average	150	150	300
Annual arithmetic mean	30	30	60
Nitrogen Dioxide (NO_2)			
1-hour average	-	-	400
24-hour average	-	-	200
Annual arithmetic mean	-	60	100
Total Suspended Particulate (TSP)			
24-hour average	120		120
Annual geometric mean	60	60	70
Fine Particulate Matter (PM_{10})			
24-hour average	50 ($\mu g/m^3$) (Ontario Ministry of the Environment Ambient Criterion)		
Fine Particulate Matter ($PM_{2.5}$)			
24-hour average	30	30	-
Airborne Arsenic			
24-hour average	0.3 ($\mu g/m^3$) (Ontario Ministry of the Environment Ambient Criterion)		

7.3.3.2 Regional and Local Study Areas

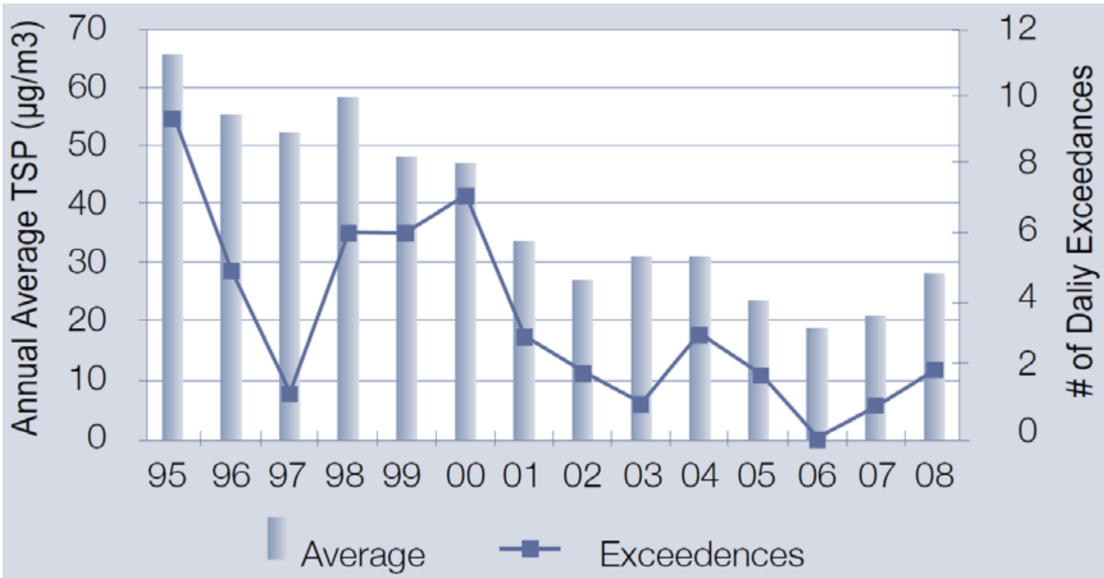
The generic Regional and Local Study Areas described in Section 3.4.1 were applied to the air quality analysis discussed below. The baseline data for these areas originate from the same source: a permanent air quality monitoring station in Yellowknife. The use of the Yellowknife station to characterize the regional environment is considered appropriate for the following reasons: i) the air quality effects associated with the Remediation Project are anticipated to be negligible outside of the LSA; ii) most human receptors within the RSA are located in Yellowknife; and iii) natural events, particularly forest fires, are likely to have had a far greater effect on regional air quality conditions since 1999 than activities at the Giant Mine site. In addition, the use of a local station to characterize the baseline air quality ensures that all emissions from Yellowknife and surrounding areas are included in the baseline. For example, emissions from transportation, space heating and industrial activities are incorporated within the baseline.

The Yellowknife air quality monitoring station is located adjacent to the Sir John Franklin High School in central Yellowknife. The station is capable of continuously sampling and analyzing a variety of air pollutants and meteorological parameters, including: TSP, fine particulate ($PM_{2.5}$ and PM_{10}), NO_X, SO_2, ground level ozone, carbon monoxide, wind speed, wind direction and temperature. The arsenic concentrations in particulate samples are also monitored. TSP levels have been monitored in Yellowknife since 1974, SO_2 since 1992, and fine particulate ($PM_{2.5}$) since 1999. In April 2006, an instrument for monitoring PM_{10} concentrations was installed. The monitoring results and graphs presented in this section are sourced from the annual air quality reports published by the GNWT's Department of Environment and Natural Resources.

Airborne Particulate

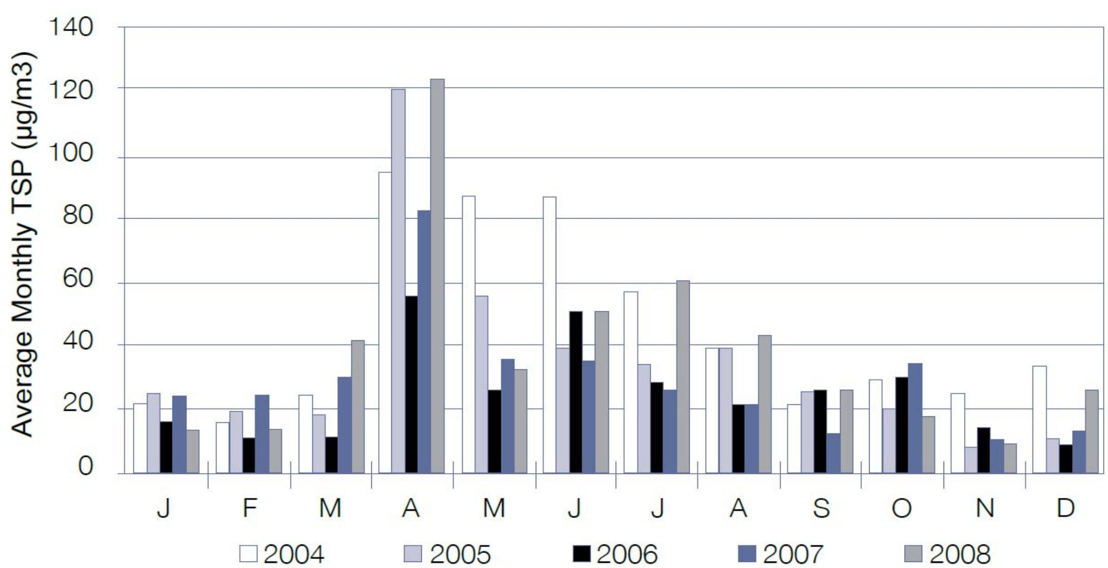
On an annual basis, TSP levels in Yellowknife tend to spike in the spring and gradually level off during the summer months. Since the early 1990's there has been an overall downward trend in the annual concentrations of TSP (Figure 7.3.2). In recent years, annual average TSP concentrations have consistently been lower than the ambient air quality standard. For example, during the period from 2005 to 2007, the annual average TSP concentration ranged from 19 to 28 $\mu g/m^3$, which is well below the NWT annual standard of 60 $\mu g/m^3$. The number of events where the 24-hr standard (120 $\mu g/m^3$) has been exceeded has also diminished, with an annual average of 1.75 days for the period 2001 to 2008. This trend is believed to be attributable primarily to the City of Yellowknife's efforts to clean roads of winter sand and gravel applications during the spring, as well as the increase in the number of paved roads within the City. TSP concentrations are typically higher during the months of April to June (Figure 7.3.3). While roads are the single largest contributor to Yellowknife's TSP concentrations, forest fires, industrial activities and fuel combustion from mobile and stationary sources also contribute.

Figure 7.3.2 Average TSP Concentrations in Air for Yellowknife



Source: GNWT – Environment and Natural Resources

Figure 7.3.3 Seasonal Variation of TSP in Air Concentrations in Yellowknife

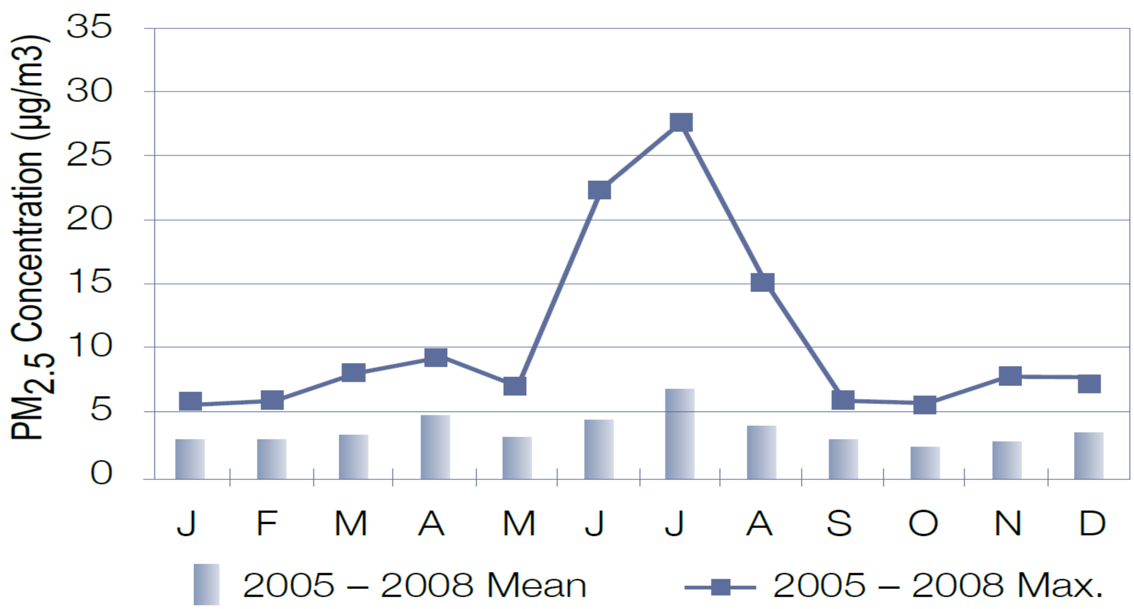


Source: GNWT – Environment and Natural Resources

For the years of 2005 to 2008, the monthly mean $PM_{2.5}$ concentrations were low, ranging from 2 to 7 µg/m^3 (Figure 7.3.4). Elevated concentrations were noted during the summer, which is principally attributed to forest fire events. In 2008, the NWT $PM_{2.5}$ 24-hour standard (30 µg/m^3) was exceeded seven times, while in 2007 it was only exceeded twice. In both years the exceedances were strongly associated with smoke from forest fire events. If the forest fire events are removed from the datasets, the daily maximums decline considerably, falling within a range of 5 to 9 µg/m^3. The data suggest that $PM^{2.5}$ levels in Yellowknife are generally low, with the greatest short-term influences being smoke from forest fires.

Similar to observations for TSP, PM_{10} concentrations in 2008 were observed to be highest in April, following the spring melt. Of the 12 incidents where PM_{10} concentrations exceeded the 24-hr benchmark of 50 µg/m^3 in 2007, the majority occurred in April. The highest daily maximum PM_{10} concentration observed in 2007, that of 105 µg/m^3, also occurred in April. Dust from sand and gravel used on winter roads is considered to be the dominant source of PM_{10}.

Figure 7.3.4 Monthly Variation in $PM_{2.5}$ Concentrations in Yellowknife

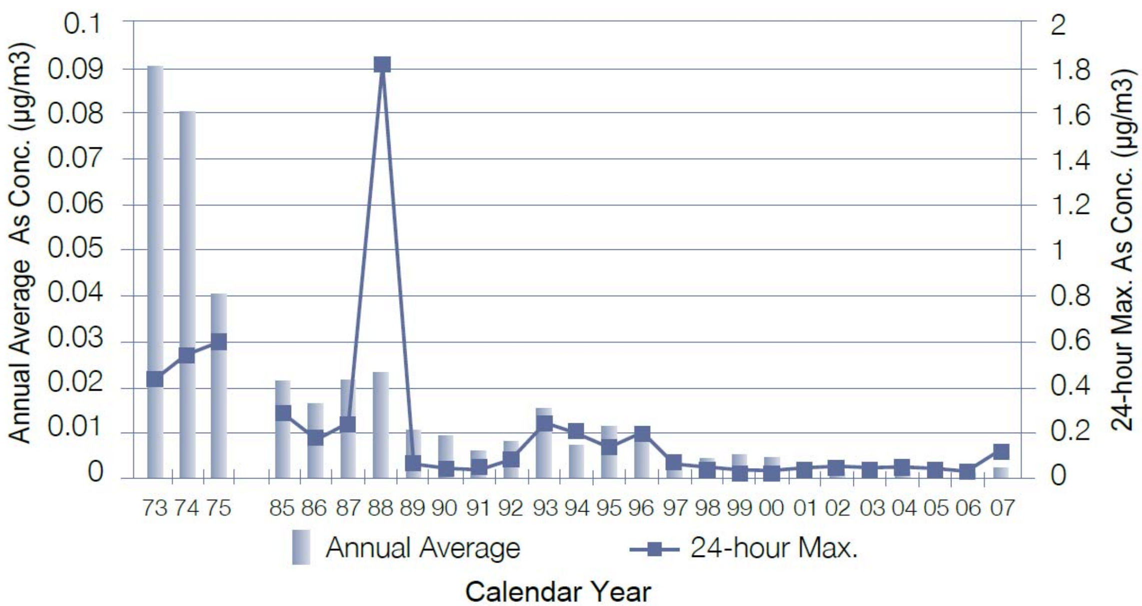


Source: GNWT – Environment and Natural Resources

Airborne Arsenic

Airborne arsenic concentrations in Yellowknife have fallen from the elevated concentrations observed in the 1970s and 1980s (Figure 7.3.5). Subsequent to the closure of the Giant Mine roaster in 1999, there was a further reduction in the arsenic concentration which has averaged between 0.002 and 0.004 μg/m^3 in recent years. These concentrations are consistent with ranges measured in remote areas. Total airborne arsenic concentrations in Yellowknife over a 24-hour period have risen above the Ontario benchmark criterion of 0.3 μg/m^3 on only two occasions. Both events occurred in 1988 and coincided with a baghouse malfunction at Giant Mine.

Figure 7.3.5 Airborne Arsenic Concentrations in Yellowknife



Source: GNWT – Environment and Natural Resources

Sulphur Dioxide

The GNWT's standards for ambient air concentrations of SO_2 have not been exceeded since 1999. In the past, the largest sources of SO_2 in the Yellowknife area were the gold mine ore roasters, the most recent being at Giant Mine, and the highest levels of SO_2 in the Yellowknife area were measured downwind from the mine (GNWT 2009c). Since Giant Mine was closed in 1999, the number of times each year that the NWT 1-hour standard was exceeded has fallen to zero. The trends of recent years continued in 2008 with no exceedances of the NWT hourly (450 μg/m^3) and 24-hour (150 μg/m^3) standards recorded. The annual average was less than 4 μg/m^3, well below the GNWT standard (30 μg/m^3).

Nitrogen Oxides

The Yellowknife monitoring station continuously monitors NO, NO_2 and NO_x concentrations. Of these compounds, more consideration has been given to NO_2 due to the greater health concerns associated with this pollutant. While there are no GNWT standards for NO_2, the GNWT considers the national standards listed in Table 7.3.2 in its air quality reporting. The concentration of NO_2 in Yellowknife has been consistently below air quality guideline values in recent years with no exceedances of the 1-hour and 24-hour national standards for NO_2 in 2007 and 2008. The maximum 1-hour average in 2007 was 105 $\mu g/m^3$ and in 2008 it was 80 $\mu g/m^3$. The annual average concentration reported in 2007 was 5 $\mu g/m^3$, while in 2008 it was 4 $\mu g/m^3$. In both 2007 and 2008, the highest monthly averages and the highest hourly concentrations occurred during the winter months. This is likely attributable to higher emissions from fuel combustion for residential and commercial heating, idling vehicles and short-term “rush hour” traffic.

7.3.3.3 Site Study Area

The generic SSA described in Section 3.4.1 has been adopted without change for the evaluation of air quality. As part of the Remediation Project, an air quality monitoring program has been carried out at Giant Mine on an annual basis each summer since 2004 to establish a baseline for ambient concentrations of particulates and inorganic trace elements. The air quality data has been collected to provide information for use in comparing effects of the planned remediation activities relative to current site conditions.

When the monitoring program started in 2004, one high-volume sampler was stationed at the former Giant Mine town site to collect TSP. Three “MiniVol” samplers were also installed at the South Pond, the Mill/Roaster Complex, and near the B3 Pit to collect TSP. A fourth MiniVol sampler was installed at the South Pond to collect PM10. Following 2004, the program was modified to permit simultaneous monitoring of both PM10 and TSP at the South Pond, the Mill/Roaster Complex and B3 Pit. An additional sampling location was established at the Northwest Pond in 2005. The location of the monitoring stations is provided in Figure 7.3.6.

Samples were collected over a period of 24 hours, at six-day intervals to coincide with Environment Canada’s National Air Pollution Surveillance Network sampling protocol. Additional samples using the MiniVol samplers were also collected between the six-day intervals. These samples were collected over a 48-hour period to ensure sufficient material was being deposited on the MiniVol filters for elemental analysis. The elemental analysis considered a suite of 28 trace elements. Since the GNWT’s Environmental Protection Act does not establish guidelines /objectives for 24-hour ambient air trace element concentrations, the Ontario Ministry of the Environment’ s ambient air quality criteria were used as the basis for determining the relative significance of trace element concentrations from the monitoring program. The results of these monitoring efforts are described in the following sections.

Figure 7.3.6 Sampling Stations for Ambient Air Quality Monitoring

Total Suspended Particulate and Coarse Particulate

Observed concentrations of TSP and PM_{10} at the mine site have varied according to year and location, as evidenced by the summary statistics presented in Table 7.3.3. In 2004, there was only one day when TSP concentrations exceeded the NWT's ambient air quality standard of 120 $\mu g/m^3$ and two days when the PM_{10} levels exceeded the 50 $\mu g/m^3$ standard. In contrast, there were numerous exceedances of the TSP and PM_{10} criteria for all other years in the monitoring record. In particular, the 2007 results indicate noticeably higher ambient concentrations of TSP and PM_{10}, with more consistent exceedances compared to monitoring results from previous years. Factors that are believed to have contributed to the higher concentrations of TSP and PM_{10} reported in 2007 include: wind dispersion of tailings; revegetation activities along the Baker Creek realignment at the B3 Pit and Roaster Complex/Mill locations; and, construction activities on Highway 4 (the Ingraham Trail) in the area of the B3 Pit, Roaster Complex/Mill and Northwest Pond locations.

Of note, TSP monitoring results from the former Giant Mine Town Site sampling location were significantly lower than those at the industrial locations. The highest maximum concentrations of both TSP and PM_{10} occurred at the Northwest Pond.

Table 7.3.3 Baseline Suspended Particulate Matter Concentrations on the Giant Mine Site

Location	Year	Total Suspended Particulate Matter			PM_{10}		
		Maximum (μg/m³)	Mean (μg/m³)	# of Exceedances	Maximum (μg/m³)	Mean (μg/m³)	# of Exceedances
Giant Mine Town Site	2004	152	23	1	n/a	n/a	n/a
	2005	27	10	0	n/a	n/a	n/a
	2006	54	16	0	n/a	n/a	n/a
	2007	32	16	0	n/a	n/a	n/a
	2008	37	15	0	n/a	n/a	n/a
	2009	12	11	0	n/a	n/a	n/a
South Pond	2004	132	22	1	127	19	2
	2005	185	83	4	92	44	5
	2006	188	103	4	160	99	12
	2007	229	133	6	132	100	9
	2008	194	114	4	194	91	7
	2009	140	95	2	111	77	11
Mill	2004	157	25	1	n/a	n/a	n/a
	2005	125	67	1	46	17	0
	2006	218	99	3	118	83	13
	2007	319	186	10	181	136	10
	2008	254	96	2	222	97	6
	2009	111	82	0	124	104	2
B3 Pit	2004	167	33	1	n/a	n/a	n/a
	2005	176	50	1	63	17	1
	2006	181	102	4	153	90	8
	2007	306	165	8	174	116	12
	2008	377	163	5	208	95	10
	2009	167	92	2	111	71	12
Northwest Pond	2004	n/a	n/a	n/a	n/a	n/a	n/a
	2005	390	145	4	28	14	0
	2006	278	127	6	167	110	10
	2007	792	258	9	236	97	11
	2008	278	129	7	194	107	10
	2009	264	125	2	111	74	10
Benchmark concentration: TSP = 120 μg/m³ (24-hr), PM_{10} = 50 μg/m³ (24-hr)							

Airborne Arsenic

A summary of the measured arsenic levels at the five monitoring locations on the Giant Mine site is provided in Table 7.3.4. No exceedances of the ambient air quality criterion for arsenic (0.3 μg/m³) were observed in 2004. In 2005, elevated arsenic levels were detected at the South Pond, B3 Pit and Northwest Pond monitoring locations. From 2006 to 2009, the only location to exceed the criterion was the Northwest Pond. Of all the monitoring locations, concentrations of airborne arsenic were lowest at the former Giant Mine Townsite, with a mean concentration of

0.003 μg/m^3 reported in 2008. This is comparable to the 24-hr concentrations that have been observed at the GNWT's air quality monitoring station in Yellowknife.

Table 7.3.4 Baseline Arsenic Concentrations in Particulate Matter on the Giant Mine Site

Location	Year	Arsenic					
		Total Particulate Matter			PM_{10} Fraction		
		Maximum (μg/m^3)	Mean (μg/m^3)	# of Exceedances	Maximum (μg/m^3)	Mean (μg/m^3)	# of Exceedances
Giant Mine Town Site	2004	0.042	0.008	0	n/a	n/a	n/a
	2005	0.048	0.008	0	n/a	n/a	n/a
	2006	0.043	0.007	0	n/a	n/a	n/a
	2007	0.012	0.004	0	n/a	n/a	n/a
	2008	0.009	0.003	0	n/a	n/a	n/a
	2009	0.005	0.005	0	n/a	n/a	n/a
South Pond	2004	0.076	0.019	0	0.015	0.006	0
	2005	0.851	0.146	2	0.335	0.049	1
	2006	0.26	0.07	0	0.081	0.043	0
	2007	0.094	0.064	0	0.022	0.015	0
	2008	0.033	0.015	0	0.008	0.008	0
	2009	0.21	0.053	0	0.018	0.018	0
Mill	2004	0.061	0.016	0	n/a	n/a	n/a
	2005	0.138	0.036	0	0.036	0.014	0
	2006	0.19	0.07	0	0.069	0.03	0
	2007	0.068	0.030	0	0.026	0.017	0
	2008	0.054	0.025	0	0.012	0.009	0
	2009	0.068	0.025	0	0.011	0.011	0
B3 Pit	2004	0.015	0.025	0	n/a	n/a	n/a
	2005	0.482	0.084	1	0.167	0.037	0
	2006	0.28	0.06	0	0.021	0.016	0
	2007	0.097	0.037	0	0.033	0.020	0
	2008	0.021	0.013	0	0.013	0.010	0
	2009	0.088	0.027	0	0.025	0.015	0
Northwest Pond	2004	n/a	n/a	n/a	n/a	n/a	n/a
	2005	0.633	0.265	4	0.221	0.050	0
	2006	0.64	0.16	3	0.264	0.14	0
	2007	1.111	0.284	3	0.222	0.061	0
	2008	0.486	0.086	1	0.075	0.024	0
	2009	0.88	0.19	1	0.039	0.016	0
Benchmark concentration: arsenic = 0.30 μg/m^3 (24-hr)							

7.3.4 Ambient Noise Environment

7.3.4.1 Local Study Area

Although data on ambient noise levels for the City of Yellowknife have not been evaluated, they are expected to be typical of levels found in other Canadian urban settings[21]. Key variables in such levels include the time of day, location and nature of activities occurring in the area. For example, a reasonably quiet backyard in an urban area can expect ambient noise levels in the vicinity of 55 decibels. In contrast, levels approaching 80 decibels are more typical of areas close to busy traffic intersections (City of Ottawa 2006). In addition to road noise, the close proximity of Yellowknife's airport to the city-proper is expected to contribute to sporadic daily spikes in ambient noise levels (a jet taking off can generate noise at 100 decibels 0.6 km away). Since the termination of operations at the Giant and Con gold mines, industrial activities are not expected to be a significant contributor to the city's overall noise levels.

7.3.4.2 Site Study Area

While ambient noise monitoring has not been conducted, noise levels attributable to activities at Giant Mine are anticipated to have reduced considerably since active operations ceased in 2004. However, short-term increases in on-site noise levels are likely to have occurred in association with heavy equipment operations, such as during the re-alignment of Reach 4 of Baker Creek. Perhaps the largest and most consistent contributor to noise levels within the SSA is traffic along Highway 4 (the Ingraham Trail), of which only a small portion is attributable to current care and maintenance activities at Giant Mine. Vehicle traffic on Highway 4 occurs throughout the year, although the road experiences higher volumes of small-vehicle traffic during summer months. The largest recurring contributor to noise levels at the site is likely the heavy transport truck traffic that passes through the site during the ice-road season in late winter. For example, in 2007 more than 11,000 trucks passed the mine on the way to the ice road.

7.3.5 Selection of Valued Components

The VCs selected for the Atmospheric Environment are presented in Table 7.3.5. In addition to warranting protection for their intrinsic value, air quality and the noise environment have the potential to influence VCs selected for other environmental components. For example, any increases in the concentrations of air quality contaminants (e.g., arsenic), could also influence

[21] Noise levels within Yellowknife are not necessarily attributable to the same sources present in other Canadian locations. For example, the use of snowmobiles and all-terrain vehicles within the City limits is a common practice which is likely to influence noise levels. At the same time, the absence of high speed transportation routes within the City is expected to result in road vehicles contributing less to urban noise levels. Notwithstanding these potential differences, noise levels in Yellowknife are not expected to be substantively different from those in other Canadian urban settings.

both humans and non-human biota. Due to this pathways effect, the VCs presented in Table 7.3.5 are also the VCs for other environmental components that are discussed in subsequent sections of this chapter.

Table 7.3.5 VCs for the Atmospheric Environment

Sub-Component	VC	Rationale
Air Quality	Closest residential and recreational receptors	- Protection of human health
	Air quality (intrinsic value)	- Aboriginal groups and northerners value components of the environment for their intrinsic value - Potential air quality effects assessed with respect to the Terrestrial Environment for roles in providing pathways to the effects on terrestrial biological components and related VCs
Noise Environment	Closest residential and recreational receptors	- Potential for noise disturbances
	Noise environment (intrinsic value)	- Potential noise effects assessed with respect to the Terrestrial Environment for roles in providing pathways to the effects on terrestrial biological components and related VCs

7.4 Aquatic Environment

7.4.1 Introduction

The existing Aquatic Environment on and in the vicinity of the Giant Mine site is described in this section. Emphasis is placed on Baker Creek and the downstream receiving environment of Great Slave Lake, particularly Yellowknife Bay. Understanding the existing conditions within these water bodies is important for determining the aspects of the Aquatic Environment that may have been affected during the historic operation of the mine, and areas that could be affected during the implementation of the Remediation Project.

The Aquatic Environment has been divided into aquatic habitat and biota. In broad terms, habitat is considered to include both the physical and chemical attributes of the environment in which aquatic species live. Descriptions of the chemical attributes of the Aquatic Environment (e.g., water and sediment quality) have already been presented in Section 7.1. Therefore, this section describes the physical habitat and the various species that inhabit it.

7.4.2 Regional and Local Study Areas

In the following descriptions of the Aquatic Environment, Great Slave Lake has been selected as the RSA. The generic LSA presented in Section 3.4.1 has been used, with a particular emphasis on Yellowknife Bay.

7.4.2.1 Habitat

Great Slave Lake is one of the largest lakes in North America, covering 28,568 km^2, and is considered to be the deepest lake on the continent, with an average depth of 73 m and a maximum depth of 614 m (Mackenzie River Basin Board (MRBB) 2003). The lake is situated on the main stem of the Mackenzie River and acts as a hydrologic, biogeochemical and sedimentary regulator for roughly 50% of the annual basin flow to the Arctic Ocean (Gibson *et al.* 2006). It is unique among Canadian lakes in that the western basin lies in, and receives drainage from, sedimentary soils to the west and south, while the eastern section receives drainage from the Precambrian Shield. The former Giant Mine is located within the portion of Great Slave Lake that is dominated by Precambrian (i.e., hard rock) geology. The difference in water chemistry and productivity between the east and west basins of Great Slave Lake is considerable. For example, Secchi disc transparencies, an indicator of water clarity, are approximately 1 to 2 m in the western basin and about 10 m in the east (Patalas 1990).

Roughly 74% of the flow into Great Slave Lake enters from the Slave River system in the south, 21% enters from other catchments bordering the lake and 5% comes from precipitation. Approximately 94% of the losses from the lake are through outflow to the Mackenzie River

(Gibson *et al.* 2006). Upstream damming of the Peace River in 1967 reduced the peak and the variability of water levels in Great Slave Lake.

A comparison of lake morphometrics and water chemistry indicates that the western basin is generally higher in several indicators of productivity (Table 7.4.1). In general, Great Slave Lake and smaller inland northern lakes are considered to be low in nutrients, alkalinity, hardness and conductivity (Pienitz *et al.* 1997; Ruhland and Smol 1998).

Table 7.4.1 Summary of Physical and Water Quality Parameters for the Western and Eastern Basins of Great Slave Lake

Parameter	Western Basin	Eastern Basin
Area (km^2)	19,400	9,168
Maximum depth (m)	60	614
Mean depth (m)	41	185
Total Dissolved Solids (mg/L)	160	50
Epilimnion[1] temperature (^oC)	10	4
Total phosphorus (µg/L)	12.5	8.8
Nitrite-nitrate (µg/L)	144	190
Silicon (mg/L)	1.3	1.0
Chlorophyll (µg/L)	2.7	1.7
Water residence time (yr)[2]	~6	~200

Source: Evans 2000, with references therein.
[1] – i.e., the upper layer of a water body
[2] – Patalas (1990).

A number of studies have been conducted on the aquatic community in the waters of the North Arm and Yellowknife Bay of Great Slave Lake, primarily to understand the fishery and the local effects of the mines at Yellowknife. Moore (1980) reported a spring bloom of phytoplankton in Yellowknife Bay with the onset of light in the spring and continued growth until the end of October. The standing crop of phytoplankton in summer was related to surface water temperature and nutrient levels. Patalas (1990) suggests that, for Great Slave Lake, plankton distribution is related to the geology of the drainage basin, morphology of the lake, inflow configuration and morphology-related temperature distribution. A survey of algal species in 279 bodies of water in the NWT, including Great Slave Lake, reported about 212 genera and 1,577 subgenera, with most species found in temperate regions throughout the world. The study reported very few endemic species that are found only in the NWT (Sheath and Steinman 1982).

Early research was also conducted on the epibenthic and phytoplankton communities at 10 stations in Yellowknife Bay. Moore (1979) reported that both benthic and phytoplankton species were more abundant in the littoral zone than in deeper areas and were dominated by oligochaetes, molluscs, chironomids and amphipods. About 50 species were present at the littoral sites, while only 24 to 34 species were present at the deeper sites. The major observation of the study was that the differences in composition, structure and density of the benthic populations were related to the abundance of the algae attached to the bottom substrate.

Underwater Video Habitat Analysis

On October 29 and 31, 2009 underwater video and in-situ water chemistry data was collected along the three alignments that are currently under consideration for the new outfall / diffuser that will be constructed in North Yellowknife Bay (the alignments were previously presented in Figure 6.8.4). Underwater video was analyzed to determine sediment type and aquatic macrophyte distribution along each of the alternative routes with particular attention to the areas around the potential diffuser locations. The results of the video analysis were qualitatively compared with the documented preferred spawning and foraging habitats of known fish species in the Yellowknife Bay area and combined with the water chemistry data to provide a general assessment of the potential for fish habitat along each of the possible alignments. Unfortunately, the quality of the video was limited so that only general conclusions relating to fish habitat could be made. For this reason, additional video is proposed along with fish studies (larval, adult) to better characterize fish and their habitat including the riparian zone. Underwater video was collected at almost all the stations shown in Figure 7.4.1, while in-situ water chemistry was collected along only two of the alignments (stations 2-# and 3-# on Figure 7.4.1).

Despite having low turbidity in the surface water at most of the stations, much of the video was heavily obscured by fine sediments like silt, clay and some sand stirred up from the bottom by the video camera apparatus. This made it difficult to draw definitive conclusions on the presence/absence of features at each station. In most cases, if a determination was made on the sediment or aquatic macrophyte types present, it was based on only a few seconds of clear video. Aquatic macrophyte coverage was classified as clumped matter, grasses and other aquatic macrophytes. Clumped matter consisted of small indistinct ‘clumps’ which had the appearance of decomposing organic matter.

The ability of the sediments to become easily disturbed indicates the presence of a large proportion of silt/clay and possibly fine sand throughout the entire sampling area. This was confirmed from the grab samples which were consistently composed of finer sediments with some gravel. The nearshore areas along the potential outfall alignments were dominated by sand rather than silt/clay and were the only areas which produced clear videos. Specifically, stations 1-1 through 1-3 and stations 2-3 through 2-11 all had predominantly sand bottoms. With a couple of exceptions, these areas were also largely devoid of aquatic macrophyte coverage. At most stations, it was not possible to confirm the presence or absence of the larger substrates (i.e. gravel, pebble, cobble or boulder), although they were noticed on rare occasions.

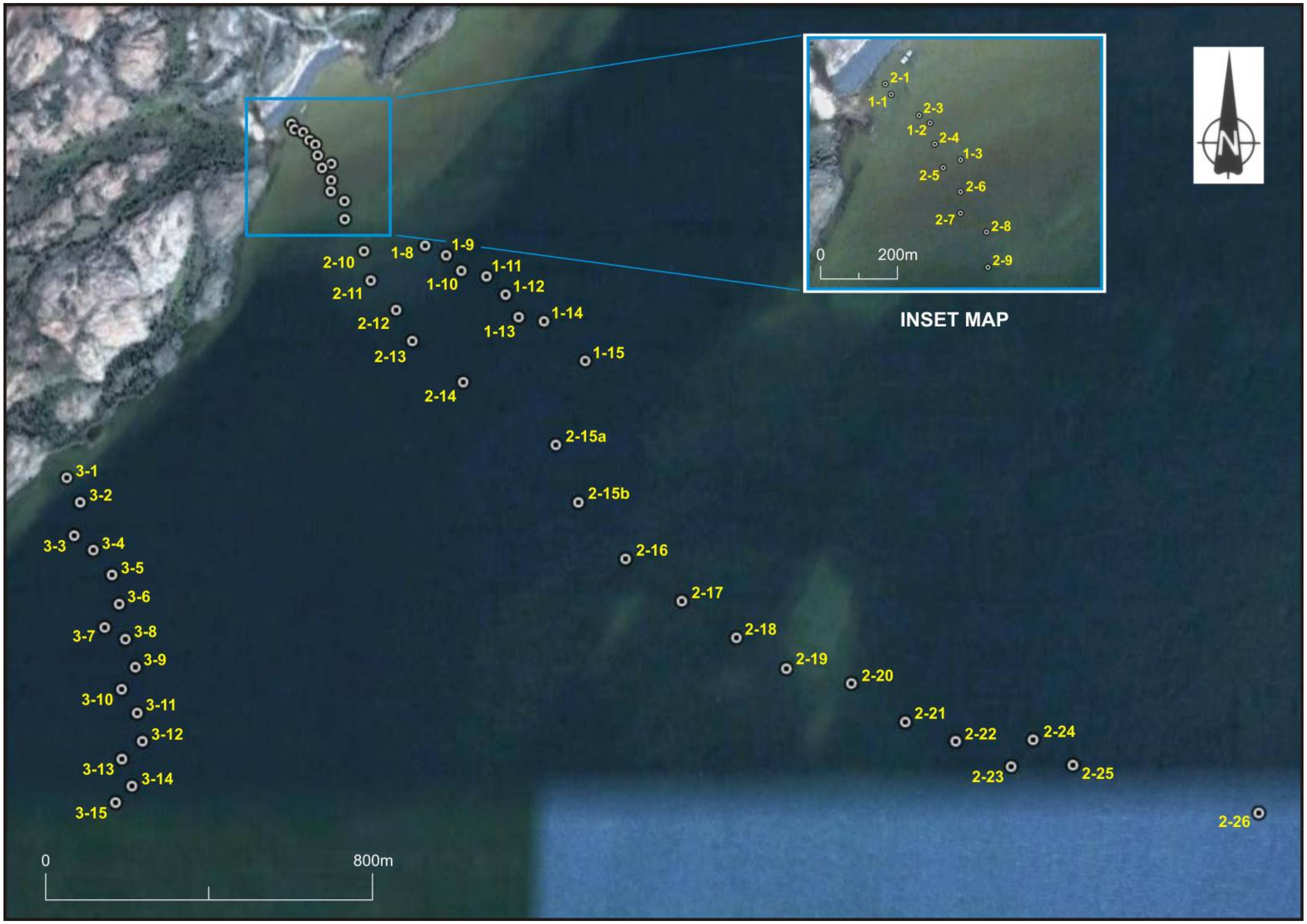
The dominant form of aquatic macrophytes seen on the video footage was the clumped matter which was assumed to be organic (Figure 7.4.2). These clumps were most noticeable at stations 2-10 through 2-22 and stations 3-1 through 3-4. Location 2 also has the greatest amount of grasses and aquatic macrophytes present, which were most visible at stations 2-16 through 2-21. The increased aquatic macrophyte presence at these stations corresponds to the presence of a raised plateau in that section of the North Yellowknife Bay, which has not been illustrated on previous bathymetry maps. However, for many of the other stations it was not possible to determine if vegetation was present.

In-situ water chemistry was very consistent between and within stations and locations. Temperatures between stations varied only a few degrees from near zero in the shallows near shore to 2 to 3 degrees Celsius at the deeper locations. Within stations, temperatures were fairly consistent at all depths, usually only varying a fraction of a degree between the top and the bottom of the water column. Dissolved oxygen also varied very little across all samples with average values of approximately 13.5 mg/L. Conductivity was extremely consistent within stations, with little to no variation. Between stations, conductivity generally fluctuated between 54 µs/cm and 59 µs/cm. The one exception to this was Station 2-15a which had conductivity readings that increased from 57 µs/cm at the surface to 69 µs/cm at the bottom. The reason for this is unknown. The pH also showed very little variation within stations. Between stations, pH ranged from 6.43 to 7.09 with a general trend of increasing pH the further the station was from shore. The consistency of these results across all stations suggest that in-situ water chemistry would have little effect on fish preference from one station or alignment to another.

The vegetated areas along each of the potential outfall locations provide the greatest opportunities for potential fish habitat (spawning and foraging) in the study area. Tables 7.4.2 and 7.4.3 show the possible strata and cover utilized by major fish species in Great Slave Lake for spawning, as well as the possible strength of association each fish has with the various substrate types, respectively. Based on the limited information available from the video, there is some potential for spawning habitat along each of the potential outfall alignments. Species such as spottail shiner (*Notropis hudsonius*) and, to a lesser extent, emerald shiner (*Notropis atherinoides*), walleye (*Sander vitreus*) and white sucker (*Catostomus commersoni*), have a higher potential to be utilizing the area for spawning habitat than other species (Table 7.4.2). Additionally, in terms of foraging habitat, lake chub (*Couesius plumbeus*), lake whitefish (*Coregonus clupeaformis*), ninespine stickleback (*Pungitius pungitius*), northern pike (*Esox lucius)* and trout-perch (*Percopsis omiscomaycus*) are all known to associate with the types of substrates observed along the potential alignments (Table 7.4.3).

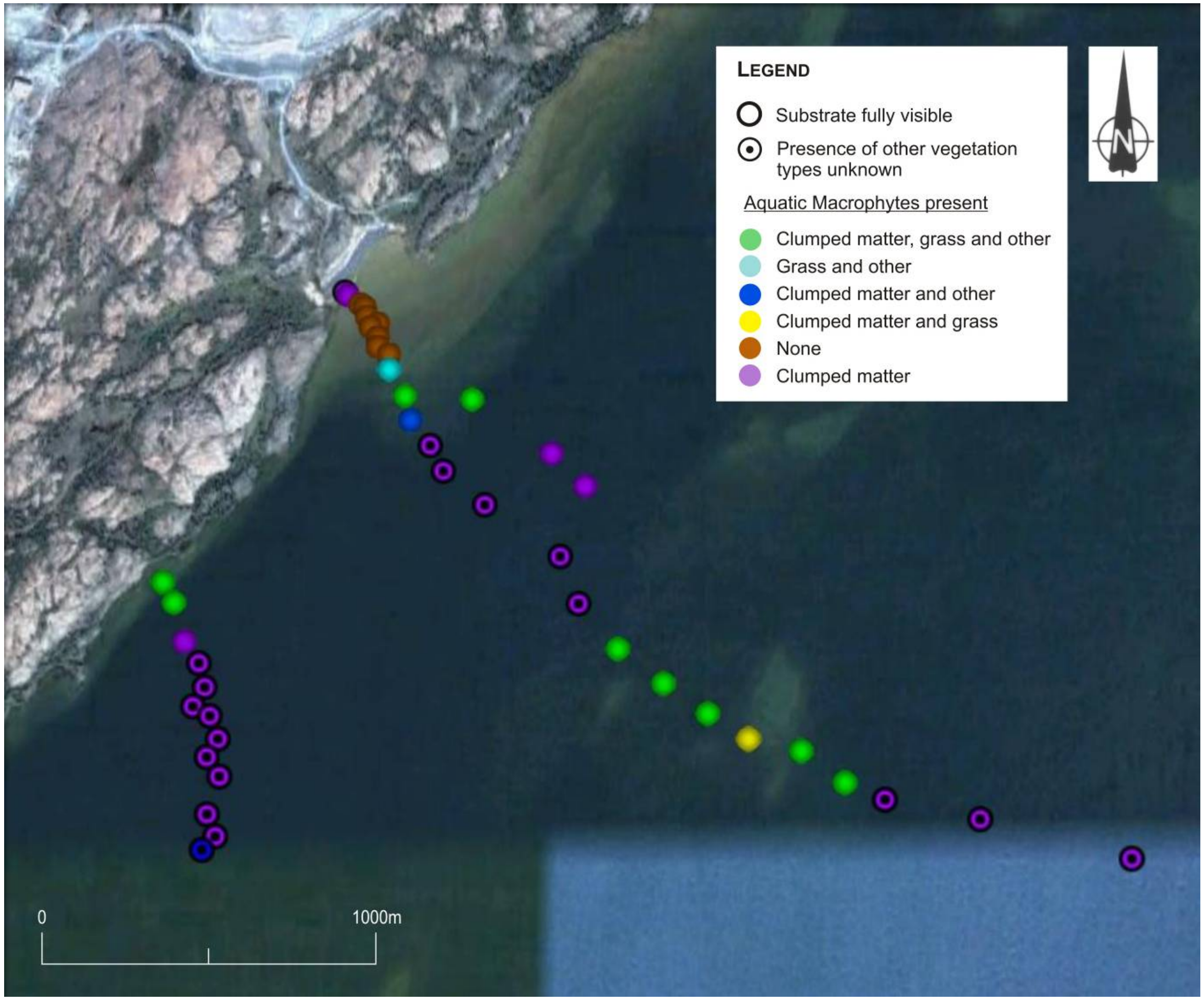
The preliminary data suggests that the highest quality habitat appears to be more associated with the potential outfall alignments rather than the corresponding diffuser locations. However, additional video information is required for confirmation since much of the video collected at the discharge locations was badly obscured, and solid conclusions cannot be drawn for those locations.

Figure 7.4.1 Underwater Video and In-Situ Water Sampling Along Potential Outfall Locations



Source Image: Google Earth 2010

Figure 7.4.2 Aquatic Macrophyte Distribution Along Potential Outfall Locations



Source Image: Google Earth 2010

Table 7.4.2 Possible Strata and Cover Utilized by Some Fish Species in Great Slave Lake

Common Name	Scientific Name	Water Depth (m)				Cover			Comments
		0-1	1-2	2-5	5+	Submergent Vegetation	Emergent Vegetation	Other	
Arctic grayling[1]	*Thymallus arcticus*	X	X	X	-	low	-	buried by and/or between gravel or rocks	eggs adhesive for short period
Emerald shiner	*Notropis atherinoides*	X	X	X	X	low	Low	-	
Lake chub	*Couesius plumbeus*	X	X	-	-	-	-	under boulders	
Lake trout	*Salvelinus namaycush*	X	X	X	X	-	-	crevices, cracks	depth a function of race
Lake whitefish	*Coregonus clupeaformis*	X	X	X	X	-	-	-	
Longnose sucker	*Catostomus catostomus*	X	X	X	-	-	-	-	
Ninespine stickleback	*Pungitius pungitius*	X	X	X	X	high	high	between rocks	
Northern pike	*Esox lucius*	X	X	-	-	-	high	flooded terrestrial vegetation	eggs adhere to vegetation
Spottail shiner	*Notropis hudsonius*	X	X	X	-	medium	Medium	-	
Trout-perch	*Percopsis omiscomaycus*	X	X	X	X	low	Low	between rocks	
Walleye	*Sander vitreus*	X	X	X	X	low	Low	-	
White sucker	*Catostomus commersoni*	X	X	-	-	low	Low	-	

[1] Scott, W.B. and E.J. Crossman. 1973.
X, Fish species present at specified depth
-, Species not reported to use specified depth stratum or cover
low, Species sometimes spawns in given cover type
medium, Species often spawns in given cover type
high, Species almost always spawns in given cover type

Table 7.4.3 Possible Strength of Association with Substrate Types for Fish in Great Slave Lake

Common Name	Scientific Name	Substrate								
		Bedrock	Boulder	Cobble	Rubble	Gravel	Sand	Silt	Clay	Hard-pan clay
Arctic grayling[1]	*Thymallus arcticus*	-	high	high	high	high	-	-	-	-
Emerald shiner	*Notropis atherinoides*	-	medium	medium	high	high	high	-	-	-
Lake chub	*Couesius plumbeus*	-	medium	-	high	high	high	low	-	-
Lake trout	*Salvelinus namaycush*	high	high	high	high	low	low	-	-	-
Lake Whitefish	*Coregonus clupeaformis*	-	medium	high	high	high	high	medium	medium	medium
Longnose sucker	*Catostomus catostomus*	-	-	-	-	high	high	-	-	-
Ninespine stickleback	*Pungitius pungitius*	-	-	medium	high	high	medium	medium	-	-
Northern pike	*Esox lucius*	-	-	-	low	low	high	high	-	-
Spottail shiner	*Notropis hudsonius*	-	-	medium	medium	high	high	-	-	-
Trout-perch	*Percopsis omiscomaycus*	-	-	-	high	high	high	high	-	-
Walleye	*Sander vitreus*	high	high	high	high	high	high	-	-	high
White sucker	*Catostomus commersoni*	-	-	-	medium	high	medium	-	-	-

[1] Scott, W.B. and E.J. Crossman. 1973.

7.4.2.2 Yellowknife Bay Benthos

The state of the benthic community provides an important component to the understanding of the health of an aquatic system. A diverse benthic community with groups of invertebrates that are known to be sensitive to some types of water pollution indicates generally good water quality and serves as a good food source for benthic-feeding and omnivorous fish species.

Moore (1979) assessed the benthic community in Yellowknife Bay in 1976 when the effluent from Giant Mine contributed to elevated concentrations of arsenic, mercury, lead, copper and zinc in the bay. Species diversity was found to be the same in impacted areas and a reference site. However, the level of contamination was reflected in the abundance of benthic organisms, with much lower densities of benthic invertebrates ($<100/m^2$) relative to background sites ($>2000/m^2$) (Moore 1979).

More recently, benthos in North Yellowknife Bay were assessed in 2004 in a survey of chemical, physical and biological characteristics of sediments from Latham Island to the mouth of the Yellowknife River (Golder 2005a). A summary of the study's findings related to benthos is presented below. Details of sediment quality data collected during the study were presented in Section 7.1.4.

The Golder (2005a) study found that invertebrate communities of North Yellowknife Bay were dominated by amphipods, clams, midges and oligochaetes, which accounted for 50 to 100% of the numbers present. Benthic invertebrate abundance, richness and the abundance of metal-sensitive invertebrates were found to be reduced in areas of elevated arsenic, to a distance of 500 m from the shoreline adjacent to Giant Mine. Some families of aquatic worms, snails, amphipods, clams and roundworms (*Naididae, Valvatidae, Talitridae, Sphaeriidaie* and *Nematoda*, respectively) were negatively affected by increasing arsenic concentrations. Other families of amphipods, aquatic worms and midges (*Haustoriidae, Tubificidae* and *Macropelopiini,* respectively), were not affected by increasing concentrations of arsenic. However, total invertebrate abundance, richness and metal-sensitive invertebrate abundance were negatively correlated with arsenic levels in sediments. Benthic invertebrate communities were negatively affected in areas where arsenic concentrations were generally greater than 150 mg/kg and gradients in benthic community structure were seen with increasing arsenic concentrations. The study showed the continuing effects of arsenic-contaminated sediments on the benthic community in North Yellowknife Bay (Golder 2005a).

7.4.2.3 Fish in Great Slave Lake

Studies of fish communities in the lakes around Yellowknife show that the species present are typical of cold, northern lakes with low productivity. A survey of fisheries in the North Slave region of the NWT reported 24 fish species in Great Slave Lake and the Yellowknife River

(Table 7.4.4). The fish species represent several trophic levels and a wide array of benthic and pelagic niches. For example, northern pike utilize the shallow shoreline areas for spawning and rearing. Young of the year walleye also migrate into the nearshore areas for rearing. These areas contain an abundance of food for northern pike and walleye (e.g., other small fish), while aquatic vegetation provides protective cover.

Although commercial and subsistence fishers and anglers are primarily interested in lake trout, lake whitefish, northern pike and walleye, the presence of a large number of forage species, including chub and shiner, shows a strong species base and good diversity in the aquatic food web. The detailed species list reported by Stewart (1997) is largely consistent with the species present in the surface waters and inland lakes of the Taiga Shield[22] (WGGSNS 2006).

While once common and a major part of traditional diets, the Great Slave Lake population of inconnu (*Stenodus leucichthys*) are now classified as "May Be At Risk". The species is considered to be rapidly declining and, where once there were five stocks in Great Slave Lake, currently only two, the Slave and Buffalo River stock, remain (WGGSNS 2006). Species considered to be "Sensitive" in the Taiga Shield are walleye, arctic grayling and the deepwater sculpin (Table 7.4.4). Walleye is at the northern limits of its range and is susceptible to overfishing. Although arctic grayling is widely distributed and the NWT population is stable, the species has been shown to be susceptible to overfishing, disturbance to habitat such as that from mining, and climate change.

[22] A description of the Taiga Shield is provided in Section 7.5.

Table 7.4.4 Inventory of Fish Species Present in Great Slave Lake and the Yellowknife River Drainage Basin

Common Name	Scientific Name	Great Slave Lake	Yellowknife River
Arctic Grayling	*Thymallus arcticus*	P[2]	P
Arctic Lamprey	*Lampetra japonica*	P	-
Burbot	*Lota lota*	P	P
Chum Salmon	*Onchorhynchus keta*	P	-
Deepwater Sculpin	*Myoxocephalus quadricornis thompsoni*	P[2]	-
Emerald Shiner	*Notropis atherinoides*	P	P
Flathead Chub	*Platygobio gracilis*	P	-
Goldeye	*Hiodon alosoides*	P	-
Inconnu	*Stenodus leucichthys*	P[1]	P
Lake Chub	*Couesius plumbeus*	P	P
Lake Cisco	*Coregonus artedi*	P	P
Lake Trout	*Salvelinus namaycush*	P	P
Lake Whitefish	*Coregonus clupeaformis*	P	P
Longnose Sucker	*Catostomus catostomus*	P	P
Ninespine Stickleback	*Pungitius pungitius*	P	P
Northern Pike	*Esox lucius*	P	P
Round Whitefish	*Prosopium cylindraceum*	P	P
Slimy Sculpin	*Cottus cognatus*	P	P
Spoonhead Sculpin	*Cottus ricei*	P	-
Spottail Shiner	*Notropis hudsonius*	P	P
Trout Perch	*Percopsis omiscomaycus*	P	P
Walleye	*Stizostedion vitreum vitreum*	P[2]	P
White Sucker	*Catastomus commersoni*	P	P
Yellow Perch	*Perca fluviatilis*	P	P

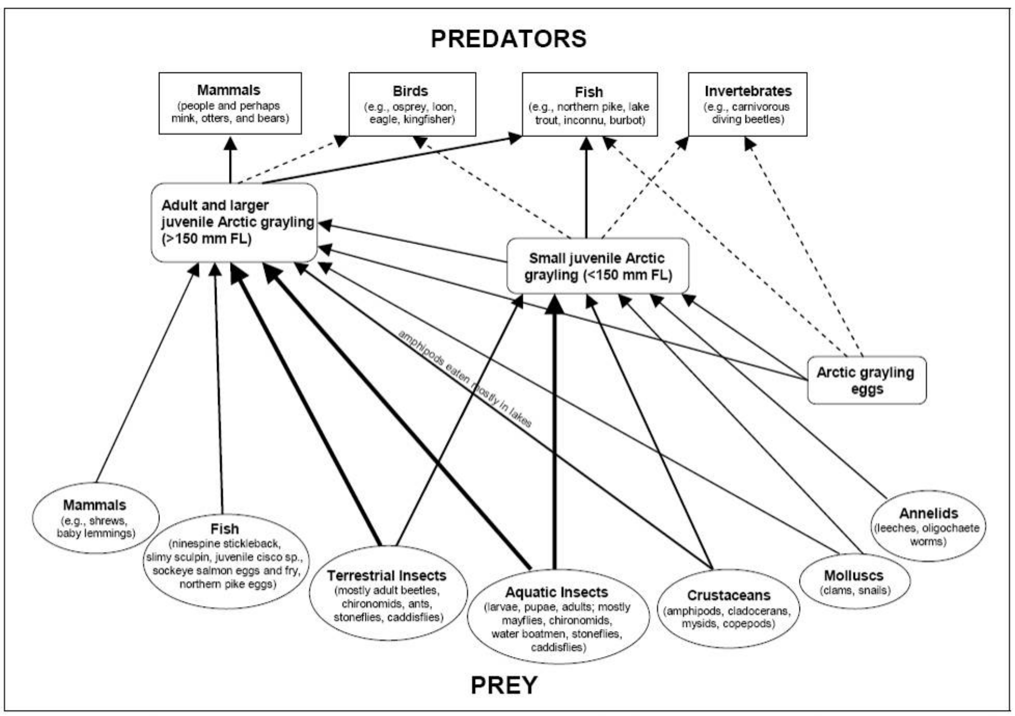
Legend: P – present
[1] – Species is categorized as "May Be At Risk" (WGGSNS 2006).
[2] – Species is categorized as "Sensitive" (WGGSNS 2006).
Source: Stewart 1997

A series of reports on the life histories and food webs of major fish species in the NWT illustrate the complexity of the aquatic food webs within these Taiga Shield lakes, and apply to water bodies such as Yellowknife Bay and the inland lakes and streams around Yellowknife (Stewart 1997, Stewart *et al*. 2007a, b, c, d). For example, the arctic grayling is widely distributed across the NWT and has been observed as one of the species returning to Baker Creek. The species is known to live year-round in small streams and all life stages of some populations can overwinter in deep pools of streams (Stewart *et al*. 2007a). The fluvial population uses the smaller streams for spawning and rearing of young, seasonal feeding habitat and as migratory corridors for juveniles and adults (Stewart *et al*. 2007a). Grayling eggs are consumed by invertebrates and juvenile and adult fish, while juvenile grayling (>150 mm) are consumed by several species of larger fish, including adult grayling (Figure 7.4.3). Adult grayling consume insects, other invertebrates, and smaller fish species, and are consumed by mammals, birds and larger predatory fish species. Many of the species listed in Table 7.4.4 have similar ecological relationships.

Fisheries surveys were conducted in lakes near Yellowknife in 1979 to determine the status of the lake trout fishery in these oligotrophic lakes[23], which were considered to have moderate to heavy levels of development and angling pressure (Roberge *et al.* 1990). Arctic grayling and walleye have been observed to migrate into the Yellowknife River in spring, while cisco and lake whitefish migrate in during the fall (Stewart 1997). Lake whitefish and lake trout were found in the lakes, as were northern pike (*Esox lucius)*, arctic grayling (*Thymallus arcticus*), round whitefish (*Prosopium cylindraceum*), lake cisco (*Coregonus artedi*), burbot (*Lota lota*), white sucker (*Catastomus commersoni*) and longnose sucker (*Catostomus catostomus*).

Commercial fisheries play a minor role in the economy of the Yellowknife area. For management purposes, Great Slave Lake is divided into six administrative areas (Read and Taptuna 2003). Area IV covers the northern section of the western basin of Great Slave Lake up to the outer edge of Yellowknife Bay (commercial fishing is prohibited in the bay). The commercial quota for Area IV is currently 409,100 kg round weight of whitefish and trout, which was reduced from a quota of 622,727 kg in 1975/1976. The total production of the main seven harvested species from 1999 to 2001 is presented in Table 7.4.5.

Figure 7.4.3 Generalized Food Web for Arctic Grayling



Note: Bold lines indicate major food pathways, in comparison to thinner lines; solid lines indicate demonstrated and dashed lines indicate putative pathways.
Source: Stewart 1997

[23] i.e., Water bodies with low nutrient levels.

Table 7.4.5 Total Production of Commercial Species (kg round weight) in Administration Area IV Between 1999 and 2002

Species	1999/00	2000/01	2001/02
Whitefish	294,658	327,770	242,723
Trout	3,653	19,865	4,217
Pike	26,185	23,925	30,098
Inconnu	6,838	9,891	6,486
Walleye	2,916	10,234	19,061
Burbot	19,069	0	9,456
Sucker	527	8,177	1,592
Total	353,846	399,862	313,633

Source: Read and Taptuna 2003.

7.4.2.4 Traditional Fishery

Studies that document the importance of the Great Slave Lake traditional fishery to Aboriginal groups in the area date from the 1960's. Keleher and Haight (1964) identified three main groups that were catching fish in the early 1960s in the North Arm: residents who fish for food for themselves and their dogs, anglers who fish for pleasure and commercial fishers. One community was composed primarily of members of the Yellowknives Dene, collecting a total of 16,900 fish by mid-December of the year, mostly whitefish (other species caught were northern pike and burbot). Approximately 82,500 pounds (37,400 kg) of fish were collected by the community in 1961. The report (Keleher and Haight 1964) illustrates the historic importance of fish to the Yellowknives Dene and other groups surrounding the North Arm of Great Slave Lake. However, lifestyle changes for Aboriginal people over the last several decades are anticipated to have resulted in a reduction in the Aboriginal dependence on the local fishery. For example, the introduction of the snowmobile is assumed to have been accompanied by a decrease in traditional fishing to feed dog teams.

In more recent times there have been studies examining the dietary intake of Dene communities, including the Yellowknife Dene, and the importance of traditional foods (Receveur *et al.* 1996, Receveur *et al.* 1998). One study determined that the average fish intake for the Yellowknife Dene was 167 g/d (consumers only) (Receveur *et. al* 1998). This can be compared to a value of 111 g/d (consumers only) for the typical Canadian adult (Health Canada 2004). The fish that are expected to comprise a large portion of the diet include whitefish, trout, loche and pike (Receveur *et al.* 1996).

7.4.2.5 Arsenic Concentrations in Great Slave Lake Fish

Data on the arsenic concentrations in fish muscle for several fish species in Yellowknife Bay, Baker Creek and Resolution Bay (a reference location on the south shore of Great Slave Lake) are shown in Table 7.4.6. The data on several fish species were combined as it was found that there was little difference in arsenic levels between species. Arsenic concentrations in long nose sucker, northern pike and lake whitefish were available for Baker Creek and Yellowknife Bay (Falk *et al.* 1973). Northern pike and lake whitefish are included for Yellowknife Bay. For Resolution Bay, burbot, inconnu, lake trout, northern pike and walleye were analyzed by Evans *et al.* (2000). Overall, arsenic concentrations in fish muscle were 0.20 µg/g wet weight (ww) in Yellowknife Bay (n=408) with levels being slightly higher in Baker Creek (0.29 µg/g (ww), n=9) (SENES 2006).

The observations noted above are very similar to the findings on predator and forage fish collected from lakes in northern Saskatchewan. In lakes with arsenic concentrations of less than 4 µg/L in the water column (as is the current case for Great Slave Lake), the arsenic concentrations in fish flesh samples were found to be independent of the water concentration. The mean arsenic concentration in fish flesh on 119 samples equalled 0.18 µg/g (ww) and ranged from a minimum of 0.03 µg/g (ww) to a maximum of 0.55 µg/g (ww) (Cameco and AREVA 2008). These statistics are very similar to those reported in Table 7.4.6 for Yellowknife Bay and Resolution Bay.

In a study by de Rosemond *et al* (2004) on arsenic speciation in fish caught in the LSA, it was found that inorganic arsenic was present at low concentrations in fish collected from Back Bay near the mouth of Baker Creek (<7.5% of total arsenic, n=34 comprising 8 lake whitefish, 8 northern pike, 8 walleye, 6 white sucker and 4 longnose sucker). This suggested there may be little toxicological risk from arsenic exposure to humans through fish consumption since inorganic arsenic is more toxic to humans than some organic arsenic forms (e.g., arsenobetaine). Other organic arsenic forms, however, may have toxic effects that are similar to inorganic arsenic. Unfortunately, laboratory analysis of arsenic speciation in the fish samples was not successful in identifying a majority (> 50%) of the organic species in almost all of the tissue samples. The results of the investigation did demonstrate that trophic status plays a role in arsenic accumulation, with benthic feeders accumulating more arsenic than higher level piscivores (de Rosemond *et al* 2004).

Table 7.4.6 Measured Arsenic Levels in Fish Muscle (µg/g (ww))

	Exposure Areas		Reference Area	
	Baker Creek	Yellowknife Bay	Resolution Bay	Overall
# of Samples	9	408	14	431
Arithmetic Mean	0.29	0.20	0.16	0.20
Standard Deviation	0.06	0.15	0.07	0.15
Geometric Mean	0.28	0.20	0.15	0.19
Geometric Std Dev	1.24	2.08	1.48	1.66
Minimum	0.21	0.02	0.08	0.02
Maximum	0.37	1.11	0.32	1.11

Note: For the purposes of the summary, values measured as < the detection limit were considered as ½ the detection limit.

Source: SENES 2006, based on data as reported in Falk *et al*. 1973.

7.4.3 Site Study Area

7.4.3.1 Habitat

In its natural state, Baker Creek served as the drainage for a relatively small catchment which flowed through a mix of bedrock, ponds and wetlands prior to discharging to Great Slave Lake. The combination of deeper pools, riffle areas and long straighter reaches provided a mixed habitat that supported invertebrates, plants, wildlife and waterfowl. The creek also provided areas for adult fish to overwinter and habitat for breeding. Prior to development of Giant Mine, high flows in spring are assumed to have allowed fish to move into and throughout the creek for breeding, while changes in water levels over the summer restricted the movement of adults.

The development of Giant Mine and construction of the highway through the site resulted in extensive changes to the natural flow and alignment of Baker Creek. These modifications, coupled with chemical loadings to the creek, are likely to have caused marked changes in the resident fish population. While the mouth of Baker Creek in Yellowknife Bay remained heavily vegetated and mostly unchanged from the natural state during the 1950s and 1960s, the opening became restricted in the 1970s due to local construction. Further upstream, various changes to the streambed and banks were made as culverts were constructed and features of the mine were developed. In particular, the excavation of the A-1 and A-2 pits caused the loss of vegetation on the banks and altered the stream channel. Figure 7.4.4 illustrates the natural and current alignments of the creek. Table 7.4.7 also presents summary descriptions of current conditions within the various reaches of Baker Creek.

Figure 7.4.4 Original and Current Baker Creek Alignments

Table 7.4.7 Description of Baker Creek Reaches

Reach	Description	Current Condition
1	Extends from marsh in Great Slave Lake to the channel north of A2 Pit; riparian vegetation is sparse and poor; channel structure and diversity is low.	395 m total length bedrock and degraded channel
2	Straight reach that is physically undisturbed from historical mine activities; large part of riparian area is intact.	600 m total length natural channel
3	Extends from north end of C1 Pit downstream to upper end of Reach 2; short alluvial section below culvert and through bedrock diversion channel; aquatic habitat and riparian habitat poor.	750 m total length bedrock channel
4	Extends upstream to the weir next to B1 Pit and downstream to below the former location of the old bridge north of C1 Pit; original channel physically disturbed and modified by contaminated sediments	350 m total length degraded pond-type channel
5	Extends from the former location of the old weir to the outlet of Baker Creek; moderately disturbed by mining activity in stream bed and riparian areas.	425 m total length degraded backwater-type channel
6	Baker Pond, and includes Trapper Creek; lake bottom and shoreline contains contaminated mine tailings; discharge point for effluent.	Approximately 3 hectares in area degraded pond

A major change to the creek system in terms of fisheries started to occur when tailings effluent began to be discharged to Baker Creek Pond during the 1960s. Although fish were observed (and collected) from the creek during this period (for example, as reported in Falk *et al.*(1973)), the effluent showed some toxicity to the resident fish population and reduced the survival of young-of-the-year and juvenile fish, either due to contaminant levels in the water or suspended solids. Altered stream flow, reduced overwintering sites for adult fish and chemical loadings to the creek collectively reduced the survival of young fish and had major impacts on the natural fish community. As an additional indication of stream health, invertebrates were virtually absent from Baker Creek prior to the treatment of effluent in the 1980s, due to the high concentration of contaminants. To illustrate, Falk *et al*. (1973) found no invertebrates at four sampling stations within the creek during a study conducted in 1972. Similarly, Moore *et al*. (1978) also found that the creek below the mine was largely devoid of fauna, aside from very low densities (<100 individuals per square metre) of worms (oligochaetes).

7.4.3.2 Baker Creek Aquatic and Riparian Vegetation

Several studies have documented the distribution of vegetation within Baker Creek because of the importance of emergent macrophytes as wildlife habitat and their role as cover and a food source for young fish. Prior to development of Giant Mine, the natural watershed of Baker Creek had long stretches of vegetation-covered banks that helped stabilize the streambed and support communities of mammals, waterfowl and fish.

Disturbance of the Baker Creek stream banks during mine development and construction of the highway caused the loss of much of the natural vegetation in some areas. In its assessment of the fish community and fisheries habitat, Dillon Consulting (1998) summarized the emergent macrophtytes in the creek. Aquatic vegetation was dominated by horsetail and cattail in large stretches of the Creek. Other areas were described as having willows, grasses and shrubs along the banks, with some areas having rock-lined banks with grass at the top.

The most detailed assessment of the aquatic vegetation in Baker Creek reported a total of 19 species present (Jacques 2003). Individual species found in the creek are listed in Table 7.4.8. One community, termed the swamp horsetail community, was situated at the outflow of Baker Creek. The dominant plant was swamp horsetail (29% of the study area), followed by Canada blue-joint, common horsetail and Richardson's water moss. The plant community in the beaver pond in the upper reaches of Baker Creek was dominated by water arum, followed by Richardson's pondweed and water sedge (Jacques 2003).

Table 7.4.8 Species of Aquatic Macrophytes Present in Baker Creek in 2003

Common Name	Scientific Name	Common Name	Scientific Name
Bladder Sedge	*Carex utriculata*	Richardson's Water Moss	*Calliergon richardsonii*
Bulrush	*Scirpus lacustris ssp. validus*	Sago Pondweed	*Potamogeton pectinatus*
Canada Blue-Joint	*Calamagrostis canadensis*	Sedge species	*Carex spp.*
Cattail	*Typha latifolia*	Swamp Horsetail	*Equisetum fluviatile*
Common Horsetail	*Equisetum arvense*	Tall cotton grass	*Eriphorum angustifolium*
Common Mare's Tail	*Hippuris vulgaris*	Water Arum	*Calla palustris*
Cow Lily	*Nuphar variegatum*	Water Sedge	*Carex aquatalis*
Flatleaf Bladderwort	*Utricularia intermedia*	Water-Plantain	*Alisma sp.*
Narrow -leaf Burreed	*Sparaganium angustifolium*	Willow	*Salix spp.*
Richardson's Pondweed	*Potamogeton richardsonii*		

Source: Jacques 2003.

7.4.3.3 Baker Creek Benthic Communities

In-stream invertebrates were sampled at several sites in Baker Creek in 1998 as part of a fisheries assessment (Dillon 1998); however, the species were not classified in detail. The 1998 study reported a benthic community that was very low in diversity, consisting of chironomids, adult caddisflies and mayflies. No benthos were found at four sites near the mine.

Benthic invertebrates were sampled at the mouth of Baker Creek in 2006 using artificial substrates as part of the environment effects monitoring (EEM) program (Golder 2008). No sites were established within Baker Creek proper. The abundance of the benthic community assemblage was higher in the Yellowknife reference area than on the sites at the Baker Creek discharge. Other indicators of benthic community diversity, such as Simpson's Evenness Index and Simpson's Diversity Index were not significantly different between sampling areas. Dominant families found during the survey were gammarid and hyallid amphipods, chironomids, mayflies and caddisflies.

Benthos and zooplankton were also assessed in 2008 as part of the fisheries assessment in Baker Creek (Golder 2009). A diverse community of worms, snails, mayflies, caddisflies, beetles and flies were reported from the realigned Reach 4, indicating good forage for hatching grayling and sucker. The benthic community present in Reach 4 was observed to include both pollution-tolerant and pollution-sensitive species that provide very good forage for the resident and migrating species in the fish community.

7.4.3.4 Metal Concentrations in Baker Creek Benthic Tissue

Benthos samples were collected from Baker Creek in July of 2002 for analysis of tissue metal concentrations (Dillon 2002). Metal concentrations were typically higher in tissue samples of benthos collected downstream of the Giant Mine site when compared to those collected upstream. This was the case for antimony, arsenic, nickel and zinc, while only copper was higher in the upstream tissue samples (Table 7.4.9). The metals with the greatest differences in concentration between upstream and downstream samples were antimony (means of 0.9 and 4.5 µg/g (dw), respectively) and arsenic (means of 43 and 136 µg/g (dw), respectively).

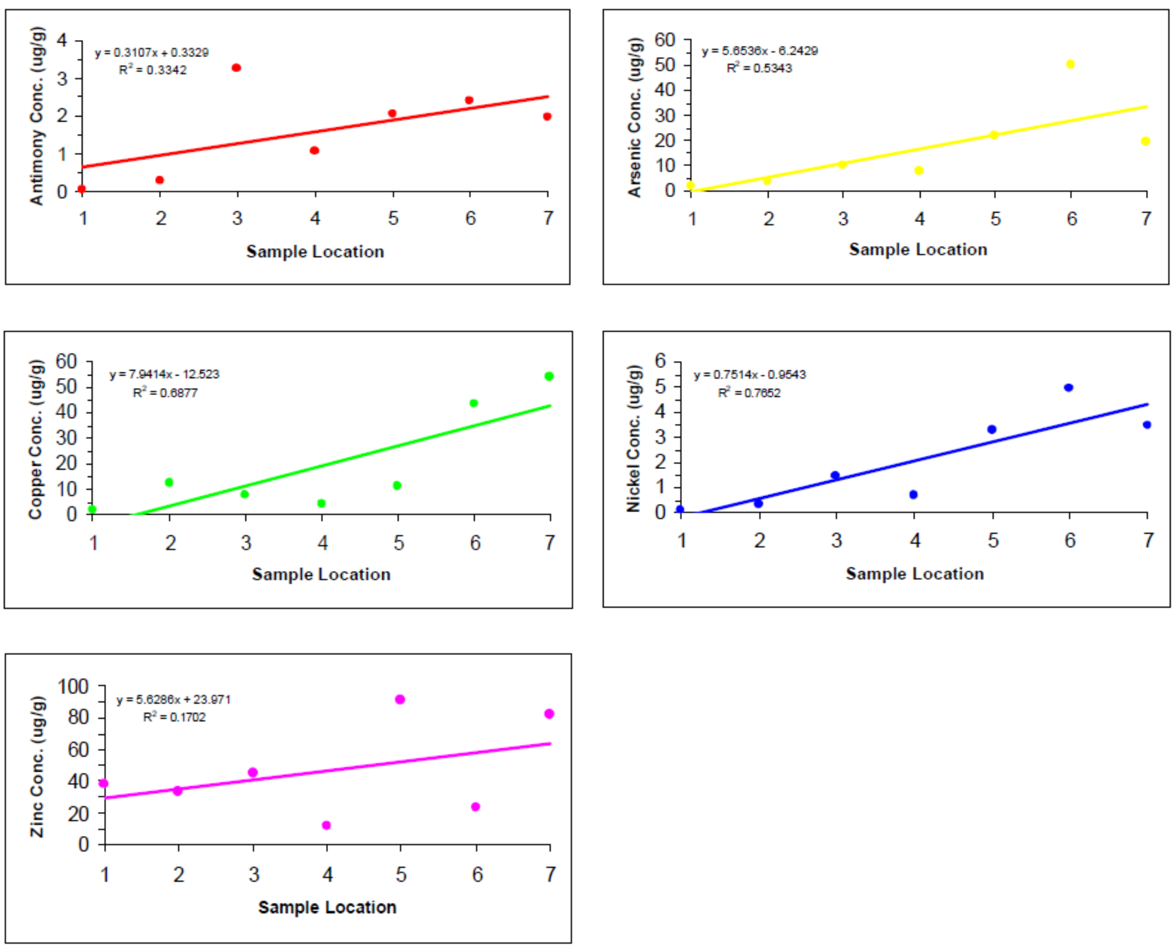
Tissue samples of benthic invertebrates were analyzed again in 2003 (Dillon 2004). As found in 2002, the concentrations of metals in benthos tissue samples were generally higher downstream of the Giant Mine site than those upstream of the site (Table 7.4.9). Arsenic, antimony, copper and nickel were much higher in tissue samples downstream than upstream. Tissue metal concentrations increased with distance downstream of the mine site (Figure 7.4.5). This was concluded to be the result of invertebrate drift (Dillon 2004). Invertebrates tend to drift downstream over time, so those furthest downstream would have had the longest period of exposure to effluent discharged from the Giant water treatment plant to Baker Creek. It is noteworthy that the tissue metal concentrations from the 2003 program were significantly lower than those reported in 2002. An explanation for the variation in the tissue metal content in benthos between sampling events was not apparent.

Table 7.4.9 Metal Concentrations in Baker Creek Benthic Invertebrate Tissue

Compound	Mean Tissue Concentration (µg/g (ww))			
	Upstream		Downstream	
	2002	2003	2002	2003
Antimony	0.9	0.17	4.5	2.14
Arsenic	43	2.65	136	21.9
Copper	316	6.98	91.85	24.2
Nickel	12.5	0.22	16.3	2.78
Zinc	98	36.1	102.5	50.7

Source: Dillon 2002, 2004.

Figure 7.4.5 Metal Concentrations in Baker Creek Benthic Invertebrate Tissue



Measured levels are reported as µg/g (dw).
Sample locations 1 and 2 are upstream of the mine. Locations 3 through 7 are progressively further downstream, with location 7 being at the mouth of Baker Creek.

Source: Dillon 2004

7.4.3.5 Fish in Baker Creek

A fisheries assessment of the Baker Creek system in August 1998 (Dillon 1998) provided a description of the fish community, fisheries habitat and streambed conditions at seven sites during the summer when young fish from spring spawning species should be present. During the period when there was effluent discharge, very few fish were collected even though sampling was conducted by both seining and electro-fishing. However, northern pike and longnose sucker were present when there was no effluent discharge and burbot were also present upstream of the mine. The major findings of the study were the very low numbers of fish overall, particularly during effluent discharge, but the presence of some larger species when there was no effluent.

Subsequent studies were conducted to determine the level of contaminants of potential concern in fish in the Creek. Fish habitat was evaluated in 2000 to provide options for restoring Baker Creek as part of the Giant Mine closure plan (Golder 2001b). The study documents several sites in the creek that might provide suitable fish habitat, namely for northern pike and longnose sucker, although many features of the stream involve man-made structures and culverts.

Fish were also collected from Baker Creek during the drawdown of the B-2 Pit Pond and Mill Ponds in July 2006. Northern pike, white sucker, lake herring and burbot were collected by beach seine and released into the Baker Creek channel (Golder 2006b). Another fish relocation program was required in October and November 2006 due to a dam failure. Several northern pike, burbot, white sucker and lake herring were caught by seine net, sometimes under the ice, and released into Yellowknife Bay (Golder 2006a). These studies demonstrate that larger adult fish are present in Baker Creek when conditions are suitable for overwintering and reproduction.

In 2006, Reach 4 of Baker Creek was realigned to the west side of Highway 4 (the Ingraham Trail). The primary objective of the realignment was to isolate the contaminated Mill Pond from Baker Creek. Secondary objectives were to provide a stable flood conveyance channel and to maintain or improve fish passage and habitat for native fish species. Improvements included riffles and deeper pools to improve spawning habitat and resting areas for adults and younger fish. In-stream changes were made to allow unobstructed passage for spawning adult fish, primarily those migrating in from Yellowknife Bay, and also spawning habitat, suitable conditions for egg viability and hatching and food availability (Golder 2008).

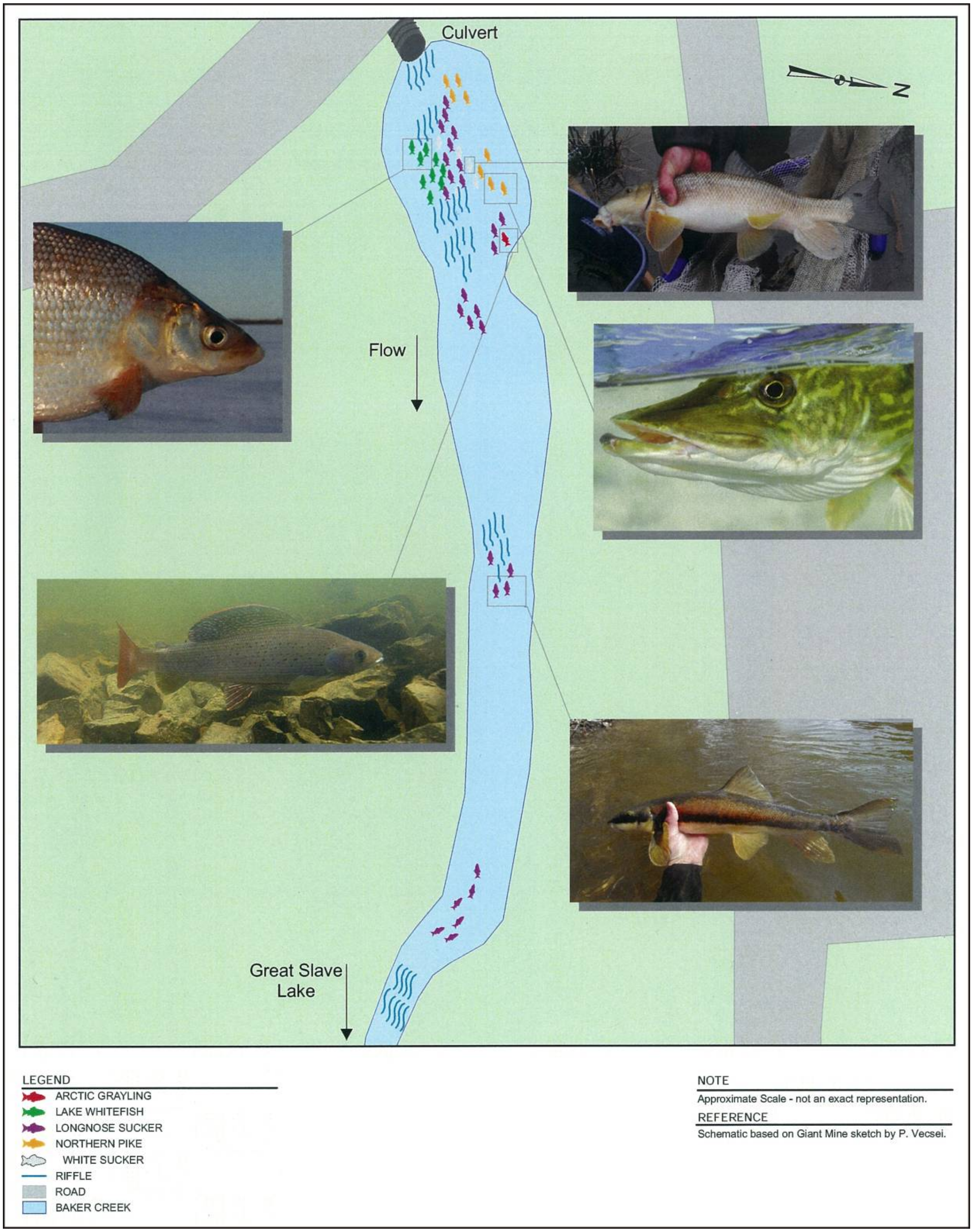
Studies conducted since the realignment of Reach 4 have shown that the modifications markedly improved the spawning success of arctic grayling within the Creek. As part of plans to realign Reach 4, INAC committed to a three year program to monitor the fish community to confirm the successful spawning of arctic grayling and to assess the overall habitat for grayling spawning and movement in Baker Creek. Other fish species were also to be assessed during the spring spawning period. Large numbers of juvenile sucker, arctic grayling, ninespine stickleback and emerald shiner were captured by dip net and released, indicating successful reproduction by these species in the spring of 2008. Egg deposition sites were observed in eight areas. The survey reported a total of 303 fish from eight species that were collected and released, and two additional species were observed but not collected. The successful breeding of several species in the Creek in 2007 and 2008 indicates that changes to Baker Creek in previous years improved breeding habitat, although the success of juvenile fish that migrated into Great Slave that will return to breed is unknown (Golder 2009). The areas occupied by adult fish in Reach 4 during the spawning period are shown in Figure 7.4.6.

In addition to monitoring of Reach 4, the EEM program for Baker Creek was completed in 2006 (Golder 2008). A total of 1,037 fish from five species, including burbot, ninespine sticklebacks, northern pike, slimy sculpin, and spottail shiner, as well as unidentified young suckers were caught in Baker Creek during the study. Very few differences were observed in the health of slimy sculpins between Baker Creek and a reference site at the Yellowknife River. The number of abnormal livers was higher in the Yellowknife River population, while the number of parasites in the sculpins was higher in Baker Creek. Overall, the body condition of the Baker Creek slimy sculpin population was determined to be higher than that in the Yellowknife River population. Similarly, condition factor, length and weight in ninespine stickleback young-of-the-year were higher in Baker Creek than the reference site. While there were differences between sampling sites for several indicators of fish health, it is not possible to determine if the differences were due to mine-related changes in Baker Creek or natural variation.

7.4.3.6 Metal Concentrations in Baker Creek Fish

As indicated in Table 7.4.6, arsenic levels in muscle from fish in Baker Creek were slightly higher than levels found in Yellowknife Bay in a survey reported by Falk *et al.* (1973). In a study conducted by Dillon in 2002 to measure the concentrations of several key contaminants in Baker Creek, small numbers of arctic grayling, northern pike, longnose sucker and a single burbot were collected upstream and downstream of the Giant Mine site. Contrary to expectations, fish caught upstream of the mine site were found to have typically higher tissue concentrations of arsenic, copper, nickel and zinc than fish caught downstream of the site. The authors speculated that the differences may have been influenced by factors such as the number and types of fish species caught upstream (3 arctic grayling, 2 northern pike and 1 burbot) versus species caught downstream of the site (3 northern pike and 7 longnose sucker) and the length of time the species had spent in the respective areas prior to the sampling event. For these reasons and the fact that the basis of the metal measurements was not reported (i.e., dry weight or wet weight), the results of the Dillon investigation are not reported here.

Figure 7.4.6 Location of Adult Fish in Reach 4 of Baker Creek During Spring Spawning in 2008



Source: Golder 2009

In a study by de Rosemond *et al* (2004), it was found that inorganic arsenic was present at low concentrations in fish collected near the mouth of Baker Creek (<7.5% of total arsenic, n=34 comprising 8 lake whitefish, 8 northern pike, 8 walleye, 6 white sucker and 4 longnose sucker). This suggested there may be little toxicological risk from arsenic exposure to humans through fish consumption since inorganic arsenic may be more toxic for humans than organic arsenic. Further, the study indicated that fish mostly accumulate arsenic through the food chain and not directly from water. It also appeared that trophic status played a role in arsenic accumulation, with benthic feeders accumulating more arsenic than higher level piscivores (de Rosemond *et al* 2004).

7.4.3.7 Toxicity Testing on Treated Minewater Discharged to Baker Creek

Sub-lethal toxicity testing of treated minewater from Giant Mine occurred twice in 2005 and once in 2006 (Golder 2008). Sub-lethal toxicity responses were present in water fleas (*Ceriodaphnia dubia*), green algae (*Pseudokirchneriella subcapitata*) and aquatic vegetation (*Lemna minor*). Fathead minnows (*Pimephales promelas*) did not show a sub-lethal toxicity response. The study considered the mixing effects within Baker Creek and the downstream receiving environment of Great Slave Lake. The effluent concentrations above which sub-lethal effects were calculated to occur were as follows (expressed as a percentage of effluent mixed with receiving waters):

- >100% for fathead minnows;
- 4.9% for *C. dubia;*
- 17.8% for P. subcapitata;
- 13.2% for *L. minor* fronds; and
- 67.7% for *L. minor* biomass.

Taking into consideration mixing within Baker Creek and downstream within Great Slave Lake, Golder concluded that sub-lethal toxicity effects are likely to occur throughout Baker Creek and marginally into Great Slave Lake.

7.4.4 Selection of Valued Components

A number of VCs have been selected to assess potential effects of the Remediation Project on the Aquatic Environment (Table 7.4.10). It should be noted that VCs for the Surface Water Environment were previously identified in Table 7.1.7.

Table 7.4.10 VCs for the Aquatic Environment

Sub-Component	VC	Rationale
Aquatic Habitat	Surface Water Quality and Sediment Quality (the VCs for the Surface Water Environment)	- Any adverse effects on the quality of surface water and sediments may result in a degradation of aquatic habitat (through potential increases in contaminant exposures of aquatic species to contaminants)
	Baker Creek and Yellowknife Bay	- The physical environments of Baker Creek and Yellowknife Bay serve as current and potential habitat for aquatic and terrestrial species. Degradation of that habitat may result in adverse effects to such species.
	Aquatic Habitat (intrinsic value)	- Aboriginal groups and Northerners value components of the environment for their intrinsic value - Fish habitat identified as an issue of concern during EA scoping
Aquatic Biota	Emergent macrophyte community (e.g., cattails)	- Potential for physical disturbance during remediation and effects from contaminants (both direct and as a food source) - Risk associated with plants growing in reclaimed areas resulting in elevated exposures of contaminants to wildlife
	Benthic invertebrates (e.g., ephemeroptera, trichoptera and chironomids)	- Potential for direct effects (on benthic invertebrates) and higher trophic levels if contaminant levels increase
	Arctic Grayling	- Spring spawner, eggs and young-of-the-year (YOY) have the potential to be affected by contaminated water and sediments in the spring - Number of adults indicates status of creek spawners - Species harvested for recreational fishing
	Lake Whitefish, Northern Pike, Longnose Sucker, Walleye	- Number of adults indicates habitat use (for various life stages, depending on timing) - Species harvested for traditional foods and recreational fishing (excluding longnose sucker)
	Resident in-stream species (e.g., sculpin or ninespine stickleback)	- Provide spatial and temporal data on habitat use for long-residency species
	All fish species	- Fish identified as an issue of concern during EA scoping - A measure of potential direct effects (on fish) and higher trophic levels

7.5 Terrestrial Environment

7.5.1 Introduction

This section of the DAR describes the Terrestrial Environment within the Study Areas. Information has been collected primarily from reports prepared by federal and territorial agencies and non-governmental groups. Particular emphasis has been placed on species of plants and animals that exist on or near Giant Mine (i.e., the SSA).

7.5.2 Regional Study Area

The Terrestrial Environment of the RSA is broadly defined as being the Taiga Shield within a vicinity of 100 km from Yellowknife. The Taiga Shield covers a broad band from the eastern edge of Great Bear Lake to Hudson Bay, and continues to Newfoundland in the east. Within the NWT, the Taiga Shield covers 330,082 km^2, or about 29% of the NWT land mass (Ecosystem Classification Group 2008).

A chief defining ecological characteristic of the Taiga Shield is the heterogeneous distribution of trees, which range from clumps of forest in areas with deeper soil to widely spaced stunted trees near the northern treeline. The extreme climate with long, cold winters, little precipitation and few nutrients results in limited tree growth. Large areas of permafrost restrict root growth for trees and shrubs. Much of the bedrock that predominates throughout the region is Archean (over 2.5 billion years old) with extensive glacial till deposits.

Another key feature of the Taiga Shield is the large number of small to large lakes distributed across the ecoregion. While many lakes are isolated or connected to local drainage systems, major drainage systems drain to Great Slave Lake and ultimately to the Arctic Ocean, or to Hudson Bay through the Thelon River system. These shallow lakes, wetlands and marshes provide productive habitat for nesting waterfowl and shorebirds, and valuable staging areas for migrating waterfowl.

The City of Yellowknife and the Giant Mine Lease area are both situated on the southwest corner of the Level 1 ecoregion (Ecosystem Classification Group 2008). The Level I ecoregion is similar to the term "biome" used in other national and international land classification systems which are based on a need to understand broad similarities of ecological communities in areas where climate, soils, landforms and topography are similar.

The Ecosystem Classification Group (2008) provides a general summary of the mammals found within the Taiga Shield High Boreal ecoregion. In addition to the barren ground caribou that overwinter in the area, large mammal species include moose and black bear. Lynx, red fox, timber and tundra wolves are widely distributed as well as furbearers such as marten, weasels, mink, otters and wolverine. Small mammals include deer mice, meadow jumping mice, meadow voles, heather voles, taiga voles and northern bog lemmings.

In addition to the species noted above, the mixture of wetlands, tundra, bedrock and forests of the southern portion of the Taiga Shield serves as habitat to support a diverse biological community of plants, birds and other wildlife.

The GNWT's Department of Environment and Natural Resources monitors the abundance and status of species in the NWT through a process known as the NWT Species Monitoring Infobase. The process provides an accounting of species in the NWT, but also assesses their status based on research studies, traditional knowledge and expert opinion. The Infobase was last updated in 2006 (WGGSNS 2006) and is a valuable resource for identifying changes in the status of individual species or changes to their environment (e.g., loss of habitat, increased hunting) which could lead to changes in their abundance or distribution.

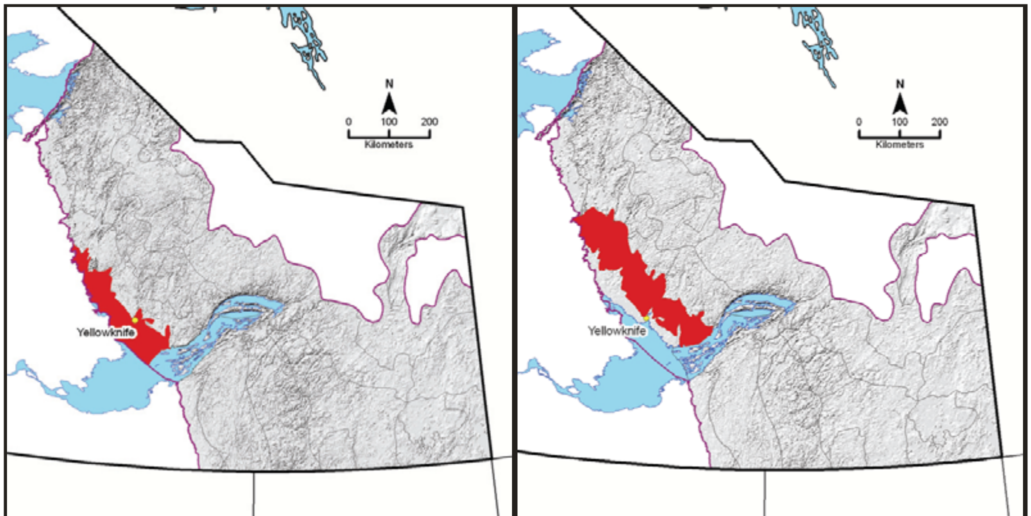
The Infobase database presently lists a total of 50 mammals, 166 bird species, 622 plant species and over 300 lichen species in the Taiga Shield ecoregion, although some are not found in the Great Slave region. Two amphibian species, the northern leopard frog and the wood frog, are also present. Although some of the species live in areas distant from Yellowknife, the large, diverse number of species, particularly of plants and birds, indicate that the lands and waters within the RSA are productive and support a diverse biological community.

7.5.3 Local Study Area

The generic LSA described in Section 3.4.1 has been used in the assessment of the Terrestrial Environment. The NWT's Ecosystem Classification Group (2008) has subdivided the Level I ecoregion into 25 Level IV ecoregions which more clearly define wildlife habitat and plant communities, such as within the North Slave region. The description of these regions surrounding Giant Mine aids in characterizing plant and animal species that may exist within the SSA. This information was also used in the human health and ecological risk assessments (Section 8.9) that estimated the risk to humans and other VCs on the mine site (SENES 2006).

Yellowknife and the area around Giant Mine lie on the border of two Level IV ecoregions termed the Great Slave Upland and Great Slave Lowland (Figure 7.5.1). These ecoregions have largely discontinuous permafrost and the forests consist primarily of jack pine and black spruce stands on nutrient-poor soils. The physical topography consists predominantly of exposed bedrock with discontinuous till and thin soils over bedrock. Mixed stands of jack pine, aspen, white spruce and birch are also common forest types within the region. Wetlands are a dominant feature.

Figure 7.5.1 Great Slave Lowland and Upland Level IV Ecoregions



Great Slave Lowland Level IV Ecoregion	Great Slave Upland Level IV Ecoregion
Total Area: 11,040 km^2(13% of the Taiga Shield High Boreal ecoregion)	Total Area: 18,609 km^2(22% of the Taiga Shield High Boreal ecoregion)

Source: Ecosystem Classification Group 2008

An inventory of bird species present in the Yellowknife area during winter is available from the Audobon Society's Christmas Bird Count. A list of the ten most abundant species in the Yellowknife area between 1998 and 2008 is presented in Table 7.5.1. The most common species are the common raven, the house sparrow and the willow ptarmigan. Other species reported during that period are the northern goshawk, black-capped chickadee, evening grosbeak, pine grosbeak and spruce grouse. These species are expected to remain in the Great Slave region throughout the year and may be found on the Giant Mine Lease area. Based on this survey, the most common game bird in the Yellowknife area throughout the year is the willow ptarmigan. The species is also part of traditional diets.

The Canadian Wildlife Service and U.S. Geological Survey (USGS 2009) conduct the North American Breeding Bird Survey (http://www.pwrc.usgs.gov/BBS/) which records breeding bird species observed along set trails during the breeding season every year. The survey has been conducted on Highway 4 (the Ingraham Trail) near Yellowknife since 1988, with roughly 45 to 50 breeding bird species observed each year. The number of individual birds reached a maximum of 743 birds in 1998, but usually numbers range from 400 to 500 birds. A list of the species observed near Yellowknife since the inception of the survey in 1988 is presented in Table 7.5.2.

Table 7.5.1 The Ten Most Abundant Bird Species Observed Around Yellowknife During the Christmas Bird Count Between 1998 and 2008

Species	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Black-billed magpie	5	10	11	9	7	2	25	26	13	9	22
Bohemian waxwing			1		8	63		19		17	8
Boreal chickadee	63	4	15		8	10	21	21	13	9	11
Common raven	1106	1336	1011	1161	700	1951	1352	1860	1218	1377	1523
Common redpoll	159		24	8	68	6	16	2	23	1	46
Gray jay	26	14	39	2	15	18	28	12	18	23	22
Hoary redpoll	21		10	1	1		1	3	3	130	73
House sparrow	195	294	244	182	281	426	268	368	201	207	280
Redpoll sp.	335	26	69	30	327	9	184	25	16	115	265
Sharp-tailed grouse	25	9	1	1							1
White-winged crossbill	80	5			60			4	13		4
Willow ptarmigan	476	171	200	99	74	67	159	158	44	414	375

Source: Audobon Society (2009).

Table 7.5.2 Bird Species Observed Near Yellowknife During the North American Breeding Bird Survey from 1988 to 2008 (USGS 2009)

Common Name	Common Name	Common Name
Alder Flycatcher	Dark-eyed Junco	Red Crossbill
American Crow	Downy Woodpecker	Red-eyed Vireo
American Kestrel	Eastern Phoebe	Redhead
American Robin	Fox Sparrow	Red-necked Grebe
American Wigeon	Gray Jay	Red-throated Loon
Arctic Tern	Great Horned Owl	Red-winged Blackbird
Bald Eagle	Green-winged Teal	Ring-billed Gull
Barn Swallow	Hairy Woodpecker	Ring-necked Duck
Belted Kingfisher	Hermit Thrush	Ruby-crowned Kinglet
Black-and-white Warbler	Herring Gull	**Rusty Blackbird****
Blackpoll Warbler	Horned Grebe	Sandhill Crane
Blue-headed Vireo	Killdeer	Semipalmated Plover
Bohemian Waxwing	Least Flycatcher	Sora
Bonaparte's Gull	Lesser Scaup	Spotted Sandpiper
Boreal Chickadee	Lesser Yellowlegs	Surf Scoter
Boreal Owl	Lincoln's Sparrow	Swainson's Thrush
Bufflehead	Long-tailed Duck	Swamp Sparrow
Canada Goose	Mallard	Tennessee Warbler
Canvasback	Merlin	Tree Swallow
Chipping Sparrow	Mew Gull	Western Grebe
Clay-colored Sparrow	Northern Flicker	Western Tanager
Cliff Swallow	Northern Pintail	White-crowned Sparrow
Common Goldeneye	Northern Shoveler	White-throated Sparrow
Common Loon	Northern Shrike	White-winged Crossbill
Common Merganser	Northern Waterthrush	White-winged Scoter
Common Nighthawk*	**Olive-sided Flycatcher***	Wilson's Snipe
Common Raven	Orange-crowned Warbler	Wilson's Warbler
Common Redpoll	Pacific Loon	Yellow Warbler
Common Tern	Palm Warbler	Yellow-rumped Warbler

*** Classified as "At risk" by the WGGSNS 2006.**
**** Classified as "May be at risk" by the WGGNS 2006.**
Source: USGS 2009.

The Great Slave Lowland Level IV ecoregion includes the North Arm of Great Slave Lake which provides valuable staging and nesting areas for migrating waterfowl, shorebirds and other groups of migrating birds. One key feature of the North Arm, and Yellowknife Bay, is the early thaw of the surface ice in the spring, thus allowing large congregations of migrating waterfowl. These congregations also include those species that move inland to nest in smaller lakes and wetlands after they have thawed in late spring and early summer.

Bird Studies Canada (2009; http://www.ibacanada.com) has listed the North Arm of Great Slave Lake as an Important Bird Area (IBA) because the large numbers of migrating waterfowl in the spring represent a sizeable fraction of the individual species either globally, continentally or nationally. This area is particularly important in years in which ice breakup is late and migrating species become concentrated in the open water. In these late thaw years, major congregations of Canada geese, scaup, northern pintail, tundra swans and surf scoters are usually present. A survey of migrating waterfowl on the Giant Mine site (Cygnus Environmental 2004) suggests that the numbers of waterfowl on the site correspond to the large numbers of staging waterfowl in the North Arm and Yellowknife Bay (see Section 7.5.3.4).

Collectively, the studies described above emphasize the importance of places like the North Arm, Yellowknife Bay and inland lakes for staging of migrating waterfowl in the spring and nesting sites for resident waterfowl.

7.5.3.1 Sensitive Species Designations

Species that may require special consideration due to their ecological characteristics (i.e., small numbers, slow reproductive rate, restricted distribution) or known threats to their habitat have been identified by the Ecosystem Classification Group. The number of plant, wildlife and bird species in the respective categories is listed in Table 7.5.3. The wolverine and grizzly bear are considered to be "sensitive" because of a very slow reproductive rate and large home ranges needed to maintain their populations. Furbearing species in the North Slave region include the least weasel, ermine and muskrat, all of which are considered to be "secure". Birds that are "At Risk" are the common nighthawk and olive-sided flycatcher while the harlequin duck, yellow rail, rusty blackbird and American white pelican are classified as "May Be At Risk".[24]

Table 7.5.3 Summary of the Numbers of Species within each Conservation Classification for the Taiga Shield Level I Ecoregion

Group	At Risk	May Be At Risk	Sensitive	Secure	Status Undetermined or Not Assessed
Mammals	1	0	6	38	5
Birds	2	4	27	115	14
Plants	0	30	61	452	68
Lichens	0	0	0	204	98

Source: WGGSNS 2006.

[24] As noted by their absence in Table 7.5.2, harlequin duck, yellow rail and the American white pelican have not been observed in the LSA.

Some of the species found in the North Slave region that have been assessed to require enhanced protection also have protection through federal legislation as a result of Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assessments and placement on the federal *Species At Risk Act* (SARA) listing, as presented in Table 7.5.4. The summary table is based on a compilation assembled by the GNWT Department of Environment and Natural Resources (from: http://www.enr.gov.nt.ca/_live/pages/wpPages/Species_at_Risk.aspx) with modifications to include only those species with ranges within the North Slave and Tlicho regions of the NWT. These regions are considered to be the most representative of the potential for sensitive species to exist within the LSA.

The assessment of plants under the NWT General Status Ranking program (WGGSNS 2006) includes 120 plant species that are "At Risk" or "May Be At Risk", including 4 species that are found entirely or predominantly in the NWT. None of these plants have been assessed under COSEWIC or the SARA process.

7.5.4 Site Study Area

The generic SSA described in Section 3.4.1 has been used in the assessment of the existing Terrestrial Environment. A number of studies have been conducted in recent years within this area to characterize the plant and bird species found on and around the Giant Mine site. These studies, which provide information on species abundance and distribution on the site, as well as limited information about their health, are described in the following sections.

7.5.4.1 Plant Communities

An ecological survey of the Giant Mine site was conducted in 2003 (Jacques 2003). The study described the aquatic vegetation in the Baker Creek watershed, terrestrial vegetation on the Giant Mine lease area and the distribution of muskrats within Baker Creek. The terrestrial vegetation survey identified a number of vegetation communities, including three upland types, two riparian, two wetland and three disturbed types. The plant communities range from largely natural stands of tree species and wetlands to barren disturbed ground caused by mine activity. The major vegetation communities on the Giant Mine lease area are described as follows, and summarized in Table 7.5.5. Terrestrial plant species observed during the 2003 survey are listed in Table 7.5.6.

Table 7.5.4 Sensitive Species Designations within the North Slave and Tlicho Regions of the NWT

Species	NWT General Status Rank	COSEWIC Assessment	Federal *Species at Risk Act* list
Mammals			
Grizzly Bear (Northwestern population)	Sensitive	Special Concern	No status
Wolverine (Western population)	Sensitive	Special Concern	No status
Wood Bison	At Risk	Threatened	Threatened
Woodland Caribou (Boreal population)	Sensitive	Threatened	Threatened
Birds			
American White Pelican	May be at Risk	N/A	No status
Common Nighthawk	Secure	Threatened	Threatened
Harlequin Duck (Western population)	May be at Risk	N/A	Special Concern
Horned Grebe (Western population)	Secure	Special Concern	No status
Olive-sided Flycatcher	At Risk	Threatened	Threatened
Peregrine Falcon subspecies anatum	Sensitive	Threatened	Threatened
Rusty Blackbird	May be at Risk	Special Concern	Special Concern
Short-eared Owl	Sensitive	Special Concern	Schedule 3
Yellow Rail	May be at Risk	Special Concern	Special Concern
Fish			
Bull Trout	May be at Risk	N/A	No status
Inconnu (Coney, Upper Mackenzie R. and Great Slave Lake)	May be at Risk	N/A	No status
Shortjaw Cisco	At Risk	Threatened	Threatened
Plants			
120 species (4 with Global Conservation Concern)	May be at Risk	N/A	N/A

Legend: N/A- not assessed.
Source: GNWT Department of Environment and Natural Resources 2010

Table 7.5.5 Summary of Major Plant Communities Found on the Giant Mine Lease Area

Plant Community	Description	Dominant species
	Upland	
Mesic forest	Found on the deepest soils between rocky outcrops; retention of moisture gives diverse community	White spruce, paper birch, willow, Labrador tea, green alder, rushes, horsetail, goldenrod, glow moss.
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
Rock outcrop	Lack of soil; vegetation in crevices of exposed bedrock	Low shrubs, herbs, mosses and lichens, bearberry, juniper and grasses
	Wetlands	
Cattail wetland	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	
Riparian shrub	Seasonally flooded banks of Baker Creek	Willow, bog birch, sweet gale, prickly rose, shrubby cinquefoil, horsetail, raspberry, scouring rush, Canada blue-joint
	Disturbed	
Disturbed meadow	Ecologically similar to mesic forest community; may be mesic forest that has been logged.	Hair grass, dwarf scouring rush, common horsetail, goldenrod, 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	

Source: Jacques 2003.

Table 7.5.6 Summary of Terrestrial Plant Species Found on the Giant Mine Lease Area during the 2003 Site Survey

Common Name	Scientific Name	Common Name	Scientific Name
Alpine bearberry	*Arctostaphylos rubra*	Mountain timothy	*Phleum commutatum*
Alsike clover	*Trifolium hybridum*	N.bastard toadflax	*Geocaulon lividum*
Aster	*Aster sp.*	Northern black currant	*Ribes hudsonianum*
Awned wheat grass	*Agropyron unilateral*	Northern grass	*Parnassia palustris*
Bog bilberry	*Vaccinium uliginosum*	One-sided wintergreen	*Orthilia secunda*
Bog birch	*Betula glandulosa*	Prickly rose	*Rosa acicularis*
Bog cranberry	*Vaccinium viti-idaea*	Purple reedgrass	*Calamagrostis purpurascens*
Canada buffalo berry	*Shepherdia canadensis*	Red-osier dogwood	*Cornus stolonifera*
Cattail	*Typha latifolia*	Reindeer lichen	*Cladina spp.*
Cladonia	*Cladonia spp*	Rock moss	*Rhacomitrium spp.*
Cloudberry	*Rubus chamaemorus*	Rough hair grass	*Agrostis scabra*
Common bearberry	*Arctostaphylos uva-ursi*	Saxifrage	*Saxifraga sp.*
Common dandelion	*Taraxacum officinale*	Sedge	*Carex spp.*
Common horsetail	*Equisetum arvense*	Sheep sorrel	*Rumex acetosella*
Common juniper	*Juniperus communis*	Shrubby cinquefoil	*Potentilla fruticosa*
Creeping juniper	*Juniperus horizontalis*	Slender wheat grass	*Agropyron trachycaulon*
Crowberry	*Empetrum nigrum*	Small yellow pond lily	*Nuphar variegatum*
Dicranum	*Dicranum sp.*	Sweet gale	*Myrica gale*
Dwarf raspberry	*Rubus arcticus ssp. acaulis*	Tall cotton grass	*Eriophorum angustifolium*
Dwarf scouring-rush	*Equisetum scirpoides*	Three-toothed saxifrage	*Saxifraga tricuspidata*
Fireweed	*Epilobium angustifolium*	Trembling aspen	*Populus tremuloides*
Foxtail barley	*Hordeum jubatum*	Tufted moss	*Aulacomnium palustre*
Goldenrod	*Solidago spp.*	Twinflower	*Linnaea borealis*
Green alder	*Alnus crispa*	Water arum	*Calla palustris*
Hair-cap moss	*Polytrichum sp.*	Water moss	*Calliergon sp.*
Jack pine	*Pinus banksiana*	Water sedge	*Carex aquatilis*
Labrador tea	*Ledum groenlandicum*	White birch	*Betula papyrifera*
Lamb's-quarters	*Chenopodium album*	White spruce	*Picea glauca*
Larch	*Larix laricina*	Wild red raspberry	*Rubus idaeus*
Marsh reedgrass	*Calamagrostis canadensis*	Willow	*Salix spp.*
Marsh willow herb	*Epilobium palustre*	Wintergreen	*Pyrola sp.*
Mosses	*Mosses*	Yarrow	*Achillea millefolium*
Mountain goldenrod	*Solidago spathulata*		

Source: Jacques 2003.

Upland Vegetation Communities

Mesic Forest - The mesic forest community is found on the deepest soils between the rock outcrops within the study area. Retention of some moisture during the growing season, as well as a relative abundance of nutrients, has allowed for higher species diversity and plant vigour in this community as compared to the scrub forest and rock outcrop communities. This community comprises mature white spruce (18% cover) and paper birch (3% cover) with a shrub under-story dominated by willow (20% cover) and Labrador tea (14% cover), with a sub-dominance of green alder (3% cover). Common herbaceous species include dwarf scouring rush (10% cover) and trace amounts of common horsetail and mountain goldenrod. The moss and bryophyte layer is usually dominated by glow moss (25% cover) and to a lesser extent by hair-cap mosses (2% cover).

Scrub Forest - The scrub forest community occupies the shallow soils between the mesic forest and the rock outcrop communities. The shallow soils result in less moisture and nutrient retention than the soils of the mesic forest community. As a result, the community structure is lower in diversity and vigour than the mesic forest community. The tree layer is typically poorly developed with a total cover ranging from 5 to 10%. Paper birch (3% cover) forms the dominant cover with lesser amounts of white spruce. The shrub layer is typically dominated by common juniper (4% cover) with minor amounts of prickly rose, Labrador tea and green alder. The dominant herb is bearberry, often covering up to 20% of the area. Northern bastard toadflax will occasionally co-dominate in this community but averages between 1 and 2% cover in general.

Rock Outcrop - The rock outcrop community is sparse in terms of ground cover and density. The vegetation in this community exists within the crevices of the exposed bedrock. The lack of moisture and nutrients has restricted this community to one of low shrubs, herbs, mosses and lichens with rare occurrences of tree species. The vegetation within this community typically covers a maximum of 10% of the area with the dominant species varying from site to site. Dominant species include bearberry, common juniper and various grasses.

Wetland Vegetation Communities

Cattail Wetland - The cattail wetland community is dominated by cattail with minor occurrences of various sedge species. This community occurs along the shorelines of the larger lakes and surrounding small water-filled depressions within the logged meadow community. These latter sites may be the result of the possible change in hydrology arising from historical logging.

Wetland Sedge - The wetland sedge communities are found in small isolated depressions in the rock outcrops, within the low areas of the meadow communities and along the shoreline of the larger lakes within the study area. The diversity of this community is low and is dominated by water sedge with cover values averaging 75%. The only other common but less dominant species was common horsetail with a cover value averaging 7%. Trace amounts of tall cotton-grass, foxtail barley and tufted moss were also observed.

Riparian Vegetation Communities

Riparian Shrub - The riparian shrub community occurs within the seasonally flooded banks of Baker Creek and is largely restricted to the northern end of Baker Creek upstream from most of the mine activities. The shrub cover in this community approaches complete cover (100%) and is co-dominated by willow and bog birch with minor amounts of sweet gale and trace amounts of prickly rose and shrubby cinquefoil. When present, the herb understory is inhabited by trace amounts of common horsetail, dwarf raspberry, dwarf scouring-rush and Canada blue-joint.

Vegetation Communities in Disturbed Areas

Disturbed Meadow - The disturbed meadow community occupies a similar ecological position as the mesic forest community type (level areas with deeper soils). Historical logging had taken place in all of the meadows sampled; thus it is likely that the disturbed meadow community has resulted from historical logging of mesic forest communities. Species composition and percent cover varied widely on a micro scale (*e.g*., within 10 m) but on a macro scale (mapped polygons) the overall species composition was homogenous. The disturbed meadow community is diverse and is generally vegetated with rough hair grass (average cover of 8%), dwarf scouring rush (26% cover), common horsetail (6% cover) and trace amounts of goldenrod, slender wheatgrass, foxtail barley, and glow moss.

Disturbed Vegetated - Areas mapped as disturbed vegetated are those areas throughout the mine area that have been sparsely revegetated with pioneer species including foxtail barley, rough hair grass, yarrow, red clover, common dandelion, lamb’s quarters, common horsetail and dock. The variability of the species occurrence and cover precluded an estimation of percent cover.

Disturbed Un-vegetated - These areas have undergone severe disturbance where no obvious vegetation exists. Such areas include dry tailings ponds and open pits, roads and other mine infrastructure sites. Figure 7.5.2 presents an overview of areas disturbed by historic mining operations.

Figure 7.5.2 Site Vegetation Disturbed by Historic Mining Operations

A number of berry species were also observed on the Giant Mine site during the environmental survey. The dominant berry species was bearberry which comprised over 5% of the plant communities. Other major berry species include wild raspberry, buffalo berry, crowberry, bog blueberry, gooseberry and low-bush cranberry. The large number of berry species and dominance of bearberry throughout the site was considered in the human and ecological health assessment (Section 8.9) because the berries could be a source of nutrition and an attractant to the site for both humans and wildlife.

The 2003 environmental survey also examined the mine site for rare or threatened plant species. The presence of any sensitive species would be a consideration in the remediation of the site and the selection of VCs. The 2006 NWT Species Monitoring Database update identifies 30 vegetation species that "May Be At Risk" in the Taiga Shield and 61 species judged to be "Sensitive" (WGGSNS 2006). However, none of the species listed in the 2006 Infobase were found on the Giant Mine lease area during the survey.

In addition to disturbances during mining operations, the natural community of plants has been modified slightly during the revegetation of areas of the Giant Mine lease area. For example, as part of the plan to stabilize the soil and reduce erosion on the banks of Baker Creek, sections of the creek and adjacent floodplain were re-planted with native and non-native plants to improve the aesthetics of the area and to improve the local environment for fish and wildlife populations (Flat River Consulting 2007). This revegetation also serves to expand wildlife and waterfowl habitat on the site and may attract more nesting species.

Willow, white spruce, birch, juniper, alder and poplar were harvested from one area of the site and re-planted on the floodplain adjacent to Baker Creek. Cattail and sedges were also transplanted on the bank of Baker Creek. Natural and commercial seed mixes were planted on slopes. Non-sterile pig manure was applied over several areas which likely introduced some non-native plant species. Early evaluations of the planting indicated mixed success, with some species surviving but others dying shortly after planting due to dry conditions (Flat River Consulting 2007).

7.5.4.2 Arsenic Concentrations in Terrestrial Vegetation

Arsenic present in terrestrial vegetation is a pathway for effects to humans and other biota. Detailed summaries of arsenic concentrations in vegetation can be found in the Tier 2 Risk Assessment for the Project (SENES 2006). A summary of the vegetation arsenic measurements is presented in Table 7.5.7 for moss, lichen and mushrooms.

Table 7.5.7 Measured Arsenic Levels in Moss, Lichen and Mushrooms (µg/g (dw))

Terrestrial Vegetation	# of Samples	Minimum	Maximum	Geometric Mean	Average	Standard Deviation
Moss	7	490	1900	1018.8	1100	452
Lichen	9	6.4	2300	55.7	336.4	754
Mushroom	5	8.3	1010	70	295.6	434

Arsenic concentrations in berries were studied by Dabeka *et al.* (1998) and associated papers. Areas of interest included the City of Yellowknife, Giant Mine, Joliffe Island (south of Latham Island) and Dettah Road. Berries analyzed included: raspberry, gooseberry, cranberry, rose hip and blueberry. A summary of the data is presented in Table 7.5.8.

Table 7.5.8 Measured Arsenic Levels in Berries (µg/g (ww))

	Yellowknife	Giant Mine	Joliffe Island	Dettah Road	Overall
# of Samples	7	6	3	2	18
Arithmetic Mean	0.10	0.52	0.12	0.04	0.24
Standard Deviation	0.06	0.70	0.04	0.001	0.43
Geometric Mean	0.08	0.28	0.12	0.04	0.12
Geometric Std Dev	2.0	3.3	1.3	1.0	2.8
Minimum	0.02	0.05	0.08	0.04	0.02
Maximum	0.20	1.91	0.12	0.04	1.91

A review of information from a Medicinal Plants Study Report prepared with the Yellowknives Dene (Chan 2003) provided a summary of arsenic concentrations in teas obtained from various medicinal plants within the study area. Table 7.5.9 provides a summary of the arsenic concentrations in medicinal teas obtained from the Giant Mine site, as well as in the vicinity of the Dettah Community.

Table 7.5.9 Measured Arsenic Levels in Medicinal Teas (µg/L)

Location	Summary of Measured Data					
	# of Samples	Minimum	Maximum	Arithmetic Mean	Geo Mean	Geo Std. Dev.
Giant Mine	9	0.1	527.4	77.8	32.3	3.8
Dettah	29	0.05	170.4	29.6	14.5	3.3

The ecological and human health implications of the arsenic concentrations reported in Tables 7.5.7, 7.5.8 and 7.5.9 were evaluated by SENES (2006). The findings of that study are presented in Section 8.9 of the DAR.

7.5.4.3 Mammals

Mammals are of prime concern because of their roles in the biotic community, but also because they are hunted and form a portion of traditional diets. Risk estimates show that some species (e.g., muskrat) may be exposed to elevated levels of contaminants such as arsenic from ingestion of contaminated food and water (SENES 2006). Knowledge of the abundance and distribution of major species is necessary to estimate the present and long-term risks associated with the site. The following descriptions present information on mammals that are considered potential VCs for the Remediation Project.

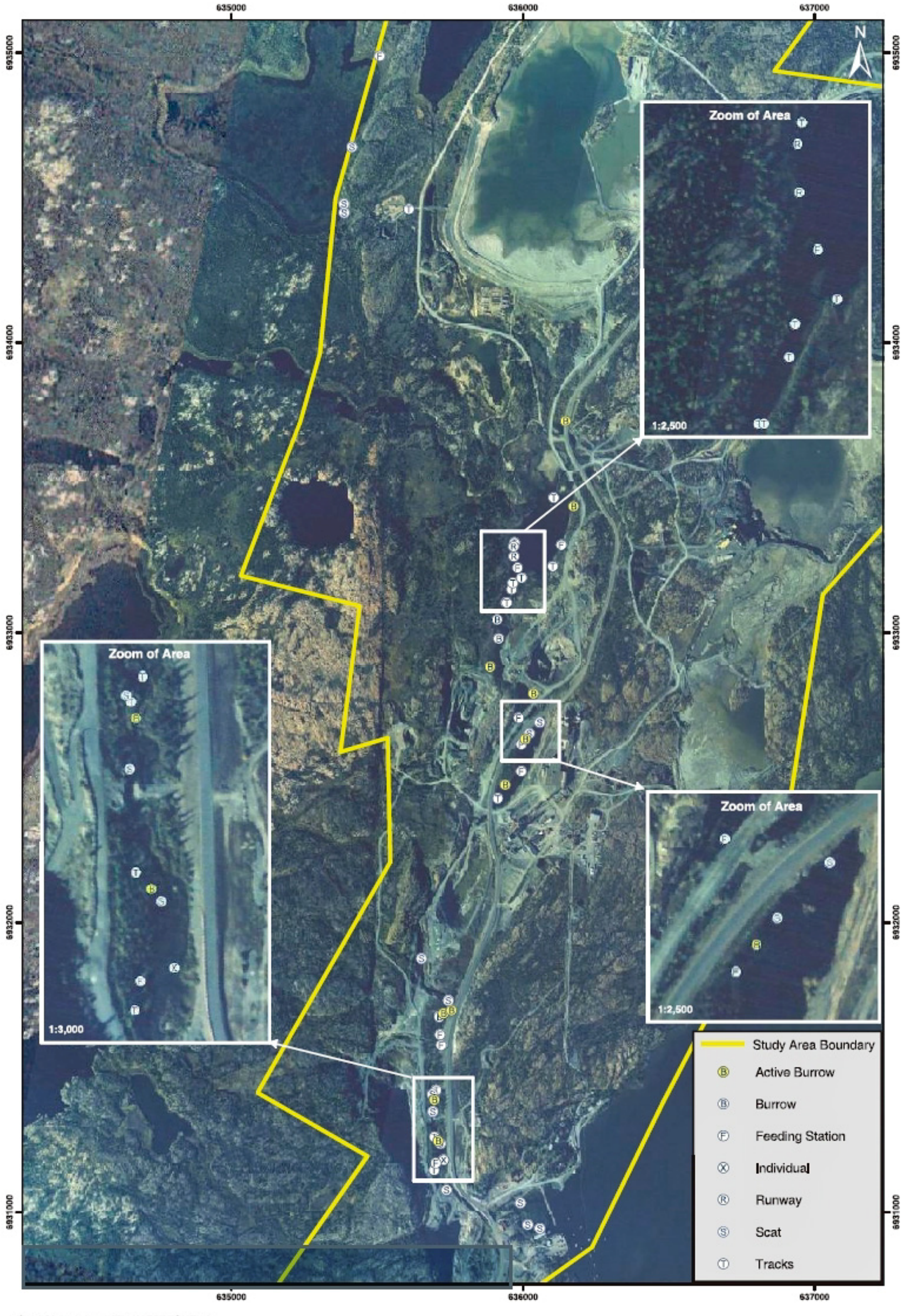
Muskrat

The numbers and distribution of muskrats have been of interest at Giant Mine because their semi-aquatic habitat in areas such as Baker Creek places them among the most highly exposed species to arsenic and other contaminants. In an effort to characterize the resident population, a survey of muskrats on the Giant Mine lease area was conducted in 2003 (Jacques 2003). The study determined the numbers and distribution of muskrats on the lease area (see Figure 7.5.3) and the types of food items in their diet, particularly aquatic vegetation. The abundance of muskrats at the end of August 2003, a time of low water levels, was determined from the numbers of occupied burrows.

Based on the 12 active burrows observed, it was estimated that an average of three burrow systems were present every kilometre of Baker Creek shoreline. The total number of muskrats was estimated to range between 66 and 197 animals. Muskrats are known to move when water levels are low or during winter. This study reported tracks between Baker Creek and Gar Lake (upstream of the mine site), suggesting that muskrats may move between the water bodies (Jacques 2003). Food items of the muskrat were primarily cattails, with some evidence of sedges, common horsetail and narrow-leaf bureed.

A follow-up study in 2004 trapped 13 muskrats from Baker Creek and Gar Lake to determine the levels of 26 metals and arsenic in the tissues of the muskrats (Golder 2004c). Table 7.5.10 provides a summary of the measured data. The analyses showed that the kidney had the highest concentration of arsenic and the muscle had the lowest. Other studies of animals generally support the finding that organs have higher concentrations of metals than does the muscle. In addition, arsenic concentrations in Baker Creek muskrats were higher than those from Gar Lake. However, there were no physical signs of gross abnormalities, pathologies or poor health in the Baker Creek muskrats.

Figure 7.5.3 Distribution of Muskrat Burrows and Tracks on the Giant Mine Site in 2003



Source: Jacques 2003

Table 7.5.10 Summary of Arsenic Levels in Baker Creek Muskrats (µg/g (ww))

	Measured Arsenic Concentrations (µg/g (ww))					
	Upstream – Gar Lake			Downstream – Baker Creek		
	Liver	Kidney	Muscle	Liver	Kidney	Muscle
Mean	0.66	0.7	0.24	1.39	2.64	0.51
Maximum	1.18	1.4	0.5	1.76	7.18	0.63

Black Bear

Black bear is one of the species identified by the Review Board as warranting inclusion as a VC. The species is present throughout the RSA and bear sightings within the LSA are not uncommon. Black bear are also expected to pass through the SSA, as confirmed by signs of bear activity observed during field studies (e.g., Cygnus Environmental 2004).

Due to their omnivorous nature, black bear consume a wide array of foods including berries, fish, terrestrial mammals and forage. Individual bears generally occupy a large home range and, as a result, Giant Mine would likely make up a small portion of the habitat for any black bears that might use the site.

With the exception of areas disturbed by urban or mining activities, almost all of the Regional, Local and Site Study Areas represent potential black bear habitat. In general, vegetated areas of the SSA, particularly during the berry season, would provide preferential feeding habitat. In addition to natural habitat, curiosity and the potential for food often results in bears being attracted to areas where human activity has occurred. Given the potential for euthanasia, traffic accidents, hunting and other adverse interactions, sites such as Giant Mine that are close to human centres are considered to be sub-standard bear habitat.

Taking into consideration the various factors described above, it has been determined that mapping of the preferred range and habitat usage for black bear would be of limited utility.

Moose

Based on input received during issue scoping, the Review Board also determined that moose should be included as a VC for the assessment. Moose habitat generally includes forested areas with a preference for bogs, swamps, streams and ponds. The large herbivore eats the leaves, twigs and buds of trees and aquatic vegetation during the summer. In the winter, moose browse on woody plants like the twigs and bark of willow, balsam, birch and aspen.

Similar to black bear, moose are present throughout much of the RSA. However, the species typically avoids human activity and, as a result, they are rarely sighted in the near vicinity of the LSA, despite the presence of otherwise acceptable habitat. Within the SSA, it is likely that low-lying forested areas within the Baker Creek drainage originally served as moose habitat prior to the development of the mine. While some potential moose habitat continues to exist within the SSA (e.g., near Gar Lake or riparian vegetation along Baker Creek), there are no records of moose being observed within the SSA over the last several decades.

Given the proximity of the SSA to human activities (e.g., Yellowknife and the Ingraham Trail), the former Giant Mine is considered to be sub-standard moose habitat. This applies to the site in its current condition and following the implementation of the Remediation Project. In this regard, neither the LSA nor the SSA are considered to be part of the preferred range in area and habitat for moose.

Caribou

In addition to being an important component of northern ecology, barren ground caribou play a critical role in Aboriginal diets and culture. Caribou move into the boreal forest, which dominates the RSA, in the late fall, feeding largely on arboreal and ground lichens. They remain south of the treeline until early spring when they migrate north to the barrens for the calving season.

While the lands surrounding north Yellowknife Bay are within the winter range for barren ground caribou, sightings in the near vicinity of Yellowknife (i.e., the LSA) are now uncommon. A variety of factors are likely contributing to the general absence of caribou, the most significant of which is assumed to be the high level of human activity. Although some potential habitat for caribou does exist within the SSA (e.g., small stands of undisturbed boreal forest), extensive human activity is expected to render the site undesirable to caribou. This is supported by the fact that caribou have not been observed within the SSA for many decades.

Even after remediation, ongoing human activities are likely to result in caribou making minimal use of the areas surrounding the former Giant Mine. On this basis, neither the LSA nor the SSA are considered to be part of the preferred range in area and habitat for caribou.

7.5.4.4 Birds

A survey of birds on the Giant Mine lease area was performed by Cygnus Environmental (2004). Observations were made at disturbed and control sites several times over a span of four months in 2004. The survey was conducted to quantify the number and species of migratory birds on the mine site, taking into consideration the potential for exposures to contaminants of concern (e.g., arsenic).

The disturbed sites were used by ducks primarily in May, when the highest numbers of lesser scaup, American widgeon and bufflehead were observed, probably staging in the open water prior to northward migration. These sites were only used by ducks during the spring migration and were not occupied during the nesting season. The Yellowknife River, which was used as a control site, had far larger numbers of birds during the same time period. A major factor in the higher use of the Yellowknife River site is the natural habitat of that area (i.e., in addition to site disturbances, natural factors also play a major role in determining species presence and abundance).

The survey showed that no duck broods were present on the disturbed sites during the summer, likely due to the lack of emergent vegetation along the shoreline. However, gulls and terns preferred disturbed sites over control sites. While no ducks were observed in Baker Creek Pond, shorebirds nested in the area. A breeding bird survey conducted as part of the study during the summer reported a total of 79 species present on site from mid-May to mid-October, most associated with the wetlands on the site, followed by the mesic forests.

Loons and grebes were observed in abundance at the control sites, but none were found on the disturbed sites. The study reported several examples of birds nesting on man-made structures, including osprey, kestrel and owl. The study showed that there is a diverse resident bird community within the SSA, using the disturbed sites and man-made structures as well as natural background areas.

None of the species identified by the WGGSNS (2006) as being "At risk" or "May be at risk" were observed within the SSA during the 2004 bird survey. However, the Review Board requested that peregrine falcon (*anatum* subspecies), which is classified as sensitive by WGGSNS (2006), be considered a VC in the assessment[25]. Although the species has not been observed within the SSA, the Remediation Project will occur within the natural range of the peregrine falcon.

Historically, the major cause of decline for peregrine falcon populations was the presence of agricultural pesticides, especially organochlorine compounds, in the environment. These compounds cause egg-shell thinning, egg breakage, reduced hatching success, reduced brood-size and reduced breeding success. Organochlorine contamination is no longer a major limiting factor for peregrines. Current threats include the small population size and the diminishing quality of habitat. Locally, peregrines may be affected by destruction of breeding sites and breeding areas, or by human intrusion near nest sites.

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[25] The *anatum* subspecies of peregrine falcon has also been classified as threatened under Schedule 1 of the federal *Species at Risk Act*.

7.5.5 Selection of Valued Components

VCs for the Terrestrial Environment presented in Table 7.5.11 were selected to assist in identifying potential effects of the Remediation Project on habitat and biota. A number of the VCs were selected based on specific requests from the Review Board (bear, moose and peregrine falcon) and general community concern (caribou).

The quality of terrestrial habitat is influenced by other environmental components such as:

- Surface Water Environment – As a pathway for contaminant exposures to terrestrial species (e.g., for the consumption of water and fish);
- Soil Quality – As a pathway for contaminant exposures, both through direct contact and the potential for uptake by vegetation which is used as a food source; and
- The Atmospheric Environment – Due to the effects of airborne contaminants and noise on terrestrial species.

VCs have previously been identified for each of these environmental components (refer to Tables 7.1.7, 7.2.2 and 7.3.5).

Table 7.5.11 VCs for the Terrestrial Environment

Sub-Component	VC	Rationale
Terrestrial Habitat	VCs for the Surface Water Environment (Table 7.1.7), Soil Quality (Table 7.2.2) and Atmospheric Environment (Table 7.3.5)	- Any adverse effects on the quality of surface water, sediments, soils, air quality and the noise environment will result in degradation of terrestrial habitat (e.g., through potential increases in contaminant exposures to terrestrial species)
	Quality of habitat (intrinsic value)	- Aboriginal groups and northerners value components of the environment for their intrinsic value
Terrestrial Biota: Mammals	Moose and Caribou	- Large mammals may be injured by physical risks such as waste rock piles and open pits - Valued by local residents; part of traditional diet and Aboriginal culture - Moose identified as VC during issue scoping by Review Board - Caribou are not anticipated to be present in the SSA. However, the species is currently the subject of heightened concern throughout the RSA
	Black Bear	- Bears are often attracted to sites where human activity is occurring, particularly if food is available. Interactions can lead to bears being destroyed - Consume a large variety of foods - Identified as VC during issue scoping by Review Board
	Wolf	- Carnivore that consumes species that can be directly exposed to contaminants (e.g., hare)
	Fur-bearing Mammals (e.g., hare, mink)	- Harvested for pelts - Some species harvested for food (e.g., hare)
Terrestrial Biota: Semi-aquatic Mammal	Muskrat	- One of the most highly exposed species to contaminants - Denning habitat could be affected or eliminated by remediation activities (particularly in the vicinity of Baker Creek)
Terrestrial Biota: Birds	Grouse/ptarmigan Osprey, kestrel, owl Mallard, merganser, scaup	- Representative species inhabiting the SSA - Nesting and feeding habitat could be affected or eliminated by remediation activities - Species are exposed to contamination via a range of food pathways (e.g., mallard to plankton; merganser to fish; scaup to benthic invertebrates)
	Peregrine falcon	- Not observed but has the potential to be present in the SSA - Potential exposures to contamination - Identified as VC during issue scoping by Review Board
Terrestrial Biota: Vegetation	Browse (e.g., alder and lichen)	- Food source for other VCs; protection of health of terrestrial animals - Species selected based on abundance, exposure to stressors from the Project, availability of data, and socio-economic value
	Berries Medicinal plants (e.g., Labrador tea)	- Food source for other VCs; protection of health of terrestrial animals (e.g., bears) - Valued by local residents; part of traditional diet and Aboriginal culture

7.6 Aboriginal Interests

This section provides information on Aboriginal Interests related to the Remediation Project. Additional information regarding Aboriginal interactions with the area prior to and during the development of Giant Mine is presented elsewhere in this document (e.g., descriptions of traditional land use prior to the development of the mine are provided in Section 4.1). The information presented is based largely on publicly available information and will be supplemented following completion of future Aboriginal engagement activities (as described in Chapter 13).

The discussion of existing Aboriginal Interests is separated into the following sub-components:

- Aboriginal Communities – A description of the communities and organizations that may have an interest in the Remediation Project, or may be affected by it;
- Traditional Land and Resource Use – A consideration of the land activities carried out by Aboriginal people that may be affected by the Remediation Project; and
- Aboriginal Heritage Resources – A description of cultural and archaeological resources on or in the near vicinity of the Giant Mine site.

For the purpose of the DAR, the term Aboriginal is understood to be those persons who are descendants of the original peoples of Canada and who are recognized in Section 35 (2) of the *Constitution Act* (1982) as Indians, Inuit and Métis.

7.6.1 Regional Study Area

The RSA for Aboriginal Interests includes those Aboriginal communities that have established an interest in the lands on and adjacent to Giant Mine by way of a historic or modern treaty, Traditional Land Use, or through a contemporary connection to the lands and resources (see Figure 7.6.1). As a result, the RSA has been defined based both on land occupancy and political or cultural affiliation boundaries. Within this context, the Aboriginal peoples within the RSA are the following:

- Members of the Akaitcho Dene First Nation;
- Tlicho citizens; and
- Métis of the North Slave Region.

Figure 7.6.1 Aboriginal Land Claim Areas

7.6.2 Local Study Area

The generic LSA for Aboriginal Interests includes the area bounded by the City of Yellowknife and the adjacent communities of Dettah and N'dilo. Within the Aboriginal population of the NWT, the residents of these communities are considered to have been the most affected by historic activities. Similarly, they are the Aboriginal groups that are the most likely to experience any effects caused by the Remediation Project.

7.6.3 Site Study Area

The SSA for the Aboriginal Communities component of the environment has been adopted without change from the generic SSA, as presented in Section 3.4.1.

7.6.4 Aboriginal Communities

7.6.4.1 Akaitcho Dene First Nations

The Akaitcho Dene First Nations (AKDFN) of the Northwest Territories consists of the Lutsel K'e First Nation (Lutsel K'e), the Deninu Kue First Nation (Deninu Kue/Fort Resolution), and the Yellowknives Dene First Nation (YKDFN from N'dilo and Dettah). The Akaitcho Dene are descendents of the T'satsaot'ine tribe (trans. copper people) and are named after the historic T'satsaot'ine leader Akeh-Cho (1786-1838). The Akaitcho Dene were signatories to Treaty 8, which was signed at Fort Resolution in 1900.

The LSA and SSA are situated within the Akaitcho Dene First Nations traditional territory. In July 2000, the Akaitcho Dene, as represented by the Treaty 8 Tribal Corporation, signed a framework agreement with the Governments of Canada and the Northwest Territories to work toward a lands, resources and self-government agreement. As part of the negotiations, an Order-in-Council was signed on November 1, 2007 to permit the withdrawal of lands from new development on an interim basis while negotiations continue. Included in the 62,000 km^2 of withdrawn lands are properties around the City of Yellowknife, some of which are close to the Giant Mine site.

Of the three First Nations, the Yellowknives Dene live in closest proximity to the Giant Mine site. Named after the Yellowknife (Weledeh) River, the Yellowknives Dene have two geographic communities, N'dilo and Dettah. However, the majority of registered members of the Yellowknives Dene reside in other communities, particularly the City of Yellowknife. As noted in Table 7.6.1, close to 3,000 registered members belong to the Akaitcho Dene First Nations.

Table 7.6.1 Persons of Akaitcho Dene First Nation Identity in the Regional Study Area

Akaitcho Dene First Nation Communities	Total Registered Members	Residing in home community	Residing outside of home community
Deninu K'ue First Nation	826	429	403
Lutsel K'e Dene First Nation	704	472	232
Yellowknives Dene First Nation	1,322	585	737

Source: INAC 2009.

7.6.4.2 Tlicho

There are four Tlicho communities: Behchokò, Gamètì, Wekweètì and Whatì. As noted in Table 7.6.2, as of July 2009 there were 3,855 registered Tlicho members.

Table 7.6.2 Tlicho People in the Regional Study Area

Tlicho Communities	Total Registered Members	Residing in home community	Residing outside of home community
Behchokò	2757	2020	737
Gamètì	321	284	37
Wekweètì	166	147	19
Whatì	611	570	41

Source: INAC 2009

The Tlicho people were signatories to Treaty 11, which was signed in the summer of 1921 at Behchokò (then Fort Rae). In 1994, the Tlicho commenced negotiations with the federal and territorial governments for a modern land claims agreement. In addition to land selection, the negotiations led to the establishment of self-government provisions to allow the Tlicho to form their own government, with powers to enact laws, share in federally-collected taxes, deliver social services, issue land use permits and appoint members to environmental co-management boards. The Tlicho Agreement came into force on August 4th, 2005.

The Tlicho have established an area of traditional land use, known as Mowhi Gogha De Niitlee, which were the lands described by Chief Monfwi during the signing of Treaty 11. Within this area, the Tlicho may exercise the rights as set out in the Agreement. The City of Yellowknife and the Giant Mine site fall within the Mowhi Gogha De Niitlee boundaries.

7.6.4.3 Métis

The Métis have had a long-standing presence in the NWT, in excess of 250 years. The Métis community principally became established in the NWT through the fur trade and were often involved in the operation of the trading posts, which became some of the NWT's first permanently settled communities.

In 2006, the North Slave region of the NWT, consisting of Yellowknife, N'dilo, Dettah and the Tlicho communities, had 1420 persons identified as being of Métis ancestry. The majority of these people, as demonstrated by Table 7.6.3, reside in the City of Yellowknife. Métis in the NWT are represented by various political organizations, mainly depending on where they live and their area of ancestry. For example, some individuals within this population may be associated with land claimant groups elsewhere in the territories who have relocated to the North Slave region.

The North Slave Métis Alliance (NSMA) is a political organization representing Métis in Yellowknife. The NSMA was formed in 1996 with the intention to negotiate and implement a land and resource agreement for the indigenous Métis. The organization has served to facilitate educational, economic, social, and cultural development. Canada is not engaged in land and resource negotiations with the NSMA.

The Northwest Territory Métis Nation (NWTMN) represents Métis indigenous to the South Slave region of the NWT, residing primarily in the communities of Fort Resolution, Fort Smith and Hay River. Canada is currently negotiating a land and resources agreement-in-principle with the NWTMN and the GNWT. The parties signed an Interim Measures Agreement (IMA) in 2002 which describes how government will consult with the NWTMN on activities in the IMA Area. Great Slave Lake lies within the boundaries of the NWT Métis Nation IMA area.

Table 7.6.3 Persons of Métis Identity in Regional Study Area

Community	Persons	% of total Community Population
Northwest Territories	**3,580**	**8.7**
Tlicho Communities		
Behchokò	30	1.6
Gamètì	-	-
Wekweètì	-	-
Whatì	-	-
Akaitcho Communities		
Dettah	10	4.0
Fort Resolution	125	25.8
Lutselk'e	10	3.1
Yellowknife	1,380	7.5

Source: Statistics Canada 2006 Census Data.

7.6.5 Traditional Land Use

The following descriptions provide an overview of the historic and contemporary Traditional Land Use exercised by Aboriginal communities on lands surrounding Giant Mine.

7.6.5.1 Aboriginal Spiritual Relationship to the Land

Close connection to the land is a key feature of cultural identity for Aboriginal people in the NWT. Until recent times, Aboriginal people have been fully dependant on the land for the provision of food, clothing and medicines. As a result of this intimate relationship with the surrounding environment, unique forms of social and economic systems, laws, language and spirituality evolved.

Because of the deep connection between culture and the land, it has been expressed, particularly by Aboriginal Elders, that the land is a repository of culture and a source of social well-being. This respect towards the land is paramount in the value systems of Aboriginal peoples. Notwithstanding reverence for the land, modernization has dramatically changed social patterns, as well as the relationship with the land for many Aboriginal people in the NWT. Such changes have occurred alongside the increasing economic importance of extractive economic activities, such as mining and oil and gas development. Along with these changes has been reduced participation in some Traditional Land Use practices (i.e. less time spent on the land), increased engagement in the wage-economy, and lifestyle changes which have had an effect on the spirituality of Aboriginal people. However, despite the profound societal changes, the cultural, spiritual and personal value of Traditional Land Use remains extremely strong in Aboriginal communities.

7.6.5.2 Practice of Traditional Activities in the Regional Study Area

The harvesting of renewable resources has been a way of life for Aboriginal communities in the north since time immemorial. In the NWT, such traditional activities consist of hunting, trapping, fishing and gathering plants from the land. Some forms of traditional harvesting, such as trapping, appear to have declined in most Aboriginal communities, in part due to lifestyle changes and alternate employment activities. However, pursuit of traditional activities still remains very important to Aboriginal communities.

Harvesting of local wildlife and fish provides a healthy alternative to store-purchased foods. Table 7.6.4 presents the number of households reporting that 75% or more of the fish and meat consumed is harvested within the NWT. Yellowknife, with its large non-Aboriginal population understandably had a much lower level of country food consumption than the other predominantly Aboriginal communities. It is important to note, however, that approximately one-third of the residents of Dettah continue to obtain the majority of their meat and fish from local sources.

Table 7.6.4 Percentage of Households Consuming Meat and Fish Harvested in the NWT

Community	% of Households*
NWT	**17.5**
Tłįchǫ communities	
Behchokò	38.0
Gamètì	50.0
Wekweètì	63.9
Whatì	46.0
Akaitcho Communities	
Dettah	31.3
Fort Resolution	43.8
Lutselk'e	68.0
Yellowknife	**5.1**

*Percentage of households reporting that most or all (75% or more) of the meat or fish consumed is harvested in the NWT. 3079 respondents were included in this survey.
Source: GNWT Bureau of Statistics 2008.

As noted in Table 7.6.5, hunting and fishing tend to be very popular activities for people within the RSA. Similarly, trapping is widely practiced in smaller communities but is of marginal importance for residents of Yellowknife.

Table 7.6.5 Hunting, Fishing and Trapping Rates

Community	Hunted and Fished (%) *	Trapped (%) *
NWT	**36.7**	**5.9**
Tłįchǫ communities		
Behchokò (Rae-Edzo)	39.0	14.3
Gamètì (Rae Lakes)	41.6	16.7
Wekweètì	64.2	19.3
Whatì	42.9	8.1
Akaitcho Communities		
Dettah	43.3	25.3
Fort Resolution	53.3	19.5
Lutselk'e	73.6	24.1
N'dilo	35.8	19.1
Yellowknife	**32.3**	**0.8**

*Refers to the percentage of people 15 years or older who hunted, fished or trapped in 2003.
Source: GNWT Bureau of Statistics 2008.

Although wild berries and plants do not play a major role in Aboriginal diets or the local economy, their collection represents an important activity for the maintenance of Aboriginal culture (as demonstrated in Table 7.6.6). Berries have traditionally been used in the preparation of dry meat, and there is considerable Aboriginal knowledge about the use of wild plants as traditional medicines.

Table 7.6.6 Berry and Plant Harvesting Rates

Region / Demographic	Gathered Berries (%)*	Gathered Plants (%)*
NWT	18.2	6.8
South Slave	24.6	8.4
Tłįchǫ	26.4	14.3
Yellowknife	13.0	2.4
Aboriginal	23.6	13.0
Non-Aboriginal	13.2	1.3

* Refers to the percentage of people 15 years or older. Source: GNWT Bureau of Statistics 2008.

7.6.5.3 Practice of Traditional Activities in the Local and Site Study Areas

Traditional Land Use within the LSA and SSA has been curtailed by both industrial development, as well as urbanization. Historically, the lands and waters around Giant Mine were used for harvesting by Aboriginal people and also served as temporary camp sites. Of particular importance, the mouth of the Yellowknife River was historically a prime fishing location. Prior to development of Giant Mine, the lands on and surrounding the site provided moose habitat, were used for berry picking and served as a source for firewood (Yellowknives Dene 2008).

Following industrial and urban development, many of these resources were eliminated from the area or were severely degraded. Due to human occupancy, large mammals such as moose and caribou are rarely found in the LSA. Lands formerly used for berry harvesting or trapping have been converted to residential or industrial uses. Large quantities of wood were consumed in the early years of mining, thereby affecting the current stock and quality of available timber. Concerns about environmental contamination originating from mining in the vicinity of Yellowknife have also contributed to the shifting of traditional activities elsewhere with the result that areas such as Wool Bay have replaced Yellowknife Bay as a harvesting location for fish (Yellowknives Dene 2005).

Beyond the physical changes that have impacted local harvesting resources, the local legal and policy framework has affected the exercise of traditional activities. For example, the discharge of firearms is restricted in the municipal boundaries of the City of Yellowknife and within 1.5 km of either side of Highway 4 (the Ingraham Trail). Trapping is also prohibited within the City of Yellowknife's boundary due to municipal by-laws.

Access within the Giant Mine lease area has been restricted to the public with the exception of the City of Yellowknife's lease area at the former town site. As such, harvesting activities are prohibited due to health and safety concerns associated with the industrial site.

7.6.6 Aboriginal Heritage Resources

Existing Aboriginal Heritage Resources are described below in the context of the LSA and SSA defined in Sections 7.6.2 and 7.6.3. The description of the LSA is based on previous studies conducted on the Aboriginal Heritage Resources present in the area. Information specific to the SSA was obtained from historic archives obtained from the Prince of Wales Northern Heritage Centre.

7.6.6.1 Aboriginal Heritage Resources in the Local and Site Study Areas

As noted above, the LSA is rich in Aboriginal history. Before the development of the gold mines and the City of Yellowknife, Aboriginal people had established fishing camps at the mouth of Yellowknife (Weledeh) River and nearby shoreline. One of these camp sites eventually became the permanent settlement of Dettah. The mosaic of historic activities, stories and legends in this area suggests that it belongs to a larger cultural landscape that extends along the north shore of Great Slave Lake. Notwithstanding the importance of Aboriginal heritage, no physical activities associated with the Remediation Project are anticipated to occur beyond the SSA. As a consequence, an examination of archaeological and Aboriginal Heritage Resources in the broader LSA was deemed unnecessary.

With regard to the SSA, much of the land within the Giant Mine lease area has been altered by the construction of roads, open pits, buildings, tailings ponds and other surface facilities. Given the long period of intensive industrial activity within the SSA, there is a high probability that significant Aboriginal Heritage Resources originally present on the site have been impacted or destroyed. However, some evidence of heritage resources has been identified. Specifically, a search of the Prince of Wales Northern Heritage Centre's Archaeological Sites Database revealed the presence of four prehistoric sites on the Giant Mine's lease lands. Three of those sites were characterized as lithic scatters which are surface deposits of cultural artefacts and debris, typically consisting of stone tools and chipped stone debris. They are the most common forms of prehistoric sites found in the NWT. The fourth site was a location near the Giant Mine parking lot where a single foiled stemmed projectile point was identified.

In addition to the prehistoric sites noted above, during consultations conducted during the spring of 2010, the Project Team was informed that Aboriginal graves are located within the SSA. Although the locations of the graves have yet to be determined, the Project Team commits to working with the YKDFN to identify and preserve any graves and additional Aboriginal Heritage Resources that may be present within the SSA.

7.6.7 Selection of Valued Components

Table 7.6.7 presents VCs that have been selected for Aboriginal Interests.

Table 7.6.7 VCs for Aboriginal Interests

Sub-Component	VC	Rationale
Aboriginal communities	Community well-being	- Large projects can result in adverse direct and indirect effects on Aboriginal communities and residents - Land, water and resources are an essential part of identity, culture and economic sustainability
Traditional Land Use	Traditional harvesting and subsistence	- Hunting, fishing and trapping are Traditional Land Uses which may be a source of food, medicines and economic benefit
Aboriginal Heritage Resources	Aboriginal heritage sites	- Important link to the past and source of cultural identity - Archaeological sites containing Aboriginal artefacts are relevant for understanding Aboriginal history and may have value for research or public education purposes

7.7 Additional Community Interests

Aspects of the baseline environment that are relevant to Aboriginal Interests were described in Section 7.6. Additional Community Interests are addressed in the current section and are broadly allocated to the following environmental sub-components:

- Land Use, Visual & Cultural Setting;
- Socio-Economic Conditions; and
- Transportation.

7.7.1 Land Use, Visual & Cultural Setting

This environmental sub-component addresses the following aspects:

- *Land Use:* Including existing uses of land within the LSA and SSA, focussing specifically on community and recreational land use. Land use policies and plans are also given consideration.
- *Visual & Cultural Setting*: The visual setting addresses the aesthetic qualities of the LSA and SSA such as landscapes, views and vistas. The cultural setting encompasses Euro-Canadian heritage resources, such as architecture or built environments, as well as cultural landscape features.

The study areas established in Section 3.4.1 have been adopted without change.

7.7.1.1 Existing Land Use

Key Features of Land Use in the Local Study Area

The lands within the LSA are used for a variety of recreational and industrial purposes by a number of groups, institutions and individuals that have established interests in the land. The LSA includes lands contained within the City of Yellowknife municipal boundaries, as well as Commissioner's Land administered by the GNWT as part of its Block Land Transfer. The lands within the City of Yellowknife's boundaries are subject to a number of By-Laws, Plans and relevant legislation including:

- City of Yellowknife General Plan;
- Zoning By-law;
- Integrated Parks, Trails and Open Space Study;
- Waterfront Management Plan; and
- Residential Growth Study.

Key Land Use features within the LSA are as follows:

Vee Lake - Vee Lake provides access to a popular series of lakes heading northwards from Highway 4 (the Ingraham Trail). The Vee Lake access road originates within the SSA and terminates at a parking lot and boat launch on the shore of the lake. Vee Lake provides an entry point for cabins located on neighbouring lakes; Walsh Lake has 19 land leases, Banting Lake has three and Ryan Lake has four leases. In addition to cabin owners, anglers frequently use the boat launch in the summer for fishing in Walsh Lake. During the winter and spring, Vee Lake and the adjacent lakes are also popular with cross-country ski enthusiasts, snowmobile operators and hunters.

The Vee Lake access road also provides access to the Ranney Hill/Marten Lake Trail, which is a hiking trail that passes through a variety of environments, including a pink granite outcrop that offers an impressive view of the surrounding landscape.

Yellowknife Ski Club – The Yellowknife Ski Club is a popular recreational organization that operates south of the Giant Mine site. The club's facilities include a ski lodge as well as 14 km of trails cut into the 42 ha property. The club's trails are intensively used in the winter and spring by approximately 500 club members. In the summer and fall, the trails continue to be used by hikers and mountain bikers. The ski club also owns and operates a small tent frame on Walsh Lake. The land occupied by the ski club is a parcel that was selected for withdrawal by the Akaitcho Dene First Nation as part of the land claims negotiations.

Yellowknife Solid Waste Management Facility - The City of Yellowknife's Solid Waste Management Facility is located on Highway 4, about 2 km north of the downtown core. It is a fenced facility that includes services for public waste drop off, recycling and hazardous waste disposal. There is also a quarry operation north of the landfill area; this quarry is planned to be converted into a landfill when expansion of the facility is required.

Yellowknife River Day Use Area **–** The Yellowknife River Day Use Area is a recreational facility owned and operated by the GNWT's Department of Industry, Tourism and Investment. The site is popular as a boat and canoe launch, as well as for picnicking. On the opposite side of Highway 4 is the Weledeh River Site, which is an outdoor facility used to hold public events.

Backbay Cemetery – The Back Bay Cemetery is a City of Yellowknife Heritage Site, consisting of 35 gravesites dating from 1936 to 1946. Many of the individuals buried in the cemetery were former mine workers, some of whom died in industrial accidents. The cemetery is located along the waterfront in Jackfish Draw, adjacent to Back Bay.

Key Features of Land Use in the Site Study Area

Within the SSA, the GNWT's Department of Municipal and Community Affairs (MACA) established Reserve R662T to allow INAC full occupancy and unrestricted surface access to the historic Giant Mine lease in order to remediate the site. With the exception of the City of Yellowknife's lease area at the Giant Mine Town Site and transportation on GNWT roads (as described below), land use within the SSA not authorized by INAC is prohibited.

The historic mining and ongoing care and maintenance activities associated with Giant Mine have been described in Chapter 4. In addition to those activities, other land uses occur within the SSA. Specifically, a small parcel of land was surrendered from the overall Giant Mine lease and was assigned to the City of Yellowknife as Lease 17889T. These lands include the Giant Mine Town Site and the area currently occupied by the Great Slave Cruising Club. The expiry date for this lease is September 30, 2030. Through the lease, the City assumes responsibility for future uses and maintenance of the lands. However, the City is not responsible for infrastructure and improvements related to historic mining operations which are located within the lease area. Development within the lease area is limited to recreation-type activities; such activities would be guided by the City's elected officials, subject to the approval of the GNWT (i.e., the landowner).

Key land use features within the SSA are as follows:

Giant Mine Town Site - The Giant Mine Town Site was established to house employees of the mine and their families. In recent years, following the mine's closure, the town site has seen limited activity. The NWT Mining Heritage Society has ownership of the old recreation hall, which is a building that the society intends to develop into a museum dedicated to the NWT's mining history. In addition to the Recreation Hall, the society also owns the A-Shaft Head

Frame, the A-Shaft Powerhouse and Hoist Room and the A-Shaft Commissary. These buildings are located on the MACA-INAC lease lands and not on the City of Yellowknife's lease lands. The society currently maintains an outdoor display of mining equipment on City leased land adjacent to the boat launch parking lot. Items from this collection have been acquired from sources across the NWT.

The other main land use at the Giant Mine Town Site is a boat launch facility that was constructed in 2001 by the City of Yellowknife to permit greater public access into Yellowknife Bay. The boat launch is accessed via a gravel road off of Highway 4 adjacent to Baker Creek.

Great Slave Cruising Club – The Great Slave Cruising Club has operated its facility just south of the Giant Mine Town Site on the City of Yellowknife's lease lands since 1990. A clubhouse located on the site is used for social functions and training courses in boater safety, navigation and first aid. Currently the club has approximately 50 members and about 20 to 25 boats moored. Several boats are also dry-docked on the club's grounds for repairs and storage. Increased use of the club's facilities is expected due to the recent closure of docking facilities in Yellowknife's old town (T. Boullard, personal communications, August, 2009).

7.7.1.2 Visual and Cultural Setting

Visual Character

The aesthetic character of the LSA and SSA varies according to location. The shoreline area from the City boundaries to beyond the Yellowknife River is generally a very attractive area which provides excellent views of Old Town, Back Bay, Latham Island and Yellowknife Bay. There are also portions of intact woodlands, such as at the Yellowknife Ski Club and near Vee Lake, which serve as aesthetically pleasing environments. The City has determined that the area possesses opportunities for waterfront development in the form of waterfront parks, viewpoints, trails, boat launches, historic preservation and enhanced recreational activities (Figure 6.1.2).

A feature of the visual character and natural heritage of the landscape is a spectacular sequence of rock outcrops to the east and south of the South Tailings Pond, extending to the tailings beach on the shore of Yellowknife Bay. These "acid washed" pillow lava formations are 2.7 billion years old and are well exposed due to the lack of lichen on the surface outcrops. The rock outcrops display numerous volcanic and sedimentary features that are popular among geologists. The City of Yellowknife has shown an interest in developing the outcrops as a UNESCO Geopark (Figure 6.1.2).

Decades of heavy industrial use have generally resulted in a degradation of the natural aesthetics of the SSA. The combination of open pits, large tailings ponds, gravel access roads and aging industrial buildings has negatively affected the natural visual character of the landscape.

Cultural and Heritage Values

The cultural value of the LSA and SSA is influenced by two main factors; the area's proximity to the City of Yellowknife, and the legacy of mining activities dating back to the 1930's. In terms of public enjoyment and recreation, the Yellowknife River, Vee Lake, Great Slave Cruising Club and the Yellowknife Ski Club are key cultural features that are used by thousands of Yellowknife residents, as well as visitors to the region.

Giant Mine itself has been identified as an important site of early Euro-Canadian settlement and mining heritage. Groups such as the NWT Mining Heritage Society have worked to ensure that the site is recognized for its part in the historic legacy of mining in the NWT. For example, of the many structures built during the exploration and mining phases of the mine, some of the remaining structures are considered by groups such as the NWT Mining Heritage Society to have cultural and heritage value. In addition, a report commissioned for the City of Yellowknife indicated that four remaining houses at the Town Site should receive heritage designation due to their historical significance in the development of the mine. The key findings of that report are presented in Section 6.11.4.

7.7.2 Socio-Economic Conditions

This section provides information on current social and economic conditions and trends in the RSA and LSA. The majority of the information presented in this section is derived from statistical reports compiled by the territorial and federal governments. Except where noted, these reports included:

- Summary of NWT Community Statistics - 2008. GNWT (2008c);
- 2009 NWT Socio-Economic Scan. GNWT (2009);
- Newstats – Bureau of Statistics, Aboriginal People - 2006 Census. GNWT (2008b);
- Rental Market Report - Yellowknife Highlights. Canadian Mortgage and Housing Corporation (CMHC 2009); and
- NWT Infrastructure Profiles. GNWT (2003).

7.7.2.1 Regional Study Area

Based on the relatively small population of the NWT, there is a potential that the Giant Mine Remediation Project will result in socio-economic effects that extend beyond the LSA (e.g., through employment and business opportunities). The North Slave Region (i.e., the RSA) is therefore relevant to the assessment of socio-economic conditions and effects that may be caused by the Remediation Project. This is consistent with past reviews of projects of a similar scale, where large RSAs were established to incorporate human resources and goods and service providers that are located beyond the local area in which a proposed development is located.

Population

The NWT's population grew from 38,724 in 1991 to 43,283 in 2008, an increase of almost 12%. As indicated by Figure 7.7.1, population growth has not been continuous during this period. Episodes of population contraction have occurred, particularly in the late 1990's, and to a lesser extent, in recent years as well.

Figure 7.7.1 Population and Percent Change in NWT Population

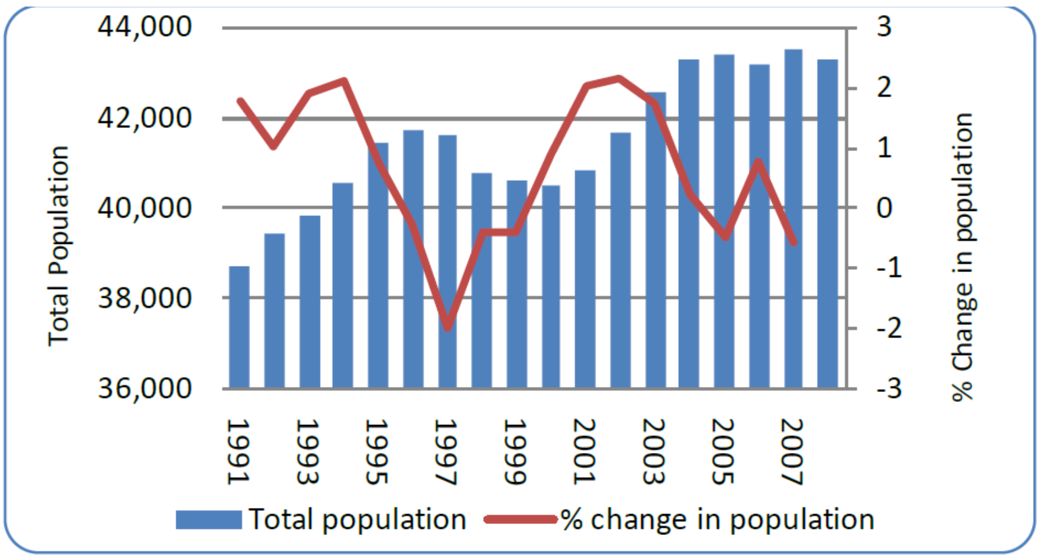
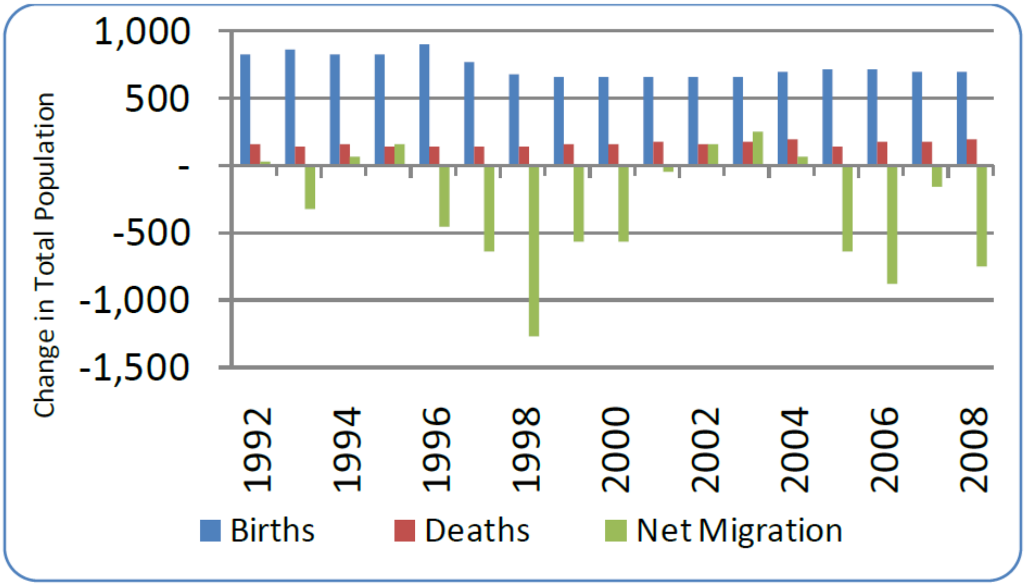


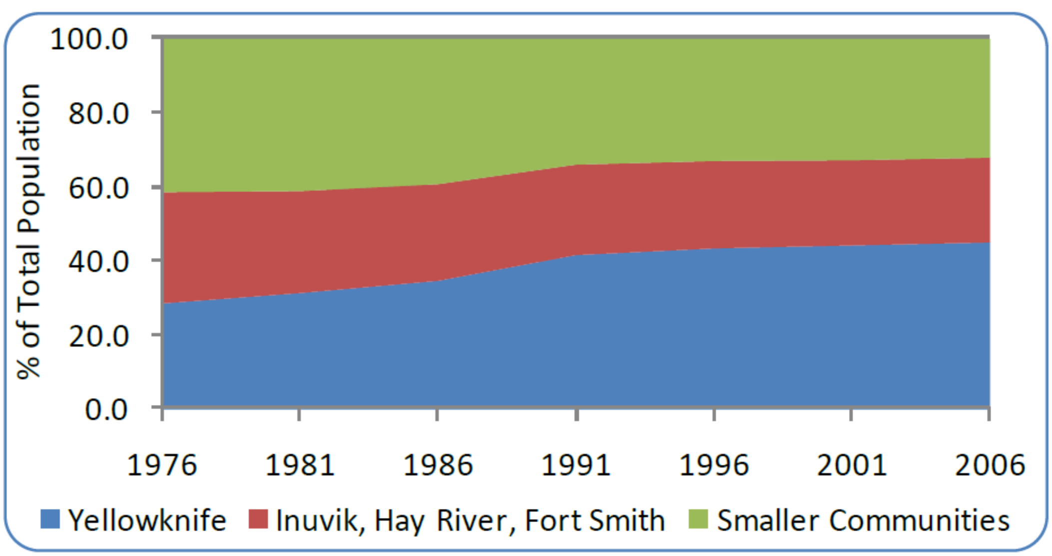
Figure 7.7.2 indicates that migration has had the greatest influence on the population of the NWT (as opposed to changes in the number of births and deaths). The period of 1996 to 2000 saw a decline in the population, linked in part to the shutdown of Yellowknife's gold mines. Since 2005, another sizeable wave of out migration has also occurred. In 2008, the NWT was the only territory or province in Canada to report a reduction in population. There are likely a number of factors influencing this trend, of which high living costs, absence of settlement programs for new immigrants, and a lack of adequate post-secondary education facilities have been cited. Despite the recent trends, population projections suggest that the NWT will grow, reaching a population of approximately 47,000 by 2017 and 50,300 by 2027.

Figure 7.7.2 Components of Population Change (1992 to 2008)



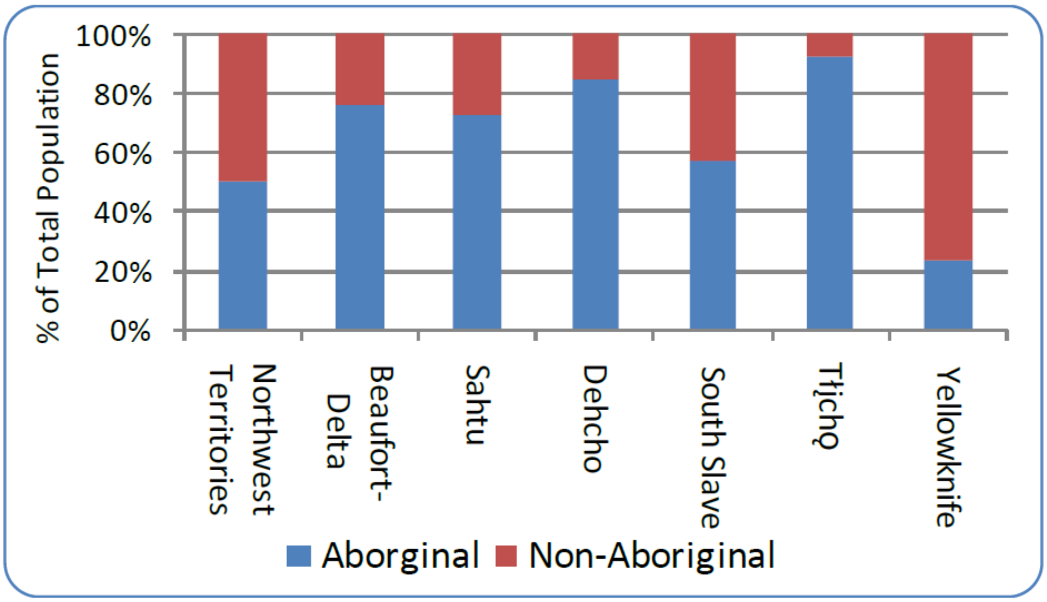
The NWT's population has steadily become more urbanized over the past three decades (Figure 7.7.3). Yellowknife, the largest community in the territory and its only city, comprised 28.6% of the NWT's population in 1976, and 45.1% of the population by 2006. Meanwhile, the NWT's medium-sized communities (Inuvik, Hay River, and Fort Smith) and smaller communities saw their proportion of the population decrease by 7.2% and 9.3%, respectively, during the same period.

Figure 7.7.3 Population Share by Community Size



The NWT's population is almost evenly divided between Aboriginal (50.7%) and non-Aboriginal (49.2%) (Figure 7.7.4). The non-Aboriginal population is mostly concentrated in the City of Yellowknife and in the larger communities of Hay River, Inuvik and Fort Smith. The Aboriginal population is more evenly distributed throughout the territory, forming the majority of inhabitants in the smaller communities. In 2006, of the 20,635 Aboriginal residents in the NWT, 12,640 were identified as North American Indian, 3,585 as Métis and 4,165 as Inuit. Of the group who are of North American Indian ancestry, the majority are descendents of the Dene (Northern Athapaskan) linguistic group.

Figure 7.7.4 Ethnicity of NWT Residents by Region in 2007



Economy of the NWT

The NWT has seen both a diversification of its economy, and an overall increase in economic activity and value. As shown in Figure 7.7.5, there was a 43% increase in Gross Domestic Product (GDP) between 1999 and 2008. The NWT's contribution to Canada's overall GDP is very small, representing approximately 0.30% of the national total. However, it is noteworthy that the territory represents roughly 0.13% of Canada's population.

Resource extraction industries, particularly mining and oil and gas, are the largest contributor to GDP at 34% (Figure 7.7.6). The public sector, through government, health services and education services, constitutes the next largest portion of the economy.

Figure 7.7.5 NWT Gross Domestic Product ($ million)

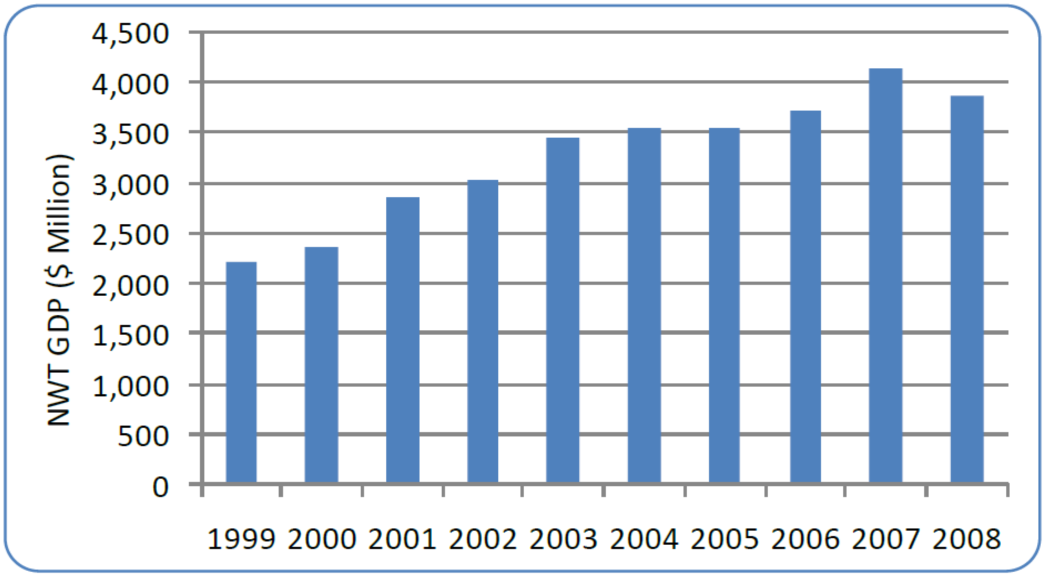
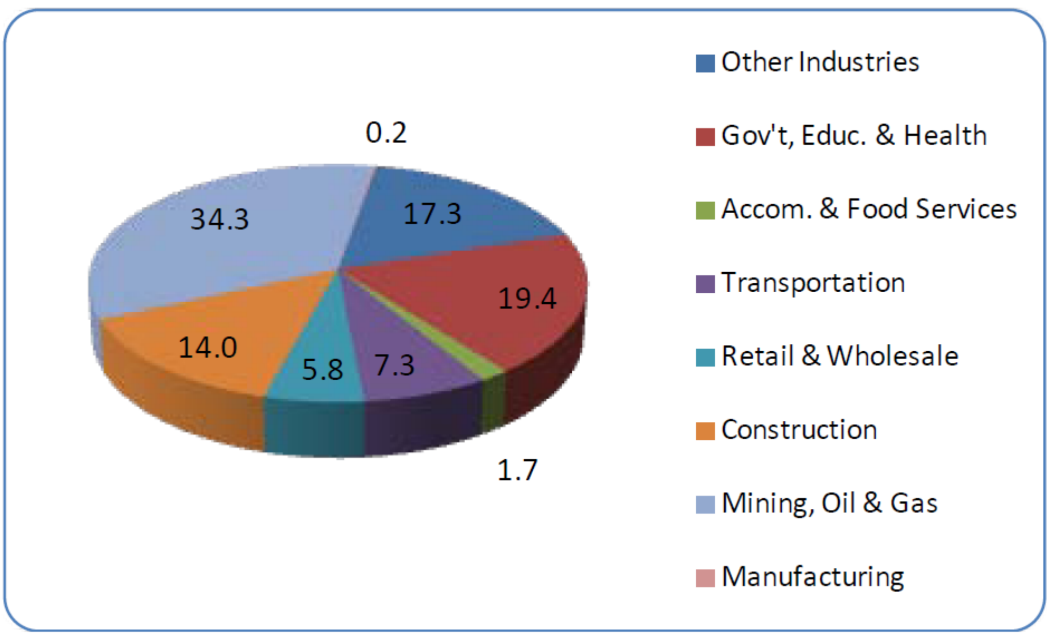


Figure 7.7.6 Percentage of Gross Domestic Product by Sector



Since 1999, the average individual income in the NWT has trended upwards, to a level of $48,396 as reported in 2006 (Figure 7.7.7). Average incomes in the NWT remain substantially higher than the Canadian average ($36,776 in 2006); however, when the average income by community-type is considered, the substantial gap between the NWT's large and small communities becomes apparent. The average income in a small NWT community is less than the Canadian average.

The difference in average incomes among community types is partially explained by the greater levels and type of employment available in Yellowknife and the large communities. The larger communities tend to offer more diverse employment opportunities, better pay and less seasonal employment. In smaller communities, the local economies tend to be more dependent on the public sector for employment. At a territorial level, the public sector employs the greatest number of people, over three times the number of people involved in resource extraction activities despite the fact that it constitutes a smaller proportion of the territorial GDP than that of the resource sector (Figure 7.7.8).

There has been a general increase in employment throughout the NWT since 1986, as measured by employment rate (i.e., the percentage of the population 15 years or older with jobs). Although growth in employment has occurred in small and medium-sized communities, Yellowknife's 81.8% employment rate is much higher than the 58.1% achieved in the rest of the NWT's communities.

Figure 7.7.7 Average Income in the NWT by Community Type

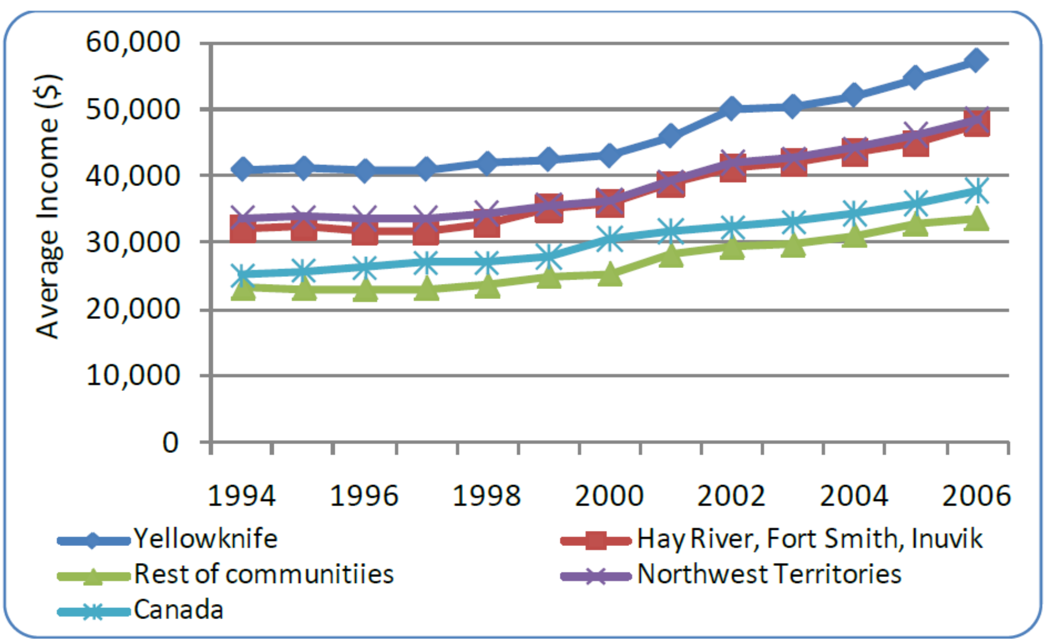
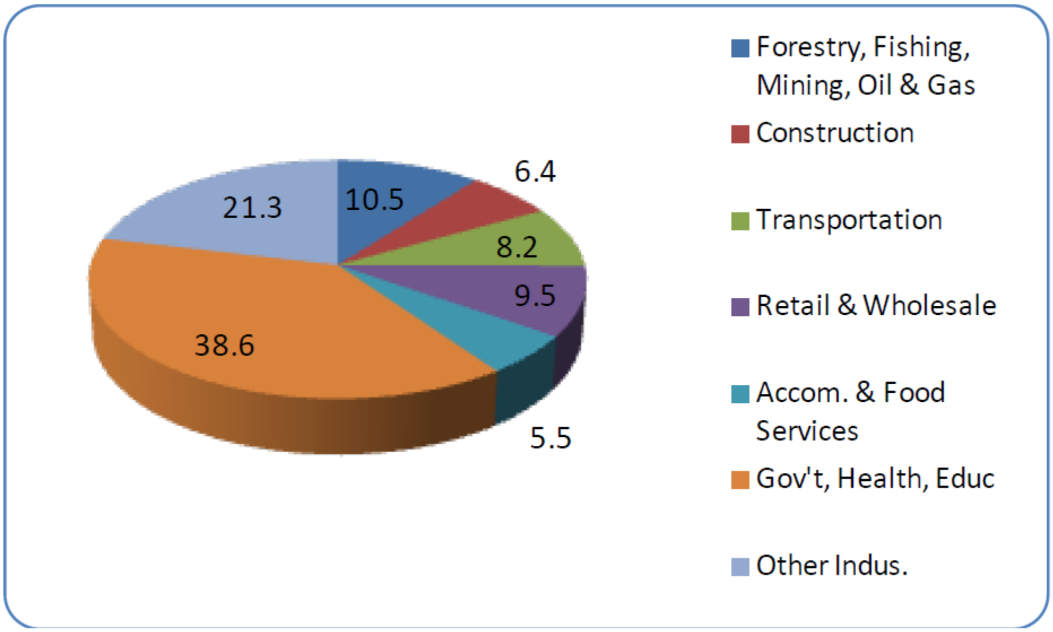
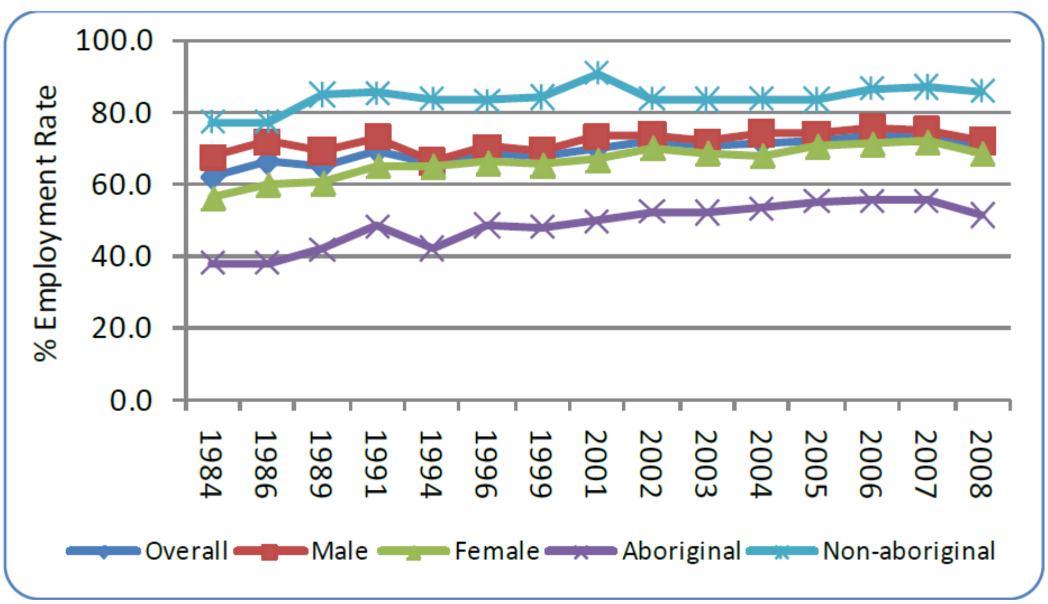


Figure 7.7.8 Percentage Share of Total Employment by Sector in the NWT



In addition to location, a variety of social factors influence employment rates in the NWT. For example, in 2008, the employment rates of Aboriginal and non-Aboriginal persons (Figure 7.7.9) were 51.4% and 85.7%, respectively. Although the Aboriginal employment rate has climbed considerably since 1984, there remains much to be achieved in this regard. An area where more progress has been made is the employment rate gap between men and women, which has narrowed to a little more than 3% in 2008 from a difference of 11.5% in 1984.

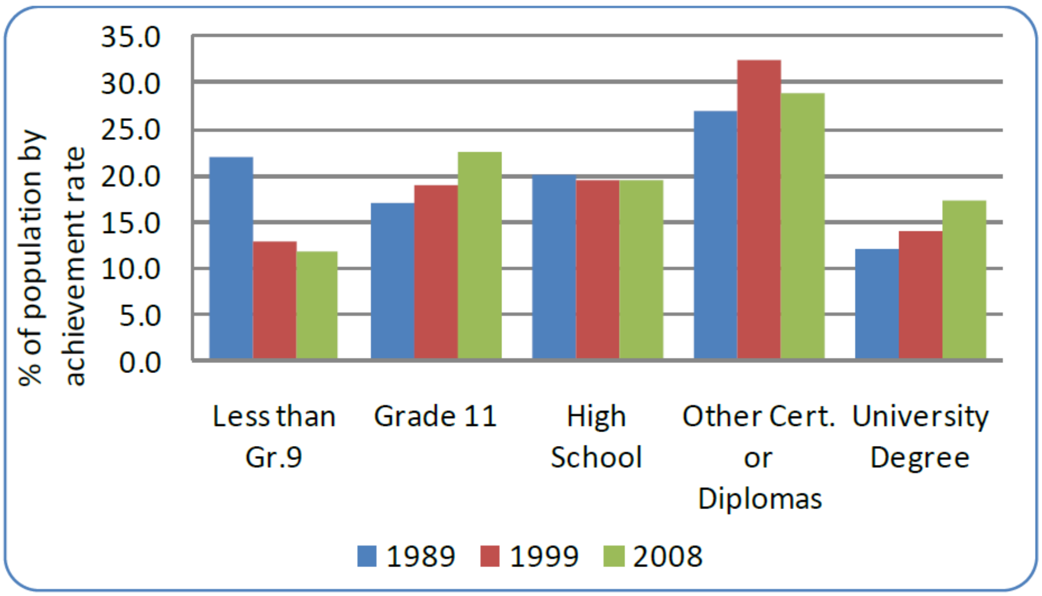
Figure 7.7.9 NWT Employment Rates by Selected Categories



Education in the NWT

One of the key social changes to occur in the NWT during the past two decades is an increase in education levels. While the NWT's education achievement levels still lag behind the Canadian average, the territory has made significant improvements. For example, during the period between 1989 and 2008, the proportion of the population with less than a grade nine education was reduced by about half (Figure 7.7.10).

Figure 7.7.10 Highest Level of Education (15 and older)

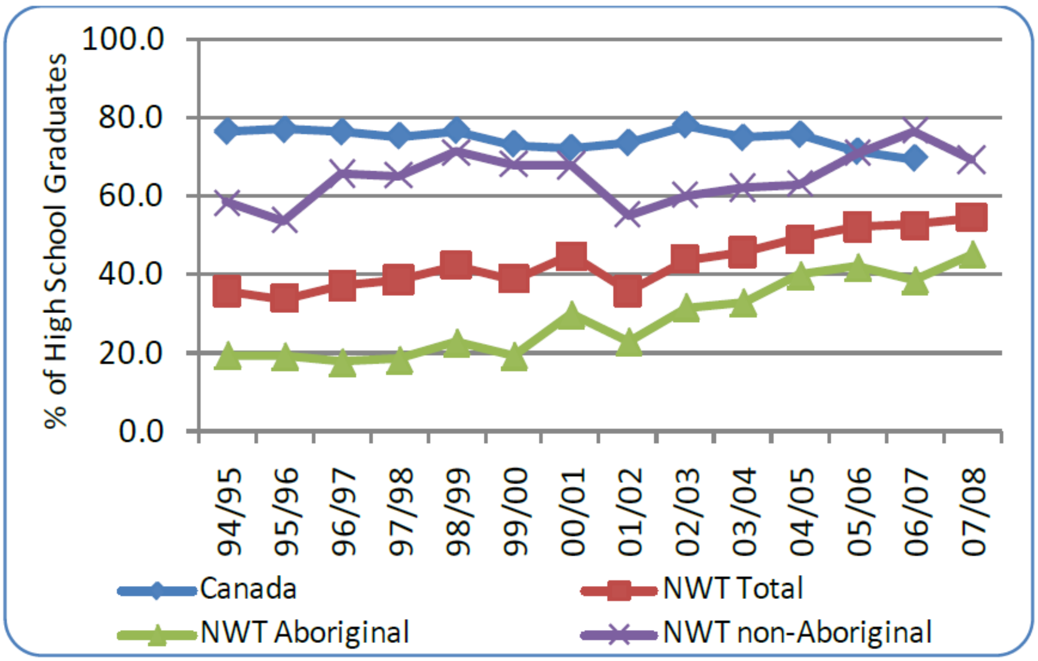


As illustrated in Table 7.7.1, substantial gaps still exist in the education achievement levels between the Aboriginal and non-Aboriginal population. An estimated 84% of non-Aboriginals have completed high school or higher education, as compared to 42 % within the Aboriginal population. In addition, non-Aboriginals are almost eight times more likely to have a university degree than Aboriginals. However, among younger Aboriginal people, progress has been made in recent years to narrow the education gap. For example, as shown in Figure 7.7.11, the percentage of 18 year old Aboriginals who are high school graduates more than doubled from 1995 to 2008.

Table 7.7.1 Highest Level of Schooling, by Ethnic Group in the Northwest Territories, 2008

	Percentage of Population	
	Aboriginal	Non-Aboriginal
Less than Gr. 9	23.9	2.3
Grade 9 - 11	34.8	13.7
High School	14.5	24.0
Other Certif. or Diplomas	23.9	32.6
University Degree	3.6	28.0

Figure 7.7.11 Percentage of High School Graduates by Ethnicity (18 and older)



7.7.2.2 Local Study Area: Dettah

Background

Dettah is a small community located on the eastern side of Yellowknife Bay. The settlement is accessible from Yellowknife by a 23 km paved all-weather road, as well as a 6.3 km ice road across Yellowknife Bay for approximately four months of the year. Dettah's population is almost entirely Aboriginal, and is one of the two YKDFN settlements. Community affairs are governed through an elected chief and council.

Population

Table 7.7.2 provides a summary of Dettah's population by age, gender and ethnic status. The population of the community grew by 13% between 1996 and 2007, which was considerably higher than the 2.0% increase in population for the entire NWT during the same period. Despite Dettah's population growth in recent years, based on the GNWT's forecasts, the community is projected to have a stable population of 228 by 2017.

Table 7.7.2 Dettah Population (as of 2007)

Age (Years)	**# of Individuals**
0-4	11
5-9	24
10-14	23
15-24	39
25-44	48
45-59	51
60 & Over	27
Total	223
Gender	**# of Individuals**
Male	113
Female	110
Ethnicity	**# of Individuals**
Aboriginal	219
Non-Aboriginal	None recorded
Avg. Annual Growth Rate (96-07)	
Total Population	1.3 %
<15 years	-0.2 %
60 Yrs. & Older	1.1 %
Population Projections	
2017	228 individuals
2022	227 individuals

Economy

With respect to the economy, Dettah can be viewed as an extension of Yellowknife given the intertwined linkages between the two communities. However, due to its ethnic composition, certain socio-economic factors such as employment and education are distinguishable from the Yellowknife baseline.

A key socio-economic indicator is employment participation rate, which is defined as the percentage of persons 15 years or older who are in the labour force, either employed or unemployed. In 2006, 165 Dettah residents were 15 years or older. Of these, 90 residents were part of the labour force and 75 were employed. This translates to a participation rate of 54.5%, and an unemployment rate of 16.7% (Table 7.7.3). In contrast, the NWT's overall participation rate was 76.5% in 2006 and the unemployment rate was 10.6%. Despite the differences in employment, the gap has narrowed considerably from the mid-1980's when Dettah reported an unemployment rate of 50%.

Table 7.7.3 Dettah Employment Participation

	2001	2004	2006
Participation rate (%)	62.5	57.3	54.5
Unemployment rate (%)	20.0	33.7	16.7
Employment rate (%)	50.0	38.0	45.5

Part of the improved employment rate may be attributable to the socio-economic agreements and impact-benefit agreements signed between the Yellowknives Dene and the diamond mining industry in recent years which have boosted employment and business opportunities for local Aboriginal communities. Separate average personal income data for Dettah is not available as it has been aggregated with results for Yellowknife. Although the average personal income for Yellowknife was reported to be $57,246 in 2006, it can be presumed that the average personal income in Dettah is less than that of Yellowknife due to its lower levels of participation in employment and its higher unemployment levels.

Education

The level of education achieved in Dettah has increased over the past two decades. In 1986, only 5.3% of the population had a high school diploma. By 2006, 37.5% of the population had completed high school or higher. This rate of completion is still considerably lower than the NWT or Canadian averages. However, as noted in Section 7.7.2.1, the number of young Aboriginal people finishing high school has increased substantially over the past decade.

Education levels are a key factor influencing employment rates. In 2006, the employment rate for the portion of Dettah's population which had a high school diploma or more was 81.6%, while those without a diploma had an employment rate of 42.2%. The community has an elementary school, Kaw Tay Whee School, that provides Kindergarten to grade 9, as well as a pre-school care program.

Community Services and Infrastructure

Due to its close proximity to Yellowknife, Dettah has limited community services and infrastructure compared to similar sized NWT communities. There is a health station in the community that provides basic care with more serious cases being referred to Yellowknife. Police services are provided from Yellowknife; however, the community does have its own fire hall. Municipal recreation services are very limited, with the school gymnasium being the only main feature. Water and sanitation services are provided by truck. Electricity is distributed via the Northwest Territories Power Corporation regional grid.

Housing

While adequate housing is generally an issue in northern communities, Dettah's housing situation has improved in the past three decades. In 1981, 33.3% of the Dettah's homes had six or more people and by 2006 the percentage had dropped to 13.3%. However, this is still considerably higher than the NWT average of 6.2%. Home ownership in Dettah is slightly higher than the territorial average, although the percentage of households in Core Need[26] is higher than territorial average: 23.4% versus 16.3% in 2004. There are no hotel-type accommodations available in Dettah.

7.7.2.3 Local Study Area: Yellowknife and N'dilo

Overview

Yellowknife is the NWT's capital, its largest community and the only city in the territory. It is located on the north shore of Great Slave Lake and is accessible by air, road and water. Yellowknife's history is inextricably linked to that of the Giant and Con mines that operated for decades inside the City boundaries. N'dilo is a Yellowknives Dene community, located on the northern tip of Latham Island within the City of Yellowknife. Many metrics of socio-economic conditions do not distinguish between Yellowknife and N'dilo. Unless indicated otherwise, the following descriptions represent the aggregate conditions of the two communities, with Yellowknife dominating the statistics due to its greater size.

Population

Table 7.7.4 summarizes the population of Yellowknife, including N'dilo, by age, gender and ethnic status. The population of the community grew by 18% between 1991 and 2006. From 1996 to 2007, the community's annual rate of growth (0.4%) was similar to the territorial average (0.2%). While Yellowknife is a young city compared to most southern Canadian cities, the cohort of persons 60 years or older has grown much faster than the entire population as a whole. Based on the GNWT projection, Yellowknife will reach a population of approximately 22,500 by 2017 and 24,000 by 2022.

[26] The GNWT defines a household to be in "Core Need" if it has any one housing problem (suitability, adequacy, or affordability) or a combination of housing problems, and the total household income is below a threshold value. The core need income threshold is an income limit for each community that represents the amount of income a household must have to be able to afford the cost of owning and operating a home or renting in the private market without government assistance.

Table 7.7.4 Yellowknife Population (including N'dilo)

Age (Years)	# of Individuals
0-4	1,463
5-9	1,365
10-14	1,494
15-24	2,932
25-44	6,847
45-59	3,870
60 & Over	1,184
Total	19,155
Gender	**# of Individuals**
Male	9,700
Female	9,455
Ethnicity	**# of Individuals**
Aboriginal	4,445
Non-Aboriginal	14,710
Avg. Annual Growth Rate (96-07)	
Total Population	0.4
<15 years	-0.7
60 Yrs. & Older	7.6
Population Projections	
2017	22,553 individuals
2022	24,140 individuals

Economy

Yellowknife's economy is the most diversified in the territory. As the territorial capital, the City's economy is anchored by a large number of jobs within the territorial and federal civil service. Yellowknife also serves as a commercial, cultural and transportation hub for the western Arctic, providing a wide array of services and amenities not typically available in the smaller communities. The City's economy is bolstered by the diamond mining industry which has been an important engine of growth for over a decade.

Because of Yellowknife's economic importance, it has been a magnet for job-seekers from across the territory, throughout Canada, and even internationally. Jobs in the City have tended to be better paid and more plentiful than elsewhere in the territory. In 2006, Yellowknife's population of individuals 15 years or older was 14,485. Of these, 12,190 were part of the labour force and 11,490 were employed (Table 7.7.5). This translates to a participation rate of 84.2% and an unemployment rate of 5.7%. As noted previously, the NWT's overall participation rate was

76.5% in 2006 and the unemployment rate was 10.6%. Statistics for N'dilo suggest that the employment rate in that community is approximately half that of Yellowknife.

Table 7.7.5 Yellowknife and N'dilo Employment Participation

	2001	2004	2006
Participation rate (%) - *Yellowknife*	85.0	84.0	84.2
Participation rate (%) - *N'dilo*	65.5	50.5	-
Unemployment rate (%) – *Yellowknife*	5.0	5.0	5.7
Unemployment rate (%) – *N'dilo*	28.9	32.0	-
Employment rate (%) - *Yellowknife*	80.8	79.7	79.3
Employment rate (%) – *N'dilo*	48.3	34.3	-

Education

The residents of Yellowknife have the highest education achievement rates in the territory. As of 2006, 80.9% of the population had a high school diploma or more, which is on par with the Canadian average. In 2006, residents with a high school diploma or more had employment rates of 84.4%, while those without a high school diploma had an employment rate reported at 57.8%.

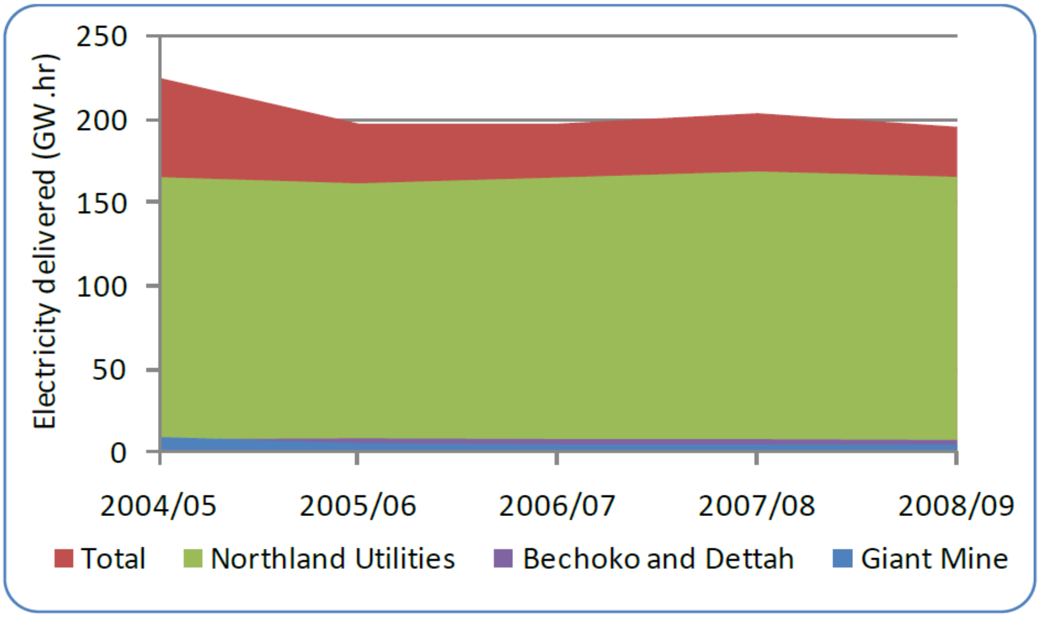
Community Services and Infrastructure

Yellowknife's size and status as the territorial capital is reflected in the number of services and amenities available to its citizens. Municipal services include the territorial headquarters for the RCMP, a municipal police force, a fire department with full-time and on-call firefighters, ambulance service and the Stanton Regional Hospital which is the largest and most advanced health care facility in the NWT. Yellowknife also has a wide range of recreational facilities, including all-season swimming pool and ice rinks. Other recreational facilities available to the Yellowknife population are described under Land Use in Section 7.7.1.1. Water and sewage services are provided through both piped and trucked systems.

The Northwest Territories Power Corporation (NTPC) operates the generation facilities and supplies electricity to Northland Utilities which supplies local users. The NTPC has the capacity to generate up to 46.5 megawatts of electricity from the three facilities (Jackfish Lake, Bluefish Hydro, and the Snare Hydro System), although the high peak usage has not exceeded 38 MW in recent years. Hydroelectricity dominates the electricity mix, with its contribution ranging from 87.2% to 99.2% between 2004/05 and 2008/09. The diesel-powered generators at Jackfish Lake make up the remaining portion.

As noted in Figure 7.7.12, the amount of electricity consumed by Giant Mine in recent years was very low relative to the total load of the electricity grid. Between 2004/05 and 2008/09 the average consumption from the mine was 6.06 GW.hr, which makes up just under 3% of the average total load (203.97 GW.h) supplied by NTPC over the same five years.

Figure 7.7.12 Annual Electricity Loads



Housing

Given its economic strength, many housing indicators tend to be better in Yellowknife compared to the NWT average. In 2006, the number of households with 6 or more persons was 3.3%, compared to the territorial average of 6.2%. By contrast, N'dilo's overcrowding rate in the same year was 20.0%.

In recent years, rental property in Yellowknife has been scarce. However economic trends in the last year, particularly reduced demand in the commodities market, appear to have softened demand for rental housing in the City. The average apartment vacancy rate in Yellowknife increased from 0.6 per cent in April 2008 to 2.8 per cent in April 2009. Despite the increase in vacancies, rental prices have risen. The percentage of households in Core Need in Yellowknife has risen from 4.7% in 1996 to 9.1% in 2006, possibly reflecting the increased cost and limited availability of suitable accommodation in a stimulated economy. In 2006, 40.2% of the households in N'dilo were in the Core Need category.

7.7.3 Transportation

This section provides an overview of the existing transportation network within the LSA, with a particular emphasis on the road network in the vicinity of Giant Mine. The majority of information presented has been derived from government reports, specifically those provided by the GNWT's Department of Transportation. Except where noted, these reports included:

- 2004, 2005, 2006 and 2007 NWT Traffic Collision Facts. GNWT (2005, 2006, 2007 and 2008); and

- Registrar's Report of the Department of Transportation 2007/8. GNWT (2008d).

The descriptions which follow are presented in the context of the following environmental sub-components:

- Road systems and traffic; and
- Road system safety.

7.7.3.1 Local Study Area

The discussion of existing transportation conditions is primarily focused within the LSA since it is within this area that any potential effects of the Remediation Project would be experienced. It is anticipated that any traffic associated with the Remediation Project beyond the LSA would not be discernable from background traffic conditions.

The key roadways and intersections selected for consideration in the LSA focus on routes that converge upon or diverge from the Giant Mine site. These routes include Highway 4 (i.e., the Ingraham Trail), from its junction with Highway 3, (at approximately Kilometre 1.5 of Highway 4) to the Dettah access road turnoff (at approximately Kilometre 12 of Highway 4). The LSA also extends north to consider the Vee Lake access road (at approximately Kilometre 7.5 of Highway 4) to its terminus at the Vee Lake boat launch.

7.7.3.2 Site Study Area

The SSA applied to the transportation component is identical to the generic SSA presented in Section 3.5.1 and consists of all roads and road access points within the site, as well as any related transportation elements internal to the site.

7.7.3.3 Road Systems and Traffic Volume

Ingraham Trail (Highway 4)

Highway 4, also known as the Ingraham Trail, currently passes through the Giant Mine site. The 69 km highway, which runs from Yellowknife to Tibbit Lake, is owned and operated by the GNWT. The first 28 km of the highway are paved and the balance are dust-controlled gravel. An 11.3 km access road connects the community of Dettah to Highway 4 approximately 2.5 km east of the Yellowknife River. The Vee Lake access road connects to Highway 4 inside the Giant Mine lease lands by way of a Y-junction located just south of the Northwest tailings pond.

The portion of Highway 4 that runs through the Giant Mine site is approximately 5.5 km. Along this segment there are a number of road junctions that permit access from the highway to the private road network within the mine site; some of these access points are gated to prevent trespassers. The road passes close to several key mine site components, such as Baker Creek, the

A2 and C1 Pits, and the Roaster Complex. The road also passes close to or directly above several of the underground arsenic trioxide storage chambers and stopes.

The quantity and type of traffic using Highway 4 is seasonally dependent. Regular users include approximately 200 people who live along the road throughout the year. In addition, the population of Dettah actively uses the highway to access Yellowknife for periods when the winter ice road is not operational. Figures 7.7.13 and 7.7.14 demonstrate the seasonal spike in traffic activity at two locations along Highway 4 (the Ingraham Trail) within the LSA. The peak traffic volumes observed during the summer months are attributed to increased travel along Highway 4 for recreational purposes.

There are several important access points or destinations for the public along the stretch of Highway 4 within the LSA. These include the Yellowknife Ski Club, the Yellowknife Waste Facility, the Great Slave Cruising Club, the Vee Lake access road, the Yellowknife River Day Use Area and the Dettah access road. Of these, the Yellowknife Landfill likely experiences the greatest traffic volume. On a summer weekend day, the landfill can receive upwards of 700 vehicles per day, while during weekdays the volume can range from approximately 350 to 400 (B. Underhay, personal communication, August 4th, 2009).

Between 1993 and 2005, the average number of vehicles that used the Vee Lake access road on a daily basis ranged from 57 to 73, with higher amounts of traffic occurring during the early spring and summer. During the period from 1995 to 2007, average traffic volumes ranged from 127 to 274 vehicles per day. Traffic volume on the Dettah access road is higher during the summer and fall and lower in the winter and early spring when the distance to Dettah is shortened by the annual construction of the 6.3 km ice road from Yellowknife.

Figure 7.7.13 Seasonal Traffic Volumes 1 km North of the Highway 3 and 4 Intersection

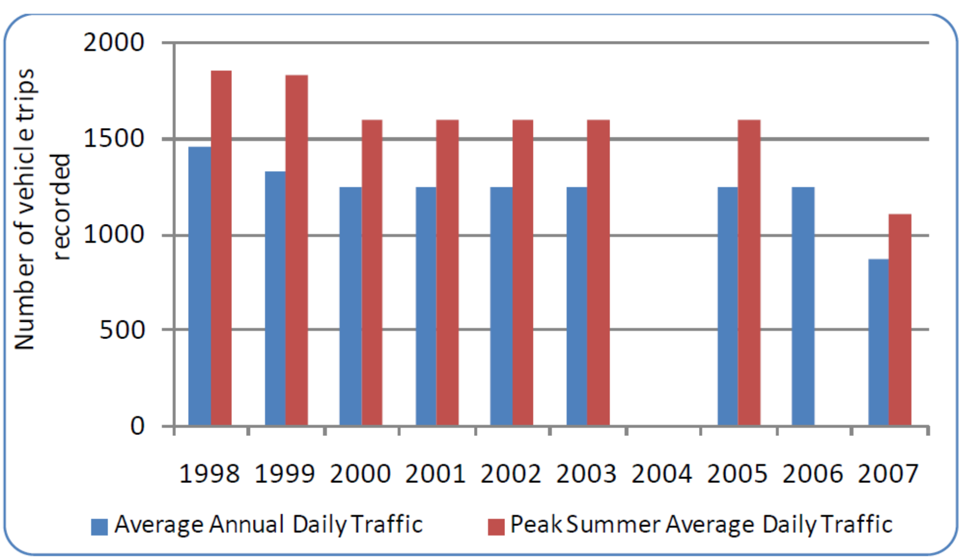
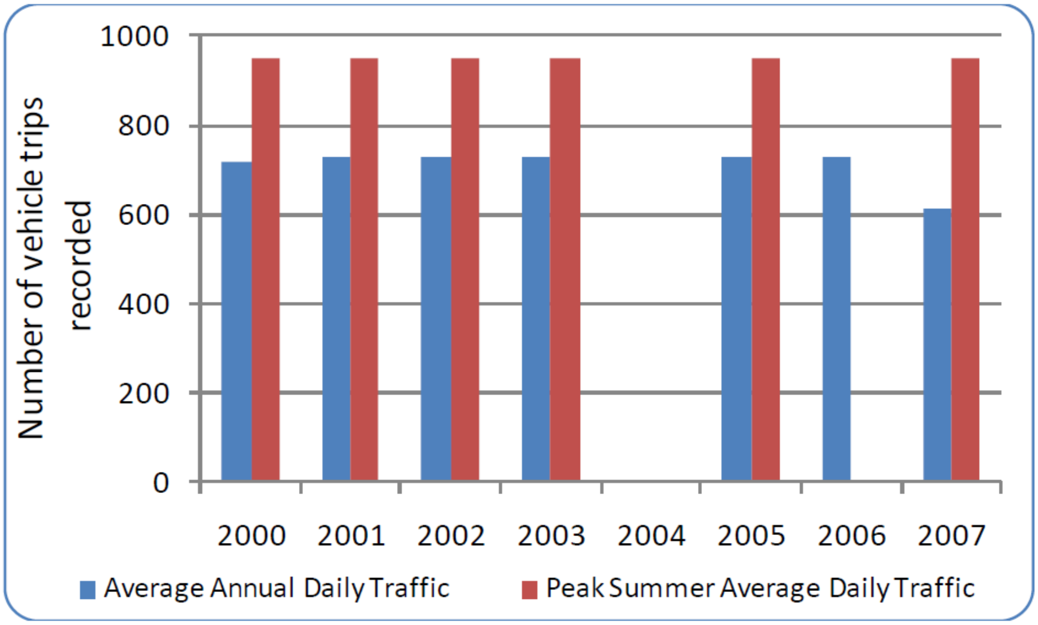


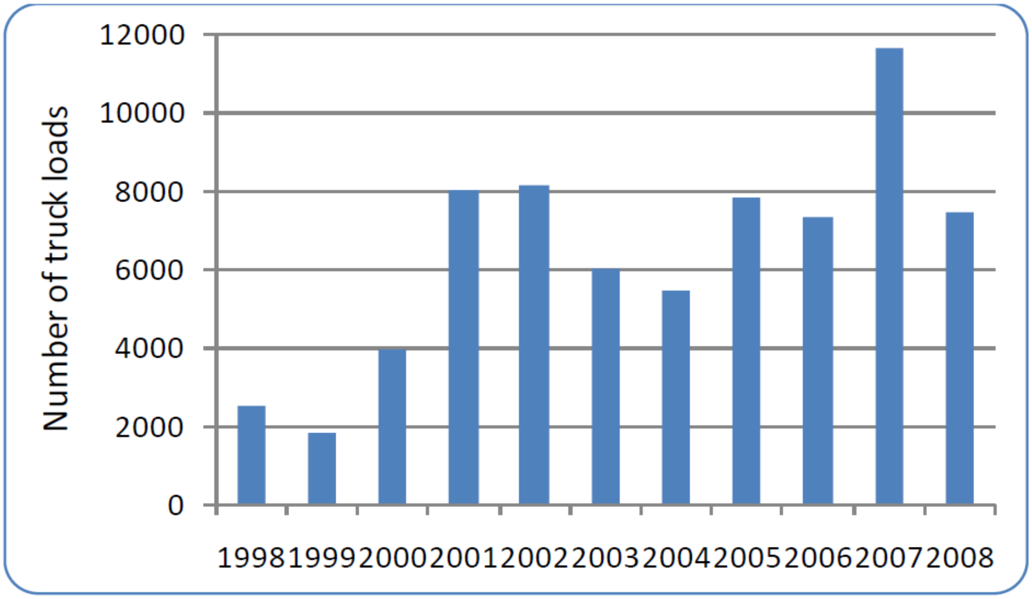
Figure 7.7.14 Seasonal Traffic Volumes 2.5 km East of the Yellowknife River Bridge



Tibbitt to Contwoyto Winter Road

Aside from summer recreational traffic, another intensive period of use on Highway 4 occurs during the winter road season. Access to the Tibbitt to Contwoyto Winter Road is carried out via the highway. The winter road was first opened in 1982 and, since 1999, has been operated by the Tibbitt to Contwoyto Winter Road Joint Venture to serve the needs of the mining and exploration industries operating in the Slave Geologic Province. Construction of the winter road typically begins in December and the road is usually open for freight haulage from the middle to late January until as late as mid-April. On average, the winter road operates for approximately 65 days each year. Figure 7.7.15 summarizes the total annual commercial truck traffic on the winter road. The amount of truck transport on the winter road varies according to climatic constraints and the requirements of the users. The number of trucks indicated in Figure 7.7.15 represents "loaded truckloads" and, therefore, are considered one-way traffic. Since 1998, there has been a trend towards increased total commercial vehicle traffic associated with the various existing mines and exploration work on the winter road.

Figure 7.7.15 Annual Truck Traffic on the Tibbit to Contwoyto Winter Road



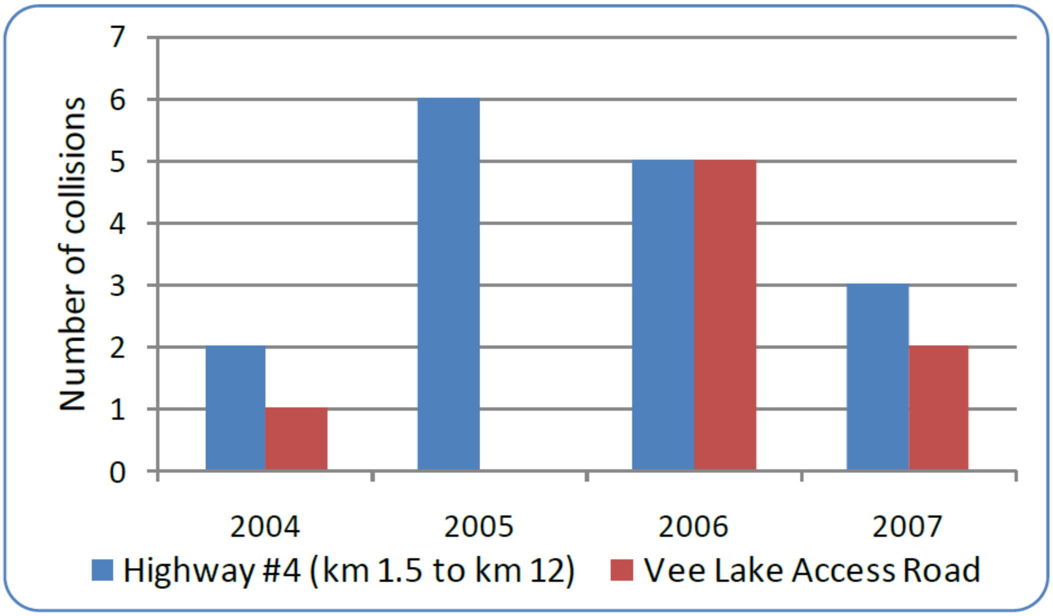
Other Modes of Transportation

While automobile traffic is by far the most common type of transportation within the LSA and SSA, there are other types of transportation of note, including recreational boating, snowmobiling and cycling. Snowmobilers are known to pass through the mine site, particularly for accessing the system of lakes north of Vee Lake. Cyclists also use Highway 4 for recreational purposes.

7.7.3.4 Transportation System Safety

Data on the incidents of collisions occurring on the roads within the LSA are presented in Figure 7.7.16. Given the small sample set, it is difficult to identify trends regarding the types of collisions or their seasonal occurrence. Between 2004 and 2007, 16 collisions were reported on Highway 4 between km 1.5 and km 12; five injuries were reported in the collisions. During the same period, eight collisions were reported on the Vee Lake access road resulting in five injuries. No fatalities were reported on these roads from 2004 to 2007. The collisions reported on the LSA roads represent a small proportion of the overall collisions that are reported to the Yellowknife RCMP detachment in any given year. For example, 401 collisions were reported to the detachment in 2007, with 65 injuries and two fatalities occurring.

Figure 7.7.16 Number of Collisions on the Local Study Area Road System



7.7.4 Selection of Valued Components

Table 7.7.6 presents VCs that have been selected for the evaluation of potential adverse effects on Additional Community Interests.

Table 7.7.6 VCs for Additional Community Interests

Sub-Component	VC	Rationale
Land Use, Visual and Cultural Setting	Recreational and community features/resource use.	- Community and recreational features and services, as well as natural resources such as lakes, trails, etc., provide a means for residents to participate in and contribute to community life - They influence people's feelings of personal health and satisfaction with community - They may also serve to attract residents and tourists
	Visual aesthetics and physical resources	- The quality of views and vistas may have an effect on the use and enjoyment of lands, community well-being and future property values - Specific well-preserved and exposed rock outcrops are an important natural heritage site and have educational and research value for the geological community
	Built heritage features and cultural landscapes	- Built heritage features, such as architecture, structural remains and artefacts, and cultural landscapes (e.g., historic buildings and cemeteries) are important for understanding early to mid-20th century Euro-Canadian history in the NWT
Socio-economics	Local and Regional population Health and safety services Municipal infrastructure and services Housing supply and property values	- Population levels, rates of growth and demographic make-up of communities influence the need for, availability and quality of municipal infrastructure, community services and affect a municipality's financial status - These factors can also influence a community's character, cohesiveness and overall well-being
	Employment	- Communities require employment opportunities to maintain adequate household incomes - Communities also benefit from a stable and skilled labour force in order to meet their economic development goals
	Business development and economic diversification	- Business development and economic diversification is important for communities to foster stable and resilient economies
	Education and vocational training	- Education and vocational training enhances the skills and knowledge in a community that contributes to its economic development
Transportation	Road system efficiency and adequacy relative to demand	- Added traffic, changing traffic patterns or impacts to the road network may affect VCs in the biophysical and socio-economic environments (e.g., dust and airborne contaminants; land use and socio-economic conditions; human health)
	Transportation system safety	- Transportation-related accidents represent a risk to human health and safety, to physical components of the Remediation Project, as well as a risk to the natural environment

7.8 Summary of Valued Components

A summary of VCs for all environmental components that were evaluated in the DAR is provided in Table 7.8.1.

Table 7.8.1 Summary of VCs for All Environmental Components

Sub-Component	VC	Rationale
Component: Surface Water Environment		
Hydrology	Baker Creek	- Changes in flows within Baker Creek important for aquatic biota
Water Quality	Members of the Public	- Protection of human health - Recreational users potentially exposed to contaminants - Site drainage through Baker Creek and treated minewater discharge to Great Slave Lake
	Water quality (intrinsic value)	- identified as a key VC by the Review Board - Aboriginal groups and northerners value components of the environment for their intrinsic value - Species sensitive to contamination of water - Changes assessed as potential pathways to aquatic and terrestrial VCs, as well as human health
Sediment Quality	Sediment quality (intrinsic value)	- Aboriginal groups and northerners value components of the environment for their intrinsic value - Species sensitive to sedimentation and turbidity, as well as contamination associated with sediments - Changes assessed as potential pathways to aquatic VCs
Component: Geological and Hydrogeological Environment		
Groundwater Flow	None identified	- No specific VCs identified, since likely environmental effects are represented as changes to groundwater flow. Changes assessed regarding role as pathways to aquatic and terrestrial environments. No such pathways exist due to the continued draw down of the mine
Groundwater Quality	Member of the public Groundwater quality (intrinsic value)	- Aboriginal groups and Northerners value components of the environment for their intrinsic value - Changes to groundwater quality assessed with respect to possible roles in providing pathways and mechanisms for effects on aquatic and terrestrial environments and on human health
Soil Quality	Member of the public Soil quality (intrinsic value)	- Aboriginal groups and Northerners value components of the environment for their intrinsic value - Changes to soil quality assessed with respect to possible roles in providing pathways and mechanisms for effects on aquatic and terrestrial environments and on human health

Table 7.8.1 Summary of VCs for All Environmental Components (Cont'd)

Sub-Component	VC	Rationale
Permafrost	Extent of permafrost	- Interacts with other components of the environment (e.g., Surface Water Environment, Terrestrial Environment)
Component: Atmospheric Environment		
Air Quality	Closest residential and recreational receptors	- Protection of human health
	Air quality (intrinsic value)	- Aboriginal groups and northerners value components of the environment for their intrinsic value - Potential air quality effects assessed with respect to the Terrestrial Environment for roles in providing pathways to the effects on terrestrial biological components and related VCs
Noise Environment	Closest residential and recreational receptors	- Potential for noise disturbances
	Noise environment (intrinsic value)	- Potential noise effects assessed with respect to the Terrestrial Environment for roles in providing pathways to the effects on terrestrial biological components and related VCs
Component: Aquatic Environment		
Aquatic Habitat	Surface Water Quality and Sediment Quality (the VCs for the Surface Water Environment)	- Any adverse effects on the quality of surface water and sediments may result in a degradation of aquatic habitat (through potential increases in contaminant exposures of aquatic species to contaminants)
	Baker Creek and Yellowknife Bay	- The physical environments of Baker Creek and Yellowknife Bay serve as current and potential habitat for aquatic and terrestrial species. Degradation of that habitat may result in adverse effects to such species.
	Aquatic Habitat (intrinsic value)	- Aboriginal groups and Northerners value components of the environment for their intrinsic value - Fish habitat identified as an issue of concern during EA scoping
Aquatic Biota	Emergent macrophyte community (e.g., cattails)	- Potential for physical disturbance during remediation and effects from contaminants (both direct and as a food source) - Risk associated with plants growing in reclaimed areas resulting in elevated exposures of contaminants to wildlife
	Benthic invertebrates (e.g., ephemeroptera, trichoptera and chironomids)	- Potential for direct effects (on benthic invertebrates) and higher trophic levels if contaminant levels increase
	Arctic Grayling	- Spring spawner, eggs and young-of-the-year (YOY) have the potential to be affected by contaminated water and sediments in the spring - Number of adults indicates status of creek spawners - Species harvested for recreational fishing

Table 7.8.1 Summary of VCs for All Environmental Components (Cont'd)

Sub-Component	VC	Rationale
	Lake Whitefish, Northern Pike, Longnose Sucker, Walleye	- Number of adults indicates habitat use (for various life stages, depending on timing) - Species harvested for traditional foods and recreational fishing (excluding longnose sucker)
	Resident in-stream species (e.g., sculpin or ninespine stickleback)	- Provide spatial and temporal data on habitat use for long-residency species
	All fish species	- Fish identified as an issue of concern during EA scoping - A measure of potential direct effects (on fish) and higher trophic levels
Component: Terrestrial Environment		
Terrestrial Habitat	VCs for the Surface Water Environment (Table 7.1.7), Soil Quality (Table 7.2.2) and Atmospheric Environment (Table 7.3.5)	- Any adverse effects on the quality of surface water, sediments, soils, air quality and the noise environment will result in degradation of terrestrial habitat (e.g., through potential increases in contaminant exposures to terrestrial species)
	Quality of habitat (intrinsic value)	- Aboriginal groups and northerners value components of the environment for their intrinsic value
Terrestrial Biota: Mammals	Moose and Caribou	- Large mammals may be injured by physical risks such as waste rock piles and open pits - Valued by local residents; part of traditional diet and Aboriginal culture - Moose identified as VC during issue scoping by Review Board - Caribou are not anticipated to be present in the SSA. However, the species is currently the subject of heightened concern throughout the RSA
	Black Bear	- Bears are often attracted to sites where human activity is occurring, particularly if food is available. Interactions can lead to bears being destroyed - Consume a large variety of foods - Identified as VC during issue scoping by Review Board
	Wolf	- Carnivore that consumes species that can be directly exposed to contaminants (e.g., hare)
	Fur-bearing Mammals (e.g., hare, mink)	- Harvested for pelts - Some species harvested for food (e.g., hare)
Terrestrial Biota: Semi-aquatic Mammal	Muskrat	- One of the most highly exposed species to contaminants - Denning habitat could be affected or eliminated by remediation activities (particularly in the vicinity of Baker Creek)

Table 7.8.1 Summary of VCs for All Environmental Components (Cont'd)

Sub-Component	VC	Rationale
Terrestrial Biota: Birds	Grouse/ptarmigan Osprey, kestrel, owl Mallard, merganser, scaup	- Representative species inhabiting the SSA - Nesting and feeding habitat could be affected or eliminated by remediation activities - Species are exposed to contamination via a range of food pathways (e.g., mallard to plankton; merganser to fish; scaup to benthic invertebrates)
	Peregrine falcon	- Not observed but has the potential to be present in the SSA - Potential exposures to contamination - Identified as VC during issue scoping by Review Board
Terrestrial Biota: Vegetation	Browse (e.g., alder and lichen)	- Food source for other VCs; protection of health of terrestrial animals - Species selected based on abundance, exposure to stressors from the Project, availability of data, and socio-economic value
	Berries Medicinal plants (e.g., Labrador tea)	- Food source for other VCs; protection of health of terrestrial animals (e.g., bears) - Valued by local residents; part of traditional diet and Aboriginal culture
Component: Aboriginal Interests		
Aboriginal communities	Community well-being	- Large projects can result in adverse direct and indirect effects on Aboriginal communities and residents - Land, water and resources are an essential part of identity, culture and economic sustainability
Traditional Land Use	Traditional harvesting and subsistence	- Hunting, fishing and trapping are Traditional Land Uses which may be a source of food, medicines and economic benefit
Aboriginal Heritage Resources	Aboriginal heritage sites	- Important link to the past and source of cultural identity - Archaeological sites containing Aboriginal artefacts are relevant for understanding Aboriginal history and may have value for research or public education purposes
Component: Additional Community Interests		
Land Use, Visual and Cultural Setting	Recreational and community features/resource use.	- Community and recreational features and services, as well as natural resources such as lakes, trails, etc., provide a means for residents to participate in and contribute to community life - They influence people's feelings of personal health and satisfaction with community - They may also serve to attract residents and tourists
	Visual aesthetics and physical resources	- The quality of views and vistas may have an effect on the use and enjoyment of lands, community well-being and future property values - Specific well-preserved and exposed rock outcrops are an important natural heritage site and have educational and research value for the geological community
	Built heritage features and cultural landscapes	- Built heritage features, such as architecture, structural remains and artefacts, and cultural landscapes (e.g., historic buildings and cemeteries) are important for understanding early to mid-20th century Euro-Canadian history in the NWT

Table 7.8.1 Summary of VCs for All Environmental Components (Cont'd)

Sub-Component	VC	Rationale
Socio-economics	Local and Regional population Health and safety services Municipal infrastructure and services Housing supply and property values	- Population levels, rates of growth and demographic make-up of communities influence the need for, availability and quality of municipal infrastructure, community services and affect a municipality's financial status - These factors can also influence a community's character, cohesiveness and overall well-being
	Employment	- Communities require employment opportunities to maintain adequate household incomes - Communities also benefit from a stable and skilled labour force in order to meet their economic development goals
	Business development and economic diversification	- Business development and economic diversification is important for communities to foster stable and resilient economies
	Education and vocational training	- Education and vocational training enhances the skills and knowledge in a community that contributes to its economic development
Transportation	Road system efficiency and adequacy relative to demand	- Added traffic, changing traffic patterns or impacts to the road network may affect VCs in the biophysical and socio-economic environments (e.g., dust and airborne contaminants; land use and socio-economic conditions; human health)
	Transportation system safety	- Transportation-related accidents represent a risk to human health and safety, to physical components of the Remediation Project, as well as a risk to the natural environment

8 Assessment of Likely Environmental Effects and Mitigation

8.1 Introduction

This chapter identifies and examines the potential adverse effects of the Remediation Project on the environment and on the Valued Components (VCs) selected for each environmental component. The assessment of likely environmental effects deals only with those effects that have been deemed plausible and potentially measurable. Potential mitigation measures and adverse effects after mitigation (i.e., residual effects), if any, are also identified. The significance of any residual effects is characterized in Chapter 12.

The fundamental objective of the Remediation Project is to improve the environment of the SSA and prevent adverse effects that would otherwise occur had no remediation plan been brought into effect. In this regard, many of the effects associated with the Remediation Project are inherently positive. Although these positive effects have not been formally evaluated, they are identified in this chapter. It is against this backdrop of positive effects that potential adverse effects of implementing the Remediation Project have been evaluated.

A number of the findings within this chapter are applicable to the first Key Line of Inquiry established by the Review Board, specifically those issues related to arsenic trioxide and its potential contamination of the receiving environment. The second Key Line of Inquiry, relating to future monitoring activities at the Giant Mine site, is addressed in Chapter 14.

8.2 Assessment Methodology

As described in greater detail in Chapter 3, the methodology used to evaluate potentially adverse effects of the Remediation Project on the environment includes:

- Selection of Valued Components (VCs) – as identified in Chapter 7;
- Identification of Project-environment interactions that have a potential for adverse environmental effects;
- Selection of evaluation criteria for each environmental component;
- Identification and assessment of adverse environmental effects likely to be caused by the Remediation Project;
- Consideration of mitigation measures for potentially adverse effects;
- Identification of residual effects; and

- Forwarding any identified residual adverse effects for the determination of their significance in Chapter 12.

This methodology is adhered to, apart from the following two exceptions:

- Assessment of Ecological and Human Health Risks - The potential health implications to humans and non-human biota living in the vicinity of Giant Mine have been evaluated through a Human Health and Ecological Risk Assessment (HHERA), as presented in Section 8.9. Although the HHERA follows a different methodology than the rest of the effects assessment, it too is a predictive exercise intended to identify the consequence of Project implementation on a suite of ecological receptors, including humans. In that sense, the HHERA mirrors elements of the regular effects assessment and is a very useful tool for comparing and evaluating the effects assessment's conclusions.

- Assessment of adverse effects on Local Resources - Section 8.11.5 evaluates the potential adverse effects of the Remediation Project on Local Resources, specifically the requirements for electricity, fuel storage, construction materials, and human resources. Although the socio-economic baseline presented in Section 7.7 provides information on the local work force and the electricity utility, a comprehensive description of existing conditions for Local Resources is not provided in Chapter 7. Therefore, additional information required to carry out the effects assessment is provided in Section 8.11.5.

8.3 Identification of Project-Environment Interactions and Likely Environmental Effects

Project-environment interactions and likely environmental effects were screened through the creation of a Project-Environment Interaction Matrix which is presented in Table 8.3.1. The matrix summarizes the plausible interactions and effects between the Remediation Project and the following environmental components:

- Surface Water Environment;
- Geological and Hydrogeological Environment;
- Atmospheric Environment;
- Aquatic Environment;
- Terrestrial Environment;
- Aboriginal Interests; and
- Additional Community Interests.

Based on the current site conditions (Chapter 5), the proposed Project activities (Chapter 6), and the description of the existing environment (Chapter 7), interactions determined to have some potential to result in adverse effects on the VCs chosen for each environmental component were identified in each cell of Table 8.3.1. Blank cells in the matrix indicate that no plausible effects were identified. Each of the identified Project-environment interactions is further evaluated in Sections 8.4 through 8.8, and Sections 8.10 and 8.11.

8.3.1 Project Activities and Phases

The Giant Mine Remediation Project is composed of a large number of individual activities, each of which has the potential to interact with multiple environmental components. On this basis, each of the activities should be evaluated to determine whether adverse environmental effects on the VCs selected for this Project might occur. However, many of the activities are sufficiently similar that they can be grouped and analyzed as a single type of activity. For example, while the arsenic trioxide chambers differ from one another (e.g., in terms of size and stability), all will be frozen and potential interactions between the Remediation Project and the environment are expected to be similar for each chamber. By grouping the Project activities into common categories, potential adverse effects can be efficiently identified and assessed. In cases where adverse effects are identified, a subsequent more detailed analysis of individual activities has been conducted.

The left column of Table 8.3.1 lists the groups of activities that were considered in the identification of Project-environment interactions. The activities have been assigned to both of the major phases of the Project: Site Remediation and Long-Term Operation and Maintenance. The groups of activities are described below.

8.3.1.1 Site Remediation Phase

As indicated in Section 3.4.2, the Site Remediation Phase is expected to last approximately 15 years. The major groupings of activities within this Phase include:

- *New Underground Development*: Any underground activities required to support installation of the freeze pipe network, minewater pumping system and disposal of contaminated surface materials and structures (e.g., backfilling, new drifts, installation of infrastructure, etc.).
- *Installation and Operation of the Freeze System*: All drilling for installation of freeze pipes (vertical and horizontal) and active freezing to establish a frozen block for each arsenic trioxide chamber.
- *Earthworks*: All earthmoving activities on surface related to removal and disposal of contaminated soils and sediments, realignment of Baker Creek, re-contouring of tailings

and sludge management areas, and acquisition and placement of cover and quarry materials (e.g., borrow, fill, cover, blast, etc.).

- *Construction of Surface Infrastructure*: All surface infrastructure required to support the Remediation Project (freeze plant, water treatment plant, outfall, etc.). Operation of the infrastructure is not included but is captured by other activities.
- *Demolition of Surface Infrastructure*: Decontamination of existing structures and equipment, demolition and disposal of waste materials on site. Any off-site disposal at licensed facilities is not part of the Remediation Project because such activities are regulated through other mechanisms.
- *Water Management*: The process of maintaining drawdown within the mine (i.e., pumping), treating minewater, discharging through the new outfall and managing minewater treatment plant sludge.
- *Transportation:* All movement of materials and personnel to, from and within the SSA required to support the Remediation Project. This includes on-site transportation within the SSA, and off-site transportation within potentially affected areas of the LSA.
- *Miscellaneous*: Any additional activities that have the potential to interact with the environment, such as clearing of vegetation and fuel management.
- *Monitoring*: Execution of a monitoring strategy that considers various remediation components (i.e. geotechnical stability, water quality) to confirm environmental performance during the implementation of the Remediation Plan.

8.3.1.2 Long-Term Operation and Maintenance Phase

For the purpose of the EA, the Long-Term Operation and Maintenance Phase of the Remediation Project is expected to be ten years. The major groupings of activities in this Phase include:

- *Passive Freezing*: Use of thermosyphons to maintain the frozen block established for each arsenic trioxide chamber.
- *Storage of Contaminants/Waste*: The Remediation Plan calls for various wastes to be stored on site indefinitely.
- *Water Management:* Identical activities as the Remediation Phase.
- *Maintenance*: The infrastructure being put in place to manage site risks (i.e., earthworks, freeze system and structures) will require varying degrees of maintenance to promote long-term performance.
- *Monitoring*: Execution of a monitoring strategy that considers various remediation components (i.e. geotechnical stability, water quality) to confirm the Remediation Plan is performing as intended.

Several activities during the Long-Term Operation and Maintenance Phase will commence prior to the end of the Remediation Phase. For example, "Storage of Contaminants/Waste" will begin several years prior to the completion of all remedial works. However, because the activity is associated primarily with the ongoing management of the site, it has been assigned to the Long-Term Operation and Maintenance Phase. Exceptions to this approach include "Water Management" and "Monitoring" which have been assigned to both phases due to their critical role in the implementation of the Remediation Project.

8.3.2 Project-Environment Interactions

To facilitate the analysis of Project-environment interactions, 13 classes of effects that could potentially affect the VCs chosen for the EA were identified. As noted on Table 8.3.1, these classes correspond to numbers 1 to 13 in the "Type of Effect" box on the interaction matrix. The effects are grouped as follows:

1. *Minor operational releases*: Despite comprehensive efforts to control releases to the environment, complete containment of such releases is seldom possible. For example, operation of heavy equipment will inevitably result in the release of small quantities of petroleum hydrocarbons (lubricants and fuel). These relatively minor releases are not classified as "accidents and malfunctions" because they occur under normal operating conditions.
2. *Increased turbidity in water:* All Project activities that involve unconsolidated granular materials coming in contact with water have the potential to result in increased concentrations of suspended solids (i.e., turbidity). While activities that come in direct contact with receiving waters (e.g., the realignment of Baker Creek) have the greatest potential for this type of effect, surface drainage through areas disturbed by land-based activities also represent an opportunity for increases in erosion and turbidity.
3. *Mobilization of contaminants*: The primary objective of many Project activities is to eliminate or manage contaminant sources that are currently on site. While this will have a net positive effect on the environment, there is a potential that some contaminants will be mobilized in the environment during the implementation of remedial activities.
4. *Erosion and sedimentation*: In addition to increasing concentrations of suspended solids in water, surface disturbances and modifications to the current hydrological regime may result in increased rates of erosion and associated sedimentation.
5. *Disturbance of existing sediments*: Project activities occurring in water have the potential to disturb sediments and any associated contaminants. As a consequence, aquatic species (e.g., benthos) and habitat (e.g., fish spawning areas) may be affected.

6. *Changes to existing hydrology:* For relatively small water bodies such as Baker Creek, some Project activities have the potential to affect the volume and timing of flows.
7. *Changes to existing hydrogeology:* Although the current groundwater levels are well below the local static water table, potential effects of the Remediation Proejct on groundwater flows requires analysis.
8. *Permafrost degradation:* In addition to the active and passive freezing of arsenic trioxide chambers, the thermal regime of other areas on the site may be affected by surface disturbances (e.g., the placement or removal of overburden). There is a possibility such activities will degrade current permafrost conditions.
9. *Suspended solids (air)*: Sources of particulate matter include the movement of large volumes of granular material, transportation activities, grading of tailing ponds, demolition of structures and the extensive drilling required to install freeze pipes.
10. *Combustion emissions:* Virtually all of the Project activities will involve the use of heavy equipment that will consume petroleum hydrocarbons. The exhaust produced from this equipment will be dispersed in the atmospheric environment surrounding the site.
11. *Noise emissions:* In addition to equipment operation, other activities (e.g., drilling).will result in noise emissions.
12. *Surface disturbances*: The presence of heavy equipment and people during the implementation of the remediation project represents a potential disturbance to terrestrial species that might otherwise be on site. Similarly, existing habitat and/or archaeological features may be disturbed during the course of remediation activities (e.g., site access and preparation).
13. *Community effects:* Some Project activities may result in adverse effects on communities. This broad grouping is intended to capture effects such as changes to land use, disturbance of heritage resources, changes in socio-economic conditions (e.g., employment opportunities) and access to local resources.

Table 8.3.1 Project-Environment Interactions and Potential Adverse Effects

	BIOPHYSICAL ENVIRONMENT															HUMAN ENVIRONMENT						
	Surface Water Environment			Geological & Hydrogeological Env.				Atmospheric Environment		Aquatic Environment		Terrestrial Environment		Health		Aboriginal Interests			Additional Community Interests			
	Hydrology	Surface Water Quality	Sediment Quality	Groundwater Flow	Groundwater Quality	Soil Quality	Permafrost	Air Quality	Noise Environment	Aquatic Biota	Aquatic Habitat	Terrestrial Biota	Terrestrial Habitat	Non-Human Biota	Humans	Traditional Land Use	Aboriginal Communities	Aboriginal Heritage Resources	Land Use, Visual & Cultural Setting	Socio-Economic Conditions	Transportation	Local Resources
1. Site Remediation Phase																						
A. New Underground Development																						
Backfill, drifts, installation of infrastructure, etc.								10														
B. Installation & Operation of Freeze System																						
Surface drilling and freeze pipe installation		1						9,10	11	1	1	11,12		9,10	9,10				13	13(all)		
Sub-surface drilling and freeze pipe installation								10						10	10							
Freeze plant operation & active freezing	6							10	11			11		10	10				13			13
C. Earthworks																						
Site access and preparation	4,6	2,3	3				8	3,9,10	11	2,3	2,3	11,12	12	3,9,10	3,9,10			12				
Contour and cap tailings / sludge ponds	4,6	2,3	3					3,9,10	11	2,3, 5	2,3,5	11,12	12	2,3,9,10	3,9,10	13	13					
Borrow and backfill	4,6	2					8	9,10	11	2	2	11,12	12	9,10	9,10				13			13
Excavation of contaminated soils	4,6	2,3	3				8	3,9,10	11	2,3	2,3	11,12		3,9,10	3,9,10	13	13					
Baker Creek rehabilitation	4,6	2,3	3				8	3,9,10	11	2,3,5,6,1 2	2,3,5,6,12	11,12	12	2,3,5,9,1 0	3,9,10	13	13				13	
Highway realignment	4,6	2,3	3				8	3,9,10	11	2,3	2,3	11,12		3,9,10	3,9,10						13	
Water treatment holding pond	4,6	2,3	3				8	3,9,10	11	2,3	2,3	11,12		3,9,10	3,9,10							
Construction of waste management facilities	4,6	2,3	3				8	3,9,10	11	2,3	2,3	11,12		3,9,10	3,9,10							
Bedrock modifications on surface	6	2					8	9,10	11	2	2	11,12		9,10	9,10							
Misc. earthworks	4,6	2,3	3				8	3,9,10	11	2,3	2,3	11,12		3,9,10	3,9,10							
D. Construction of Surface Infrastructure																						
New structures on surface (excludes operation)								10	11			11,12		9	10				13			
Great Slave outfall / diffuser		2,3	3							2,3,5	2,3,5			2,3,5,9,1 0	3,9,10	13	13					
E. Demolition of Surface Infrastructure																						
Decontaminate		1	1					3,9,10		1	1											
Demolish and dispose (but not long-term storage)								3,9,10	11			11,12	12	3,9,10	3,9,10	13	13		13			
F. Water Management																						
Drawdown								10				11										13
Treatment								10	11			11							13			13
Discharge of treated minewater to Great Slave Lake	6	3	3							3,6	3,6			3	3	13	13					
Sludge management		1						10		1	1											
G. Transportation																						
On-site					1	1		9,10	11			11,12		9,10	9,10						13	
Off-site					1	1		9,10	11			11,12		9,10	9,10						13	
H. Miscellaneous																						
Vegetation clearing	4,6						8	9,10	11			11,12	12	9,10	9,10				13			
Fuel management		1			1	1				1	1											13
I. Monitoring																						

Table 8.3.1 Project-Environment Interactions and Potentially Adverse Effects (Cont'd)

	BIOPHYSICAL ENVIRONMENT															HUMAN ENVIRONMENT						
	Surface Water Environment			Geological & Hydrogeological Env.				Atmospheric Environment		Aquatic Environment		Terrestrial Environment		Health		Aboriginal Interests			Additional Community Interests			
	Hydrology	Surface Water Quality	Sediment Quality	Groundwater Flow	Groundwater Quality	Soil Quality	Permafrost	Air Quality	Noise Environment	Aquatic Biota	Aquatic Habitat	Terrestrial Biota	Terrestrial Habitat	Non-Human Biota	Humans	Traditional Land Use	Aboriginal Communities	Aboriginal Heritage Resources	Land Use, Visual & Cultural Setting	Socio-Economic Conditions	Transportation	Local Resources
2. Long-Term Operation and Maintenance Phase																						
A. Passive freezing (maintenance of frozen block)	6																		13			
B. "Storage" of contaminants/waste																13	13					
C. Water management																						
Drawdown									11													
Treatment									11										13			13
Discharge of treated minewater to Great Slave Lake	6	3	3					10		3,6	3,6	11		6	6	13	13					
Sludge management		1								1	1											
D. Maintenance																						
Earthworks (e.g., covers, slope stability, drainage)	4,6	2,3	3				8	9,10	11	2,3	2,3	11,12		3,9,10	3,9,10							
Freeze system (e.g., thermosyphons)																						
Structures																						
E. Monitoring																						

TYPE OF EFFECT

1 - Minor Operational Releases
2 - Increased Turbidity in Water
3 - Mobilization of Contaminants
4 - Erosion and Sedimentation
5 - Disturbance of Existing Sediments
6 - Changes to Existing Hydrology
7- Changes to Existing Hydrogeology
8 - Permafrost Degradation
9 - Suspended Solids (air)
10 - Combustion Emissions
11 - Noise Emissions
12 - Surface Disturbances
13 – Community Effects

8.4 Surface Water Environment

This section describes the predicted effects of the Remediation Project on the Surface Water Environment which comprises three sub-components: Hydrology, Water Quality and Sediment Quality.

8.4.1 Evaluation Criteria

Predicted changes in conditions in the Surface Water Environment as a result of the Remediation Project were evaluated against applicable criteria, as shown in Table 8.4.1. The criteria were applied for evaluation of changes in conditions, as well as the effects that would result from the change.

Table 8.4.1 Evaluation Criteria for the Surface Water Environment

Environmental Sub-component	Evaluation Criteria
Hydrology	• Percentage change to baseline flow • Whether a change results in hydrology being more representative of natural conditions • Professional judgement
Water Quality	• Health Canada's Guidelines for Canadian Drinking Water Quality • Canadian Water Quality Guidelines for Protection of Freshwater Aquatic Life (CWQG-FAL) • Human Health and Ecological Risk Assessment findings • Metal Mine Effluent Regulations • Water quality criteria from former water licence • Criteria established for other relevant industrial developments • Professional judgement
Sediment Quality	• CCME Interim Sediment Quality Guidelines (ISQGs) • CCME Probable Effects Levels (PELs) • Human Health and Ecological Risk Assessment findings • Professional judgement

8.4.2 Hydrology

8.4.2.1 Positive Effects of Remediation

The Remediation Project will focus on transforming the existing highly modified hydrology of Baker Creek to a more natural condition. This transformation will be associated primarily with the movement of the discharge point for treated minewater from Baker Creek to Great Slave Lake. Under existing conditions, the discharge of treated minewater to Baker Creek has resulted in an un-natural hydrological regime during the summer months. The movement of the discharge point for treated minewater to Great Slave Lake will, therefore, return the hydrology of the creek to a state that is more representative of natural conditions.

In addition to the diversion of the treated minewater discharge to Great Slave Lake, physical changes to Baker Creek are also anticipated to have a positive effect on hydrology. While the design of Baker Creek has yet to be finalized, elements of the naturalized creek are anticipated to include channel modifications to create new aquatic habitat, to carry peak flood events and reduce the potential for water discharges to underground mine workings. These proposed changes are similar to those that were successfully implemented during the rehabilitation of Baker Creek's Reach 4 that occurred in 2006 and 2007.

8.4.2.2 Summary of Interactions

Table 8.3.1 identified a number of interactions between Project activities and the hydrology of the site. Only those interactions which were determined to have potential for adverse effects were identified. The types of effects and associated activities related to hydrology are as follows:

Changes to Existing Hydrology:

- Freeze plant operation, active freezing and passive freezing (remediation and long-term operation & maintenance);
- Earthworks (all activities during remediation and long-term operation & maintenance);
- Discharge of treated minewater to Great Slave Lake (remediation and long-term operation & maintenance); and
- Vegetation clearing (remediation).

Erosion and Sedimentation:

- Earthworks (all activities during remediation and long-term operation & maintenance with the exception of bedrock modifications on surface); and
- Vegetation clearing (remediation).

8.4.2.3 Assessment of Potential Effects

Table 8.4.2 presents an assessment of interactions and potential adverse effects associated with hydrology. The assessment took into consideration the fact that one of the objectives of the Project is to return the hydrology of the site to a more natural condition. On this basis, only those effects that would create a less natural hydrological regime were determined to be negative. Similarly, the assessment was conducted on the basis that Baker Creek is the key hydrologic feature within the SSA and that small, ephemeral drainage pathways are of less importance.

As noted in Table 8.4.2, a major change to the hydrology of the site will occur as a result of the diversion of the treated minewater discharge from Baker Creek to Great Slave Lake. Discharge from the water treatment plant currently comprises a significant portion of the volumetric flow of Baker Creek during the latter half of summer when the flow of the creek would otherwise normally be low to negligible. While the removal of this input to Baker Creek will have an effect on hydrology, by returning the flows of the creek to a more natural condition, the changes are considered to be positive (as described in Section 8.4.2.1). The effect of this change in flow on aquatic biota is described in Section 8.7.

The potential for adverse effects on the hydrological regime during both phases of the project is discussed in detail in Table 8.4.2.

8.4.2.4 Mitigation Measures

A number of mitigation measures will be implemented to minimize potential adverse effects of the Project on site hydrology. These measures, which are further described in Table 8.4.2, include:

- *Freeze plant design* - Incorporation of "in design features" to address the potential for ice blockages in surface waters;
- *Baker Creek design* - A detailed design for Baker Creek that will ensure that the hydrology of the creek is returned to a more natural condition; and
- *Erosion and sedimentation controls* - Implementation of standard operational practices to prevent potentially adverse effects to hydrology caused by erosion and sedimentation that might occur during earthmoving activities and vegetation clearing. Specific measures are presented in Table 8.4.2. Details will be addressed in Environmental Management Plans.

8.4.2.5 Residual Effects

With the implementation of mitigation measures, none of the potential interactions are likely to result in adverse residual effects on the hydrology of the site; therefore, no adverse residual effects are expected on Baker Creek, the VC selected for Hydrology. Potential effects to aquatic habitat and biota that may be caused by changes to existing hydrology are given consideration in the assessment of effects regarding the Aquatic Environment (Section 8.7).

Table 8.4.2 Assessment of Potentially Adverse Effects on Hydrology

Activity	Project Phase(s)	Description of Project-Environment Interactions	Analysis of Effects	Mitigation	Residual Effects	Is Further Consideration Required? When?
Changes to Existing Hydrology						
Freeze plant operation and active freezing. Passive Freezing	Remediation Long-Term Operation & Maintenance	The operation of the freeze system may result in the alteration of the thermal regime in areas directly adjacent to parts of Baker Creek. The formation of a large block of ice in Baker Creek has been identified as a potential effect warranting analysis.	The potential for this effect will receive a comprehensive analysis during the detailed design of the realigned Baker Creek and the freeze system. The ongoing freeze optimization study will assist in the analysis of this potential effect.	Potential effects from the freeze system will be addressed during the detailed design of Baker Creek. Wherever possible, the creek alignment will not coincide with the frozen blocks.	No residual adverse effects are anticipated.	Yes. During the detailed design phase for the freeze system.
Earthworks (all activities)	Remediation Long-Term Operation & Maintenance	The Project will involve relocation of Baker Creek in some reaches and alteration in others.	While virtually all earthworks have the potential to influence the hydrology of the site, the realignment of Baker Creek is anticipated to dominate the potential effects on hydrology. The analysis of potential effects from earthworks, therefore, focuses on those activities associated with the realignment of the creek. The net effect of earthworks on the hydrology of Baker Creek is anticipated to be positive due to the transformation of the creek to a more natural condition. The detailed design of the creek will be based on a variety of factors including but not limited to: flood carrying capacity, habitat creation, erosion resistance and the restoration of a natural hydrograph. The alignment will also be influenced by the presence of site risks (e.g., arsenic trioxide vaults and the potential for underground flooding) and surface infrastructure (e.g., thermosyphons and transportation routes). All of these factors will be balanced to encourage the greatest positive influence on the hydrology of the site during the detailed design phase. However, during construction, earthwork activities in, and adjacent to Baker Creek, may cause some short-term adverse effects to the creek's hydrology. These effects are most likely to arise due to the temporary diversion or storage of water, as well as the temporary stockpiling and redistribution of substrate in the stream which could affect stream flow. All these potential adverse effect are temporary, and will cease with the completion of construction activities.	Mitigation measures will be included in the Baker Creek restoration concept as "in-design features" to minimize potential adverse effects to hydrological features (such as water balance and flow velocities). Examples of such features have been demonstrated in the Reach 4 relocation project, which incorporated a wide flood plain and a channel that is free to move within the flood plain. Other potential design features to improve hydrology include: 1) Ensuring that permanent and ephemeral tributary systems within the mine area incorporate terminal depositional areas prior to discharging to the creek; 2) Construction of small terminal delta wetlands off the main channel to promote depositional processes; 3) Implementation of filtering and confinement of fine sediments carried from upland areas; 4) Stabilization of excavated or disturbed areas to promote vegetative growth.	No residual adverse effects are anticipated.	Yes. During the detailed design phase for Baker Creek and in the preparation of Environmental Management Plans.
Discharge of Treated Minewater to Great Slave Lake	Remediation Long-Term Operation & Maintenance	The redirection of treated minewater directly into Great Slave Lake will have an effect on the hydrological character of Baker Creek.	The redirection of treated minewater from Baker Creek to Great Slave Lake will have an effect on the creek's flow characteristics, particularly during the summer months when the natural flow is currently supplemented by minewater discharge. During the summer, Baker Creek's average daily flow upstream of the mine is 1,500 m^3/day. In contrast, water discharge from the Water Treatment Plant has historically been approximately 12,500 m^3/day over the period of July and August. Once the minewater discharge is transferred from the creek to Great Slave Lake, it is expected that the lower reaches of the creek will essentially dry up every few years during mid- to late summer (similar to what is known to occur upstream of the mine site). However, by returning the flows of the creek to a more natural condition, the changes are considered to be positive.	None required.	No residual adverse effects are anticipated.	No.
Vegetation Clearing	Remediation	The clearing of vegetation could affect hydrology by accelerating surface run-off.	Potential effects of vegetation clearing on hydrology are represented in the previous discussion concerning the effects of earthworks. Taking into consideration the limited amount of vegetation clearing associated with the Project, such effects are anticipated to be negligible.	Refer to earthworks mitigation. The footprint of areas requiring removal of vegetation is to be minimized.	No residual adverse effects are anticipated.	No.

Table 8.4.2 Assessment of Potentially Adverse Effects on Hydrology (Cont'd)

Activity	Project Phase(s)	Description of Project-Environment Interactions	Analysis of Effects	Mitigation	Residual Effects	Is Further Consideration Required? When?
Erosion and Sedimentation						
Earthworks (all activities except Bedrock modification on surface)	Remediation Long-Term Operation & Maintenance	The Project will involve extensive earthworks activities. Surface water flows traversing through the site will interact with these activities. Exposure of unconsolidated granular materials to surface flow may result in increased erosion and deposition within the stream channel, altering its hydrologic character.	Potential effects of erosion and sedimentation from earthworks are well understood. For example, in the absence of mitigation, severe, erosion and sedimentation could occur during the excavation of contaminated soils. Associated concerns include increased concentrations of suspended solids in water (affecting water quality) and downstream sediment deposition (potentially affecting hydrology and aquatic habitat). Contaminants currently on site may also be mobilized through erosion and deposition, thereby exposing downstream VCs to contamination that would otherwise not be present. Potential sources of erosion and sedimentation warranting the most attention include those activities which: 1) are a source of chemical contaminants; 2) occur in the near vicinity of natural water bodies; and/or 3) involve large areas being exposed for extended periods. Excavation of contaminated soils or sediments in the vicinity of Baker Creek is considered to be the "worst-case" scenario of such activities. While the potential effects of erosion and sedimentation are relatively easy to identify, they are difficult to accurately quantify due to the influence of numerous variables (e.g., material properties, ambient conditions, stream "energy", contaminant concentrations). In this context, a conservative approach is typically adopted whereby appropriate mitigation measures are put in place for all activities subject to erosion. Sedimentation or erosion on a scale that could impinge on site hydrology is not predicted to occur. Taking into consideration the extensive proposed mitigation measures, any increases in erosion or sedimentation are anticipated to be localized and of short duration and not sufficient to alter site hydrology. Further, a net positive effect of earthworks on the hydrology of the site is anticipated (e.g., through restoration of a more natural hydrological character within Baker Creek).	Based on the nature of remediation activities, the earthworks are not anticipated to result in erosion or sedimentation worse than the current condition. Further, the removal of contaminant sources and physical stabilization of the site (e.g., capping of tailings) is expected to result in a net reduction of sedimentation and erosion. Nonetheless, mitigation measures will be required to minimize potential adverse effects. These measures will include standard operational practices to control erosion and sedimentation. Typical practices include: 1) When carrying out earthwork or vegetation clearing activities in the vicinity of a drainage course or a body of water, silt fences, floating silt curtains and/or containment berms will be used, as appropriate, to prevent the release of sediment into water. 2) Areas subject to potential erosion will remain open for the minimum period necessary to implement the required work. 3) Avoiding doing work during wet and rainy periods in areas where sedimentation poses a problem; 4) Directing run-off to vegetated areas away from a water body; 5) Properly containing and stabilizing stock-piled material and spoil piles to prevent sediment from entering any water body - this includes covering spoil piles with biodegradable mats or tarps or planting them with preferably native grass or shrubs. 6) Where suitable, planting disturbed areas, preferably with native trees, shrubs or grasses, and covering such areas with mulch to prevent erosion and to help seeds germinate. If there is insufficient time remaining in the growing season, the site should be stabilized (e.g., cover exposed areas with erosion control blankets to keep the soil in place and prevent erosion) and vegetated the following spring. 7) Erosion, sediment and drainage controls are to be maintained during all stages of work, inspected regularly, and repaired if damage occurs. Further details regarding erosion and sedimentation controls will be developed and submitted for approval as part of the submittals process for Environmental Management Plans.	No residual adverse effects are anticipated.	Yes. During the detailed design phase for Baker Creek and in the preparation of Environmental Management Plans.
Vegetation Clearing	Remediation	The clearing of vegetation could affect hydrology by encouraging obstructive erosion or sedimentation processes similar to those which earthworks might cause. Riparian vegetation cleared during the Baker Creek rehabilitation could affect, in very localized areas, the hydrological conditions of the creek.	Potential effects of vegetation clearing on erosion and sedimentation are represented in the previous discussion concerning the effects of earthworks. Taking into consideration the limited amount of vegetation clearing associated with the Project, such effects are anticipated to be negligible. Riparian vegetation in the Baker Creek channel plays a minor role in defining the stream's hydrological characteristics. Furthermore not all reaches of the creek will be subject to vegetation removal, thus limiting the extent of any possible effect.	Refer to earthworks mitigation. The footprint of areas requiring removal of vegetation is to be minimized. Similar to the successful work carried out in Reach 4, the rehabilitation of the Baker Creek will include efforts to restore riparian vegetation.	No residual adverse effects are anticipated.	No.

8.4.3 Surface Water Quality

8.4.3.1 Positive Effects of Remediation

A key goal of the Remediation Project is to protect the water resources of Baker Creek and Great Slave Lake from the adverse effects that would otherwise occur if arsenic sources on site were left unmanaged (particularly arsenic trioxide stored in underground vaults). Specifically, the first objective of the Remediation Project is:

> *"To 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"*

Once implemented, the Remediation Project will greatly reduce the risks associated with underground arsenic trioxide. The avoidance of such risks through the implementation of the frozen block method represents the greatest benefit of the Remediation Project.

In addition to the avoidance of risks noted above, the total arsenic loadings to Baker Creek after implementation of the remediation project are anticipated to reduce from 800 kg/year to 480 kg/year. Similarly, total arsenic loadings to Yellowknife Bay would drop from 910 kg/year to 690 kg/year. These reductions are expected to result in a measureable improvement to the water quality of Baker Creek and Yellowknife Bay over time. Predictions of post-remediation arsenic concentrations in surface water relative to applicable guidelines are summarized in Table 8.4.4.

Table 8.4.3 Arsenic Loadings to Surface Waters

Sources	Estimated Arsenic Releases to Water (kg/year)		
	Current	**Post-Remediation**	**No-Remediation**
Inputs to Baker Creek			
Baker Creek Upstream of Giant Mine	220	220	220
Tributaries from West of Giant Mine	67	67	67
Current Water Treatment Plant	290	n/a	n/a
Runoff from Surface Facilities to Baker Creek	220	190	220
Underground Mine to Baker Creek[a]	0	0	7,100
Total Inputs to Baker Creek	800	480	7,607
Inputs to Yellowknife Bay			
From Baker Creek	800	480	7,607
Direct Runoff to Yellowknife Bay	110	69	110
New Water Treatment Plant[b]	n/a	140	n/a
Total Inputs to Yellowknife Bay	910	690	7,717

Notes: Numbers may not add up due to rounding
n/a: not applicable
a: Estimates of arsenic release after complete flooding of the mine with uncontrolled discharge of the resulting contaminated minewater range from 2,000 – 12,000 kg/year.
b: The calculated arsenic loading of the New Water Treatment Plant is based on an annual average discharge concentration of approximately 400 µg/L. Actual performance of the New Water Treatment Plant may be better than this, as demonstrated by 2009 discharges to Baker Creek being on average 300 µg/L.

Table 8.4.4 Comparison of Post-Remediation Arsenic Concentrations Relative to Applicable Guidelines

	CCME Guideline for Protection of Freshwater Aquatic Life (5 µg/L)				Canadian Guideline for Drinking Water (10 µg/L)			
	Baker Creek	**Back Bay**	**North YK Bay**	**South YK Bay**	**Baker Creek**	**Back Bay**	**North YK Bay**	**South YK Bay**
Mean Arsenic Concentration (µg/L)	118	3	1.4	0.59	118	3	1.4	0.59
Meets CCME Guideline?	x	√	√	√	x	√	√	√

x – Both the mean and 95th percentile arsenic concentrations exceed the guideline
√ - All predicted arsenic concentrations are below the guideline; YK = Yellowknife
Source: SENES 2006

It is important to note that the improvements described above are relative to the current situation which includes the perpetual operation of the existing water treatment facility. In contrast, the benefits of the Remediation Project compared to an unmanaged scenario are much more striking. An unmanaged scenario would involve "walking away" from the site prior to implementing the proposed remedial works and allowing the mine to reflood. Under such a scenario, the total loads to Baker Creek and Yellowknife Bay have been estimated to be approximately 7,600 kg/year and 7,700 kg/year respectively. This would represent more than an eight-fold increase in the total arsenic loads to local surface waters. Although an unmanaged scenario would not be allowed to occur, the consequences associated with the scenario serve to illustrate the positive effects of the Remediation Project.

In addition to reduced arsenic loadings, the Remediation Project will result in other positive effects on surface water quality. For example, the capping of tailings facilities will reduce the potential for surface erosion which could lead to elevated turbidity in surface waters. Collectively, the full suite of Project activities is anticipated to result in substantive improvements in water quality, particularly relative to the unmanaged scenario.

8.4.3.2 Summary of Interactions

Table 8.3.1 identified a number of interactions between Project activities and Surface Water Quality. Only those interactions which were determined to have some potential for adverse effects were identified. The types of effects and associated activities related to surface water quality are as follows:

Minor Operational Releases:

- Surface drilling and freeze pipe installation (remediation);
- Decontamination of surface infrastructure (remediation);
- Sludge management (remediation and long-term operation & maintenance); and
- Fuel management (remediation).

Increased Turbidity in Water:

- Earthworks (all activities during remediation and long-term operation & maintenance); and
- Construction of Great Slave Lake outfall/diffuser (remediation).

Mobilization of Contaminants:

- Earthworks (all activities during remediation and long-term operation & maintenance, with the exceptions of borrow and backfill, and bedrock modification on surface during remediation);
- Construction of Great Slave Lake outfall/diffuser (remediation); and
- Discharge of treated minewater to Great Slave Lake (remediation and long-term operation and maintenance).

The potential formation of arsenic-contaminated pit lakes has not been evaluated. For the purpose of this assessment, it was assumed that partial dewatering of the mine will be maintained indefinitely at either the 425 Level or immediately below the base of the open pits at the 100 Level. Arsenic concentrations in water pumped from the mine are anticipated to remain at levels that will require long-term treatment. On this basis, scenarios involving raising minewater to levels that would allow for the formation of pit lakes are beyond the scope of this EA study.

8.4.3.3 Assessment of Potential Effects

Table 8.4.5 presents an assessment of Project-environment interactions and potential adverse effects on water quality. As described in the table, the majority of potential effects are typical of major construction projects involving extensive earthworks in the vicinity of surface water resources. Potential effects associated with such activities include increased turbidity caused by surface erosion and disturbance of sediments. In addition, there is a potential that existing contamination will be mobilized by construction activities (e.g., earthworks in contaminated soils and the construction of the new outfall / diffuser in Great Slave Lake). Although total arsenic loadings to surface waters are expected to decrease, discharge of treated minewater through the new diffuser represents a new point source of contamination to Great Slave Lake.

As described in Table 8.4.5, potential effects of the Project on Surface Water Quality include minor operational releases from a variety of activities (e.g., surface drilling and freeze pipe installation). Although minor releases are not expected to result in substantive effects on surface water quality, some residual effects may occur, regardless of the effectiveness of the selected mitigation measures.

Many of the activities associated with the Project involve disturbing granular materials and sediments. A key concern with such activities is the potential for increased erosion and turbidity which can have an adverse effect on water quality (intrinsic value). Due to their large footprint and extended duration, earthworks such as the contouring and capping of the tailings and sludge containment areas are a particular concern. Other earthworks in the near vicinity of surface waters (e.g., excavations in or near Baker Creek) are a concern due to the potential for increased erosion and turbidity if effective mitigation measures are not put in place. Increased turbidity can also occur in situations where the Project results in a disturbance of sediments. The construction of the Great Slave Lake outfall / diffuser is an example of such an activity.

In addition to increased turbidity, the Project also has the potential to mobilize contamination that is currently on site. Activities that could mobilize contamination are generally the same as those which could cause an increase in turbidity (i.e., earthworks and the construction of the Great Slave Lake oufall / diffuser). Consequently, the potential effects and mitigation for turbidity and mobilization of contamination are very similar. A notable exception is the discharge of treated minewater to Great Slave Lake; although the Project will result in an overall improvement of water quality, the point discharge from the new outfall may have an effect on water quality in the immediate vicinity.

The release of contaminants to surface waters could, in theory, lead to adverse effects on aquatic and terrestrial biota (via the surface water pathway). However, the long-term historic mobilization of contaminants within the surface water environment (e.g., during the operational period of the mine) is expected to dominate effects of this nature. In contrast, the short-term incremental effects of contaminant mobilization caused by the Remediation Project are anticipated to be negligible relative to baseline conditions. On this basis, while localized and short-term contaminant mobilization may occur during implementation of the Project, adverse effects on species interacting with surface waters are not anticipated. This includes aquatic species, wildlife and vegetation. Nonetheless, for completeness, this pathway effect has been advanced for consideration of effects on the Aquatic Environment (Section 8.7) and Terrestrial Environment (Section 8.8). The effects of contaminant concentrations in the environment have also been considered in the human health and ecological risk assessment (as summarized in Section 8.9).

8.4.3.4 Mitigation Measures

While the Project itself has been designed to eliminate and/or mitigate potential impacts to surface water environments, additional mitigation measures will be required to reduce the potential for new impacts during Project implementation. As noted in Table 8.4.5, mitigation measures to be implemented include:

- *Prevention practices* - Implementation of standard operational practices to prevent minor operational releases, erosion and contaminant mobilization;
- *Environmental Management Plans* - Preparation of comprehensive operational management plans (e.g., Environment, Health & Safety (EH&S) Plan, Fuel Management Plan and Spill Response Plan); and

- *Diffuser / outfall design* - Optimizing the location and performance of the outfall/diffuser to minimize effects on water quality.

8.4.3.5 Residual Effects

The adverse residual effects to Surface Water Quality, and, therefore, to its selected VCs (members of the public, water quality as an intrinsic value and identified as a key VC by the Review Board) that are anticipated to occur during Project implementation are listed below. The residual effects are based on the findings of Table 8.4.5 and have been forwarded to Chapter 12 for a determination of their significance.

- A small quantity of drilling fluids, potentially contaminated with arsenic, may enter surface waters;
- A small quantity of wash water from the decontamination of buildings, potentially contaminated with arsenic, may enter surface waters;
- A temporary increase in turbidity as a result of earthworks activities;
- A temporary increase in turbidity during the construction of the water treatment outfall and diffuser;
- Minor mobilization of contamination (e.g., soils and sediments) as a result of earthworks;
- Minor mobilization of contamination (e.g., sediments and pore water) during the construction of the outfall and diffuser;
- Treated minewater discharged from the diffuser will exceed the CWQG –FAL guideline for arsenic within a small volume of water; and
- The discharge of treated minewater may alter the thermal conditions of the water column in the vicinity of the diffuser.

As noted in Section 7.1.5, water quality is a key determinant in the condition of the Aquatic Environment, and also links to potential effects on Terrestrial VCs and Human Health. Due to these associated effects, Surface Water Quality is also presented as a potential pathway to effects on VCs in other environmental components considered in subsequent sections of Chapter 8.

While the Project may result in several short-term adverse effects on surface water quality, in the long-term, the Project is expected to have a positive influence on water quality by eliminating existing and future potential sources of contamination. However, there will be residual risks associated with elevated contaminant concentrations that will be present in surface waters after remediation. The implications of elevated contaminant concentrations in surface waters have been evaluated through a comprehensive human health and ecological risk assessment, as described in Section 8.9.

Table 8.4.5 Assessment of Potentially Adverse Effects on Surface Water Quality

Activity	Project Phase(s)	Description of Project-Environment Interactions	Analysis of Effects	Mitigation	Residual Effects	Is Further Consideration Required? When?
Minor Operational Releases						
Surface drilling and freeze pipe installation	Remediation	The drilling of surface holes for the installation of freeze pipes may result in minor operational releases of cuttings and drilling fluids into surface water. There is also a potential that contaminated materials (including arsenic trioxide) will be inadvertently brought to surface during the drilling process and that these materials will contaminate surface water. This contaminated surface water could ultimately affect Baker Creek, thereby affecting the aquatic and terrestrial environments as well as human health.	Given the quantity of drilling to occur, there is a reasonable potential that some form of operational release will occur during the course of regular Project activities. Under normal operating conditions there will be very few situations in which drilling fluid/cuttings would escape from the drill pad and be released into the surrounding environment. For drilling into the arsenic dust, cuttings will remain underground (there is a void space between the bedrock and the arsenic dust so all the cuttings will go into this void instead of up to the surface). Instead of wet drilling (e.g., with mud), drilling within arsenic dust is anticipated to involve dry techniques (i.e., air). The potential for releases to the atmospheric environment is considered in Section 8.6.	Comprehensive Environmental Management Plans appropriate for the nature of the work will be prepared. The plans will identify and address all activity and site-specific risks. Mitigation measures will be selected to address all identified risks. With regard to operational releases of cuttings and drilling fluids into surface water, the mitigation measures will be similar to those identified for erosion and sedimentation control (refer to Table 8.4.2). In addition, containment dikes/barriers will be used to prevent drilling fluids from escaping the drill pad where drilling is taking place. Capping of holes will also be performed to reduce the possibility of blow outs. Emergency response procedures will also be developed to address the potential for contaminated materials being released on surface during the drilling process.	Yes. A small quantity of drilling fluids, potentially contaminated with arsenic, may enter surface waters at some point during remediation.	Yes. During the preparation of Environmental Management Plans. Residual effect forwarded to Chapter 12 for an evaluation of significance.
Decontamination (of surface infrastructure)	Remediation	Prior to demolition and disposal, some structures and materials will be decontaminated (e.g. the Roaster Complex). While the decontamination procedure will be selected by the Remediation Contractor, it has been assumed that small quantities of contaminated wash water will be produced. This wash water, which is expected to have elevated arsenic concentrations, would be stored on site and/or treated prior to discharge	There is a potential that small volumes of untreated wash water would inadvertently be released to the surface water environment during the course of normal operating procedures. Any such releases could affect the environmental quality of Baker Creek. As with all liquid materials, the potential for releases of untreated wash water to the environment cannot be eliminated.	Measures as identified in the Environmental Management Plans. Anticipated measures include but are not limited to: minimizing the volume of wash water and construction of cut-off ditches and sumps.	Yes. A small quantity of wash water from the decontamination of buildings, potentially contaminated with arsenic, may enter surface waters at some point during remediation.	Yes. During the preparation of Environmental Management Plans. Residual effect forwarded to Chapter 12 for an evaluation of significance.
Sludge Management	Remediation Long-Term Operation & Maintenance	As part of the treatment process, the sludge by-product from water treatment will require management and disposal. The iron-arsenic precipitate (sludge) produced in the Water Treatment Plant will be dewatered prior to transport to an onsite landfill. Any leachate generated in the landfill will be collected, stored and treated as required prior to discharge.	There is a theoretical potential that some sludge or sludge leachate would escape collection and make its way to the surface water environment. The probability of a large release to surface waters prior to disposal is considered to be low as water treatment will be subject to continuous monitoring and operational oversight. Specifically the Water Treatment Plant and sludge management facilities will be subject to regular inspections. Furthermore, the form of arsenic in the treated sludge is fairly inert, with low solubility and limited bioavailability.	The sludge management system, including the landfill and leachate collection, will be designed such that the potential for sludge and sludge leachate releases is minimized. Regular monitoring will be conducted to verify performance. In addition, the Environmental Management Plans will include appropriate mitigation for inadvertent releases.	No residual adverse effects are anticipated.	Yes. During the preparation of Environmental Management Plans.

Table 8.4.5 Assessment of Potentially Adverse Effects on Surface Water Quality (Cont'd)

Activity	Project Phase(s)	Description of Project-Environment Interactions	Analysis of Effects	Mitigation	Residual Effects	Is Further Consideration Required? When?
Minor Operational Releases						
Fuel Management	Remediation	Similar to any other type of development that depends on heavy machine operation, there exists a potential for minor operational releases of fuel and other petroleum hydrocarbons during the course of active remediation.	Minor operational releases of fuel have the potential to affect water quality. Despite comprehensive efforts to control releases to the environment, complete containment of such releases is seldom possible.	As part of the Environmental Management Plans, Fuel Management and Spill Response Plans will be developed. Typical management and mitigation measures include: 1) Fuel in bulk quantities will be stored in double-walled containers. The fuel dispensing area will be lined and a sump will be dug to collect any spills that may occur. 2) An emergency response plan will be in place to deal with fuel spills and other types of unauthorized discharges. 3) Spill kits will be available at fuel storage and dispensing facilities. 4) Spill response training will be provided to personnel. 5) Daily inspection of vehicles and fuel storage facilities will be carried out. The volume of fuel released (if any) is expected to be small and the Spill Response Plan is anticipated to be effective in controlling any releases. With the mitigation measures in place, it is unlikely that large quantities of fuel would be released to water.	No residual adverse effects anticipated.	Yes. During the preparation of Environmental Management Plans.
Increased Turbidity in Water						
Earthworks (all activities)	Remediation Long-Term Operation & Maintenance	Earthworks have been identified as a potential cause of increased erosion. One of the primary concerns of erosion is the potential for increased turbidity that can negatively affect water quality. Relative to other earthworks, the spatial extent of activities required to contour and cap the tailings areas and sludge ponds is large. Exposure of unconsolidated granular materials to surface flow may result in increased erosion rates. Likewise, activities associated with the excavation of contaminated soils and contouring of these areas have the potential to contribute suspended solids loadings to Baker Creek and Great Slave Lake. Since surface water is a pathway to the aquatic environment, this potential effect on surface water quality could adversely affect aquatic habitat and biota.	By definition, virtually all sources of erosion have the potential to increase concentrations of suspended solids in water (i.e., turbidity). Excavation of soils or sediments in the vicinity of Baker Creek is considered to be the "worst-case" scenario of such activities. In the absence of mitigation, excavation of soils and/or sediments in the vicinity of the creek has the potential to result in increased turbidity. In addition to the creek itself, the spatial extent of such effects could extend to the littoral zone of Great Slave Lake in the vicinity of the creek discharge. Any turbidity increases are expected to be temporary in nature and the extent of the turbidity plume will be limited due to the high-energy environment of Baker Creek and Great Slave Lake which will encourage rapid plume dissipation. In addition, the incorporation of standard mitigation measures will reduce the possibility of such effects.	Mitigation measures to avoid increases in turbidity while remediation activities are being carried out are the same as those for erosion and sedimentation control. These measures were detailed in Section 8.4.2.4 and in Table 8.4.2 with respect to erosion and sedimentation that might be caused by earthworks activities. Although detailed designs have yet to be developed, currently disturbed areas (e.g. tailings areas, sludge management ponds and contaminated soils sites) are expected to be vegetated using a mixture of agronomic and native species to reduce surface erosion potential.	Yes. While mitigation measures are expected to be effective in reducing turbidity, complete avoidance of this effect is seldom possible. A temporary increase in turbidity as a result of earthworks activities is, therefore, anticipated.	Yes. During the preparation of Environmental Management Plans. Residual effect forwarded to Chapter 12 for an evaluation of significance.

Table 8.4.5 Assessment of Potentially Adverse Effects on Surface Water Quality (Cont'd)

Activity	Project Phase(s)	Description of Project-Environment Interactions	Analysis of Effects	Mitigation	Residual Effects	Is Further Consideration Required? When?
Construction of Great Slave Lake outfall / diffuser	Remediation	Detailed designs and the method of construction for the outfall / diffuser have yet to be finalized. For the purpose of the DAR, it has been assumed the outfall will be constructed using small diameter polyethylene plastic pipe placed directly on the lake bottom and anchored with weights, except in the section near the shoreline, which would be installed in an excavated trench or covered with rip rap within the ice scour zone. Three outfall alignments and diffuser locations are under consideration. For the purpose of the DAR, an estimated outfall length of 1,500 m and a diffuser depth of 10 m have been assumed. Some disturbances of sediment are likely to occur during the construction of the outfall / diffuser, particularly in near-shore environments where trenching may be required.	Disturbances of sediment along the outfall alignment would result in localized increases in turbidity and potentially affect aquatic biota residing in or frequenting that area. However, as described in Section 7.4.2.1, there appears to be nothing unique about the existing habitat along the three alignments that are currently being considered and similar habitat occurs throughout the Back Bay and North Yellowknife Bay areas. The fish habitat has been characterized as marginally to moderately suitable spawning habitat for northern pike, white sucker, longnose sucker, and possibly lake trout and lake whitefish. There is considerable tailing (silt) deposits from earlier mining activities in the substrate which may affect spawning activities and fish egg survival. Given the high energy environment of the shoreline (e.g., mixing and dispersion from wave action) of Great Slave Lake, it is anticipated that any turbidity would quickly dissipate. Taking into consideration the proposed mitigation measures, any increases in turbidity are anticipated to be localized and of short duration.	Silt curtains will be employed during construction of the outfall to minimize the area affected by dispersion of sediment solids disturbed during placement of the outfall pipe. At the completion of construction activities, the silt curtain will not be removed until suspended sediment levels return to background conditions.	Yes. While mitigation measures are expected to be effective in reducing turbidity, complete avoidance of this effect is seldom possible. Construction of the diffuser / outfall is, therefore, anticipated to cause a temporary increase in turbidity.	Yes. During the preparation of Environmental Management Plans. Residual effect forwarded to Chapter 12 for an evaluation of significance.
Mobilization of Contaminants						
Earthworks (all activities, excluding Borrow and backfill, and Bedrock modification on surface).	Remediation Long-Term Operation & Maintenance	Earthworks have been identified as a potential cause of increased erosion. Any contaminated materials that are eroded could be distributed in the aquatic environment, thereby causing effects to aquatic species and habitat.	There are currently several sources on site that are gradually releasing contaminants to the surface water environment. While these sources will be addressed as part of the Remediation Project, any earthworks in contaminated areas have the potential to temporarily increase the rate at which contaminants are released, particularly through erosion. Excavation of contaminated soils or sediments in the vicinity of Baker Creek is considered to be the "worst-case" scenario for such activities. The release of contaminants to surface waters could lead (via the surface water pathway) to adverse effects on aquatic and terrestrial biota. However, the long-term historic mobilization of contaminants within the surface water environment (e.g., during the operational period of the mine) is expected to dominate effects of this nature. In contrast, the short-term incremental effects of contaminant mobilization caused by the Remediation Project are anticipated to be negligible relative to baseline conditions. On this basis, while localized and short-term contaminant mobilization may occur during implementation of the Project, effects on species interacting with surface waters are not anticipated. This includes aquatic species, wildlife and vegetation. Nonetheless, for completeness, this pathway effect has been advanced for consideration of effects on the Aquatic Environment (Section 8.7) and Terrestrial Environment (8.8). The effects of contaminant concentrations in the environment have also been considered in the human health and ecological risk assessment (as summarized in Section 8.9).	Refer to the mitigation measures for erosion and sedimentation effects presented for hydrology (Table 8.4.2). In addition to standard erosion control measures, mitigation for earthworks occurring in contaminated areas will include collection of surface runoff and excavation water at low points in the area being remediated. Water will be stored, sampled and, if required, treated prior to discharge. While small quantities of surface water runoff may escape collection from areas in close proximity to Baker Creek, it is expected that the effects would be limited to the short period of time when the excavation work is carried out. Short-term incremental adverse effects are anticipated to be minor relative to the long-term positive effects of remediation. Further details regarding erosion and sedimentation controls will be developed and submitted for approval as part of the Environmental Management Plans. This aspect will be investigated during the detailed design phase.	Yes. Although mitigation measures are expected to be effective in reducing mobilization of contaminants, complete avoidance of this effect is seldom possible. A temporary increase in contaminant mobilization as a result of earthworks activities is therefore anticipated.	Yes. During the preparation of Environmental Management Plans. Residual effect forwarded to Chapter 12 for an evaluation of significance.

Table 8.4.5 Assessment of Potentially Adverse Effects on Surface Water Quality (Cont'd)

Activity	Project Phase(s)	Description of Project-Environment Interactions	Analysis of Effects	Mitigation	Residual Effects	Is Further Consideration Required? When?
Construction of Great Slave Lake outfall / diffuser	Remediation	Depending on the construction method, some disturbances of sediments in Great Slave Lake may occur during the construction of the outfall / diffuser. Arsenic contamination present in the sediments from the historic operation of the mine may be released into the water column during this process.	Sediments in the vicinity of the proposed alignments for the outfall /diffuser have elevated concentrations of arsenic and other metals as a consequence of the historic operation of the mine (i.e., through the discharge of tailings, discharge of minewater and atmospheric deposition). Mobilization of these contaminants into the water column could affect both aquatic and terrestrial (semi- aquatic) biota such as benthic invertebrates, fish and muskrat. However, any potential increases in contaminant concentrations in the water column associated with construction are not anticipated to be measurable beyond the immediate vicinity of the outfall / diffuser alignment. Further, any effects that might occur are expected to rapidly dissipate following the placement of the outfall / diffuser. Within the context of the long-term positive effects associated with re-locating the discharge point for treated minewater from Baker Creek to Great Slave Lake, any short-term and minor contaminant mobilization attributable to the construction of the outfall / diffuser is considered to be minor.	Measures to control mobilization of contamination during the construction of the outfall / diffuser will be the same as those used to control turbidity (i.e., silt curtains).	Yes. Complete containment within the silt curtain is not likely. Further, while the silt curtain will control contamination associated with suspended solids, it is not expected to control the mobilization of dissolved metals. Construction of the diffuser / outfall is therefore anticipated to result in a temporary increase in contaminant mobilization.	Yes. During the detailed design phase for the outfall/diffuser and in the preparation of Environmental Management Plans. Residual effect forwarded to Chapter 12 for an evaluation of significance.
Discharge of treated minewater to Great Slave Lake	Remediation Long-Term Operation & Maintenance	The relocation of the treated minewater discharge point from Baker Creek to Great Slave Lake will improve water quality within the creek, particularly during the summer months when discharge currently occurs. While the Remediation Project will also result in a net reduction of arsenic loadings to Great Slave Lake, the discharge of treated minewater through the new outfall/diffuser represents a new point source to the lake. The direct deposition of treated minewater into Great Slave Lake has implications on water quality and water temperatures directly adjacent to the proposed diffuser, and hence to the terrestrial and aquatic biota frequenting that area.	The design goal for the diffuser is to achieve a minimum dilution ratio of 80:1 (i.e., 80 parts lake water to 1 part effluent) within the initial mixing zone, which is defined by the area in the near-field where turbulent conditions generated at the diffuser ports results in effective mixing of effluent with lake water. The preliminary diffuser design indicates that a dilution ratio of 80:1 can be achieved within an area of less than 250 m^2 (Hay 2005). This area is equivalent to that of the red dots displayed in Figure 6.8.4. The 80:1 dilution ratio was selected to reduce arsenic concentrations in the receiving water to below the CWQG-FAL of 5 µg/L (0.005 mg/L) outside of the initial mixing zone. As described in Section 7.1.3.1, the CWQG-FAL values are broadly applicable, conservative values that endeavour to protect the most sensitive life stages of the most sensitive species in aquatic ecosystems. The CWQG-FAL values also aim toward concentration levels where no observable effects are expected to occur. The modelling for the preliminary diffuser design assumed a maximum arsenic concentration in treated minewater of 400 µg/L (0.4 mg/L) when in fact, the average arsenic concentration in the discharge is likely to be less; a well-operated plant employing Best Available Technology (BAT) can meet an average discharge level of about 200 µg/L (0.2 mg/L) of arsenic on an annual average basis. At an average annual discharge arsenic concentration of 200 µg/L (0.2 mg/L) and a dilution factor of 80:1, the arsenic concentration at the edge of the mixing zone would increase by 2.5 µg/L (i.e., one-half the CWQG-FAL). In addition to arsenic present in the treated minewater, the thermal effects of the discharge must also be considered, particularly during winter when Great Slave Lake is covered with ice. The primary concern in this regard is human safety; if	Optimizing the performance of the selected water treatment technology to ensure discharge concentrations are maintained as low as reasonably achievable. The diffuser itself is an "in design" mitigation feature that is intended to minimize potential environmental effects of the discharge (both chemical and thermal). The diffuser location and detailed design will be optimized to ensure the design goals are met. If dispersion is insufficient to avoid adverse effects to ice cover, consideration will be given to cooling the treated minewater prior to discharge. Similarly, access restrictions in the vicinity of the diffuser will be considered (e.g., temporary fencing of areas with insufficient ice cover).	Yes. Treated minewater discharged from the diffuser will exceed the CWQG –FAL guideline for arsenic within a small mixing zone. The discharge will also alter the thermal conditions of the water column in the vicinity of the diffuser.	Yes. During the detailed design phase for the outfall/diffuser. Residual effects forwarded to Chapter 12 for an evaluation of significance.

Table 8.4.5 Assessment of Potentially Adverse Effects on Surface Water Quality (Cont'd)

Activity	Project Phase(s)	Description of Project-Environment Interactions	Analysis of Effects	Mitigation	Residual Effects	Is Further Consideration Required? When?
			heat carried in the discharge water delays or prevents the formation of ice, there may be an increased risk that individuals traveling on the lake (e.g., by snowmobile) would fall through the ice. In addition, if the thermal loading is not adequately dispersed, localized effects on aquatic biota could occur. However, similar to chemical dispersion, any temperature differential between the discharge and receiving water would rapidly be reduced by the mixing of lake and effluent waters in the near-field mixing zone. Also, because mine water temperature is typically in the range of 4 to 6^0C, the thermal loading is not expected to be an issue.			

8.4.4 Sediment Quality

8.4.4.1 Positive Effects of Remediation

As described in Section 6.9, the remediation of Baker Creek may include removal of contaminated sediments; covering contaminated sediments (to limit direct exposures and transfer to the water column); and/or rerouting the creek through uncontaminated areas. Regardless of the approach used, consideration will also be given to the placement of new granular material to optimize the hydrological and ecological performance of the creek. These physical alterations will result in an overall improvement in the sediment quality of Baker Creek within the SSA.

As noted in Section 8.4.3, the Project will also have a positive effect on the water quality of Baker Creek and Great Slave Lake in the vicinity of the mine. The lower arsenic concentrations in water are anticipated to have a positive influence on the quality of sediment by reducing the rate at which arsenic is transferred from water to sediment. The Project will also isolate contaminant sources that could otherwise continue to contribute contaminant loads to surface waters and sediment through erosion and/or leaching. For example, excavation and management of contaminated soils in the vicinity of the Roaster Complex will eliminate an ongoing source of contaminant loads to the sediments of Baker Creek.

8.4.4.2 Summary of Interactions

Table 8.3.1 identified a number of interactions between Project activities and the quality of sediment in the vicinity of the site. Only those interactions which were determined to have some potential for adverse effects were identified. When selecting Project-environment interactions, it was acknowledged that any effects on water quality could also influence sediment quality. However, water quality effects that were determined in Section 8.4.2 to be unlikely or potentially minor, were not evaluated due to the even lower probability of adverse effects on sediment quality. Taking this into consideration, the types of effects and activities associated with sediment quality are as follows:

Mobilization of Contaminants:

- Earthworks (all activities during remediation and long-term operation & maintenance, with the exception of Borrow and backfill, and Bedrock modification on surface during remediation);
- Construction of Great Slave Lake outfall/diffuser (remediation); and
- Discharge of treated minewater to Great Slave Lake (remediation and long-term operation and maintenance).

Minor Operational Releases

- Decontamination of surface infrastructure (remediation).

8.4.4.3 Assessment of Potential Effects

Table 8.4.6 presents an assessment of Project-environment interactions and potential adverse effects on sediment quality. As described in detail in the table, there is some potential that contaminants mobilized during earthworks, the construction of the outfall / diffuser and the discharge of treated minewater to Great Slave Lake would result in the deposition of additional contaminants to sediments.

During the Remediation Phase, earthworks are not anticipated to result in erosion or sedimentation any worse than the current condition. While some contaminant mobilization may occur, the effects on sediment quality are expected to be minor. Similarly, although localized disturbances of sediments will occur during the construction of the outfall / diffuser, it is unlikely that any adverse effects to sediment quality will be measurable. With regard to the discharge of treated minewater from the new diffuser in Great Slave Lake, rapid mixing within the water column is anticipated to reduce the potential for adverse effects on sediment quality in the near vicinity of the diffuser.

8.4.4.4 Mitigation Measures

As noted in Section 8.4.4.1, the Project will help to mitigate historic impacts to sediments within Baker Creek. Lower arsenic loads from the site are also expected to reduce the potential for further contamination. Nonetheless, additional mitigation measures will be required to minimize any adverse effects on sediment quality associated with the implementation of certain Project activities. These mitigation measures, which are described in more detail in Table 8.4.6, include:

- *Prevention and emergency response* – Standard operational practices to prevent contaminant mobilization and minimize sediment disturbances will be defined in Environmental Management Plans.
- *Baker Creek design* – The construction process for the realignment of the creek will be designed to control the potential for adverse effects associated with sediment disturbances. Overall, the optimization of the creek design will offset any localized and minor sediment quality effects that might occur in the short-term.
- *Outfall / diffuser design* –The detailed designs (including location) for the outfall/diffuser will be selected to minimize potential sediment disturbances and disruption of fish habitat during construction and to minimize the zone of influence associated with treated minewater discharges.

8.4.4.5 Residual Effects

The adverse residual effects to Sediment Quality and its associated VC (i.e., the intrinsic value of sediments) that have the potential to occur during Project implementation are listed below. The residual effects are based on the findings of Table 8.4.6 and have been forwarded to Chapter 12 for a determination of their significance. The residual effects are as follows:

- Mobilization of contaminated soils, sediment and pore water during earthwork activities;
- Mobilization of contaminants during construction of the diffuser/outfall; and
- Increased contaminant loadings in the vicinity of the diffuser in Yellowknife Bay (Great Slave Lake).

As noted in Section 7.1.5, the quality of sediment is a key determinant in the condition of the Aquatic Environment. Due to these associated effects, Sediment Quality is also presented as a potential pathway to effects on VCs in the Aquatic Environment component. The implications of these and other related effects have been evaluated through a comprehensive human health and ecological risk assessment, as described in Section 8.9.

Table 8.4.6 Screening of Potentially Adverse Effects on Sediment Quality

Activity	Project Phase(s)	Description of Project-Environment Interactions	Analysis of Effects	Mitigation	Residual Effects	Is Further Consideration Required? When?
Mobilization of Contaminants						
Earthworks (all activities, excluding work in previously undisturbed materials)	Remediation Long-Term Operation & Maintenance	As described in detail in Chapter 5, contamination is currently present at a number of areas throughout the site. In general, earthworks and other Project activities are anticipated to be effective in mitigating any long-term adverse effects associated with these contaminant sources. However, during the course of Project implementation, short-term increases in erosion rates may occur. This has the potential to release contaminated and uncontaminated materials into the surface water environment. Materials released to the water column will ultimately settle and, as a consequence, have the potential to affect sediment quality. Release of leachable contaminants may also occur as a result of disturbance of contaminated sediments and/or soils. In turn, these potential effects could have an adverse effect on aquatic biota, particularly benthic invertebrates.	Potential sources of erodible solids and leachable contaminants warranting the most attention include those activities which: 1) are a source of chemical contaminants; 2) occur in the near vicinity of natural water bodies; and/or 3) involve large areas being exposed for extended periods. Based on these factors, for activities involving earthworks, the excavation of contaminated soils or sediments in the vicinity of Baker Creek is considered to have the greatest potential for contaminant mobilziation. While the potential effects of erosion and sedimentation can be readily identified, they are difficult to quantify accurately due to the influence of numerous variables (e.g., material properties, ambient conditions, stream "energy", precipitation events and intensities, contaminant concentrations). In this context, a conservative approach is typically adopted whereby appropriate mitigation measures are put in place for all activities subject to erosion (e.g., those measures identified in Table 8.4.2). Taking into consideration the nature of remediation activities, the earthworks are not anticipated to result in erosion or sedimentation any worse than the current condition. Further, the removal of contaminant sources and/or physical stabilization of the site is expected to result in a net reduction in erosion potential. Nonetheless, mitigation measures will be required to minimize potential adverse effects associated with contaminants mobilized by earthworks.	The mitigation measures to address erosion and sedimentation effects related to on-site hydrology (Table 8.4.2) are also applicable to sediment quality. During the rehabilitation of Baker Creek, to limit the possibility of mobilizing sediment solids and/or contaminated pore water, leading to further contamination downstream, earthworks will be carried out while the creek is dewatered wherever possible. In creek reaches where realignment is planned, remediation work can be carried out under dry conditions after creek flows have been diverted or during periods approved by DFO Further details regarding erosion and sedimentation controls will be developed as part of the Environmental Management Plans. Collection of contaminated water in areas with high dissolved arsenic or PHC concentrations for subsequent treatment may also be required. This aspect will be investigated during the detailed design phase.	Yes. Mobilization of contaminated soils, sediment and pore waters during earthwork activities may have an adverse effect on sediment quality.	Yes. During the detailed design phase for Baker Creek *and* in the preparation Environmental Management Plans. Residual effect forwarded to Chapter 12 for an evaluation of significance.
Construction of Great Slave Lake outfall / diffuser	Remediation	Depending on the construction method, sediments in the vicinity of the proposed outfall/diffuser alignments with elevated concentrations of arsenic and other metals may be disturbed during the Remediation Phase. By disturbing these sediments, existing contamination may be mobilized and, as a consequence, other sediments in the vicinity may be affected. In its role as a pathway, this altered sediment quality could have an adverse effect on aquatic habitat and biota.	Disturbance from construction may cause sediment, as well as dissolved metals, such as arsenic, to be agitated and mobilized into the water column, with possible deposition in sediments elsewhere in Yellowknife Bay. The quantity of sediment that might be disturbed during the construction of the outfall/diffuser is very small relative to the entire footprint of historically impacted sediment in North Yellowknife Bay. Further, it is unlikely that any adverse effects to existing sediment quality attributable to sediment disturbances during construction will be measurable.	A silt curtain will be utilized to minimize the effects of sediment disturbance during construction of the outfall. However, mobilization of dissolved metals such as arsenic in the lake sediments may still occur.	Yes. Mobilization of existing contaminants during construction of the diffuser/outfall may have an adverse effect on sediment quality.	Yes. During the detailed design phase for the outfall/diffuser *and* in the preparation of Environmental Management Plans. Residual effect forwarded to Chapter 12 for an evaluation of significance.

Table 8.4.6 Screening of Potentially Adverse Effects on Sediment Quality (Cont'd)

Activity	Project Phase(s)	Description of Project-Environment Interactions	Analysis of Effects	Mitigation	Residual Effects	Is Further Consideration Required? When?
Discharge of treated minewater to Great Slave Lake	Remediation Long-Term Operation & Maintenance	The relocation of the treated minewater discharge point from Baker Creek to Great Slave Lake will reduce chemical loads to the creek. As a consequence, the potential for arsenic deposition to the sediments of the creek will be reduced. However, the chemical loads will be transferred to the vicinity of the diffuser in Great Slave Lake. Contaminants discharged from the diffuser have the potential to affect the sediments of Yellowknife Bay.	The detailed design of the diffuser will optimize the dispersion of treated minewater. The currently proposed locations of the diffuser have been selected due to their ability to best contribute to the dispersion. These factors will reduce the potential for contaminant exchange with sediments.	The detailed designs (including location) for the outfall/diffuser will be selected to minimize potential sediment disturbances and disruption of fish habitat during construction. The outfall/diffuser will incorporate multiple ports to optimize mixing with Yellowknife Bay water and minimize the zone of influence of the discharge plume.	Yes. Increased contaminant loadings in the vicinity of the new diffuser that may have an adverse effect on sediment quality.	Yes. During the detailed design phase for the outfall/diffuser. Residual effect forwarded to Chapter 12 for an evaluation of significance.
Minor Operational Releases						
Decontamination (of surface infrastructure)	Remediation	Prior to demolition and disposal, some structures and materials will be decontaminated (e.g. the Roaster Complex). While the decontamination procedure will be selected by the Remediation Contractor, it has been assumed that small quantities of contaminated wash water will be produced. This wash water, which is expected to have elevated arsenic concentrations, would be stored on site and/or treated prior to discharge.	As described in Table 8.4.5, there is a potential that small volumes of untreated wash water would inadvertently be released to the environment during the course of normal operating procedures. Theoretically, arsenic present in any such releases could affect sediment quality. However, taking into consideration the mitigation measures that will be put in place and the small volumes of untreated wash water that might be released, it is unlikely that adverse effects to sediment quality would occur during decontamination activities.	Measures as identified in the Environmental Management Plans. Anticipated measures include but are not limited to: minimizing the volume of wash water and construction of cut-off ditches and sumps.	No residual adverse effects are anticipated.	Yes. During the preparation of Environmental Management Plans.

8.5 Geological and Hydrogeological Environment

Potential adverse effects of the Project on the geological and hydrogeological environment are evaluated in this section. The analysis was conducted based on the environmental sub-components of groundwater flow, groundwater quality, soil quality and permafrost. These sub-components have been dramatically altered by the historic operation of Giant Mine (as previously described in Chapters 5 and 7).

8.5.1 Evaluation Criteria

The evaluation criteria listed in Table 8.5.1 were used to assist with the analysis of potential effects on the Geological and Hydrogeological Environment. The fact that any subsurface contamination is effectively contained within the SSA through the continued drawdown of groundwater was considered when selecting the criteria. Similarly, although groundwater is a theoretical pathway to other environmental components (Aquatic Environment, Terrestrial Environment and Human Health), the hydraulic capture zone created by the drawdown eliminates this pathway. As a consequence, uncontrolled releases from the SSA and/or migration to other environmental components will not occur under normal operating conditions.

Table 8.5.1 Evaluation Criteria for the Geological and Hydrogeological Environment

Environmental Sub-component	Evaluation Criteria
Groundwater Flow	• The degree to which groundwater flows may result in contaminant migration to areas beyond the SSA • Whether a change may result in groundwater flows being more representative of natural conditions
Groundwater Quality	• Predicted increases in contaminant concentrations in groundwater beyond the SSA • Health Canada Canadian Drinking Water Quality Guidelines
Soil Quality	• Predicted increases in contaminant concentrations in soils • Site Remediation Criteria for Arsenic in the Yellowknife Area • CCME Soil Quality Guidelines (Industrial Criteria) • Human Health and Ecological Risk Assessment findings
Permafrost	• Loss of permafrost in previously undisturbed ground

8.5.2 Groundwater Flow

Under baseline conditions, the dewatering of the mine has resulted in a major alteration of the natural groundwater flow regime in the vicinity of the site. There are no mechanisms by which the continued drawdown will have an incremental adverse effect on groundwater flow (e.g., increased off-site flow and contaminant migration relative to baseline conditions). On the contrary, several Project activities will reduce the possibility of groundwater flow through contaminated areas (e.g., the freezing of arsenic trioxide chambers and drawdown of minewater). On this basis, further analysis of potentially adverse effects on groundwater flow is not required. As such, no residual adverse effects are anticipated on the Groundwater Flow sub-component.

Since the groundwater flow through contaminated areas will be reduced, no adverse effects on the aquatic or terrestrial environments from groundwater flow (i.e., a pathway) would occur.

8.5.3 Groundwater Quality

8.5.3.1 Positive Effects of Remediation

A key criterion for the selection of the remedial approaches described in Chapter 6 was the extent to which each approach would limit the potential for groundwater contamination. The implementation of the remedial approaches is expected to result in almost complete containment of existing site contamination and will achieve a substantive reduction of environmental risks relative to current conditions. Examples of positive groundwater quality effects associated with the Project are summarized below.

Underground Arsenic Inventory – The frozen block method is expected to completely isolate arsenic trioxide present in underground vaults. However, the mine also has a large inventory of materials outside of the proposed frozen zones (e.g., tailings and waste rock backfill) that also contain soluble arsenic compounds. Some of this material will be submerged during the partial reflooding of the mine and, over time, arsenic will be released into the groundwater that infiltrates into the mine workings. Any arsenic released through this process will continue to be contained and treated in the new water treatment plant as long as necessary to prevent the potential for adverse effects.

Tailings and Sludge Containment Areas – Arsenic present in the tailings and sludge containment areas on surface is currently leaching and infiltrating into the subsurface. The re-contouring and capping of these areas will reduce the rate of leaching and infiltration, particularly from the Northwest Pond In addition, the continued collection and treatment of groundwater that has percolated through the tailings and into the underground mine will assist in reducing the effects of arsenic released to groundwater through this process.

Overall, the Project is expected to result in the elimination of adverse effects to groundwater that would otherwise occur if the current sources of contamination were left unmanaged.

8.5.3.2 Summary of Interactions

As noted above, many Project activities are being implemented with the objective of protecting groundwater quality. In this context, there are very few activities that have potential to cause adverse effects on groundwater quality. The type of effect and activities associated with groundwater quality are:

Minor Operational Releases:

- Transportation (remediation); and
- Fuel management (remediation).

8.5.3.3 Assessment of Potential Effects

Minor operational releases from transportation and fuel management are a potential concern. The materials of greatest interest include those which are contaminated with arsenic trioxide, and hydrocarbon fuels, which could be spilled during the course of Project implementation. However, taking into consideration standard mitigation measures that will be in place (e.g., EH&S and Spill Response Planning), the potential for a minor operational release leading to an adverse effect on groundwater quality is considered to be very low. Furthermore, the hydraulic capture zone, would serve to eliminate the possibility of any contamination having an adverse effect on the receiving environment surrounding the Project.

8.5.3.4 Mitigation Measures

As discussed above and in Table 8.5.2, a variety of "in design" features will serve to limit the potential for the Project to result in contamination of groundwater outside the footprint of the SSA. Any minor operational releases would be captured within the induced hydraulic capture zone of the mine workings.

8.5.3.5 Residual Effects

With mitigation measures in place, no adverse residual effects on Groundwater Quality are anticipated, and hence, no residual effects on the VCs selected for groundwater quality (intrinsic value of groundwater, member of the public) are expected.

Table 8.5.2 Assessment of Potentially Adverse Effects on Groundwater Quality

Activity	Project Phase(s)	Description of Project-Environment Interactions	Analysis of Effects	Mitigation	Residual Effects	Is Further Consideration Required? When?
Minor Operational Releases						
Transportation	Remediation	Minor operational releases of hydrocarbons or materials contaminated with arsenic trioxide during transportation could enter groundwater.	It is unlikely that the quantities of contaminants that would escape to the environment under a "Minor Operational Release" scenario would result in substantive groundwater contamination.	As part of the Environmental Management Plans, Fuel Management and Emergency/Spill Response Plans will be prepared. Typical management and mitigation measures include: 1) Fuel in bulk quantities will be stored in double-walled containers. The fuel dispensing area will be lined and a sump will be dug to collect any spills that may occur. 2) An emergency response plan will be in place to deal with fuel spills and other types of unauthorized discharges. 3) Spill kits will be available at fuel storage and dispensing facilities. 4) Spill response training will be provided to personnel. 5) Daily inspection of vehicles and fuel storage facilities will be carried out. In addition to the specific mitigation measures cited above, the hydraulic capture zone maintained under the SSA ensures that spills making contact with the water table are unable to migrate beyond the site .	No residual adverse effects are anticipated.	Yes. During the preparation of Environmental Management Plans.
Fuel management	Remediation	Minor operational release of hydrocarbons during vehicle refuelling and maintenance could enter groundwater.			No residual adverse effects are anticipated.	Yes. During the preparation of Environmental Management Plans.

8.5.4 Soil Quality

As described in Chapter 5, the soil[27] quality of some areas within the SSA has been adversely affected by historic mining operations. For example, areas have been contaminated with arsenic by emissions from the processing facilities, tailings spills, and use of mine rock for construction. Soils have also been contaminated by other metals and petroleum hydrocarbons. Although not classified as soil, tailings present in the four surface impoundments also represent a potential contaminant source.

8.5.4.1 Positive Effects of Remediation

The Project will involve the implementation of a variety of activities to control potentially adverse effects associated with historic soil contamination. Examples of those activities include: i) excavating and managing soils that exceed specified clean-up criteria (i.e., the GNWT industrial criterion for arsenic); ii) decontamination, demolition and disposal of contaminated structures and equipment; and iii) capping tailings areas and sludge ponds. Collectively these activities are expected to improve the overall quality of the soil on site.

8.5.4.2 Summary of Interactions

As indicated in Table 8.3.1, Minor Operational Releases were identified as the only mechanism by which adverse effects to soil quality might occur during normal operating conditions. The activities with some potential to cause new soil contamination were determined to be:

- Transportation (remediation); and
- Fuel management (remediation).

While other activities might result in contaminant releases that could affect soil quality (e.g., a spill of arsenic trioxide on surface), such events would not be part of normal operations and, as a consequence, have not been considered in this analysis. Instead, such scenarios have been considered in the analysis of accidents and malfunctions (as presented in Chapter 10).

8.5.4.3 Assessment of Potential Effects

Table 8.5.3 presents an analysis of potential adverse effects of the Remediation Project on soil quality. By definition, minor operational releases involve small releases over a limited spatial area for a short duration. A small fuel spill, lubricant leak or the tracking of contaminated soils from one area to another are representative examples of such releases. It is expected that

[27] For the purposes of this evaluation, "soil" is considered to include all granular materials on surface (i.e., native soils and other granular materials associated with the historic operation of the mine).

transportation and fuel management activities will follow standard operating procedures that minimize the potential for releases that could adversely affect soil quality. While these procedures are expected to be highly effective, the possibility of minor operational releases cannot be completely be eliminated.

8.5.4.4 Mitigation Measures

As noted in Table 8.5.3, mitigation measures to be implemented include:

- *Vehicle maintenance* – Regular scheduled vehicle inspection and maintenance to prevent hydrocarbon leaks;
- *Prevention practices* - Implementation of standard operational practices to prevent minor operational releases; and
- *Environmental Management Plans* - Preparation of Environmental Management Plans to prevent and mitigate potential effects to soils.

In addition to the measures mentioned above, releases of contaminants can be also be mitigated by applying the remediation techniques that will be used for other aspects of the Project (e.g., for areas currently contaminated with hydrocarbons).

8.5.4.5 Residual Effects

The adverse residual effect to soil quality and its associated VC (intrinsic value of soil quality, member of the public) that has the potential to occur during implementation of the Remediation Project is listed below. The residual effect is based upon the findings of Table 8.5.3 and has been forwarded to Chapter 12 for a determination of its significance.

- Operational releases of hydrocarbons and arsenic-contaminated materials associated with transportation activities.

As noted in Section 7.2.7, soil quality is a determinant in the condition of the Aquatic Environment, the Terrestrial Environment and Human Health. Due to these associated effects, Soil Quality is also presented as a potential pathway to effects on VCs in those environmental components. On this basis, the implications of elevated contaminant concentrations in soils have been evaluated through a comprehensive human health and ecological risk assessment, as described in Section 8.9.

Table 8.5.3 Screening of Potentially Adverse Effects on Soil Quality

<table>
<tr><th>Activity</th><th>Project Phase(s)</th><th>Description of Project-Environment Interactions</th><th>Analysis of Effects</th><th>Mitigation</th><th>Residual Effects</th><th>Is Further Consideration Required? When?</th></tr>
<tr><td colspan="7">Minor Operational Releases</td></tr>
<tr><td>Transportation</td><td>Remediation</td><td>Minor operational releases of hydrocarbons or arsenic contaminated materials during transportation could affect soil quality.</td><td rowspan="2">The quantities of contaminants that would escape to the environment under a “Minor Operational Release” scenario are anticipated to be small, resulting in a limited volume of soil that would become contaminated. The duration when such releases might happen is expected to be short, limiting the extent of the potential impact.</td><td rowspan="2">As part of Environmental Management Plans, a Fuel Management Plan and Emergency/Spill Response Plans will be developed. Typical management and mitigation measures include:

1) Fuel in bulk quantities will be stored in double-walled containers. The fuel dispensing area will be lined and a sump will be dug to collect any spills that may occur.

2) An emergency response plan will be in place to deal with fuel spills and other types of unauthorized discharges.

3) Spill kits will be available at fuel storage and dispensing facilities.

4) Spill response training will be provided to personnel.

5) Daily inspection of vehicles and fuel storage facilities will be carried out.

Activities to address contaminated surficial material, as described in Chapter 6, can be applied to those soils contaminated as a result of minor releases.</td><td>Yes.
Minor operational releases of hydrocarbons and arsenic - contaminated materials associated with transportation activities are anticipated.</td><td>Yes.
During the preparation of Environmental Management Plans.

Residual effect forwarded to Chapter 12 for an evaluation of significance.</td></tr>
<tr><td>Fuel management</td><td>Remediation</td><td>Minor operational release of hydrocarbons during vehicle refuelling and maintenance could affect soil quality.</td><td>No adverse residual effects are anticipated.</td><td>Yes.
During the preparation of Environmental Management Plans.

Residual effect forwarded to Chapter 12 for an evaluation of significance.</td></tr>
</table>

8.5.5 Permafrost

Potential adverse effects of the Project on the Permafrost Environment are evaluated in this section. As noted in Table 8.5.1, the loss of permafrost in previously undisturbed ground was used as the criterion to determine if the Project would have an adverse effect on the environment.

8.5.5.1 Positive Effects of Remediation

The frozen block method essentially involves the recreation of permafrost conditions in areas surrounding the arsenic trioxide chambers. Important positive effects are associated with the elimination of groundwater flow through the chambers. In addition, other aspects of the Project will assist in reducing the potential for adverse environmental effects that might otherwise occur. For example, the capping of tailings ponds, which may have permafrost in some areas, will serve to reduce arsenic loadings to surface water environments. Any disturbances to existing permafrost that might occur during the implementation of the Project have been evaluated within the context of these positive effects.

8.5.5.2 Summary of Interactions

Throughout the duration of the Project, major earthworks (borrow source and contaminated soils excavation, road construction/removal, new infrastructure/building construction, etc) will occur across the Site. For the most part, these works will occur in areas where historic mining practices have already disturbed the ground/soil conditions and any permafrost that might have been present. On this basis, adverse effects on permafrost are expected to occur only in areas where undisturbed materials will be excavated for borrow material (soil and/or rock) or where contaminated soils are removed from previously undisturbed, or minimally disturbed areas. Degradation or removal of permafrost that has re-established in disturbed areas (e.g., portions of tailings ponds) has not been classified as adverse. Similarly, no adverse effects are expected to occur through the creation of new permafrost, including the establishment of frozen blocks around the arsenic chambers.

Based on the above rationale and as indicated in Table 8.3.1, the type of effect and activities with some potential to result in changes to existing permafrost include:

Permafrost Degradation:

- Earthworks (all activities during the remediation and long-term operation & maintenance phases, excluding contouring and capping of tailings/sludge ponds); and
- Vegetation clearing (remediation).

8.5.5.3 Assessment of Potential Effects

Table 8.5.4 presents an assessment of potential permafrost effects associated with the Project. The primary mechanism by which existing permafrost might be affected is through excavation activities in areas that were previously undisturbed. Degradation or removal of ice-rich permafrost has the potential to result in thaw settlement and terrain disturbances. Complete thawing will cause the ground to lose any strength associated with ice cementation, with implications for the stability of slopes, structures and foundations. Additional potential effects include increased hydraulic conductivity and soil erosion. Notwithstanding these potential effects, the total footprint of permafrost that might be degraded or removed by excavation activities is relatively minor in comparison to the overall environmental improvements that will be achieved by the Project.

The clearing of vegetation can have a similar effect on permafrost because vegetation serves to insulate the ground. When vegetation is removed, surface soil temperature can increase and underlying permafrost can degrade, as described above.

8.5.5.4 Mitigation Measures

To the extent feasible, disturbance of areas known to possess permafrost will be avoided. For example, previously disturbed borrow sources will be used preferentially over new sources where permafrost may be present. If permafrost areas cannot be avoided, excavations will be regraded/sloped, armoured and vegetated to promote permafrost development. Standard erosion control measures will be implemented to prevent water quality effects associated with erosion, turbidity and sedimentation. All structures will be designed and constructed in accordance with permafrost conditions that are anticipated to establish following completion of the Remediation Project. The same measures to prevent or minimize effects from permafrost degradation from vegetation removal will be applied.

8.5.5.5 Residual Effects

The adverse residual effect to Permafrost that has the potential to occur during implementation of the Remediation Project is the localized loss of permafrost. The residual effect is based on the findings of Table 8.5.4 and has been forwarded to Chapter 12 for a determination of significance.

As noted on Table 7.2.2, permafrost interacts with the Surface Water Environment and the Terrestrial Environment. Due to this interaction, permafrost is also presented as a potential pathway to effects on VCs in those environmental components.

Table 8.5.4 Assessment of Potentially Adverse Effects on Permafrost

Activity	Project Phase(s)	Description of Project-Environment Interactions	Analysis of Effects	Mitigation	Residual Effects	Is Further Consideration Required? When?
Permafrost Degradation						
Earthworks (all activities, excluding contouring and capping of tailings/sludge ponds)	Remediation Long-Term Operation & Maintenance	The Project will involve excavation of borrow material (soil and rock) in areas previously undisturbed. Other Project activities such as the realignment of Baker Creek and site access/preparation may also occur in areas that were not disturbed by the historic operation of the mine. If permafrost is present, these activities may result in the degradation or removal of it.	Degradation or removal of ice-rich permafrost has the potential to result in thaw settlement and terrain disturbances. On complete thawing, the ground will lose any strength associated with ice cementation, with implications for the stability of slopes, structures and foundations. Additional potential effects include increased hydraulic conductivity and soil erosion. Since permafrost interacts with the Surface Water Environment and the Terrestrial Environment, it is a potential pathway to effects on VCs for those environmental components.	To the extent feasible, disturbance of areas known to possess permafrost will be avoided. For example, previously disturbed borrow sources will be used preferentially over new sources where permafrost may be present. If permafrost areas cannot be avoided, excavations will be regraded/sloped, armoured and/or vegetated to promote permafrost development. Erosion control measures (as described in the Earthworks interaction in Table 8.4.5 of the Surface Water Quality effects section) will be implemented to prevent adverse effects associated with erosion, turbidity and sedimentation. All structures will be designed and constructed in accordance with permafrost conditions that are anticipated to establish following completion of the Remediation Project.	Yes. Localized loss of permafrost is anticipated.	Yes. Residual effect forwarded to Chapter 12 for an evaluation of significance.
Vegetation clearing	Remediation	Vegetation will be cleared from some areas of the site. In most situations this will occur in previously disturbed areas that have revegetated with time. In a limited number of cases, vegetation may be removed from areas that were not physically disturbed by the historic operation of the mine.	Vegetation and associated organic matter in surface soils provide insulation for shallow permafrost, particularly in areas with high peat content. Vegetation clearing, therefore, has the potential to result in a degradation of permafrost. However, clearing is anticipated to be required only in those situations where earthworks are required. In such a situation, earthworks are expected to dominate any effects on permafrost and the influence of vegetation removal will be relatively minor. A separate analysis of the permafrost effects caused by vegetation removal is, therefore, not justified.	The mitigation measures described above for earthworks also apply to vegetation clearing.	No adverse residual effect is expected.	No.

8.6 Atmospheric Environment

This section describes the predicted effects of the Project on the Atmospheric Environment which includes the following two sub-components: Air Quality and the Noise Environment.

8.6.1 Evaluation Criteria

To assess the potential for any predicted measurable changes to the Atmospheric Environment, evaluation criteria/indicators were identified as listed in Table 8.6.1. Where possible, any predicted changes in the Atmospheric Environment were determined on the basis of quantifiable parameters.

Table 8.6.1 Evaluation Criteria for the Atmospheric Environment

Environment Sub-component	Evaluation Criteria
Air Quality	• GNWT Ambient Air Quality Guidelines for SO_2, TSP and $PM_{2.5}$ • Canadian National Ambient Air Quality Objectives – Maximum Acceptable Concentration for NO_2 • Ontario Ministry of the Environment Ambient Criterion for PM_{10} and Airborne Arsenic (adopted by the GNWT) • Professional judgement
Noise Environment	• NWT Occupational Exposure Limits • Complaints from residents made to municipal authorities • Professional judgement

8.6.2 Air Quality

8.6.2.1 Positive Effects of Remediation on Air Quality

The implementation of the Project is expected to have long-term positive benefits on air quality. During the existing care and maintenance activities, the site is monitored and dust mitigation measures are routinely carried out as required. However, current conditions allow for the occasional dispersion of air-borne contaminants (dust and arsenic) under certain circumstances. The completion of the Remediation Phase should serve to immobilize existing sources of air-borne contaminants. For example, the capping and revegetation of tailings areas is anticipated to result in improved air quality within the SSA and surrounding environment.

8.6.2.2 Summary of Interactions

As indicated in Table 8.3.1, the majority of Project activities have some potential to interact with air quality. The interactions are associated predominantly with the movement of granular materials (i.e., earthworks) and extensive use of combustion equipment (bulldozers, haul trucks, etc.). The types of effects and associated activities related to air quality are as follows:

Mobilization of Contaminants:

- Earthworks (all activities in areas where contaminated soils/materials are currently present during the remediation and long-term operation & maintenance phases); and
- Demolition of surface infrastructure (remediation).

Suspended Solids (air):

- Surface drilling and freeze pipe installation (remediation);
- Earthworks (all activities during remediation and long-term operation & maintenance phases);
- Demolition of surface infrastructure (remediation);
- Transportation (remediation); and
- Vegetation clearing (remediation).

Combustion Emissions:

- New underground development (remediation);
- Installation and operation of freeze system (remediation);
- Earthworks (all activities during remediation and long-term operation & maintenance);
- Construction of new surface infrastructure (remediation);
- Demolition of surface infrastructure (remediation);
- Water management (remediation and long-term operation & maintenance);
- Transportation (remediation); and
- Vegetation clearing (remediation).

8.6.2.3 Assessment of Potential Effects

This section provides an assessment of the potential effects of the Project on air quality. Table 8.6.7 provides a summary of the analysis of potential effects. The effects assessment is based on the results of air quality modelling, specifically the use of the United States Environmental Protection Agency's (U.S. EPA) Industrial Source Complex Short-Term (ISCST3) model. This particular model has been found to be well suited for simulating atmospheric dispersion of emissions from diffuse sources (e.g. dust emissions from tailings management areas and roads; standard contaminant emissions from mobile equipment) as well as emissions from discrete point sources (e.g. building vents and stacks). The model was used to estimate maximum 1-hour, 24-hour and annual average ground-level concentrations of various air quality parameters at sensitive receptor locations, chosen as VCs for this assessment. The following receptor locations were selected for the effects assessment based on the fact that they are associated with extensive public use or occupancy:

- R1 - Yellowknife River Park;
- R2 - N'dilo Residential Receptor;
- R3 - Back Bay Residential Receptor;
- R4 - Boat Launch Recreational Receptor; and
- R5 - Municipal Landfill Receptor.

The locations of the receptors are depicted in Figures 8.6.1 to 8.6.4. No on-site receptors (workers) were considered, as they will be subject to stringent occupational health and safety protocols for protection of worker health. The predicted changes in air quality at each of the receptor locations were evaluated against applicable ambient air quality criteria (guidelines and objectives) as presented in Table 7.3.2 and Table 8.6.1.

Existing air quality in the area surrounding Giant Mine is a combination of emissions from sources in the general Yellowknife area (e.g., dust from traffic and wind erosion) plus a component that flows into the area from upwind sources (forest fires, etc.). When a modelling assessment is undertaken to predict the incremental effects of a project on air quality, it is standard practice to add the incremental project contributions to baseline conditions as air quality standards, guidelines and objectives are based on total exposure.

Historic data from the Yellowknife air quality monitoring station located adjacent to the Sir John Franklin High School in central Yellowknife and monitoring data from the Giant Mine site were used to estimate baseline contaminant levels. Baseline particulate matter (PM_{10}, $PM_{2.5}$), NO_2 and SO_2 background concentrations were estimated as median values based on measurements made over the 2005/2006 period at the Yellowknife monitoring station. Total suspended particulate (TSP) background concentrations were estimated as the low end of average annual concentrations from the Yellowknife monitoring station to remove the influence of road dust emissions on the measured levels which are known to be influenced by emissions from streets in Yellowknife at certain times of the year. On the other hand, the baseline arsenic concentration was cautiously estimated to equal the high end of average annual concentrations from the Yellowknife monitoring station.

To assess the likely effects of Project activities on air quality, the ISCST3 predictive model incorporated a series of Emission Factor Equations. To produce predictions that were both robust and conservative, a "worst-case" scenario for the possible generation of TSP, arsenic and combustion emissions, was developed. This scenario assumed that the following activities, each capable of generating atmospheric emissions, would occur simultaneously:

- Freeze Plant Operation and Active Freezing;
- Baker Creek Rehabilitation;
- Contaminated Soils Excavation and Remediation;
- Tailings and Sludge Pond Remediation;
- Freeze System Installation; and
- Buildings and Infrastructure Demolition and Disposal.

All major sources of particulate matter, arsenic and combustion emissions were characterized and included in the emission inventories for each of the Project activities outlined above. Table 8.6.2 provides a summary of operating parameters used in the evaluation of air quality effects associated with the worst-case scenario. In addition, to provide conservative and defensible predictions, the modelling exercise made the following assumptions:

- The peak power requirement of three megawatts (MW) for active freezing was assumed to be provided by diesel-fired electricity generation at the Jackfish Power Plant operated by the Northwest Territories Power Corporation. The power plant was assumed to operate continuously during active freezing;
- All other Project activities were assumed to occur for 10 hours per day, 7 days per week and 365 days per year;
- Winter activities were assumed to be 50% of the peak summer rates based on reduced operations during the coldest months of the year;
- Dust emissions from haul roads and areas where active earthworks are to occur were assumed to be 80% controlled during the unfrozen period of the year through light watering and, when required, the application of chemical suppressants. During the winter months, it was assumed that mine roads would be sanded with clean material (i.e., no arsenic concentrations); and
- Arsenic emission rates were estimated as a percentage of TSP emission rates based on average concentrations from samples collected at each activity area of the site.

Table 8.6.2 Operating Assumptions for "Worst-Case" Air Emissions Scenario

Activity	Location	Equipment
Freeze Plant operation and Active Freezing	Jackfish Power Plant	3 MW of Electrical Power from Diesel Generators
Baker Creek Rehabilitation	Baker Creek	CAT 320 Excavator CAT Sheep 815-6 Compactor
	Borrow Pit A2	CAT 320 Excavator Four (4) Tandem Trucks hauling backfill material
Contaminated Soils Excavation and Remediation	Soils Surrounding Roaster Building	CAT 320 Excavator Four (4) Tandem Trucks hauling contaminated soils
	B1 Pit	CAT D8 Bulldozer CAT Sheep 815-6 Compactor
Tailings and Sludge Pond Remediation	South Tailings Pond	CAT D8 Bulldozer CAT D10 Bulldozer CAT Sheep 815-6 Compactor
	Borrow Pit A1&C1	CAT 320 Excavator CAT D8 Bulldozer Six (6) Rock Trucks hauling backfill material
Freeze System Installation	Underground Vaults	Three (3) DR24 Drills
Buildings and Infrastructure Demolition and Disposal	Roaster Building	Two (2) Concrete Saws Truck-Mounted Crane

Several ISCST3 dispersion model runs were undertaken to predict maximum 1-hour, 24-hour and annual average ground-level concentrations at sensitive receptor locations and at gridded receptor locations. The contaminant concentrations are the sum of modelled worst-case concentrations and estimated baseline concentrations. Tables 8.6.3 to 8.6.6 present the maximum predicted air quality concentrations at the sensitive receptor locations. As indicated in the tables, there are no predicted exceedances of applicable arsenic, TSP, PM_{10}, $PM_{2.5}$, NO_2 or SO_2 criteria associated with the worst-case scenario at any of the sensitive receptor locations.

Table 8.6.3 Predicted Arsenic Concentrations in Air at Off-Site Sensitive Receptors

Receptor	Maximum 24-hour Arsenic Concentration (μg/m³)
R1 - Yellowknife River Park	0.02
R2 - N'dilo Residential Receptor	0.01
R3 - Back Bay Residential Receptor	0.01
R4 - Boat Launch Recreational Receptor	0.02
R5 - Municipal Landfill Receptor	0.01
Ambient Air Quality Criterion	**0.3**
Background	**0.004**

Table 8.6.4 Predicted Particulate Matter Concentrations in Air at Off-Site Sensitive Receptors

Receptor	Annual Average Concentration (μg/m^3)	Maximum 24-hour Concentration (μg/m^3)		
	TSP	TSP	PM_{10}	$PM_{2.5}$
R1 - Yellowknife River Park	18	29	18	10
R2 - N'dilo Residential Receptor	19	30	15	9
R3 - Back Bay Residential Receptor	19	31	16	7
R4 - Boat Launch Recreational Receptor	20	47	25	10
R5 - Municipal Landfill Receptor	19	31	16	7
Ambient Air Quality Criterion	**60**	**120**	**50**	**30**
Background	**18**	**18**	**9**	**2**

Table 8.6.5 Predicted Nitrogen Dioxide Concentrations in Air at Off-Site Sensitive Receptors

Receptor	Annual Average Concentration (μg/m^3)	Maximum 24-hour Concentration (μg/m^3)	Maximum 1-hour Concentration (μg/m^3)
R1 - Yellowknife River Park	6	14	98
R2 - N'dilo Residential Receptor	7	15	127
R3 - Back Bay Residential Receptor	7	16	150
R4 - Boat Launch Recreational Receptor	7	29	194
R5 - Municipal Landfill Receptor	8	29	220
Ambient Air Quality Criterion	**100**	**200**	**400**
Background	**6**	**6**	**6**

Table 8.6.6 Predicted Sulphur Dioxide Concentrations in Air at Off-Site Sensitive Receptors

Receptor	Annual Average Concentration (μg/m^3)	Maximum 24-hour Concentration (μg/m^3)	Maximum 1-hour Concentration (μg/m^3)
R1 - Yellowknife River Park	3	6	51
R2 - N'dilo Residential Receptor	3	8	77
R3 - Back Bay Residential Receptor	4	8	72
R4 - Boat Launch Recreational. Receptor	4	11	119
R5 - Municipal Landfill Receptor	3	9	121
Ambient Air Quality Criterion	**30**	**150**	**450**
Background	**3**	**3**	**3**

Modelled concentrations of arsenic, TSP, PM_{10}, $PM_{2.5}$, NO_2 and SO_2 are also presented in Figures 8.6.1 to 8.6.4. The red line shown in each figure indicates any areas within which the applicable air quality criterion is expected to be exceeded under the worst-case scenario. As shown in Figure 8.6.1, arsenic concentrations in the central portion of the site are predicted to exceed the 24-hour criterion, particularly when wind erosion is taken into consideration (the effect of windblown dust is similar for all other particulate-based contaminants). When wind erosion emissions are not considered, contaminated soils remediation activities are the primary source of arsenic in air. Consistent with the results reported in Table 8.6.3, Figure 8.6.1 illustrates that arsenic concentrations are predicted to remain well below the 24-hour criterion at all off-site receptor locations.

Figure 8.6.2 illustrates the predicted concentrations of particulates, including wind erosion sources. The figure indicates that the maximum 24-hour predicted concentrations will exceed applicable criteria in the areas immediately surrounding Project activities. The modeled concentrations are comparable to those observed during baseline air quality monitoring conducted at the site in recent years (2004 through 2008). Similar to arsenic, particulate matter concentrations are shown to be well below applicable criteria at the locations of the off-site receptors.

Figures 8.6.3 and 8.6.4 present the predicted maximum 1-hour and 24-hour modelling results for the combustion emissions of NO_2 and SO_2. For both parameters, the 1-hour concentrations are predicted to exceed applicable criteria in the immediate vicinity of areas where heavy equipment activity will be at its highest. There are no model-predicted exceedances of 24-hour criteria for NO_2 and SO_2.

Based on the worst-case emissions modelling exercise described above, the Project is not anticipated to have adverse effects on off-site human receptors. However, consistent with the effects assessment of other environmental components, an evaluation of specific Project-environment interactions that have some potential of resulting in adverse effects is presented in Table 8.6.7.

Figure 8.6.1 Predicted Arsenic Concentrations in Air (24 Hr)

Figure 8.6.2 Predicted Particulate Matter Concentrations in Air (24 Hr)

Figure 8.6.3 Predicted Nitrogen Dioxide Concentrations in Air

Figure 8.6.4 Predicted Sulphur Dioxide Concentrations in Air

8.6.2.4 Mitigation Measures

A number of mitigation measures will be implemented to minimize adverse effects of the Project on air quality. These measures, which are further described in Table 8.6.7, include:

- *Training* - Work crews involved in freeze pipe drilling will be trained to respond to circumstances when pockets of arsenic trioxide are encountered in order to avoid its mobilization to the surface.
- *Dust suppression* - To reduce dust emissions, haul roads and areas where earthworks are to be carried out will receive water applications. The application of chemical dust suppressants (e.g., calcium chloride) will be considered in situations where water provides insufficient dust control.
- *Preventative demolition techniques* – Methods will be selected methods to control the airborne release of contaminants during demolition, decontamination of buildings and surface infrastructure containing asbestos or arsenic trioxide. One potential method includes carrying out such activities under negative pressure and with the use of filters.
- *Maintenance* – All heavy equipment will be maintained in good condition and operated in accordance with applicable regulations.

8.6.2.5 Residual Effects

With mitigation measures in place, no residual effects are anticipated on Air Quality and the VCs associated with it (i.e. closest off-site residential and recreational receptors; intrinsic value of air quality).

As noted in Section 7.3.5, air quality is a determinant in the condition of the Terrestrial Environment. Due to this associated effect, Air Quality is also presented as a potential pathway to effects on Terrestrial Environment VCs. Since there are no residual effects on the VCs for Air Quality, no pathway effects on the VCs for the Terrestrial Environment are plausible.

Table 8.6.7 Assessment of Potentially Adverse Effects to Air Quality

Activity	Project Phase(s)	Description of Interactions and Effects	Analysis of Effects	Mitigation	Residual Effects	Is Further Consideration Required? When?
Mobilization of Existing Contamination						
Surface drilling and freeze pipe installation	Remediation	Drilling activities may intercept pockets of arsenic trioxide dust that could be released on surface.	The potential for this Project-environment interaction was confirmed during the Freeze Optimization Study when a similar release occurred. However, in that event, the quantity discharged was very small and the duration of the event was almost instantaneous, with the dust quickly settling on the ground. Clean-up crews were quickly able to respond to the event and contain the contaminants. The potential for adverse effects to air quality at off-site receptors is, therefore, considered to be low.	Prior to starting the drilling program, work crews will be instructed as how to respond should a pocket of arsenic trioxide dust be encountered to prevent its transport to the surface. Emergency response plans will be in effect and will include plans to specifically address potential fugitive arsenic trioxide emissions during the freeze pipe drilling program. Clean-up kits will be kept at drilling sites in the event of a release.	No residual adverse effects on off-site receptors are anticipated.	Yes. During the preparation of Environmental Management Plans.
All Earthworks (except for borrow excavation, backfill placement and Bedrock modifications on surface)	Remediation	Activities such as excavation of contaminated surficial materials, tailings pond remediation and the Baker Creek rehabilitation have the potential to cause the mobilization of airborne arsenic through use of heavy machinery and haul trucks. Strong winds may also be a contributing factor to mobilization (wind erosion) of arsenic-containing particulate.	Based on modelling carried out for the worst-case emissions scenario, maximum arsenic concentrations in air at off-site receptors will remain well below the criterion for arsenic in air (0.3 ($\mu g/m^3$). While proposed mitigation measures will limit the extent of an adverse effect, elevated concentrations of airborne arsenic above the applicable air quality criterion within the SSA is possible under certain worst-case activity scenarios. However, on-site workers will be protected by regulated occupational health and safety standards. These will be outlined in the Remediation Contractor's work plans and commitments. Any fugitive emissions of particulate matter during implementation of the Project will eventually be deposited as dust fall. Under extreme circumstances the dust fall could result in effects to vegetation (e.g., through physical effects and/or contaminant uptake). This could, in turn, affect species that consume the vegetation. However, long-term historic and current deposition of particulate matter emissions from the site (e.g., wind blown dust from tailings ponds) are expected to dominate effects of this nature. The short-term incremental effects of dust deposition that may be caused by the Remediation Project are anticipated to be negligible relative to baseline conditions. As a consequence, deposition of dust (and any associated contamination) is not anticipated to result in residual adverse effects on vegetation or other terrestrial receptors. On this basis, the effect has not been advanced to the evaluation of Project effects on the Terrestrial Environment (Section 8.8).	Modelling of the worst-case emissions scenario included the following built-in mitigation measures: • Application of a chemical suppressant (e.g., calcium chloride) and light watering of haul during the unfrozen period. • Sanding of mine site roads with clean material during winter These measures are anticipated to achieve an 80% reduction in arsenic emissions (through the control of particulate matter emissions). In the event that these proposed mitigation measures are not sufficient to control emissions (e.g., during a prolonged summer drought) the frequency and magnitude of water and chemical suppressant applications will increase. Similarly, if remediation activities are determined to be a source of elevated emissions (specifically dust), consideration will be given to staging activities during periods when the effects of emissions and/or dispersion can be minimized.	No residual adverse effects on the closest residential or recreational receptors (off-site) are anticipated.	Yes. During the preparation of Environmental Management Plans.

Table 8.6.7 Assessment of Potentially Adverse Effects to Air Quality (Cont'd)

Activity	Project Phase(s)	Description of Interactions and Effects	Analysis of Effects	Mitigation	Residual Effects	Is Further Consideration Required? When?
Demolition of Surface Infrastructure (all activities)	Remediation	The Roaster Building Complex contains large quantities of asbestos and arsenic trioxide. Other structures contain smaller quantities of the same materials and/or at lower concentrations. In the absence of controls, arsenic, asbestos and other potential contaminants could become mobilized in the air during building demolition activities.	The demolition of the Roaster Building Complex (and any other building known to contain arsenic trioxide or asbestos) will be carried out under highly controlled conditions. The demolition procedures will incorporate built-in mitigation measures that will substantially reduce the possibility of fugitive emissions from this activity.	Mitigation measures to limit emissions from building demolition will be identified in Environmental Management Plans. Potential options include: • removing surface contamination prior to demolition (i.e., decontamination); • maintaining negative pressure on structures during decontamination; • treatment of exhaust air with high-efficiency particulate arrestor (HEPA) filters; and • applying an adhesive to potential sources of loose contamination to reduce emissions during demolition activities The demolition process will also avoid the use of techniques that have the potential to suspend particulates and contaminants in the air (e.g., use of explosives). In situations where demolition methods have the potential to result in emissions, such work will be performed under meteorological conditions that minimize the risks associated with atmospheric dispersion.	No residual adverse effects on the closest residential or recreational receptors (off-site) are anticipated.	Yes. During the preparation of Environmental Management Plans.
Suspended Solids (air)						
Surface drilling and freeze pipe installation	Remediation	Approximately 608 holes totalling a combined length of over 50,000 metres will be drilled from the surface in order to install the freeze pipe collars (this does not include underground drilling). This extensive amount of drilling has the potential to result in the release of suspended particulate matter.	Drilling techniques will be determined by the Remediation Contractor. However, it is anticipated that the preferred techniques will be limited to wet drilling. The drilling fluids (e.g., mud) are anticipated to act as an effective dust suppressant. The amount of dust generated by drilling is expected to be minimal relative to other activities (e.g., earthworks and transportation on unpaved haul roads).	The use of wet drilling (i.e., "built-in" mitigation).	No residual adverse effects are anticipated.	Yes During the preparation of Environmental Management Plans.
Earthworks (all activities)	Remediation Long-Term Operation & Maintenance	Earthworks and Transportation were collectively assessed through the modelling for the worst-case scenario. Given the extensive amount of heavy equipment operation and transportation along unpaved haul roads during the Remediation Phase, these combined activities will result in the release of airborne particulate matter.	The worst-case scenario modelling results indicate that, for off-site receptors (i.e., the VCs for Air Quality), concentrations of dust will remain below applicable criteria and will generally be consistent with baseline conditions. While the proposed mitigation measures will limit the extent of an adverse environmental effect, elevated concentrations of suspended solids above applicable air quality criteria within the SSA are possible under certain worst-case activity scenarios. However, on-site workers will be protected by regulated occupational health and safety standards. These will be outlined in the Remediation Contractor's work plans and commitments.	As noted above under the heading "Mobilization of Existing Contamination", modelling of the worst-case emissions scenario includes a series of built-in mitigation measures. In addition to mitigating arsenic releases, these same measures will be effective in controlling suspended solids in air.	No residual adverse effects on the closest residential or recreational receptors (off-site) are anticipated.	Yes. During the preparation of Environmental Management Plans.
Transportation	Remediation					
Demolition of Surface Infrastructure	Remediation	Following decontamination, structures throughout the site will be demolished. Depending on the approach used, demolition can result in the suspension of particulate matter.	The presence of arsenic and/or asbestos contamination in many of the structures necessitates the use of highly controlled decontamination and demolition procedures. As a consequence, potential emissions of particulate matter will be greatly reduced. Any residual particulate emissions are anticipated to be minor in comparison to other Project activities (e.g., earthworks).	Mitigation measures for the control of contaminant mobilization will also effectively control particulate matter emissions.	No residual adverse effects are anticipated.	Yes. During the preparation of Environmental Management Plans.

Table 8.6.7 Assessment of Potentially Adverse Effects to Air Quality (Cont'd)

Activity	Project Phase(s)	Description of Interactions and Effects	Analysis of Effects	Mitigation	Residual Effects	Is Further Consideration Required? When?
Vegetation clearing	Remediation	Plants provide stability for surficial soils and, if removed, increased wind erosion can occur.	The quantity of vegetation expected to be cleared during the Remediation Phase will be very small relative to the Project footprint. Further, vegetation has already been cleared from much of the site during historic mining operations. Any increases in wind erosion and particulate concentrations associated with vegetation clearing are expected to be imperceptible.	To the extent feasible, areas with vegetation will not be disturbed. Revegetation will be carried out in areas where vegetation has been disturbed for the purpose of the Project (e.g., new borrow sources).	No residual adverse effects are anticipated.	No.
Combustion Emissions						
Installation & Operation of Freeze System (all activities)	Remediation Long-Term Operation & Maintenance	Almost all of the Project activities involve the use of internal combustion engines; this will result in emissions that have the potential to affect air quality.	The modelling results suggest that NO_2 and SO_2 concentrations will not exceed applicable air quality criteria at any of the five off-site receptor locations, and hence no adverse effects on the receptors are expected. Under certain 'worst-case' scenarios, elevated concentrations of NO_2 and SO_2 above applicable air quality criteria are possible within the SSA. However, on-site workers will be protected by regulated occupational health and safety standards. These will be outlined in the Remediation Contractor's work plans and commitments.	The fleet of motorized remediation equipment will be maintained in good working condition.	No residual adverse effects on the closest residential or recreational receptors (off-site) are anticipated.	No.
Earthworks (all activities)	Remediation Long-Term Operation & Maintenance					
New Underground Development	Remediation					
Construction of new structures on site	Remediation					
Demolition of Surface Infrastructure (all activities)	Remediation					
Transportation	Remediation					
Vegetation Clearing	Remediation					

8.6.3 Noise Environment

8.6.3.1 Summary of Interactions

As indicated in Table 8.3.1, the majority of Project activities have some potential to interact with the noise environment. Similar to air quality effects, the interactions are associated primarily with the movement of granular materials (i.e., earthworks) and extensive use of combustion equipment (bulldozers, haul trucks, etc.). The activities likely to generate noise emissions include:

- Surface drilling and freeze pipe installation (remediation);
- Freeze plant operation and active freezing (remediation);
- Earthworks (all activities during the remediation and long-term operation & maintenance phases);
- Construction of surface infrastructure - New structures on surface (remediation);
- Demolition of surface infrastructure (remediation);
- Water Management – Drawdown and Treatment (remediation and long-term operation & maintenance);
- Transportation (remediation); and
- Vegetation clearing (remediation).

8.6.3.2 Assessment of Potential Effects

Table 8.6.8 presents an assessment of potential effects associated with noise produced during the implementation of the Project. In addition to the potential effects of the Project's implementation on the intrinsic aspects of the Noise Environment, as noted in Table 7.3.5, the assessment of effects also considered the closest residential or recreational receptors, which correspond to the five off-site sensitive receptors identified in the air quality analysis. Human receptors (i.e., workers) were not considered within the SSA due to the fact that they will be subject to occupational health and safety standards. For example, to protect the well-being of workers, noise will be regulated by the standards established under the NWT Occupational Exposure Limits.

No effects on off-site receptors, the VCs chosen for the noise environment, are anticipated. Noise effects on terrestrial animals are discussed in Section 8.8 Terrestrial Environment.

8.6.3.3 Mitigation Measures

All heavy equipment will be equipped with standard industrial noise suppression devices and will be maintained in good working order. Although no noise effects on off-site receptors are anticipated, to the extent feasible, efforts will be made to schedule remediation activities so as to minimize any potential noise effects to human receptors.

8.6.3.4 Residual Effects

With mitigation measures in place, no residual effects on the Noise Environment and its associated VCs (i.e., the closest off-site residential and recreational receptors) are anticipated.

As noted in Section 7.3.5, the noise environment is a determinant in the condition of the Terrestrial Environment. Due to this associated effect, the Noise Environment is presented as a potential pathway to effects on Terrestrial Environment VCs and is discussed in Section 8.8.

Table 8.6.8 Assessment of Potentially Adverse Effects to the Noise Environment

Activity	Project Phase(s)	Description of Interactions and Effects	Analysis of Effects	Mitigation	Residual Effects	Is Further Consideration Required? When?
Noise Emissions						
Surface drilling and freeze pipe installation	Remediation	All Project activities involving the use of heavy equipment will generate noise.	The level of heavy equipment activity associated with the Project is anticipated to be no higher than levels that existed during the operational phase of the mine. Therefore, it is unlikely that the Project will result in large increases in noise levels relative to historic conditions. Noise emitted by remediation activities will be attenuated by distance as it travels off-site. Factors contributing to attenuation include distance, ground surface roughness and obstructions provided by topography. Based on these factors, noise levels at off-site locations with human receptors (e.g., the VCs for Air Quality) will be substantially lower than those experienced on site. However, on-site noise will be regulated by the standards established under the NWT Occupational Exposure Limits. Taking the above factors into consideration, the Project is not anticipated to result in substantive increases in noise levels at locations with human receptors Some noise-sensitive terrestrial animals may be disturbed by noise levels produced by the Project, particularly during the Remediation Phase. Further discussion of noise effects on terrestrial animals is in Section 8.8.	All heavy machinery will be equipped with standard industrial noise suppression devices and will be maintained in good working order. To the extent feasible, efforts will be made to schedule remediation activities so as to minimize potential noise effects to human and terrestrial receptors.	No residual adverse effects on the closest residential or recreational receptors (off-site) are anticipated.	No.
Freeze plant operation & active freezing	Remediation					
Earthworks (all activities)	Remediation Long-Term Operation & Maintenance					
Construction of new structures on surface	Remediation					
Demolition and disposal of surface infrastructure	Remediation					
Water Management (drawdown and treatment)	Remediation Long-Term Operation & Maintenance					
Transportation	Remediation					
Vegetation clearing	Remediation					

8.7 Aquatic Environment

This section describes the predicted effects of the Project on the Aquatic Environment which is composed of two sub-components: aquatic biota and aquatic habitat. Each of the Project-environment interactions identified in Table 8.3.1 was reviewed to determine if they are likely to result in measureable adverse effects relative to baseline conditions. In large part, the potential effects of these interactions also relate to changes in the Surface Water Environment evaluated in Section 8.4. The pathways of effects identified for Surface Water Quality (Table 8.4.5) and Sediment Quality (Table 8.4.6) have been given consideration for their potential interaction with VCs associated with the Aquatic Environment.

8.7.1 Evaluation Criteria

The evaluation criteria used to asses potential environmental effects to aquatic habitat and biota are identified in Table 8.7.1.

Table 8.7.1 Evaluation Criteria for the Aquatic Environment

Environmental Sub-component	Evaluation Criteria
Aquatic Habitat	Quantity (i.e., area) and quality (i.e., function and relative productivity with respect to the aquatic community)
Aquatic Biota	Potential for population effects on VC species

8.7.2 Aquatic Habitat and Biota

In the following sub-sections, the effects of the Project on aquatic biota and aquatic habitat are considered together.

8.7.2.1 Positive Effects of Remediation

As indicated in Section 8.4.3, the Project is anticipated to reduce arsenic loadings to the surface water environment. Specifically, total arsenic loadings to Baker Creek are projected to decrease by approximately 40 percent relative to current conditions and 93 percent when compared to an unmanaged site (i.e., without remediation and on-going water treatment).

In addition to water quality improvements, the Project will have a net positive effect on sediment quality, as described in Section 8.4.4. The potential effects of existing contamination in the sediments of Baker Creek will be reduced, either through contaminant removal or engineered controls (e.g., excavation of contaminated sediments, creation of new alignments, and/or placement of barriers to exposure).

The water quality and sediment quality improvements noted above will be accompanied by several positive physical changes to the Aquatic Environment. In particular, a key objective for the realignment and naturalization of Baker Creek is the enhancement of aquatic habitat. In this regard, instead of having an adverse effect on fish habitat within Baker Creek, the Remediation Project is expected to result in substantive improvements. Detailed design considerations for the restoration of Baker Creek will continue to be developed in close consultation with DFO Habitat Management Staff. The design efforts will be guided by the working principles noted in DFO's *Policy for the Management of Fish Habitat* which specifically includes No Net Loss provisions to ensure that adverse impacts to fish habitat are prevented and, where such impacts are unavoidable, that they are minimized and compensated for.

Another positive aspect of the Project is the proposed relocation of the discharge location for treated minewater from Baker Creek to Great Slave Lake. This will assist in re-establishing a more natural hydrological condition in Baker Creek and thus a more favourable aquatic habitat.

Collectively, these changes are anticipated to have a positive effect on the Aquatic Environment of Baker Creek. Any potential adverse effects associated with the Project have been evaluated within this context.

8.7.2.2 Summary of Interactions

While chemical loadings and physical disturbances (e.g., the excavation of streambed sediments and aquatic vegetation in some reaches of Baker Creek) are not anticipated to result in an overall degradation of aquatic habitat, they may result in short-term and localized adverse environmental effects. Project-environment interactions with a potential to result in such effects were identified in Table 8.3.1. The interactions, all of which are common to both aquatic habitat and biota, are as follows:

Minor Operational Releases:

- Surface drilling and freeze pipe installation (remediation);
- Decontamination of surface infrastructure (remediation);
- Sludge management (remediation and long-term operation & maintenance); and
- Fuel management (remediation).

Increased Turbidity in Water:

- Earthworks (all activities during remediation and long-term operation & maintenance); and
- Construction of Great Slave Lake outfall/diffuser (remediation).

Mobilization of Contaminants:

- Earthworks (all activities during remediation and long-term operation & maintenance, with the exceptions of borrow and backfill, and bedrock modification on surface during remediation);
- Construction of Great Slave Lake outfall/diffuser (remediation); and
- Discharge of treated minewater to Great Slave Lake (remediation and long-term operation and maintenance).

Disturbance of Existing Sediments:

- Contouring and capping of tailings – foreshore tailings (remediation);
- Baker Creek rehabilitation (remediation); and
- Construction of Great Slave Lake outfall/diffuser (remediation).

Changes to Existing Hydrology:

- Baker Creek rehabilitation (remediation); and
- Discharge of treated minewater to Great Slave Lake (remediation and long-term operation and maintenance).

Surface Disturbances:

- Baker Creek rehabilitation (remediation).

Of the various interactions identified above, those classified as Minor Operational Releases, Increased Turbidity and Mobilization of Contaminants are pathway effects from the Surface Water Environment. Those interactions were described in detail in Section 8.4 and are not repeated in the current section. A more detailed discussion of pathways, including figures, is presented in Section 8.9.

As indicated in Section 8.5, contamination in soils and groundwater could also have an effect on the Aquatic Environment. However, in both cases, exposures to the Aquatic Environment would occur only via the Surface Water Environment. As a consequence, a separate analysis of such effects is not warranted.

The potential implications of contaminant concentrations on aquatic receptors, regardless of the nature of a particular effect (i.e., direct or as a pathway), are presented in the ecological and human health risk assessment in Section 8.9.

8.7.2.3 Assessment of Potential Effects

Table 8.7.2 presents an assessment of Project-environment interactions and potential adverse effects on the Aquatic Environment.

In addition to the pathway effects noted above, physical disturbances also have the potential to result in adverse effects to the Aquatic Environment. The removal of existing riparian habitat or dredging of contaminated sediments from some areas of Baker Creek are examples of such disturbances. Even though there will be some short-term adverse effects on aquatic habitat and biota, the physical disturbances required for the restoration of Baker Creek are anticipated to result in an overall improvement of aquatic habitat in the long-term. Similarly, any physical disturbances of aquatic habitat caused by other Project activities will result in some adverse short-term effects, but are expected to have a net positive effect on both habitat and biota.

Movement of the discharge point for treated minewater from Baker Creek to Great Slave Lake will reduce chemical loadings to the creek. While this change will have a clearly positive effect on the Aquatic Environment of Baker Creek, the elimination of volumetric flows associated with the discharge warrant consideration. This is particularly important during late summer months when, based on current conditions, the discharge of treated minewater often represents the majority of flow within the creek. As indicated in Table 8.7.2, it was concluded that flows associated with the current discharge to the creek are not relevant to Arctic grayling use of the creek as spawning habitat. A similar relationship is expected to apply to other spring spawners such as longnose and white suckers, and northern pike. However, there is a potential that benthic invertebrates, resident fish species (e.g., ninespine stickleback) and any species spawning late in the summer would be affected during years in which natural flows reduce to low levels following movement of the discharge point. This is not considered to be an adverse Project effect because the creek will be returned to a more natural condition. Nonetheless, consideration will be given to mitigating the effect.

8.7.2.4 Mitigation Measures

Mitigation measures to control potential effects to the Surface Water Environment were identified in Section 8.4. The same measures will assist in mitigating potential adverse effects to the Aquatic Environment. In addition, as described in Section 6.9.3, “in-design” features that promote habitat creation will be integrated into the remedial strategy for Baker Creek. To facilitate the development of a design for Baker Creek, a process has been initiated to evaluate a range of alternatives for the creek, taking into consideration habitat creation and other requirements of the remediated creek (e.g., flood capacity). Participants in this process have included INAC, the GNWT, PWGSC, DFO and Environment Canada. Final designs for the creek will also take into consideration any feedback obtained through future community consultation activities (refer to Chapter 13).

8.7.2.5 Residual Effects

The adverse residual effects to Aquatic Environment VCs (i.e., Baker Creek, Yellowknife Bay, emergent macrophytes, benthic invertebrates, selected fish, and the intrinsic value of aquatic habitat) that are anticipated to occur during Project implementation are listed below. The residual effects are based upon the findings of Table 8.7.2 and have been forwarded to Chapter 12 for a determination of their significance.

- Disturbance of sediments in Baker Creek.
- Disturbance of sediments during construction of the diffuser / outfall in Great Slave Lake.
- Disturbance of sediments when the cover on foreshore tailings is extended.
- Removal of riparian vegetation as a consequence of surface disturbances along Baker Creek's channel.

As noted in Sections 8.4.3 and 8.4.4, both surface water quality and sediment quality are key determinants in the condition of the Aquatic Environment. Therefore, residual effects on these sub-components have the potential to affect the VCs in the Aquatic Environment. Those residual effects have been forwarded to Chapter 12 for a determination of significance.

Table 8.7.2 Assessment of Potentially Adverse Effects on the Aquatic Environment

Activity	Project Phase(s)	Description of Interactions and Effects	Analysis of Effects	Mitigation	Residual Effects	Is Further Consideration Required? When?
Minor Operational Releases						
Potential effects of Minor Operational Releases on the Aquatic Environment would occur only through effects to the Surface Water Environment. The analysis of such effects, mitigation and residual effects are described in Table 8.4.5 (Surface Water Quality) and Table 8.4.6 (Sediment Quality). The adverse residual effects related to minor operational releases on surface water have been forwarded to Chapter 12 for a determination of significance. Through this analysis, the significance of the surface water pathway on aquatic habitat and biota, and their respective VCs, will also be determined.						
Increased Turbidity						
Potential effects of Increased Turbidity on the Aquatic Environment would occur only through effects to the Surface Water Environment. The analysis of such effects, mitigation and residual effects are described in Table 8.4.5 (Surface Water Quality). The adverse residual effects related to increased turbidity on surface water have been forwarded to Chapter 12 for a determination of significance. Through this analysis, the significance of the surface water pathway on the aquatic habitat and biota, and their respective VCs, will also be determined.						
Mobilization of Existing Contamination						
Potential effects of Mobilizing Existing Contamination on the Aquatic Environment would occur only through effects to the Surface Water Environment. The analysis of such effects, mitigation and residual effects are described in Table 8.4.5 (Surface Water Quality) and Table 8.4.6 (Sediment Quality). Of particular concern to members of the public are the effects of mobilization of arsenic into the water column on fish harvested for traditional foods and for recreational fishing (i.e,, on the VCs Arctic grayling, lake whitefish, northern pike and walleye). The adverse residual effects related to mobilization of existing contamination on surface water have been forwarded to Chapter 12 for a determination of significance. Through this analysis, the significance of the surface water pathway on the aquatic habitat and biota, and their respective VCs, will also be determined. In addition, Section 8.9 presents an analysis of human health and ecological risks associated with arsenic exposures via all credible pathways of exposure.						
Disturbance of Existing Sediments						
Baker Creek rehabilitation	Remediation	The proposed restoration of Baker Creek is likely to include the remediation of contaminated sediments in selected areas. Potential approaches include excavation of contaminated areas and/or placement of a cover of clean fill.	Physical disturbances during rehabilitation of the creek may cause effects to the Aquatic Environment, particularly for low-mobility or immobile VCs, such as benthic invertebrates and emergent macrophytes (e.g., cattails). The removal of existing riparian habitat or dredging of contaminated sediments from some areas of the creek are examples of such disturbances. However, these disturbances will be implemented to create an overall improvement in habitat and environmental conditions. As a consequence, the physical disturbances required for the restoration of Baker Creek are anticipated to result in an overall improvement of the Aquatic Environment. Similarly, any physical disturbances of aquatic habitat caused by other Project activities are expected to have a net positive effect.	The disturbance of sediments is required to achieve the environmental improvements associated with the Remediation Project. Contaminants from disturbed sediments may leach into surface water, thereby affecting habitat for fish VCs, such as Arctic grayling which uses Baker Creek for spawning in the spring. Contaminated water and sediments can adversely affect eggs and young-of-the year. Any short-term and localized adverse effects will be off-set through overall improvements in aquatic habitat. Similar improvements have already been successfully demonstrated during the rehabilitation of Baker Creek's Reach 4. While design considerations for the creation of new habitat for the rest of Baker Creek are in the preliminary stages, a working group comprising representatives of DFO, Environment Canada, INAC, PWGSC and GNWT has been formed to lead investigations into options for rehabilitating the creek. This group will take into account fish habitat and resident fish species (both VCs for the Aquatic Environment) when determining the best design for Baker Creek. Rehabilitation of Baker Creek and the construction of the outfall / diffuser will be timed to avoid key life stages of VC species (e.g., spring and fall spawning periods).	Yes. Aquatic habitat (i.e., sediments and water quality) and some biota (benthos and macrophytes) in Baker Creek will be disturbed as a result of rehabilitation work.	Yes. During the detailed design phase for Baker Creek *and* in the preparation of Environmental Management Plans. Residual effect forwarded to Chapter 12 for an evaluation of significance.
Construction of Great Slave Lake outfall / diffuser	Remediation	Depending on the construction method, physical disturbances to existing sediments in the vicinity of the proposed outfall/diffuser alignments may occur.	Potential interactions and effects are similar to those for the rehabilitation of Baker Creek (see above). Given the small footprint that the outfall and diffuser are to occupy, the potential for adverse effects to aquatic habitat and hence to biota is limited. Nonetheless, in the immediate vicinity of the outfall, effects on VCs, such as benthic invertebrates and emergent macrophytes, may occur.		Yes. Construction of the diffuser / outfall in Great Slave Lake will affect aquatic habitat (sediments) and, therefore, benthos and macrophytes.	Yes. During the detailed design phase for the outfall/diffuser *and* in the preparation of Environmental Management Plans. Residual effect forwarded to Chapter 12 for an evaluation of significance.

Table 8.7.2 Assessment of Potentially Adverse Effects on the Aquatic Environment (Cont'd)

Activity	Project Phase(s)	Description of Interactions and Effects	Analysis of Effects	Mitigation	Residual Effects	Is Further Consideration Required? When?
Contouring and capping of tailings areas (historic foreshore tailings)	Remediation	The Remediation Plan proposes to extend the geotextile layer and rip-rap cover over the beached tailings in Yellowknife Bay. This activity has the potential to result in the disturbance of existing sediments during construction.	Potential interactions and effects are similar to those for the rehabilitation of Baker Creek (see above).		Yes. Extension of the cover on foreshore tailings will disturb a small area of sediments, and thus affect aquatic habitat for benthos, macrophytes and fish.	Yes. During the detailed design phase for the historic foreshore tailings cover. Residual effect forwarded to Chapter 12 for an evaluation of significance.
Changes to Existing Hydrology						
Baker Creek rehabilitation	Remediation	The realignment of Baker Creek is anticipated to dominate potential effects on the hydrology of the site, and thus will affect the aquatic habitat of Baker Creek.	As described in Section 8.4, the rehabilitation of Baker Creek is anticipated to be positive due to the transformation of the creek to a more natural condition. The detailed design of the creek will be based on a variety of factors including habitat creation and enhancement, and the particular requirements of resident in-stream species such as sculpin and ninespine stickleback.	Measures will be implemented to optimize the aquatic habitat of the creek (as opposed to mitigating potentially adverse effects). The Baker Creek rehabilitation concept will, therefore, include a series of "in-design" hydrological features to promote habitat creation. Examples of the features under consideration include: 1. Construction of stream channel sections at slopes that create stream flow velocities that encourage fish passage (e.g., grayling). 2. Creation of diverse flow regimes and habitat features that enhance conditions for multiple life stages of aquatic species, such as Arctic grayling which spawns in the creek.	No residual adverse effects are anticipated.	Yes. During the detailed design phase for Baker Creek.
Discharge of treated minewater to Great Slave Lake	Remediation Long-Term Operation & Maintenance	The redirection of treated minewater directly into Great Slave Lake will have an effect on the hydrological character and Aquatic Environment of Baker Creek.	As described in Section 7.1.2.1, under natural conditions, flows within Baker Creek decrease to very low levels (i.e., relative to peak flows) on a regular basis during late summer. However, under current conditions, the discharge of approximately 750,000 m^3 of treated minewater during the summer months prevents the possibility of the creek drying out. This volume, which is equivalent to a flow rate of 0.1 m^3/s during the discharge period, represents the majority of flow within the creek during low flow periods. As noted previously, movement of the discharge point for treated minewater from Baker Creek to Great Slave Lake has the advantage of reducing exposure of potential contaminants from the site to fish within the creek. The hydrology of the creek will also be returned to a more natural condition, which is considered to be a positive outcome. However, the movement of the discharge point may have an adverse effect on any aquatic species that have colonized the creek due to the presence of flows throughout the summer. Recent observations within Baker Creek provide insight regarding the potential for adverse effects in this regard. For example, Golder (2009) investigated spawning, larvae	The potential for effects associated with the movement of the treated minewater discharge will be evaluated and, to the extent possible, mitigated during the development of detailed designs for the remediation of Baker Creek. For example, consideration will be given to the creation of deep pools that could serve as habitat for resident species during periods of naturally low flows.	No residual adverse effects are anticipated. The movement of the discharge point from Baker Creek to Great Slave Lake is expected to result in a net positive effect.	Yes. During the detailed design phase for Baker Creek.

Table 8.7.2 Assessment of Potentially Adverse Effects on the Aquatic Environment (Cont'd)

Activity	Project Phase(s)	Description of Interactions and Effects	Analysis of Effects	Mitigation	Residual Effects	Is Further Consideration Required? When?
			distribution and movement of Arctic grayling (a VC species) within the creek. The study determined that spawning occurs for Arctic grayling in May and early June during the period when natural discharge flows are highest. Furthermore, similar to the practice in recent years, discharge of treated minewater to the creek did not begin until after the outmigration of Arctic grayling YOY. Taking these factors into consideration, the flows associated with the current practice of discharging treated minewater to Baker Creek are not relevant to Arctic grayling use of the creek as spawning habitat (chemical loadings are, however, having a negative effect on the aquatic environment of the creek). A similar relationship is expected to apply to other spring spawners such as longnose and white suckers, and northern pike. Based on the above, movement of the treated minewater discharge to Great Slave Lake is not expected to have an adverse effect on spring fish spawning and outmigration of YOY fish. However, there is a potential that benthic invertebrates, resident fish species (e.g., ninespine stickleback) and any species spawning late in the summer would be affected during years in which natural flows reduce to low levels following movement of the discharge point. This is not considered to be an adverse Project effect because the creek will be returned to a more natural condition. Nonetheless, consideration will be given to mitigating the effect.			
Surface Disturbances						
Baker Creek rehabilitation	Remediation	The realignment of Baker Creek is anticipated to cause the removal of some riparian vegetation, which is a component of aquatic habitat.	The removal of existing riparian vegetation may adversely affect both aquatic habitat and biota. The following effects are possible consequences of the removal of riparian vegetation: • Reduction in cover; • Reduction in primary productivity and food availability; • Increase in water temperature; and • Increase in water flow. In turn, these may have an adverse effect on all fish species VCs that use this habitat. Effects on benthic invertebrates may also occur. However, rehabilitation of Baker Creek will be implemented to create an overall improvement in habitat and environmental conditions.	Removal of aquatic vegetation will be limited to the extent possible. In addition, while design considerations for Baker Creek rehabilitation work are at the preliminary stage, it is intended that the creation of new habitat will be incorporated into the final design for this component of the Project. Options under consideration will include creation of new riparian habitat and vegetation for various aquatic and semi-aquatic species.	Yes. Riparian vegetation will be removed as a consequence of surface disturbances along Baker Creek's channel during rehabilitation activities.	Yes. During the detailed design phase for Baker Creek. Residual effect forwarded to Chapter 12 for an evaluation of significance.

8.8 Terrestrial Environment

As with other environmental components, the Project will achieve measureable improvements in the Terrestrial Environment of the SSA. However, the Project activities required to achieve those improvements will involve short-term and localized interactions with terrestrial habitat and species. This section describes those interactions and any potentially adverse effects to terrestrial VCs that could result.

8.8.1 Evaluation Criteria

The evaluation criteria used to assess potential environmental effects to the Terrestrial Environment's sub-components are identified in Table 8.8.1.

Table 8.8.1 Evaluation Criteria for the Terrestrial Environment

Environmental Sub-component	Evaluation Criteria
Terrestrial Habitat	Quantity (i.e., area) and quality (i.e., function and relative productivity with respect to the regional terrestrial community).
Terrestrial Biota	Potential for population effects on VC species.

8.8.2 Terrestrial Habitat and Biota

The effects of the Project on terrestrial biota and terrestrial habitat are considered together. Although some of the terrestrial species identified in Section 7.5 no longer frequent the area surrounding the Giant Mine site, their absence is likely attributable to a variety of factors. For example, caribou have not been observed in the vicinity of Giant Mine for decades. While the mine has likely contributed to their absence, activities related to the City of Yellowknife and other human activities are also expected to play an ongoing role in discouraging some species from returning to the area after remediation.

8.8.2.1 Positive Effects of Remediation

As described in Section 7.5, the terrestrial habitat of the SSA has experienced major alterations through more than sixty years of industrial activity. The Project is expected to result in a net improvement in the quality and quantity of terrestrial habitat. Similarly, after remediation, current adverse effects on biota using the site will be reduced. Factors contributing to the expected improvements include:

- Habitat quality - Activities such as the excavation of contaminated soils and capping of tailings areas will reduce the influence of historic contamination, most notably the reduction of arsenic loadings, on the quality of terrestrial habitat; and
- Habitat creation – The revegetation of tailings areas and the naturalization of Baker Creek will provide new habitat (relative to current conditions).

Any potentially adverse effects on the Terrestrial Environment have been evaluated within the context of the positive effects noted above.

8.8.2.2 Summary of Interactions

Table 8.3.1 identified only two types of Project-environment interactions that have some potential to result in adverse effects on the terrestrial environment. The first is broadly defined as surface disturbances, which focuses on those activities that are likely to interact with any natural terrestrial habitat that remains on and in the vicinity of the site. For example, a Project activity that results in a reduction of terrestrial habitat falls into this category (e.g., vegetation clearing). Similarly, any activities that discourage the use of the site by terrestrial biota have also been assigned to this category. For certain species, the mere presence of humans on the site during the remediation phase will constitute such a disturbance.

The second type of interaction deals with noise emissions from the Project activities. As noted in Table 8.3.1, almost all Project activities with some potential to cause surface disturbances (either to habitat or biota) also generate noise. Due to the strong correlation between surface disturbances and noise, the potential effects related to these two types of interactions are evaluated in parallel. On this basis, the Project-environment interactions evaluated for the Terrestrial Environment included:

Surface Disturbances and Noise Emissions:

- Surface drilling and freeze pipe installation (remediation);
- Freeze plant operation and active freezing (remediation);
- Earthworks – all activities (remediation and long-term operation & maintenance);
- Construction of new structures on surface (remediation);
- Demolition of surface infrastructure (remediation);
- Water treatment (remediation and long-term operation & maintenance);
- Transportation – on and off-site (remediation and long-term operation & maintenance); and
- Vegetation clearing (remediation).

In addition to surface disturbances and noise emissions, effects to the Terrestrial Environment may occur due to pathway effects from contamination present in surface water, groundwater, soils and air. The potential implications of the surface water pathway, particularly with respect to mobilization of arsenic, on terrestrial receptors (the VCs black bear, caribou, wolf, grouse, mallard, merganser and scaup, as well as humans) are assessed in detail in the ecological and human health risk assessment in Section 8.9. Figures showing the various pathways to terrestrial biota are also included in Section 8.9.

8.8.2.3 Assessment of Potential Effects

Table 8.8.2 presents an assessment of Project-environment interactions and potential adverse effects on the Terrestrial Environment. The screening differentiates between activities that may affect terrestrial habitat and those that would only affect biota. In general, habitat effects were viewed as being of greater importance due to their longer duration (e.g., demolition of structures used by birds for nesting) as compared to the short-term effects on biota (e.g., species avoiding the site during brief periods with elevated noise emissions). The analysis of Surface Disturbances presented in Table 8.8.2, therefore, focuses primarily on those activities that are anticipated to interact with Terrestrial Habitat.

Effects on habitat include removal of littoral vegetation related to the rehabilitation of Baker Creek. This removal will affect species that use littoral habitat for nesting, denning, and food sources, such as several of the Terrestrial Environment VCs – muskrat, mink and ducks (mallard, merganser and scaup). The removal of vegetation related to earthworks activities such as site preparation and contouring and capping of tailings areas with borrow material and backfill will also eliminate existing habitat. These vegetated areas provide a food source for species favouring herbaceous plants and berries (e.g., hare, bear, grouse), as well as nesting sites (e.g., owl). The removal of surface infrastructure may result in loss of nesting habitat for various bird species including osprey, kestrel and owls. However, the creation of new habitat resulting from naturalization of Baker Creek, and the revegetation of tailings and borrow areas, will provide an improvement in both quantity and quality of on-site habitat. In addition, there is an abundance of superior habitat in the LSA and RSA. Therefore, there is little or no potential for adverse population effects on VC species due to loss of on-site habitat during the Remediation Phase.

Many terrestrial species will likely avoid the site during the Remediation Phase due to the presence of heavy machinery and people. However, since none of the NWT species classified as being “at risk” or sensitive have been identified on or near the site for many years, it is unlikely that there is any potential for population effects on such species or on selected VC species as a result of noise emissions.

8.8.2.4 Mitigation Measures

A number of mitigation measures will be implemented to promote the protection and enhancement of the terrestrial environment. These measures include:

- *Borrow source optimization* - New borrow sources will be used only in situations where insufficient material is available from previously disturbed areas;
- *Revegetation* - Any disturbed areas will be revegetated and/or offset by naturalization activities in other areas. To the extent possible, re-naturalization of areas will use indigenous species to encourage native re-colonization;
- *Wildlife surveys* - Detailed habitat surveys will be conducted of any areas that are to be disturbed to confirm that habitat for rare or endangered species are not present; and
- *Consultation with expert departments and Traditional Knowledge Holders* - The Project Team will secure the input of government wildlife regulators and traditional knowledge holders during work schedule planning in order that remediation activities consider the presence and key life stage of sensitive species in a work area.

8.8.2.5 Residual Effects

The adverse residual effects to the Terrestrial Environment and to several of the selected VCs (black bear, muskrat, fur-bearing mammals, moose, osprey, kestrel, owl and peregrine falcon) that are anticipated to occur during Project implementation are listed below. The residual effects are based on the findings of Table 8.8.2 and have been forwarded to Chapter 12 for a determination of their significance.

- Earthwork activities will result in surface disturbances that will affect terrestrial habitat;
- The demolition of existing surface infrastructure and buildings may eliminate existing terrestrial habitat; and
- Noise emissions will discourage use of the site as terrestrial habitat, particularly during the Remediation Phase.

As noted previously, the implications of contaminant pathways arising mainly from the mobilization of arsenic in the surface water environment on terrestrial receptors, including the VCs black bear, caribou, wolf, grouse, mallard, merganser scaup and humans, are assessed in the ecological and human health risk assessment in Section 8.9.

Table 8.8.2 Assessment of Potentially Adverse Effects on the Terrestrial Environment

<table>
<tr><th>Activity</th><th>Project Phase(s)</th><th>Description of Interactions and Effects</th><th>Analysis of Effects</th><th>Mitigation</th><th>Residual Effects</th><th>Is Further Consideration Required? When?</th></tr>
<tr><td colspan="7">Minor Operational Releases</td></tr>
<tr><td colspan="7">Potential effects of Minor Operational Releases on the Terrestrial Environment would occur only through effects to Surface Water Quality and Soil Quality. The analysis of such effects, mitigation and residual effects are described in Table 8.4.5 (Surface Water Quality) and Table 8.5.3 (Soil Quality). The adverse residual effects related to Minor Operational Releases to Surface Water Quality and Soil Quality have been forwarded to Chapter 12 for a determination of significance. Through this analysis, the significance of the surface water and soil pathway on terrestrial biota VCs will be determined.</td></tr>
<tr><td colspan="7">Mobilization of Existing Contamination</td></tr>
<tr><td colspan="7">Potential effects involving the Mobilization of Existing Contamination would occur only through effects to Surface Water Quality. The analysis of such effects, mitigation and residual effects are described in Table 8.4.5 (Surface Water Quality). The adverse residual effects related to the Mobilization of Existing Contamination on Surface Water Quality have been forwarded to Chapter 12 for a determination of significance. Through this analysis, the significance of the surface water pathway on terrestrial biota VCs will be determined.</td></tr>
<tr><td colspan="7">Surface Disturbances</td></tr>
<tr><td>Earthworks: Site access and preparation</td><td>Remediation</td><td>Some site access and preparation activities will occur in areas that have had only minor disturbances during historic operations. For example, the overland portion of the alignment for the new outfall may traverse vegetated areas that currently serve as terrestrial habitat.</td><td rowspan="2">The vast majority of Project activities will occur in previously disturbed areas. If present, vegetation and surface soils will be removed prior to extraction of granular materials. This vegetation likely serves as habitat and/or a food source for animals such as hare, grouse and ptarmigan.

The spatial extent of activities in undisturbed areas will be minor relative to the areas that will be revegetated/naturalized as part of the Project. Further, habitat investigations conducted to date have not identified unique or sensitive habitats within the SSA that are not otherwise regionally abundant.</td><td rowspan="4">Although disturbances to existing habitat are inevitable, the magnitude of adverse effects can be lessened through appropriate mitigation. Potential approaches include the following:
• New borrow sources will only be used in situations where insufficient material is available from previously disturbed areas;
• Any disturbed areas will be revegetated and/or offset by naturalization activities in other areas;
• The Project Team will secure the input of government wildlife regulators and traditional knowledge holders during work schedule planning to ensure that remediation activities consider the presence and key life stage of resident species (e.g., muskrats and shorebirds);
• Re-naturalizing areas using indigenous species to encourage re-colonization; and
• Detailed habitat surveys of any areas that are to be disturbed to confirm that habitat for certain life stages (e.g., nesting) or for rare or endangered species, if present, will not be affected.</td><td rowspan="4">Yes.
Earthwork activities will result in surface disturbances that will adversely affect terrestrial habitat.</td><td rowspan="2">Yes.
During the design of the revegetation strategy for the site (selection of seed mix, etc.) and in the preparation of Environmental Management Plans (e.g., protocols for vegetation surveys).
Residual effect forwarded to Chapter 12 for an evaluation of significance.</td></tr>
<tr><td>Earthworks: Borrow and backfill</td><td>Remediation</td><td>Some of the potential borrow sources are located in previously undisturbed areas or, if previously disturbed, have started to naturally revegetate. As a consequence, the areas currently serve as terrestrial habitat for the broad variety of species present in the LSA and SSA, including those selected as VCs for the Terrestrial Environment.</td></tr>
<tr><td>Earthworks: Contour and cap tailings areas and sludge ponds</td><td>Remediation</td><td>Standing water in disturbed areas such as the Northwest Tailings Pond is currently being used as a staging ground for waterfowl during their northward migration.</td><td>While the contouring/capping of tailings areas and sludge ponds will reduce the potential for surface water and groundwater contamination, terrestrial habitat will be eliminated in the process. Due to the potential for chemical exposures (e.g., to arsenic) such habitat is considered substandard and elimination of tailings and sludge management ponds is desirable. In addition, there is an abundance of superior habitat within the LSA. On this basis, the elimination of standing water is viewed as having a net positive effect on terrestrial habitat.</td><td>No.</td></tr>
<tr><td>Earthworks: Baker Creek rehabilitation</td><td>Remediation</td><td>Some portions of Baker Creek have a relatively natural littoral zone that serves as habitat for species identified as VCs such as muskrat, mink, mallard, merganser and scaup as well as shorebirds. Other semi-aquatic species may also inhabit this area. The rehabilitation and realignment of the creek is likely to disturb portions of this habitat.</td><td>A key design criteria for the rehabilitation of Baker Creek will be the extent to which new habitat is created. Based on the success of rehabilitation efforts in Reach 4, which included the naturalization of the littoral zone, the rehabilitated creek can achieve major improvements over current conditions. While existing habitat may be affected during the remediation process, a net improvement in the quality and quantity of terrestrial habitat will occur.</td><td>Yes.
During the detailed design phase for Baker Creek and in the preparation of Environmental Management Plans.

Residual effect forwarded to Chapter 12 for an evaluation of significance.</td></tr>
<tr><td>Demolition of surface infrastructure</td><td>Remediation</td><td>Surface infrastructure serves as potential nesting habitat for various bird species (e.g., the VC species of osprey, kestrel and owls). Structures may also be serving as habitat for other species (e.g., fox).</td><td>Due to concerns regarding structural stability, almost all surface infrastructure will be demolished, thereby eliminating existing habitat. Alternate habitat for any potentially affected species is generally available elsewhere in the LSA. Eliminating the use of infrastructure as habitat and the creation of new habitat is expected to have a long-term positive effect on the Terrestrial Environment. However, any resident individuals could be affected at the time of demolition.</td><td>To the extent possible, demolition will be staged at times that minimize potential short-term effects. For example, consideration will be given to demolishing structures only during periods when possible nesting birds, such as owls or peregrine falcons are absent. Similarly, live trapping and relocation of small mammals could also be performed. Pre-demolition audits will be conducted to determine if structures are being used as habitat.</td><td>Yes.
The demolition of existing surface infrastructure and buildings is anticipated to eliminate existing terrestrial habitat.</td><td>Yes.
During the preparation of Environmental Management Plans (e.g., a Wildlife Management Plan).

Residual effect forwarded to Chapter 12 for an evaluation of significance.</td></tr>
</table>

Table 8.8.2 Assessment of Potentially Adverse Effects on the Terrestrial Environment (Cont'd)

Activity	Project Phase(s)	Description of Interactions and Effects	Analysis of Effects	Mitigation	Residual Effects	Is Further Consideration Required? When?
Vegetation clearing	Remediation	Any vegetation clearing that might be required has been addressed in the Earthworks activities described above (Site access and preparation).				
Noise Emissions						
Surface drilling and freeze pipe installation	Remediation	Industrial activities similar to historic operations will be implemented throughout the Remediation Phase of the Project. Some activities will also continue during the Long-term Operation and Maintenance Phase. The physical presence of equipment and personnel, as well as noise emissions from heavy equipment, may discourage use of the site by terrestrial biota.	Many terrestrial species will likely avoid the site during the period of active remediation due to the presence of people and heavy equipment. However, based on the generally degraded condition of existing habitat and proximity to other human activities, use of the site by species that might be adversely affected by the Project is already very low. Specifically, none of the NWT species classified as being "at risk" or sensitive have been identified in the near vicinity of the site in recent decades (see Section 7.5 for a summary of baseline conditions). In addition, any species that avoid the site will find an abundance of superior habitat in the surrounding environs. While some species are likely to avoid the site, human activity may serve as an attractant to other species (e.g., bears). However, based on the similarity between the proposed activities and historic mining operations, substantive changes to the status quo are not anticipated. Overall, the Remediation Project will result in an improvement of the terrestrial habitat of the SSA. With time, the improved habitat may encourage the re-colonization of the site by species that have been absent for many years. In this regard, the creation of new habitat is expected to have a net positive influence on terrestrial biota. However, even after remediation is complete, biota using the site may be exposed to chemical and physical risks that are elevated relative to background conditions that exist in the Regional Study Area.	Mitigation to minimize the potential for new adverse effects on terrestrial biota will include the following: • When possible, implementing remedial works during periods that avoid key life stages of resident species (e.g., muskrats, shorebirds, and nesting birds such as owls) and waterfowl that stage in the area during the migration seasons; and • Use of industry-standard noise suppression devices on all equipment.	Yes. Noise emissions will discourage use of the site as terrestrial habitat, particularly during the Remediation Phase.	Yes. During the preparation of Environmental Management Plans (e.g., a Wildlife Management Plan). Residual effect forwarded to Chapter 12 for an evaluation of significance.
Freeze plant operation and active freezing	Remediation					
Earthworks (all activities)	Remediation and Long-term Operation & Maintenance					
Construction of new structures on surface	Remediation					
Demolition of existing surface infrastructure	Remediation					
Water Treatment	Remediation and Long-term Operation & Maintenance					
Transportation – on and off-site	Remediation					
Vegetation clearing	Remediation					

8.9 Assessment of Ecological and Human Health Risks

8.9.1 Overview

Previous sections of this Chapter describe potential interactions between the Remediation Project and the biophysical components of the environment. These components include:

- Surface Water Environment (Section 8.4);
- Geological and Hydrogeological Environment (Section 8.5);
- Atmospheric Environment (Section 8.6);
- Aquatic Environment (Section 8.7); and
- Terrestrial Environment (Section 8.8).

As described previously, the Remediation Project is being implemented to reduce the potential that historic contamination at Giant Mine will result in adverse effects to each of these environmental components. In this regard, the Remediation Project is anticipated to result in an overall improvement of environmental quality. However, some contaminants will continue to be present at concentrations that are elevated relative to natural levels, even after remediation. In particular, arsenic concentrations in some environmental media will remain elevated relative to background concentrations for many years.

To better understand the risks associated with elevated arsenic concentrations after the implementation of the Remediation Project, an ecological and human health risk assessment was carried out by SENES (2006). The risk assessment included a complete review of available data on arsenic levels in the LSA, prediction of future arsenic intakes by ecological and human receptors, and a comparison of the predicted intakes to toxicological reference values (TRVs). Since that time, there has been additional data collected in the study area related to arsenic levels in water and sediments. These data have been reviewed and it was determined that the predicted water and sediment concentrations used in the 2006 risk assessment agree reasonably well with current measured levels in Yellowknife Bay as well as at the outlet of Baker Creek. On this basis, the results of the 2006 risk assessment are still valid. In addition, bioavailability studies and environmental effects monitoring (EEM) studies have been conducted since the 2006 risk assessment and there have been updates to arsenic TRVs. The updated information on bioavailability and TRVs do not result in any changes to the conclusions of the risk assessment. In fact, the available information and EEM studies indicate that the 2006 risk assessment most likely over-estimates the risks associated with post remediation site conditions (i.e., it represents a cautious estimate of the risks).

Figure 8.9.1 provides an overview of the calculation steps involved in the risk assessment. In general terms, the calculations allow a risk assessor to estimate the intake of arsenic by selected ecological and human receptors (i.e., by animals and people with particular dietary habits living in the study area). Although the calculations follow a relatively straightforward logic, the assessment of ecological and human health risks by this method is never an exact science. In fact, the method requires a number of inputs and assumptions, some of which are well established and some of which are less well understood.

8.9.2 Arsenic Sources

The remediation measures proposed in Chapter 6 are expected to decrease the arsenic discharges from surface sources within the mine area. As discussed in Section 8.4.3, the post-remediation arsenic loadings are expected to be:

- 290 kg/yr from background sources (220 kg/yr upstream of the mine and 70 kg/yr from tributaries);
- 190 kg/yr in surface runoff that would flow into Baker Creek from the Giant Mine site; and
- 140 kg/yr of arsenic from the treatment plant and 70 kg/yr from surface run-off that would enter directly into north Yellowknife Bay.

Based on these estimates, the total post-remediation arsenic loading to Baker Creek would be 480 kg/yr, and the total loading to north Yellowknife Bay would be 690 kg/yr (including the Baker Creek loading). The arsenic loading assessment is based on only partial removal of arsenic-contaminated sediments in Baker Creek. It was assumed that some portions of Baker Creek will still have sediments with arsenic concentrations of up to 2,200 mg/kg (dry weight basis). In addition, it was assumed that sediments in Back Bay and Yellowknife Bay would be left as is.

Figure 8.9.1 Steps in Risk Assessment Calculations

8.9.2.1 Arsenic in Other Environmental Media

To assess the total intake of arsenic by ecological and human receptors in the Yellowknife area, it was necessary that the risk assessment consider sources other than direct releases from Giant Mine. Chapter 7 summarizes previous studies of arsenic concentrations in water, sediment, benthic organisms, aquatic plants, fish, air, soil, and terrestrial vegetation in the Yellowknife area. Complete data summaries are provided in Appendix A of SENES (2006). In brief, there is a substantial data set available to characterize the arsenic concentrations in environmental media in the Yellowknife area. It should be noted that, while arsenic is present in various media, it does not biomagnify (i.e., does not increase in the tissue of an animal that consumes vegetation or prey containing arsenic) up the food chain.

The data were used in several different ways in the risk assessment calculations:

- Water and sediment quality data were used to calibrate a model of arsenic transport and fate in Baker Creek, Back Bay, and Yellowknife Bay (see Section 8.9.3 below);
- Data on arsenic concentrations in soils, garden vegetables, and berries were used to calculate summary statistics that were then used directly in calculations of arsenic intakes from those sources;
- Data on arsenic concentrations in fish, benthic organisms, and aquatic plants were used to estimate site-specific "transfer factors". Transfer factors are used to determine concentrations of arsenic in these media into the future;
- Studies of the speciation of arsenic in fish from Yellowknife Bay were used to infer the effects of fish-derived arsenic in humans; and
- Investigations of muskrat in Baker Creek were used to infer the effects of arsenic on the reproductive success of this species.

During the analysis, some weaknesses in the available data became apparent. For example, arsenic levels in terrestrial wildlife were typically below detection limits. This necessitated the use of cautious assumptions, supported by information from studies undertaken elsewhere, as to how much arsenic would be present in the tissue of wildlife. The available literature studies did not present any information on the speciation of arsenic in wildlife. In addition, the analytical method used to assess arsenic speciation in fish obtained from Yellowknife Bay was not able to clearly distinguish between the toxic and non-toxic forms of arsenic. Therefore, to be cautious (conservative), it was assumed that all arsenic in terrestrial species and any "uncertain" arsenic present in fish would be in a toxic form. It is important to note that Koch *et al.* (2008) conducted a study of arsenic speciation in terrestrial birds in Yellowknife. The results of the study found that the arsenic present in these species was predominantly non-toxic. Thus, the 2006 risk assessment is expected to result in an over-estimation of exposure and risk.

8.9.3 Transport and Fate of Arsenic in the Aquatic Environment

8.9.3.1 Processes

For the risk assessment calculations, the arsenic released from the Giant Mine site was assumed to enter directly into Baker Creek or north Yellowknife Bay and from there into the other segments of Great Slave Lake (as shown in Figure 7.1.2). The interactions between waterborne and sediment-bound arsenic are very important in determining the exposure of aquatic organisms. Therefore, it was necessary that the risk assessment calculations take those interactions into account.

The behaviour of arsenic in natural waters is reasonably well understood. Studies of other lake systems and the Yellowknife area studies cited in Appendices A and B of SENES (2006) show that arsenic exists primarily as the soluble inorganic form in lake water and is, therefore, transported along with the water. The same studies also show that arsenic is removed from natural waters by reactions with sediments. Settling solids scavenge arsenic from the water column and carry it to the lake bottom, where it can be buried by subsequent sediment deposition. Contaminated sediments can also release arsenic back into the water column. In cases where the concentrations of arsenic in the water were historically higher than they are today, the sediments can become a long-term source of arsenic.

8.9.3.2 Modelling

The arsenic transport and sediment uptake processes within Back Bay, North Yellowknife Bay and South Yellowknife Bay were simulated with the help of a mathematical model known as LAKEVIEW. The processes simulated by LAKEVIEW include:

- Historical inputs of arsenic and arsenic accumulation in sediments;
- Future inflows of water and dissolved arsenic from Baker Creek and the Yellowknife River;
- Distribution of arsenic among Back Bay, North Yellowknife Bay and South Yellowknife Bay;
- Adsorption of arsenic on sediments, arsenic reactions in lake sediments, and subsequent release back into the water column;
- Burial of sediments by natural deposition of suspended solids; and
- Transport of water and arsenic into and out of the three lake segments.

All available sediment and water quality monitoring data from the area were reviewed and used to calibrate the LAKEVIEW model. In brief, the calibration comprised quantifying sediment pore water, surface water and sediment-solids interactions, and adjusting estimates of historical arsenic loads to match available data. SENES (2006) provides supporting details used in the calibration of the model.

The calibration results provided interesting insights into how the system responds to changes in arsenic inputs. In particular, the model calibration showed that surface water in Back Bay and Yellowknife Bay responded within a few years to previous reductions in arsenic inputs, but that arsenic concentrations in sediments are responding much more slowly. One implication is that the currently elevated arsenic concentrations in sediments are, in large part, due to the very high arsenic discharges that occurred during the initial periods of operation at Giant Mine (i.e., from uncontrolled roaster stack emissions and prior to the water treatment improvements). Another implication is that future improvements in arsenic concentrations in sediments would take decades, even if arsenic releases to the lake could be completely eliminated.

8.9.3.3 Future Concentrations of Arsenic in Water and Sediments

The calibrated LAKEVIEW model was subsequently used to simulate dispersion and sediment uptake of arsenic that would be released from the mine workings under the post-remediation conditions discussed above. As discussed in Section 8.9.1, the predicted water and sediment concentrations agree reasonably well with the current measured levels in Yellowknife Bay as well as at the outlet of Baker Creek. Table 8.4.4 summarizes the water quality predictions, and compares them to water quality guidelines for aquatic life and drinking water.

As indicated in Table 8.4.4, only the predicted arsenic concentration in Baker Creek exceeds the CCME guideline for the protection of freshwater aquatic life and the Canadian guideline for drinking water. The predicted arsenic concentrations in Back Bay and North and South Yellowknife Bay are within the water quality guidelines. However, it should be noted that the guidelines are designed to be protective of a wide range of aquatic species and water uses, some of which are not found in Baker Creek. The next two sections provide a more site-specific assessment of the effects of the predicted arsenic concentrations for ecological and human health.

The predicted arsenic concentrations in sediments indicated that sediment toxicity benchmarks would be exceeded in Baker Creek and Back Bay, where as predicted sediment concentrations in Yellowknife Bay only exceeded the lowest sediment toxicity benchmarks. The recent EEM studies (Golder 2008) support the risk assessment results as they indicate that there are more effects on the benthic invertebrate community close to the mouth of Baker Creek relative to areas further away in Yellowknife Bay.

8.9.4 Arsenic Intakes by Ecological Receptors

8.9.4.1 Assessment Methods

To make the connection between predicted arsenic concentrations and intakes by plants, fish and animals, it was necessary to carry out pathways calculations. The pathways calculations estimate the amount of arsenic taken in by species at various levels in the food chain, on the basis of assumptions as to the amount of time that each species spends in the arsenic-contaminated areas and their water and food intakes during that period. Figure 8.9.2 illustrates the main pathways considered in the ecological risk assessment.

For estimating the exposure and uptake of arsenic by aquatic species, it was assumed they would be exposed to arsenic in Baker Creek, Back Bay and/or Yellowknife Bay. It is not known with certainty how long aquatic species remain in each location. To be cautious, it was assumed that the aquatic species were present 100% of the time in each water body.

For the terrestrial receptors, the estimates took into consideration exposure to arsenic in drinking water, soils or sediments, aquatic or terrestrial vegetation (by herbivores and omnivores) and wildlife (by omnivores and carnivores). The inhalation pathway was not evaluated for terrestrial ecological receptors since it is considered to be insignificant in ecological risk assessments and the toxicity data for evaluating inhalation is severely limited. The arsenic present in drinking water and food items was assumed to be 100% bioaccessible. For soils and sediments, however, limitations to arsenic bioaccessibility were considered.

Appendix D of SENES (2006) provides details of the assumed feeding habits for each species, and the calculations to estimate arsenic intake by each pathway. Probabilistic (i.e. based on probability or chance) methods were used to account for uncertainty in several of the model inputs. For all of the terrestrial species, the lower bound (5^{th} percentile), expected (mean) and upper bound (95^{th} percentile) exposures of arsenic were estimated.

8.9.4.2 Potential for Effects in Aquatic Species

To assess the potential effects in aquatic species, the predicted concentrations of arsenic in water at each location were compared to appropriate toxicity reference values. For each aquatic species considered in the assessment, the toxicity reference value was set at the lowest concentration (i.e., the Effect Concentration, or EC) at which 25% of the test species might show a toxic effect in a long-term test (EC_{25}). Additional model runs were carried out using lowest concentrations at which 10% of the test species show a toxic effect (EC_{10}) as the toxicity reference value.

Figure 8.9.2 Pathways Considered in Ecological Risk Assessment

Table 8.9.1 compares the estimated arsenic in water concentrations to aquatic toxicity reference values, and shows that the predicted post-remediation arsenic levels are unlikely to have an adverse effect on aquatic species in Back Bay or Yellowknife Bay. Within Baker Creek, there may be a potential for adverse effects at upper bound concentrations on both predator and forage fish. However, recent biological surveys indicate the presence of both predator and forage fish in Baker Creek, upstream and downstream of the mine workings. This suggests that the toxicity reference values used in this assessment may over-estimate the actual risks.

Table 8.9.1 Comparison of Estimated Arsenic Concentrations to Aquatic Toxicity Reference Values

Aquatic Receptor	Remediation Case			
	Baker Creek	Back Bay	North Yellowknife Bay	South Yellowknife Bay
Aquatic Plant	✔	✔	✔	✔
Benthic Invertebrates	✔	✔	✔	✔
Predatory Fish	x^2	✔	✔	✔
Forage Fish	x^1	✔	✔	✔

Notes: x^1 - The predicted upper bound (95th percentile) concentration exceeds the EC_{25} toxicity reference value, and the lower bound (5th), expected (mean) and upper bound (95th percentile) concentrations exceed the EC_{10} toxicity reference value.
x^2 - The predicted lower bound (5th) and expected (mean) concentrations exceeds the EC_{10} toxicity reference value, but is below the EC_{25} toxicity reference value
✔ - Indicates that all predicted arsenic concentrations are below the EC_{25} and EC_{10} toxicity reference value.

8.9.4.3 Potential for Effects in Terrestrial Species

The predicted intakes of arsenic by the terrestrial species were also compared to toxicity reference values, in this case Lowest Observable Adverse Effects Levels (LOAEL) obtained from literature data. A LOAEL is the lowest concentration where an effect can be seen in laboratory testing.

There were a number of uncertain components in the terrestrial risk assessment. Cautious assumptions were adopted whenever the uncertainties could not be resolved. For example, for the terrestrial receptors, it was assumed that while in the study area, they spent time in the location of highest arsenic exposure (i.e. Baker Creek), that they obtain 100% of their food and water from the study area, and that the arsenic present in these media is directly transferred into the species. In addition, most terrestrial species were assumed to consume either soil or sediment, but only a portion of the arsenic in these media was assumed to be biologically available.

The results of the risk assessment showed that, with two notable exceptions, the estimated arsenic intakes for terrestrial species were below toxicity reference values. Estimated arsenic intakes from all sources for bear, caribou, grouse, and wolf were predicted to be well below toxicity reference values for these species. Likewise, the arsenic intakes predicted for waterfowl were well below the applicable toxicity reference values.

The first exception was that of hare in the vicinity of Baker Creek, where the expected (mean) and upper bound (95th percentile) predicted intakes exceeded the toxicity reference value. The major source of arsenic for hare is terrestrial vegetation. Measured arsenic levels, representative of current conditions, were used in the assessment. While the Remediation Plan provides for removal of contaminated soils with arsenic content of greater than 340 mg/kg, the cautious assumption was made that arsenic levels in terrestrial vegetation would not change.

The second exception involves small aquatic furbearers (mink and muskrat) living in the aquatic environment on Baker Creek. LOAEL's were predicted to be exceeded for both species. The predicted arsenic intake by the small aquatic fur-bearers is related to the assumed levels of arsenic in the creek water, creek sediments, and aquatic plants. Post-remediation arsenic loadings to Baker Creek from the Giant Mine site will reduce substantially relative to existing conditions, but upstream inputs will continue. Field studies were carried out to determine whether adverse effects were occurring in small aquatic furbearers along Baker Creek. The field evidence indicated the presence of active dens that support a substantial population of muskrat along Baker Creek and that there was no evidence of effects on the reproductive success of muskrat. These results indicate that it is unlikely that the presence of arsenic in Baker Creek is causing adverse effects on small aquatic furbearers.

8.9.5 Arsenic Intakes by Human Receptors

8.9.5.1 Assessment Methods

Pathways calculations were also used to estimate the amount of arsenic that could be taken in by people living in the region. The pathways considered in this case are shown in Figure 8.9.3 and include:

- Direct intake of arsenic in drinking water;
- Intake of arsenic-contaminated soil, as dust or from hands;
- Intake of arsenic via locally obtained fish and wildlife;
- Intake of arsenic via locally grown garden produce and wild berries;
- Intake of arsenic via medicinal teas made from local plants; and
- Intake of arsenic in store-bought foods imported from other areas.

Figure 8.9.3 Pathways Considered in Human Health Risk Assessment

Several hypothetical human receptors were defined to represent different ages, diets, and residence locations. The intake of arsenic via each pathway was calculated for each receptor. The top half of Table 8.9.2 summarizes the arsenic intake pathways associated with each hypothetical receptor.

Additional calculations were then completed to assess the effects of possible changes in eating habits. For example, one set of calculations checked the case where Receptor 1 (i.e., someone residing at the Giant Townsite) in Table 8.9.2 was assumed to eat fish from Baker Creek and drink water directly from Back Bay. Other variants that were examined included combinations of drinking water and fish sources, eating berries from the Giant Mine site, and diets with very high fish consumption.

The estimation of arsenic intakes involved some uncertainties. Cautious assumptions were used whenever the uncertainties could not be resolved. For example, it was assumed that all receptors spend their entire lifetime in the vicinity of Giant Mine and are exposed to the maximum concentration of arsenic throughout their lifetime. Individuals were also assumed to obtain a relatively large portion of their food from local sources. These assumptions mean that the calculations are likely to over-estimate the true intake of arsenic by typical residents of the area.

Table 8.9.2 Estimated Intake of Inorganic and Toxic Organic Arsenic by Human Receptors

Diet	Receptor 1 a – Adult; c - Child		Receptor 2 a – Adult; c - Child		Receptor 3 a – Adult; c - Child		Receptor 4 a – Adult; c - Child	
Dietary Component								
Drinking Water	Municipal Supply		Municipal Supply		Municipal Supply		Municipal Supply	
Soil	Giant Townsite		Latham Island		City of Yellowknife		Dettah Community	
Garden Produce	Giant Townsite		Latham Island		City of Yellowknife		Dettah Community	
Berries	Giant Mine Site		Latham Island		City of Yellowknife		Dettah Community	
Large Game	Baker Creek		Baker Creek		Baker Creek		Dettah Community	
Small Game	Baker Creek		Baker Creek		Baker Creek		Dettah Community	
Ducks	Baker Creek/Back Bay		Back Bay		North Yellowknife Bay		South Yellowknife Bay	
Fish	Back Bay		Back Bay		North Yellowknife Bay		South Yellowknife Bay	
Medicinal Teas	-		Giant Mine Site		-		Dettah Community	
Supermarket Foods	Imported		Imported		Imported		Imported	
Estimated Mean Toxic Arsenic Intakes (mg/(kg d))								
	Adult	Child	Adult	Child	Adult	Child	Adult	Child
Remediation Case	<u>0.00088</u>	0.0016	<u>0.00077</u>	0.0013	0.00067	0.0013	0.00056	0.0010
Total arsenic intake by typical Canadian adult from all sources – 0.0001 (mg/(kg d)) to 0.0007 (mg/(kg d)).								
Arsenic Intakes by Yellowknife adults from all sources excluding market foods – 0.00012 (mg/(kg d)) to 0.00049 (mg/(kg d))								
Arsenic intakes by adults in other communities with elevated arsenic levels in local environment excluding market foods – 0.001 (mg/(kg d)) to 0.009 mg/(kg d))								
Estimated Mean Incremental Lifetime Carcinogenic Risk (Excluding Market Foods)								
	Composite Person		**Composite Person**		**Composite Person**		**Composite Person**	
Remediation Case	4.2 in 10,000		6.1 in 10,000		1.6 in 10,000		3.7 in 10,000	

<u>Notes:</u> Mean arsenic intakes included contributions from toxic arsenic forms and from market foods.
Underline indicates that estimated mean intake exceeds the typical range of intakes for the general Canadian population, i.e., 0.0001 to 0.0007 mg/(kg d) for adults and 0.0002 to 0.0021 mg/(kg d) for children aged 5 to 11 years old.
Composite Person encompasses 11 years as a child and 59 years as an adult.

Arsenic concentrations in water, local fish and wildlife were predicted using the methods discussed in the preceding two sections. Arsenic concentrations in soils from different locations and in locally grown garden produce were estimated from data collected by others, generally for the Yellowknife Soils Arsenic Remediation Committee. Arsenic concentrations in store-bought foods were estimated from a Canada-wide survey. SENES (2006) details the assumed arsenic concentrations and reviews the available data for each case.

It was assumed that all of the arsenic present in drinking water and other food sources, with the exception of fish, would be in the more toxic inorganic form. Two recent studies (Cohen *et al*. 2002; Mass *et al*. 2001) have suggested that some forms of organic arsenic could also be toxic. A study to measure the forms of arsenic in fish from the Giant Mine area was commissioned in 2003 (de Rosemond *et al* 2004). The study could not identify all of the organic arsenic forms present; based on the results of the study it was cautiously assumed that 78% of the organic arsenic in fish would be toxic. Again, SENES (2006) provides details of the calculations.

8.9.5.2 Estimated Daily Arsenic Intakes

The bottom of Table 8.9.2 summarizes the estimated daily arsenic intakes for each hypothetical receptor. Receptor 1 (resident at Giant Mine Townsite) was predicted to have the highest arsenic intake, followed by Receptor 2 (resident at Latham Island).

Figure 8.9.4 shows the relative importance of different arsenic sources for each hypothetical receptor. Interestingly, store-bought foods are estimated to be the largest source of arsenic in all cases. The importance of the other sources varies. Receptor 1 (resident at Giant Mine Townsite) is estimated to receive a significant proportion of the arsenic intake from local produce (grown in a garden at the Giant Mine Townsite) and berries (assumed to be gathered from the Giant Mine site). Receptor 2 (resident at Latham Island) is estimated to receive a significant proportion of arsenic intake from fish that are assumed to be obtained only from Back Bay. Receptors 2 and 4 (resident in Dettah) are estimated to receive significant proportions of their arsenic intake from locally harvested game. Those results reflect both the greater proportion of country foods in the Receptor 2 and 4 diets, and the conservative assumptions used to estimate arsenic concentrations in local wildlife. For example, the caribou consumed were assumed to have spent 10% of their lifetimes in the Giant Mine area. This is considered to be a highly conservative estimate.

Figure 8.9.5 provides a schematic representation of the mean arsenic intakes for the most exposed adult receptors (Receptors 1 and 2) and provides a comparison to estimated exposure levels in communities with high arsenic levels. For simplicity, results of the additional calculations to assess dietary variants are not shown in Figure 8.9.5. In brief, the additional calculations showed that obtaining the entire fish portion of one's diet from Baker Creek could increase the estimated arsenic intakes by a factor of 5 to11. Other changes in the assumed dietary characteristics had much less effect on estimated arsenic intakes.

Figure 8.9.4 Breakdown of Total Arsenic Intake by Pathways

Figure 8.9.5 Comparison of Arsenic Intakes

Figure 8.9.5 and the bottom of Table 8.9.2 also compares the estimated arsenic intakes to values typical of the Canadian population as a whole, and to estimated arsenic intake rates in other Canadian communities that also have elevated levels of arsenic. Only the estimated intake rates for Receptors 1 and 2 are above the range typical of the Canadian population as a whole. Even those estimates are at the low end of the range associated with other Canadian cities such as Deloro, Ontario, and Wawa, Ontario that have elevated levels of arsenic and where studies have not shown health effects.

8.9.5.3 Potential for Human Health Effects

Perhaps the greatest source of uncertainty in the risk assessment process is in the relationship between arsenic intakes and potential health effects. Evidence from many studies shows that long-term intake of arsenic at sufficiently high rates results in skin cancers. The skin cancers predominantly occur as squamous cell and basal cell carcinomas, which are highly treatable if detected in time. Ingestion of inorganic arsenic has also been reported to increase the risk of cancer in the bladder, lung, liver, kidneys and prostate, and other health-related effects of a less serious nature (ATDSR 2000 and references therein).

The most difficult question surrounds whether health effects such as those described above can be expected to result from long-term exposure to low levels of arsenic. The U.S. EPA reviewed studies (U.S. EPA 2004 IRIS) with information on the linkage between arsenic intake and skin cancer, and determined that the most useful basis for quantitative risk assessment was an epidemiology study conducted in an area of Taiwan where the well water content was high in arsenic (Tseng *et al*. 1968 and Tseng 1977). However, several documents and authors point to the difficulty in using the Taiwanese data to estimate cancer risks in North American populations. Furthermore, the quantitative relationships between arsenic intake and cancer risk in the Taiwanese study apply directly only to relatively high arsenic intakes. There is no agreed basis for extrapolating the data to the lower intakes typical of other cases. The assumption that a linear relationship exists and that any exposure to arsenic, even at very low intakes, will result in a proportionate increase in cancer risks is adopted in most risk assessments. This approach is recognized as being cautious and, therefore, most likely over-estimates cancer risks.

In an analysis by Health Canada (2004), the cancer risk models based on Taiwanese data have been updated (Morales *et al*. 2000). Health Canada also assumed the linear dose–response relationship and used the Taiwanese data to develop a slope factor of 1.2 $(mg/(kg\ d))^{-1}$ for use in the drinking water guideline, based on kidney cancers in men and lung cancer in women. That value implies that Receptor 1 (resident at Giant Townsite), with an average lifetime total arsenic intake rate of 0.001 mg/(kg d), would increase the receptor's lifetime risk of getting cancer by 1.2 x 0.001 = 0.0012, or roughly 12 in 10,000.

Figure 8.9.6 provides a comparison of the predicted incremental lifetime risks from exposure to arsenic for Receptor 2 (resident at Latham Island with the highest predicted risk) to other Canadian cancer statistics (Canadian Cancer Statistics 2003). In addition, the bottom portion of Table 8.9.2 provides the lifetime risks for the other receptors considered in the assessment. It should be noted that the lifetime risks include exposure to arsenic in various media such as soils, water and traditional foods but do not include exposure to arsenic present in market foods. As seen in Figure 8.9.6, the predicted cancer risks are well below the lifetime incidence cancer rate of 3 in 10 for the Northwest Territories population (Canadian Cancer Statistics 2003) as well as the incidence of lung cancer (5 in 100) or skin cancer (2 in 100) in the Canadian population. These results suggest that the development of cancer from total arsenic exposure would be 20 to 300 times lower than the overall cancer risk.

8.9.6 Uncertainties

As with any risk assessment, there are a number of uncertainties involved in the calculations. Table 8.9.3 summarizes the major assumptions adopted for the ecological and human health risk assessments. Each assumption was reviewed to determine whether it was likely to lead to under-estimation or over-estimation of risks. The resulting table allows the overall effect of these assumptions to be examined. It is clear that the majority of assumptions lead to “over-estimation” of risks.

Figure 8.9.6 Comparison of Cancer Risk

Table 8.9.3 Summary of Uncertainties in Assessment of Ecological and Human Health Risks

Assumption	Effect of Assumption			
	Possibly Leads to Under-estimation of Risks	Leads to Neither Over- nor Under-estimation	Likely Leads to Over-Estimation of Risks	Could Lead to Over or Under-Estimation
Arsenic Sources				
Estimates of Arsenic Releases from Giant Mine			x	
Estimates of Arsenic in Water, Soils, Sediments		x		
Estimates of Arsenic in Market Foods		x		
Arsenic Transport and Fate				
Mass Transfer Coefficients - Exchange between water column and sediment calibrated against measured levels		x		
Historic Loads to Area - Not known with certainty but estimated in part through model calibration		x		
Arsenic Intake by Ecological Receptors				
Residence Time of Aquatic Species - assumed to be in each water body 100% of time - Fish - Benthos and Aquatic Plants		 x	 x 	
Aquatic Toxicity Reference Values - Based on Laboratory Toxicity Testing			x	
Dietary and Feeding Characteristics of Terrestrial Species -Based on Literature Information		x		
Exposure of Terrestrial Species - Assumed while in the study area to obtain all food and water from Baker Creek - Ducks assumed to spend 100% of whole time in study area on each waterbody			 x x	
Bioaccessibility - Assumed arsenic bioaccessibility measured in sediments is the same as for soils[1]				x
Terrestrial Toxicity Reference Values - Based on Laboratory Toxicity Testing[2]				x

Table 8.9.3 Summary of Uncertainties in Assessment of Ecological and Human Health Risks (Cont'd)

Assumption	Effect of Assumption			
	Possibly Leads to Under-estimation of Risks	Leads to Neither Over- nor Under-estimation	Likely Leads to Over-Estimation of Risks	Could Lead to Over or Under-Estimation
Arsenic Intake by Human Receptors				
Residency Time - Assumed to be present for a full 70-year lifetime at each location and to be exposed at maximum conditions			x	
Soil Ingestion for Humans - Assumed soil ingestion constant for whole year			x	
Backyard Garden Produce - Assumed to occur every day for whole year. Amount of produce grown based on literature studies			x	
Drinking Water Intakes - Assumed all receptors obtain drinking water from the municipal supply		x		
Dietary Intake Rates of Food			x	
Local Meat Sources - Assumed that all arsenic is in toxic inorganic form			x	
Local Fish Sources - Assumed 3% of total arsenic is in inorganic form - Assumed 78% of organic arsenic is in toxic form[3]		x	x	
Arsenic Toxicity Reference Values - Oral cancer slope factor based on Taiwanese Data[4]			x	

Notes:

1. From a human health perspective, the soil pathway is relatively minor and as such it is unlikely that the estimated risk estimates would change. For the terrestrial animals, soil represents a larger fraction of exposure; however, given that the estimated intakes are well below the TRV for all animals that consume soil with the exception of the hare, the findings would not be different.
2. It is unknown whether the toxicity reference values derived from laboratory studies on mice are directly applicable to the wildlife in question.
3. Additional research carried out on fish in Yellowknife Bay indicated that 3% of the total arsenic is in the inorganic form. However, the analytical method used was unable to specify non-toxic organic forms. The results of the test indicate that as much as 78% of the organic arsenic could potentially be toxic.
4. The derivation of risks using the 2004 Health Canada slope factor is cautious since it is based on upper bound estimates of exposure. However, there are other slope factors provided by the U.S. EPA and older Health Canada documents that are more restrictive.

8.9.7 Risk Assessment Conclusions

The conclusions of the ecological and human health risk assessments are summarized as follows:

- The predicted post-remediation arsenic release of 190 kg/year from the site to Baker Creek, in addition to arsenic from upstream, is expected to result in arsenic concentrations above the CCME guideline of 5 µg/L for protection of aquatic life, and may result in adverse effects on fish in Baker Creek. However, biological surveys on Baker Creek found that both predator and forage fish were present in Baker Creek, upstream and downstream of the mine workings. This observation suggests that the toxicity reference values for arsenic used in this assessment may over-estimate the actual risks.
- Aquatic plants and fish in Back Bay and Yellowknife Bay are not at risk of adverse effects from post-remediation arsenic releases.
- The assessment predicts that some small aquatic furbearers (e.g. mink and muskrat) in the Baker Creek watershed may be at risk after remediation, albeit at a lower level when compared to current conditions due to historical contamination in the watershed. However, field investigations found that muskrat populations are reproducing and there are active dens along the creek. Taken as a whole, these results suggest that the arsenic present in Baker Creek does not appear to have an adverse effect on the muskrat population.
- The estimated total arsenic intakes for Yellowknife area residents, inclusive of individuals with traditional food diets, were found to generally fall within the range of typical arsenic intakes estimated for other Canadians. Even though arsenic levels in the area are higher than found in most Canadian communities, the human health risk assessment results suggest that there would be no measurable change in cancer risk to people in the study area.

8.10 Aboriginal Interests

This section describes a preliminary analysis of predicted effects of the Remediation Project on Aboriginal Interests. Three sub-components comprise this environmental component: Aboriginal Communities; Traditional Land Use; and Aboriginal Heritage Resources.

The analysis presented in this section has taken into consideration Aboriginal input provided through consultation that was conducted during the development of the Remediation Plan. This input was supplemented by additional consultation sessions with Aboriginal Communities on the implementation of the Remediation Project during the spring of 2010. While this engagement has provided valuable input, there remains a need for on-going involvement of Aboriginal Communities as the Project advances through the regulatory and detailed design phases. In particular, this input is required to finalize the analysis of Project effects, select mitigation measures and determine potential residual effects associated with implementation of the Remediation Project.

The Project Team's proposed plan for involving Aboriginal Communities in future phases of the Remediation Project is presented in Chapter 13.

8.10.1 Evaluation Criteria

To determine if any adverse effects are likely to occur as a result of the Remediation Project, the evaluation criteria identified in Table 8.10.1 were selected.

Table 8.10.1 Evaluation Criteria for Aboriginal Interests

Environmental Sub-component	Evaluation Criteria
Aboriginal Communities	Community perceptions of environmental health
Traditional Land Use	Magnitude of Project-related changes in Traditional Land Use activities relative to baseline conditions
Aboriginal Heritage Resources	Loss or displacement of archaeological artefacts or sites determined to have heritage value

8.10.2 Aboriginal Communities

This section provides an overview of the potential effects of the Project on Aboriginal Communities, specifically the concept of "well-being". Within this analysis, the concept of Aboriginal Community well-being considers the potential effects the Project may have on the special relationship between the land as well as the cultural and social health of Aboriginal Communities within the LSA. It recognizes the possibility that certain types of remediation activities have the potential to generate concern which, in turn, may lead to adverse effects on community well-being. Additional components of well-being that are relevant to both Aboriginal and non-Aboriginal communities are dealt with separately in Section 8.11 (e.g., housing and economic opportunities).[28]

8.10.2.1 Positive Effects of Remediation

The implementation of the Remediation Project may improve the well-being of Aboriginal persons living in the LSA. The starting point for these positive effects is the current baseline of concern among Aboriginal people regarding the historic and on-going effects of mining on their environment and traditional lifestyles. One of the most commonly expressed concerns by community members is the fear of contaminants and their potential to impact the health of wildlife and people. It is expected that, by immobilizing existing sources of contaminants, the Project may help to reduce the level of anxiety that the mine site has provoked among members of local Aboriginal Communities. The physical improvements associated with the Project, such as the demolition of contaminated buildings and the capping of tailing ponds may also assist in reducing Aboriginal concerns about the site.

8.10.2.2 Summary of Interactions

Potential interactions of the Remediation Project with Aboriginal Communities have been assigned to the category of "Community Effects". This has been done to acknowledge that, regardless of the positive effects of the Remediation Project, the implementation of individual remedial activities has the potential to cause concern that could affect Aboriginal Community well-being. Within this context, the type of effect and the interactions identified in Table 8.3.1 as having some potential to affect Aboriginal Community well-being are as follows:

Community Effects:

- Contour and cap tailings / sludge ponds (Remediation);
- Excavation of contaminated soils (Remediation);
- Baker Creek rehabilitation (Remediation);
- Construction of Great Slave Lake outfall / diffuser (Remediation);
- Demolition of surface infrastructure (Remediation);
- Discharge of treated minewater to Great Slave Lake (Remediation and Long-Term Operation & Maintenance); and
- Storage of contaminants/waste (Long-term Operation & Maintenance).

[28] It deserves noting that many non-Aboriginal residents within the LSA also share similar concerns. However, due to the long-standing concerns expressed by members of local Aboriginal communities about issues of well-being that are linked to the Giant Mine, it has been deemed more appropriate to address such effects in this section.

8.10.2.3 Assessment of Potential Effects

Based on the criteria noted in Table 8.10.1, an adverse effect on local Aboriginal Communities may occur if community well-being is perceived as being affected by Project activities that are deemed to be injurious to the land and people. A positive effect would occur if the implementation of the Project leads to an improved sense of community well-being by fostering restoration of the linkage between the land and Aboriginal people.

The Project activities that were determined to have some potential to interact with the well-being of Aboriginal Communities are the same as those that were evaluated for effects on Traditional Land Use (refer to Section 8.10.3). In most respects, any Project activities that affect the practice of Traditional Land Use are anticipated to have a similar effect on community well-being. For example, the direct discharge of treated minewater to Great Slave Lake may result in a reduction of fishing activity in Yellowknife Bay by Aboriginal residents. By extension, changes in Traditional Land Use (e.g., fishing) has the potential to result in an effect on community well-being.

On this basis, it has been assumed that the assessment of potential effects to Traditional Land Use presented in Table 8.10.2 also applies to the well-being of Aboriginal Communities. As a result, a separate evaluation of potential effects on Aboriginal Communities has not been performed. The validity of this conclusion will be revisited following the completion of additional consultations with Aboriginal Communities.

8.10.2.4 Mitigation Measures

Measures to mitigate effects on the components of the biophysical environment that Aboriginal Communities are likely to be concerned with (e.g. water quality, aquatic and terrestrial biota) are described in Sections 8.4 to 8.8. In addition to implementing the identified mitigation measures, the Project Team will continue to engage Aboriginal Communities to ensure their concerns and recommended forms of mitigation are identified. The proposed approach to ensure this occurs is presented in Chapter 13.

8.10.2.5 Residual Effects

Potentially adverse residual effects on Aboriginal Communities are understood to be linked to Traditional Land Use. The extent to which residual effects on Traditional Land Use affect Aboriginal communities will be determined following the completion of additional consultations with Aboriginal communities.

8.10.3 Traditional Land Use

This section provides an overview of the potential effects of the Remediation Project on Traditional Land Use. For the purpose of the DAR, Traditional Land Use includes harvesting activities by Aboriginal people, such as fishing, hunting, trapping and the gathering of medicinal and edible plants.

8.10.3.1 Positive Effects of Remediation on Traditional Land Use

Since the mid-part of the 20th century, use of the lands and waters around Giant Mine for traditional activities has been curtailed. A combination of habitat degradation associated with industrialization, increased human activity and concerns about contamination have made the area unattractive for harvesting. Additionally, due to existing hazards and the proximity of the site to the City of Yellowknife, traditional harvesting activities on and in the immediate vicinity of Giant Mine are currently restricted.

The remediation of Giant Mine is intended to result in a site that is largely compatible with the surrounding landscape. Sources of contaminants will be isolated from the environment, habitat will be improved (e.g., within Baker Creek) and some wildlife may return to the site. While these factors may encourage Traditional Land Use, the site will remain within the boundaries of the City of Yellowknife and, as such, restrictions on trapping and the discharge of firearms will continue to be enforced. Similarly, use of the remediated lands for other purposes (e.g., recreational or light industrial development) may not be compatible with traditional activities.

Overall, it is considered unlikely that the remediation of Giant Mine will result in the site being used extensively for traditional practices. However, by addressing concerns related to environmental contamination, increased traditional use of the lands surrounding the mine may occur.

8.10.3.2 Summary of Interactions

Table 8.3.1 presents a screening of Project-environment interactions and potential adverse effects on the Traditional Land Use sub-component. Only those interactions which were determined to have some potential for adverse effects were identified. Although Aboriginal concerns about the Project are assumed to be attributable to potential effects on the biophysical environment (e.g., mobilization of contaminants), such concerns have been assigned to the category “Community Effects”. This has been done to acknowledge that Traditional Land Use after remediation has occurred will be strongly influenced by the historical use of Giant Mine and the perception of environmental quality post-remediation.

The type of effect and associated activities related to Traditional Land Use identified in Table 8.3.1 are as follows:

Community Effects:

- Contour and cap tailings / sludge ponds (Remediation);
- Excavation of contaminated soils (Remediation);
- Baker Creek rehabilitation (Remediation);
- Construction of Great Slave Lake outfall / diffuser (Remediation);
- Demolition of surface infrastructure (Remediation);
- Discharge of treated minewater to Great Slave Lake (Remediation and Long-Term Operation & Maintenance); and
- Storage of contaminants/waste (Long-term Operation & Maintenance).

8.10.3.3 Assessment of Potential Effects

The Project is expected to interact with Traditional Land Use by changing the existing site conditions such that it may create opportunities for potential future use. This assessment is based on the fact that all Traditional Land Use, including harvesting, are currently restricted within the Giant Mine lease boundary. Similarly, it is recognized that the waters associated with the site (e.g., Baker Creek outlet and the shoreline of North Yellowknife Bay) are not used in any substantial way by members of Aboriginal Communities, in part due to concerns over elevated contaminant levels on the land and in the water.

Based on the criteria noted in Table 8.10.1, an adverse effect on Traditional Land Use may occur if a change in land use takes place that adversely affects the future ability or willingness of Aboriginal harvesters to use the lands and adjacent waters for traditional use. In contrast, a positive effect would be one which enhances the ability of Aboriginal communities to use the area for Traditional Land Use.

The evaluation of potential adverse effects on Traditional Land Use is presented in Table 8.10.2. As indicated in the table, a number of Project activities have the potential to result in Aboriginal concerns that may affect Traditional Land Use. Specific examples of potential Community Effects to Traditional Land Use include:

- Aboriginal residents have expressed concerns regarding the atmospheric dispersion of dust from the site (particularly tailings areas). Although the Remediation Project will mitigate such effects, earthworks during implementation have the potential to cause similar effects.

- The discharge of treated minewater directly into North Yellowknife Bay may generate concern among Traditional Land users who fish there. Concerns about water quality and contamination of country foods could cause harvesters to avoid the area, leading to changes in subsistence, recreational and commercial harvesting patterns.

8.10.3.4 Mitigation Measures

Measures to mitigate effects on the components of the biophysical environment that Aboriginal harvesters are likely to be concerned with (e.g. water quality, aquatic and terrestrial biota) are described in Sections 8.4 to 8.8. In addition to implementing the identified mitigation measures, the Project Team will continue to engage Aboriginal Communities to ensure their concerns and recommended forms of mitigation are identified. The proposed approach to ensure this occurs is presented in Chapter 13.

8.10.3.5 Residual Effects

While individual activities may result in short-term and minor effects to Traditional Land Use, the Remediation Project as a whole will lead to an overall improvement in environmental quality. On this basis, the Project is not anticipated to cause adverse effects to Traditional Land Use relative to baseline conditions. This conclusion is based on initial consultations regarding the implementation of the Remediation Project. However, further consultation with Aboriginal Communities will be conducted to determine the validity of this conclusion.

Table 8.10.2 Assessment of Potentially Adverse Effects to Traditional Land Use

<table>
<tr><th>Activity</th><th>Project Phase(s)</th><th>Description of Interactions and Effects</th><th>Analysis of Effects</th><th>Mitigation</th><th>Residual Effects</th><th>Is Further Consideration Required? When?</th></tr>
<tr><td colspan="7">Community Effects</td></tr>
<tr><td>Contour and cap tailings / sludge ponds</td><td>Remediation</td><td rowspan="5">Disturbance of tailings, sludge, soils and sediments during remedial activities has the potential to release contamination to the environment (e.g., release of pore water and atmospheric dispersion of dust). In the absence of mitigation, demolition of surface infrastructure also has the potential to release contaminants to the environment.</td><td rowspan="5">Predicted biophysical effects associated with these activities have been presented in Sections 8.4 to 8.8.

Aboriginal residents have expressed concerns regarding the atmospheric dispersion of dust from the site (particularly tailings areas). Although the Remediation Project will mitigate such effects, earthworks during implementation have the potential to cause similar effects.

Concerns have also been expressed regarding the release of contamination to the aquatic environment. Any Project activities with a potential to result in contamination to the Aquatic Environment are, therefore, anticipated to be a source of Aboriginal concern.

Overall, the Project is anticipated to assist in alleviating some Aboriginal concerns about environmental contamination. However, the potential for perceived effects during the implementation of the Project may alter Traditional Land use in the vicinity of the site.</td><td rowspan="7">Measures to mitigate effects on the biophysical environment associated with these activities are described in Sections 8.4 to 8.8.

The Project Team will continue to engage Aboriginal Communities to ensure their concerns and recommended forms of mitigation are identified (see Chapter 13). The Project Team will also implement a communication strategy specifically directed to local harvesters to respond to concerns. The strategy will include provisions for regular updates on Project activities, as well as the sharing of environmental monitoring data.

As part of the Monitoring Program (see Chapter 14), the integrity of arsenic trioxide chambers will be checked routinely; also, water released to the environment from the new minewater treatment plant will meet all applicable regulations and guidelines.

An extensive Emergency Response Plan will be in place at the site for both phases of the Project.</td><td rowspan="7">No residual adverse effects are anticipated (subject to confirmation during future consultation)

While individual activities may result in short-term and minor effects, the Remediation Project as a whole will result in overall improvements to environmental quality. On this basis, the Project is not anticipated to result in adverse effects to Traditional Land Use relative to baseline conditions.

This conclusion is based on initial consultations regarding the implementation of the Remediation Project. However, further consultation with Aboriginal Communities will be conducted to determine the validity of this conclusion.</td><td rowspan="7">Yes.

During the implementation of subsequent consultation and communication activities.</td></tr>
<tr><td>Excavation of contaminated soils</td><td>Remediation</td></tr>
<tr><td>Baker Creek rehabilitation</td><td>Remediation</td></tr>
<tr><td>Demolition of surface infrastructure</td><td>Remediation</td></tr>
<tr><td>Construction of Great Slave Lake outfall / diffuser</td><td>Remediation</td></tr>
<tr><td>Discharge of treated minewater to Great Slave Lake</td><td>Remediation

Long-Term Operation and Maintenance</td><td>Treated minewater will be discharged directly into Great Slave Lake. While the relocation of the discharge point will not result in a net increase in arsenic loading to Great Slave Lake, the location of the discharge will change and have implications for water quality directly adjacent to the proposed diffuser.</td><td>The discharge of treated minewater directly into North Yellowknife Bay may generate concern among Traditional Land users who fish there. Concerns about water quality and contamination of country foods could cause harvesters to avoid the area, leading to changes in subsistence, recreational and commercial harvesting patterns.</td></tr>
<tr><td>Storage of contaminants/waste</td><td>Long-Term Operation and Maintenance</td><td>The Remediation Project involves the long-term storage of materials on the site (e.g., arsenic trioxide). If accidently released to the environment, these materials represent potential sources of contamination.</td><td>The ongoing presence of potential contamination (even if managed in engineered facilities) may represent a source of potential concern for Aboriginal people. This concern may affect the future practice of traditional activities within the surrounding environment.</td></tr>
</table>

8.10.4 Aboriginal Heritage Resources

This section provides an overview of the potential effects the Project may have on Aboriginal Heritage Resources. Specifically, the potential for disturbances of archaeological heritage sites is evaluated.

8.10.4.1 Summary of Interactions

Table 8.3.1 presents a screening of Project-environment interactions and potential adverse effects on Aboriginal Heritage Resources. Only those interactions which were determined to have some potential for adverse effects were identified. The type of effects and associated activity related to Aboriginal Heritage Resources are as follows:

Surface Disturbances:

- Site access and preparation.

In addition to site access and preparation, other activities identified in Table 8.3.1 have a theoretical potential to disturb Aboriginal Heritage Resources (e.g., any excavation). However, such activities would always be preceded by access to and preparation of the site. On this basis, and for the sake of brevity, the analysis presented in the following sections focuses on disturbances that might be caused during site access and preparation. Nonetheless, the assessment of potential effects, mitigation measures and residual effects are equally applicable to all Project activities.

8.10.4.2 Assessment of Potential Effects

Based on the criteria noted in Table 8.10.1, an adverse effect would occur if the Project resulted in the disturbance or destruction of archaeological or heritage resources considered to be of importance to Aboriginal communities. The judgment of the Prince of Wales Northern Heritage Centre (PWNHC; i.e., the territorial heritage regulator) is also important in this regard. Factors that could contribute to such a determination include the rarity, condition, spiritual importance or research importance of any archaeological heritage sites that may exist on site.

Prior to evaluating the effects the Project might have on archaeological artefacts and sites, it should be reiterated that the Giant Mine site has been subjected to over 60 years of heavy industrial activity involving extensive surface disturbances. This activity has likely affected some Aboriginal Heritage Resources, such that they are permanently lost. However, as noted in Section 7.6.6.1, four prehistoric sites have been identified on the Giant Mine's lease lands. In addition to the prehistoric sites, through consultations conducted during the spring of 2010, the Project Team was informed that Aboriginal graves are located within the SSA.

Potential effects on these and other sites are the focus of the assessment presented in Table 8.10.3. A particular emphasis has been placed on those activities that are likely to involve the disturbance of new ground. As noted above, such activities are addressed under the common category of “Site access and preparation”.

8.10.4.3 Mitigation Measures

Table 8.10.3 identifies a number of measures that will be put in place to mitigate against the potential for adverse effects to Aboriginal Heritage Resources. These include measures to further evaluate known sites of archaeological heritage and investigations of any previously undisturbed areas prior to earthworks. While these measures are expected to reduce the potential for disturbing Aboriginal Heritage Resources, the possibility cannot be eliminated. For this reason, a number of additional measures, such as contacting the PWNHC for further direction when an object is located, will be put in place to limit losses in the event archaeological artefacts or sites are identified. Aboriginal input will be sought throughout this process.

8.10.4.4 Residual Effects

Based on the findings of Table 8.10.3, the mitigation measures are anticipated to be effective in addressing potential impacts to Aboriginal Heritage Resources. No adverse residual effects on Aboriginal Heritage Resources and its associated VCs are anticipated.

Table 8.10.3 Assessment of Potentially Adverse Effects to Aboriginal Heritage Resources

Activity	Project Phase(s)	Description of Interactions and Effects	Analysis of Effects	Mitigation	Residual Effects	Is Further Consideration Required? When?
Surface Disturbances						
Site access and preparation	Remediation	Some Project activities will occur in areas that have been minimally disturbed during previous mining operations. For example, some of the proposed borrow sites are in areas that have experienced minimal surface alteration. Similarly, the on-land portion of the outfall from the Water Treatment Plant may be constructed in areas that are largely undisturbed by industrial activity. Activities in previously undisturbed areas have the potential to adversely affect any Aboriginal Heritage Resources that may exist at those locations.	To date, four sites with historic Aboriginal artefacts have been identified and more finds are possible in previously undisturbed areas. Aboriginal graves are also reported to exist on site. Of the 150 hectares identified as potential borrow sources for the Remediation Project, an estimated 114 hectares are considered to be “undisturbed” by historic mining activities. However, a substantial proportion of these potential sources lie outside the boundaries of the Giant Mine lease. As such, they are the sources that are the least likely to be exploited due to permitting and transportation costs. Other previously undisturbed areas that may be affected by the Remediation Project are very small relative to the total disturbed area of the site. For example, the area that could be disturbed by the on-land portion of the outfall is estimated to be less than one hectare.	The four previously identified sites with historic Aboriginal artefacts will be evaluated by an archaeologist from the Prince of Wales Northern Heritage Centre (PWNHC). The Project Team will also work with Aboriginal Communities in an effort to locate any Aboriginal graves. In addition, all areas that have the potential of being subjected to new surface disturbances will be evaluated by the PWNHC prior to the initiation of remediation. In utilizing available borrow materials, the Project Team will set priorities for sources that have been previously disturbed. This strategy should have a mitigating effect on the likelihood of adversely affecting undiscovered heritage resources. Potential measures to be include: • 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 • In the event that an archaeological site or specimen is encountered or disturbed by any remediation activity, all activity in the area will be put on hold until such time that the PWNHC has been contacted for further direction • Educate all employees involved in surface disturbance activities of any protocols regarding Aboriginal Heritage Resources.	No residual adverse effects are anticipated. The mitigation measures are expected to be effective in addressing potential impacts to Aboriginal Heritage Resources.	Yes. Protocols for the management and reporting of archaeological artefacts and sites to be developed. Archaeological site investigation to be carried out prior to Project initiation, or surface disturbances.

8.11 Additional Community Interests

While Section 8.10 focused on the effects the Project could have on Aboriginal Interests, the current section evaluates the potential effects of the Project on Additional Community Interests (i.e., those interests that are not unique to the local Aboriginal population). Similar to the baseline descriptions provided in Section 7.7, the analysis has been divided into the following environmental components: Land use, Visual & Cultural Setting; Socio-Economic Conditions; Transportation; and Local Resources.

8.11.1 Evaluation Criteria

To determine the potential for adverse effects on Additional Community Interests, relevant evaluation criteria were identified, as listed in Table 8.11.1. Where possible, any relative change was determined on the basis of quantifiable parameters. However, professional judgement remained an important factor since many of the environmental sub-components under consideration were not readily measurable numerically.

8.11.2 Land Use, Visual and Cultural Setting

This section presents an overview of the potential effects of the Project on the Land Use, Visual and Cultural Setting environmental sub-component. Table 8.11.2 provides an assessment of potential adverse effects that might be caused by the Project.

8.11.2.1 Positive Effects of Remediation

With the exception of travel on territorial roads, current access and use of the Giant Mine site by members of the public is prohibited. Within this context, the implementation of the Project is expected to have a substantial positive influence on Land Use and Visual Setting. For example, remediation activities such as the capping and revegetation of tailings ponds and the demolition of buildings will aesthetically improve the site. The improvements to be made in the Visual Setting will likely outweigh any adverse effect that may accrue from the addition of new infrastructure on site, such as the freeze system. Similarly, following remediation, the majority of the site will be available for a wide array of land uses that are currently prohibited.

Table 8.11.1 Evaluation Criteria for Additional Community Interests

Environmental Sub-components	Evaluation Criteria
Land Use, Visual & Cultural Setting	• Regular disturbance/nuisances to offsite residences, businesses and institutions which may change the manner in which land is used (i.e., increased noise, dust, or traffic) • Compliance with legislation, regulations, policy and good planning practice • Existing and future use and development of land (impact on present and planned land use) • Impact on views and vistas (based on sensitivity of the vantage point; extent of obstruction, distance from mine site and duration of view) • Loss or displacement of built heritage features
Socio-economic Conditions	• Magnitude of Project-induced changes in the population relative to baseline and/or projected conditions • Magnitude of Project-induced changes in employment, business activity, income, municipal costs and revenues relative to baseline and/or projected conditions • Magnitude of direct and indirect Project-induced demands on municipal infrastructure and services relative to baseline and/or projected conditions • Magnitude of Project-induced changes in housing stock relative to baseline and/or projected conditions
Transportation	• Likelihood and/or magnitude of changes in onsite traffic levels on public roads • Likelihood and/or magnitude of changes in offsite traffic levels • Magnitude and frequency of Project-induced changes in motor vehicle accidents relative to baseline conditions
Local Resources	• Magnitude of Project-induced changes in electricity consumption relative to baseline and/or projected conditions • Magnitude of Project-induced change in unit price of electricity for domestic and commercial consumers • Magnitude of Project-induced fuel storage requirements relative to baseline and/or projected conditions • Magnitude of Project-induced borrow material requirements relative to baseline and/or projected conditions • Magnitude of Project-induced changes in availability of skilled and unskilled labour relative to baseline and/or projected conditions

Table 8.11.2 Assessment of Potentially Adverse Effects to Land Use, Visual Setting and Cultural Setting

Activity	Project Phase(s)	Description of Interactions and Effects	Analysis of Effects	Mitigation	Residual Effects	Is Further Consideration Required? When?
Community Effects						
All activities	Remediation	Remediation activities may have a temporary adverse effect on the enjoyment of lands used by the community that are adjacent to the Giant Mine site, particularly around the Vee Lake area and the Great Slave Cruising Club/boat launch.	Those activities requiring heavy machinery, or otherwise generating noise or dust, may be a source of sensory disturbance for land users near the mine site. This may be especially the case when important events are to be held near the Giant Mine site. Examples of such events include the Commissioner's Cup Yacht Race and the Yellowknife Ski Club Loppett. Disturbances to these community events from remediation activities may also result in negative attitudes toward the Project.	Effective lines of communication will be maintained with community organizations using land adjacent to Giant Mine. This will assist in ensuring that all parties are aware of Land Uses that might be disturbed during the Remediation Phase. To the extent feasible, attempts will be made to schedule Project activities in such a way to reduce the potential for disruption.	No residual adverse effects are anticipated.	No.
Installation and Operation of Freeze System and the Water Treatment Plant	Remediation and Long-Term Operation & Maintenance	The operation of the active and passive freezing system requires that land needed for the freeze pipe/thermosyphon array, freeze plant and water treatment plant be subject to a land reservation for long-term operation and maintenance. The reservation will eliminate the use of this land for applications by other potential users.	Approximately 30 hectares will be required for the freeze plant system (including the area encircled by the freeze pipe/thermosyphon array) and the new water treatment plant. In comparison, the area encompassed by the Giant Mine lease boundary is more than 800 hectares. The land reservation, therefore, represents less than 4% of the total lease lands. Other lands within the lease will become available for other uses. Relative to current conditions, the installation and operation of the freeze system and water treatment plant are not expected to result in adverse effects to Land Use.	The total area required for the freeze system and water treatment plant will be minimized through planning practices that aim to minimize the footprint occupied by the remediation infrastructure. To this end, the freeze plant will be sited in the approximate centre of the four freezing areas in close proximity to the water treatment plant.	No residual adverse effects are anticipated.	No.
Borrow and backfill	Remediation	The Project will require the extraction of approximately 1.4 million m^3 of borrow material from approximately 30 potential borrow source areas. Extensive borrow pit development could lead to new visual impacts on the site	Not all borrow extraction will involve exploitation in new areas as many of the proposed sources are in previously disturbed areas. Relative to current conditions, the development of new borrow sources is not considered to represent an adverse visual effect.	At the end of the Remediation Phase, borrow sources will be regraded, contoured and, where possible, revegetated to encourage conformity with the surrounding landscape.	No residual adverse effects are anticipated.	No.

Table 8.11.2 Assessment of Potentially Adverse Effects to Land Use, Visual Setting and Cultural Setting (Cont'd)

Activity	Project Phase(s)	Description of Interactions and Effects	Analysis of Effects	Mitigation	Residual Effects	Is Further Consideration Required? When?
New structures on surface	Remediation and Long-Term Operation & Maintenance	The establishment of new structures on the surface is an integral part of the Project. Permanent facilities, such as the freeze plant and freeze pipe/thermosyphon array and the new water treatment facility may have an adverse effect on the visual setting of the Giant Mine site.	While these new structures are required for the implementation of the Project, they are not inconsistent with the historic heavy industry that has taken place at the site. The installation of the new structures will be in an area of the mine site that has already been subject to substantive adverse visual effects (e.g. nearby open pits and deteriorating industrial buildings). The public's visual exposure to these new structures will mainly occur as they travel along Highway 4 (the Ingraham Trail). The highway's curving alignment along this section of the road will likely limit the amount of time that the public will be exposed to the structures. Should the Department of Transportation reroute the highway, this may also serve to reduce the number of persons who will view the new structures. Relative to current conditions, the new structures on surface are not considered to represent an adverse visual effect.	None proposed	No residual adverse effects are anticipated.	No.
Demolition and disposal of existing buildings	Remediation	A number of historic buildings have been identified as having potential heritage value.	Based on current plans, the following buildings with potential heritage value will be demolished unless other parties (e.g., the NWT Mining Heritage Society or the City of Yellowknife) assume associated environmental and/or safety risks: • House No. 217 • House No. 168 • House No. 203 • House No. 206 • A-Shaft Head Frame • A-Shaft Powerhouse and Hoist Room • A-Shaft Commissary • Recreation Hall In the case of the A-Shaft Head Frame, the presence of the structure may impede a component of the Remediation Project (i.e., the sealing of the shaft). As a consequence, the Project Team anticipates that this structure will have to be demolished. The demolition of the buildings noted above could result in an adverse effect on the cultural setting of the Giant Mine area.	The Project Team will endeavour to accommodate the efforts of any parties wanting to preserve the structures, provided the fundamental objectives of the Project are not compromised. Should no arrangements be made to transfer environmental and/or safety risks to other institutions, the Project Team will: • Work with interested parties to carry out photo documentation prior to demolition; • Allow for the removal of contents that may be of heritage value (safety permitting); and • Work with interested parties to facilitate the relocation of buildings off site.	Yes. Buildings and surface infrastructure that may have heritage value may be demolished as part of Project implementation.	Yes. Further dialogue with parties interested in preserving Giant Mine's heritage buildings. Residual effect forwarded to Chapter 12 for determination of significance.
Loss of vegetation	Remediation and Long-Term Operation & Maintenance	Some vegetation will need to be cleared as part of the Project implementation (e.g., portions of the water treatment outfall alignment; vegetation overlaying new borrow areas). The elimination of this vegetation could have an effect on the visual setting of the Giant Mine site.	Large areas of the Giant Mine site have already been cleared of vegetation from past activities. Relative to the historic effects to vegetation, the proposed clearing will be of minor consequence to the visual setting of the site. In addition, revegetation will occur on other areas of the site.	Clearing of vegetation will be minimized. However, if required, disturbed areas will be revegetated. To the extent possible, new infrastructure will be located in previously disturbed areas.	No residual adverse effects are anticipated.	No.

8.11.2.2 Summary of Interactions

For the Land Use, Visual and Cultural Setting environmental sub-component, all Project-environment interactions have been assigned to the category of "Community Effects". The type of effect and relevant interactions include:

Community Effects:

- Installation and Operation of Freeze System and the Water Treatment Plant (remediation and long-term operation & maintenance);
- Borrow and backfill (remediation);
- New structures on surface (remediation and long-term operation & maintenance);
- Demolition and disposal of existing buildings (remediation); and
- Loss of vegetation (remediation).

8.11.2.3 Assessment of Potential Effects

<u>Land Use</u>

An adverse effect on Land Use was assumed to occur only if a long-term or permanent change in existing patterns of Land Use takes place, thereby reducing the community's use and enjoyment of the lands. Additionally, the introduction of a new Land Use that is inconsistent with applicable plans or policies could also be considered an adverse effect, depending on the magnitude of the variance. A positive effect would be one that meets the Land Use plans and/or enhances the community's use and enjoyment of lands.

While future Land Use of the former Giant Mine site has yet to be determined, it will be guided by the policies, by-laws, legislation and regulations of the following governments and agencies having jurisdiction over Land Use:

- INAC, in cooperation with the GNWT, for lands permanently reserved to facilitate the continued operation of the frozen block and water treatment system;
- GNWT, for Commissioner's Land associated with Lease R662T;
- The City of Yellowknife for land within the boundaries of Lease 17889T, as well as any other land that may be subsequently transferred from the territorial government to the City in the future; and
- The Akaitcho Dene First Nation in the event that it receives lands within the Giant Mine lease boundaries as a result of a future negotiated comprehensive land claim settlement with the federal and territorial governments.

In general, site conditions after remediation will allow for a broad range of Land Uses, such as recreation and residential development. Exceptions include the area required to support the Long-term Operation and Maintenance Phase of the Project (i.e., the area of the water treatment and freeze plants). Future Land Uses will also be strongly influenced by arsenic concentrations in surficial materials. Specifically, some restrictions may be in place for the relatively small portion of the site that will be cleaned-up to industrial soil remediation objectives[29].

Notwithstanding the restrictions noted above, none of the site is expected to experience a reduction in the scope of Land Uses relative to current conditions. On the contrary, the range of permissible Land Uses will increase substantially for the vast majority of the site. As a consequence, the Project is expected to have an overall positive influence on the future Land Use of the site.

Visual Setting

The underlying assumption of the effects assessment is that the aesthetic character of the Giant Mine site has undergone adverse impacts due to more than fifty years of industrial activity. Based on the criteria listed in Table 8.11.1, the Project would only cause an adverse effect on the visual setting if it resulted in an overall increase in the industrial character of the site. This, in turn, could adversely affect the community's use and enjoyment of the lands. A positive effect would be one that reduces the industrial character of the site and encourages a viewshed that is better integrated into the surrounding natural landscape.

The Project will improve the visual setting of the site through the decommissioning and removal of several key industrial features (e.g., buildings). Other activities, including the naturalization of Baker Creek and revegetation of tailings areas will also have a positive influence on the aesthetic character of the site. While the visual setting of the site will improve relative to current conditions, some aesthetic effects from the historic operation of the mine will remain after remediation (e.g., the presence of open pits). In addition, new infrastructure such as the freeze system and water treatment plant will introduce new features within the visual setting of the site. These effects are unavoidable if the primary objectives of the Project are to be achieved.

Cultural Setting

With respect to Cultural Setting, an adverse effect is defined as any Project-induced disturbance to, or destruction of, built heritage features considered to be of major importance by affected communities. A positive effect is one that results in the protection of built heritage features.

[29] As noted in the Review Board's December 2008 *Reasons for Decision*, the selection of soil remediation objectives is not part of the scope of assessment.

The Project is expected to affect the cultural setting of the Giant Mine site through the proposed demolition of buildings that have heritage value regarding mining history and early Euro-Canadian settlement in Yellowknife. Heritage resources associated with local Aboriginal people are considered in Section 8.10.4.

8.11.2.4 Mitigation Measures

Measures to mitigate potential adverse effects to the Land Use, Visual & Cultural Setting environmental sub-component are cited in Table 8.11.2 and include:

- *Infrastructure planning* - The total area required for new infrastructure will be minimized through planning practices that aim to minimize the footprint to be occupied. Further, to the extent possible, new infrastructure will be located in previously disturbed areas;
- *Naturalization practices* - Borrow sources will be regraded, contoured and, where possible, revegetated to encourage conformity with the surrounding landscape;
- *Work Scheduling* - To the extent feasible, attempts will be made to schedule Project activities in such a way to reduce the potential for disruption of nearby community activities; and
- *Heritage preservation* – The Project Team will endeavour to accommodate the efforts of any parties wanting to preserve mine structures, provided the fundamental objectives of the Project are not compromised.

8.11.2.5 Residual Effects

The adverse residual effect to Land Use, Visual & Cultural Setting that has the potential to be caused by the implementation of the Remediation Project is listed below. The residual effect to the VCs (built heritage features and cultural landscape) is based on the findings of Table 8.11.2 and has been forwarded to Chapter 12 for a determination of significance.

- Buildings and surface infrastructure that may have heritage value may be demolished as part of Project implementation.

8.11.3 Socio-Economic Conditions

This section provides an overview of the potential effects of the Project on the Socio-Economic Conditions sub-component, as it pertains to the VCs identified in Table 7.7.6. The VCs evaluated collectively represent factors that are important in contributing to the concept of “community well-being”.

8.11.3.1 Positive Effects of Remediation

The total cost of the Remediation Phase of the Project is currently estimated to be approximately $ 480 million (including contingency). This will result in substantial socio-economic benefits to the residents of the LSA and the broader NWT. Such benefits would be associated primarily with direct employment and business opportunities. Benefits are also expected to accrue during the Long-Term Operation and Maintenance Phase of the Project when expenditures are estimated to be approximately $2 million per year.

Given its size, diverse work force, and the presence of well-established, experienced businesses, the communities of the LSA (Yellowknife, N'dilo, and Dettah) are well positioned to maximize the opportunities made available from the Project. Much of the remediation work required is anticipated to be compatible with the communities' available skill sets. For example, heavy equipment operators, who are well represented locally, will constitute a major component of the workforce during the Remediation Phase. In this regard, there are anticipated to be very few (if any) barriers to employment for northern individuals or companies, either as direct employees or as contract workers.

While local residents are generally in a good position to capitalize on the employment and business opportunities of the Project, a number of measures will be put in place to maximize their participation. These measures are described in Section 6.13.

8.11.3.2 Summary of Interactions

All Project activities will involve interactions with Socio-Economic Conditions. Such interactions can be positive (as described above) but may also be adverse. Because all Project activities have the potential to interact with Socio-Economic Conditions, the methodology used to identify interactions between the Project and other environmental components is not applicable to the current context. Instead of analyzing individual Project-environment interactions, all Project activities have been aggregated and examined for their potential collective effect on the VCs selected for this environmental sub-component.

8.11.3.3 Assessment of Potential Effects

The assessment of potential effects of the Project on Socio-Economic Conditions focussed on the relevant VCs that were selected in Section 7.7.4. The evaluation of potential effects is presented in Table 8.11.3 and is summarized below.

Table 8.11.3 Assessment of Potentially Adverse Effects on Social-Economic Conditions

Activity	Project Phase(s)	Description of Interactions and Effects	Analysis of Effects	Mitigation	Residual Effects	Is Further Consideration Required? When?
Community Effects						
All Activities	Remediation	The implementation of the Project will potentially require workers from outside the LSA, especially during the Remediation Phase. Such an influx has the potential for an adverse effect on the demographic character and cohesiveness of communities within the LSA. Based on preliminary analysis, the maximum workforce expected during the Remediation Phase is estimated to be approximately 120 persons, of which up to 75% could realistically be drawn from northern communities, mainly from within the LSA.	The 120 persons required for the Remediation Phase represents approximately 1% of the available workforce of the LSA. Assuming that only 30 workers would be brought in from outside the NWT, this would represent 0.25% of the available workforce and about 0.15% of the combined population of the LSA. The combination of the following factors suggests that a large population influx is not likely and, as such, adverse effects are not expected: • Relative to the size of the available workforce within the LSA, the labour requirements for the Project are small; • Relative to the population within the LSA, the size of the projected worker influx is extremely small (30 persons); • The Project Team will be encouraging local involvement in the Remediation Project by way of incentives for Aboriginal, local and northern employment, business opportunities and training. This is anticipated to result in a reduction of in-migration to support the labour needs of the Project.	The Project Team will be instituting procurement procedures to encourage employment, business and training opportunities for Aboriginal, local and northern residents.	No adverse residual effects are anticipated.	Yes. Preparation of a comprehensive procurement strategy that optimizes employment, business and training opportunities for Aboriginal, local and northern residents.
All Activities	Remediation Long-Term Operation & Maintenance	The Project may exert a demand on persons with certain specialized skills and trades. During periods of high activity (e.g., the Remediation Phase) it is possible that the Project would have an adverse effect on the local economy due to wage inflation, worker shortage and frequent job turn-over.	It is unlikely that the level of employment activity associated with Project would lead to worker scarcity, higher costs of living and price (including wage) inflation for the following reasons: • The population of the LSA makes it more robust to economic fluctuations than it would for smaller communities; • Expenditures during the Remediation Phase are expected to average approximately $50 million per year. This represents less than one percent of the NWT's $5.4 billion Gross Domestic Product reported in 2008; • The 120 persons required for the Remediation Phase represents approximately 1% of the available workforce of the LSA. The available workforce within the LSA would appear to be sufficiently large and diverse to provide skilled and unskilled workers in the numbers required during the Remediation Phase without leading to local skill shortages; • Remediation activities may entice skilled workers from other projects, such as the diamond mines, due to the opportunity to work within their home communities; • The nature of the work required for the Remediation Phase appears to be compatible with the skill sets present in the community. These include diamond drilling and heavy machinery operations	The Project Team will be instituting procurement procedures to encourage employment, business and training opportunities for Aboriginal, local and northern residents.	No adverse residual effects are anticipated.	Yes. Preparation of a comprehensive procurement strategy that optimizes employment, business and training opportunities for Aboriginal, local and northern residents

Table 8.11.3 Assessment of Potentially Adverse Effects on Social-Economic Conditions (Cont'd)

Activity	Project Phase(s)	Description of Interactions and Effects	Analysis of Effects	Mitigation	Residual Effects	Is Further Consideration Required? When?
All Activities	Remediation	The increase in activity at the mine site during the Remediation Phase may result in increased demand on community services. In particular, emergency response services provided in the City of Yellowknife (i.e., firefighting, ambulance, medical) may be required to respond to any emergencies at the site. There may be requirements for additional orientation and training of emergency service providers with respect to unique risks associated with the Remediation Project (e.g., arsenic trioxide). First aid capabilities will be provided on site by the Remediation Contractor. However, it is possible that treatment at the Stanton Territorial Hospital may be required occasionally. As such, the Project may result in increased demand for emergency medical services from the community. Other demands on community services, such as policing and recreation facilities, might occur due to the influx of workers from outside the NWT.	The demand for emergency response services are expected to be infrequent and unpredictable. However potential demands are expected to be generally consistent with historical mining operations at Giant Mine, although the projected workforce will be smaller. It is unlikely that the Project will result in a substantial increase in the population of the LSA; of the 120 workers required during the Remediation Phase, an estimated 30 would be required from outside the LSA. This small population increase is not anticipated to have an adverse effect on the availability of community services.	Remediation activities will be carried out within a regulated work environment under the authority of the Workers' Safety and Compensation Commission. Funding for the provision of some emergency medical services (e.g., ambulance services) to meet the direct demands of the Project, as well as any special training that might be required, may be established under a Community Agreement. As part of the Environmental Management Plans, Memoranda of Understanding (or similar types of arrangements) with key emergency response services will be developed. This will help to ensure that when such services are required at the Giant Mine site, the responders are acquainted with, and equipped to deal with the unique conditions and challenges of the site. Environmental Management Plans will be shared with emergency response providers.	No adverse residual effects are anticipated.	Yes. Through the development of Memoranda of Understanding with key emergency response service providers. During the preparation of Environmental Management Plans.
All Activities	Remediation	The influx of workers may have an adverse effect on the cost and availability of housing within the LSA. This could be compounded by the low vacancy rates for rental accommodation in Yellowknife, as well as the low number of dwellings available in the real estate market.	The Project is unlikely to cause a substantial increase in the population of the LSA. Of the 120 workers required during the Remediation Phase, an estimated 30 individuals would be required from outside the LSA. Workers sourced from outside the LSA are most likely to have highly specialized skills, such as building demolition or freeze plant construction, which will be required for relatively short periods. As such, these workers are unlikely to require permanent housing in the LSA.	The Project Team will be instituting procurement procedures to encourage employment, business and training opportunities for Aboriginal, local and northern residents.	No adverse residual effects are anticipated.	Yes. Preparation of a comprehensive procurement strategy that optimizes employment, business and training opportunities for Aboriginal, local and northern residents

Local and Regional Population

Rapid demographic changes can adversely affect a community's character and cohesion. For example, the implementation of other major projects within close proximity to northern communities has resulted in concerns about the impact of worker in-migration on infrastructure and services, as well as the overall social fabric of communities.

The current Project is anticipated to have a minor effect on the overall population and demographics of the communities in the LSA. Further, based on their history of involvement with the mining industry, the communities in the LSA are considered to be reasonably tolerant of modest population growth and demographic changes that might be associated with the Project.

Health and Safety Services, Municipal Infrastructure and Services

The availability and quality of essential services such as fire fighting, police services, ambulance and health care has an important role in maintaining a community's health and a sense of safety, both on a daily basis and during crisis situations. The implementation of the Project will largely rely on the emergency response and health care services provided by the City of Yellowknife. The degree to which those services will be adversely affected will be influenced by the size of the workforce, the number of migrant workers, the duration of the Remediation Phase, and the type and intensity of activity that will occur.

Consistent with the evaluation criteria established in Table 8.11.1, an adverse effect on community services and infrastructure might occur in situations where there is a sustained demand on local services (e.g. medical treatment of a migrant work force) and/or increased costs to the government providing the service. An example of a positive effect is one that would enhance the capacity of local government to provide better services.

As noted in Table 8.11.3, the Project is not expected to place a demand on community services and infrastructure that cannot be met by the City of Yellowknife. For this reason, no adverse effects on this environmental sub-component are anticipated.

Housing Supply and Property Values

Adequate housing provides privacy and security which contribute to psychological health and a sense of personal safety. Housing can affect a community's character, cohesion and financial health. Concerns have been raised in recent years regarding the effect that major developments have on housing availability and price. This is particularly true for communities such as Yellowknife, which not only has a relatively small stock of homes available on the market, but also low vacancy rates in the rental market. For the current Project, the potential effects on housing will be influenced by the size of the proposed workforce, the number of migrant workers in that workforce, the duration of the Remediation Phase, and the type and intensity of activity that will occur.

Based on the criteria noted in Table 8.11.1, an adverse effect on housing would occur if the Project activities resulted in substantive cost increases in the rental and real estate market. A positive effect would occur if the Project resulted in improved availability and/or affordability of rental and real estate properties.

As indicated in Table 8.11.3, the relatively modest employment levels associated with the Project are not expected to result in a noticeable change in the overall housing market.

Employment, Business Development, Economic Diversification, Education and Vocational Training

Based on the criteria noted in Table 8.11.1, an adverse effect on the economy would occur if the implementation of the Project leads to local labour shortages. It may also occur if the local labour force and businesses are unable to take full advantage of the opportunities associated with the Project due to a lack of qualifications to implement certain components of the work. A positive effect would occur if the implementation of the Project increases local and regional employment, income, and expertise, and enhances local businesses.

The Remediation Phase will likely cause a sustained demand on the local construction and mining labour force for close to a decade. While most of the potential economic effects are expected to be positive, it is possible that the demand for workers could cause local labour shortages which, in turn, may affect local economic development through possible wage inflation or high worker turnover rates. Given the relatively small scale of the Project relative to the regional economy, the potential for an adverse effect is low.

Another possible adverse effect may occur if more specialized skills required for remediation activities cannot be met by the local or regional labour force, thus requiring external sourcing. The extent of this adverse effect would depend on the training and experience of the local workforce, as well as the capacity of local businesses to respond to these demands. As noted above, a number of initiatives will be put in place to minimize this potential. While there will likely remain some requirements for external sourcing, the Project as a whole is anticipated to result in positive effects on the economy of the LSA and RSA.

8.11.3.4 Mitigation Measures

The following measures are proposed to mitigate adverse effects to Socio-economic Conditions:

- *Procurement strategy* - The Project Team will be instituting procurement procedures to encourage employment and business opportunities for Aboriginal, local and northern residents;
- *Health and safety planning* - Remediation activities will be carried out within a regulated work environment under the authority of the Workers' Safety and Compensation Commission. Appropriate Environmental Management Plans will be developed; and
- *Emergency response planning* – As part of the Environmental Management Plans, Memoranda of Understanding (or similar types of arrangements) will be developed with key emergency response services (fire, police, ambulance) to ensure the full range of required services are available to the Project, without compromising the availability of the same services for other users within the LSA.

8.11.3.5 Residual Effects

As indicated in Table 8.11.3, the Project is not anticipated to result in residual adverse effects on Socio-economic Conditions and its associated VCs.

8.11.4 Transportation

8.11.4.1 Summary of Interactions

Table 8.3.1 identified the following interactions between Project activities and the Transportation environmental sub-component. Only those interactions which were determined to have some potential for adverse effects were identified. The type of effect and associated activities related to Transportation are as follows:

Community Effects:

- Baker Creek rehabilitation (remediation);
- Highway realignment (remediation); and
- On- and off-site transportation (remediation).

8.11.4.2 Assessment of Potential Effects

The SSA and LSA are traversed by roads that are important elements in the social and economic life of the local communities. Public roads within these areas will be affected by various Project activities, including physical upgrades and increases in traffic. Table 8.11.4 presents an assessment of potential Project effects on the efficiency and safety of the transportation System.

The efficiency of the transportation system and its adequacy to meet the demands placed upon it are essential factors in the convenient and efficient movement of persons and goods. Although the Project will place additional demands on local roads, the transportation system is anticipated to have sufficient residual capacity to manage such demands without causing a decrease in the overall efficiency of the system.

The safety of the road system is of direct concern to community members as unsafe roads are a threat to community well-being. While there is a possibility that traffic accidents attributable to the Project will occur, increases in the probability of transportation accidents are anticipated to be minimal.

8.11.4.3 Mitigation Measures

Measures will be put in place to minimize the influence of the Project on the effective functioning of local roads and to promote public safety (refer to Table 8.11.4). These may include staging the implementation of disruptive activities during periods when the potential for effects is at its lowest. To minimize the potential for traffic collisions, Environmental Management Plans will include a Traffic Management Plan to prevent and respond to transportation safety risks. The Plan is anticipated to include, among other things, the following measures:

- All applicable traffic safety regulations will be observed;
- Only trained and certified persons will be permitted to operate heavy equipment and haul trucks;
- Protocols will be established for all road crossings;
- Signage alerting road users to construction activities and slow-moving vehicles will be posted;
- Access to on-site roads will be gated and monitored by security personnel; and
- Detailed measures to respond to potential transportation incidents.

8.11.4.4 Residual Effects

Based on the findings presented in Table 8.11.4, no adverse residual effects on the VCs selected for the Transportation environmental sub-component are anticipated.

Table 8.11.4 Assessment of Potentially Adverse Effects to Transportation

<table>
<tr><th>Activity</th><th>Project Phase(s)</th><th>Description of Interactions and Effects</th><th>Analysis of Effects</th><th>Mitigation</th><th>Residual Effects</th><th>Is Further Consideration Required? When?</th></tr>
<tr><td colspan="7">Community Effects</td></tr>
<tr><td>Baker Creek rehabilitation and Highway realignment</td><td>Remediation</td><td>The relocation of approximately 1 km of Highway 4, proposed culvert upgrades, Baker Creek realignment and bridge construction may have an adverse effect on the use of Highway 4. Potential effects could include road diversions, traffic delays, reduction in the posted speed limit near the mine site and possible road closures during peak periods of construction.</td><td>As a comparison, major highway improvements by the GNWT Department of Transportation have been implemented without causing major disruptions to road users (e.g., the 2008 Highway 4 reconstruction between kilometres 32 and 35). Based on the nature of activities to be implemented and the currently low traffic volumes in the area, substantial delays are not expected.</td><td rowspan="2">Environmental Management Plans will include a Traffic Management Plan to control transportation movements associated with the Project and to minimize the influence of Project activities on other road users. Where possible, activities that might disrupt traffic will be staged to minimize potential effects. This will take into consideration:
• Peak traffic periods for commuters living in Dettah or along Highway 4
• Work shift changes at Giant Mine
• Ice Road traffic
• Important community events that require use of roads in the SSA

The Traffic Management Plan will identify transportation safety risks and specific mitigation measures required to prevent and respond to incidents. Examples of the measures to be taken include:
• All applicable traffic safety regulations will be observed;
• Only trained and certified persons will be permitted to operate heavy equipment and haul trucks;
• Protocols will be established for all road crossings;
• Signage alerting road users to construction activities and slow-moving vehicles will be posted;
• Access to on-site roads will be gated and monitored by security personnel; and
• Measures to respond to potential transportation incidents.</td><td rowspan="2">No residual adverse effect anticipated.</td><td rowspan="2">Yes.
During the preparation of Environmental Management Plans.</td></tr>
<tr><td>On- and off-site transportation</td><td>Remediation</td><td>The Project will result in temporary increases of traffic volumes that could have an adverse effect on the use of local roads by other users. Increases of off-site traffic volumes will be associated with the transportation of materials to/from the site, as well as commuting workers

Increases in on-site traffic will be attributed primarily to heavy machinery carrying out earthwork activities and the hauling of borrow material.

Increases in on-site traffic (e.g., road crossings by slow moving heavy equipment) and off-site traffic (e.g., haul trucks transporting borrow materials on public roads), could result in an increased likelihood of collisions on Highway 4 or the Vee Lake Access Road. The use of heavy trucks and equipment on public roads could also damage the road, which might pose a compounding risk to road users.</td><td>With regard to off-site transportation, an average of 870 vehicles travelled Highway 4 in the vicinity of Giant Mine on a daily basis in 2007. In contrast, an average of 1,460 vehicles travelled the same route in 1998, prior to the closure of Giant Mine. While current traffic levels may increase slightly during the Remediation Phase, levels are expected to remain well below those which existed during the mining operation. The peak remediation workforce is expected to be smaller than the Giant Mine workforce during the last years of production.

For most of the year, recreational and residential use dominates the traffic volumes of Highway 4. However, for several months during the winter season, the route also serves as the sole access to the Tibbitt-Contwoyto Winter Road which is used to supply mining operations to the northeast. Transport trucks heading to the Tibbitt-Contwoyto Winter Road typically leave in four-vehicle convoys every 20 minutes. Given this time interval, it should not be difficult to stage remediation activities, such as road crossings by heavy equipment, in order to not interfere with the convoys.

In addition to Highway 4, increased traffic volumes on the Vee Lake Access Road are expected (due to haulage of borrow material) However, the average daily traffic volume on this road is typically low (e.g., a peak daily average of 66 vehicles in 2005) and, as a result, the incremental activity is expected to have a negligible effect on traffic.
The majority of on-site traffic by heavy equipment will be confined to mine roads, on which the general public is prohibited from travelling.

As noted in section 7.7.3.4, the rate of collisions occurring on public roads in the vicinity of Giant Mine is fairly low (24 recorded between 2004 and 2007). While it is possible that additional collisions could occur, any increase in the probability of collisions is expected to be minimal due to the small projected increase in traffic associated with the Project.</td></tr>
</table>

8.11.5 Local Resources

Major undertakings have the potential to deplete Local Resources which can also result in increased costs for other users. During the scoping sessions for the EA, various participants identified use of Local Resources by the Remediation Project as a potential concern. This is reflected in the Review Board's *Terms of Reference* which require a determination of the effects the Project might have on local infrastructure and utility costs. Potential effects on infrastructure were evaluated in Section 8.11.3 (Socio-economic Conditions). With regard to utility costs, this topic is dealt with in the current section.

For the purposes of the DAR, the Local Resources selected as having some potential to be adversely affected by the Project include: Electricity, Fuel Storage, Construction Materials, and Human Resources. Although the socio-economic baseline presented in Section 7.7 provides some background information that is relevant to the current analysis, comprehensive descriptions of existing conditions for Local Resources are not provided in Chapter 7. Instead, the required baseline information is presented in Table 8.11.5 along with the assessment of potentially adverse effects on Local Resources.

8.11.5.1 Summary of Interactions

Table 8.3.1 identified the following interactions between Project activities and the Local Resources environmental sub-component. Only those interactions which were determined to have some potential for adverse effects were identified. The type of effect and associated activities related to Local Resources are as follows:

Community Effects

- Freeze plant operation and active freezing (Remediation);
- Borrow extraction and backfilling (Remediation);
- Water management (Remediation and Long-Term Operation & Maintenance);
- Fuel Management (Remediation).

In addition to these specific project-environment interactions, Human Resources interact with all Project components in a manner similar to the interactions described in Section 8.11.3.

8.11.5.2 Assessment of Potential Effects

Electricity Use

Electrical power consumed by the Project will be provided by the Northwest Territories Power Corporation (NTPC). During scoping sessions, concerns were raised whether NTPC has sufficient spare capacity to meet the requirements of the Remediation Project and if the costs associated with this additional supply would be borne in part by users other than Giant Mine. Also of relevance is whether the additional demand would require NTPC to produce more electricity using diesel-powered generators (i.e., those located at the Jackfish Power Plant).

Based on the criteria noted in Table 8.11.1, an adverse effect on the electrical resource would occur if the Project were to result in a reduction of service or increase in associated costs for other users. As described in Table 8.11.5, the incremental electricity demand associated with the Project is not expected to result in substantive changes to the quality or cost of electricity for other users. As a consequence, adverse effects on the electrical resource are not anticipated.

Fuel Storage

Based on the criteria noted in Table 8.11.1, an adverse effect on fuel storage would occur if Project activities led to shortages of fuel storage space, thereby resulting in increases in the cost of petroleum products for other users. While the Project may result in a temporary decrease in the availability of fuel storage, such decreases are expected to be minor relative to the available storage capacity within the LSA.

Construction Materials

The Project's requirements for borrow materials will result in a reduction of readily available materials for other users in the LSA. Depending on the magnitude of this reduction, material shortages and/or higher prices may result. Additional construction materials required for the Project (e.g., for the construction of new infrastructure) will be sourced from beyond the LSA and are not anticipated to have an adverse effect on the availability of Local Resources.

Human Resources Use

Based on the criteria noted in Table 8.11.1, an adverse effect on human resources would occur if the implementation of the Project leads to shortages in the local labour market. A positive effect would occur if the implementation of the Project increases the size and skill level of the local workforce, such that the community can leverage its experience for future opportunities.

In recent years, the strong economic performance of the communities in the LSA (and Western Canada in general), has resulted in shortages of some types of trades and professions. While the labour market has softened from its peak of a few years ago, strong economic growth may resume during the Remediation Phase and, as such, certain trades and skill-sets may again be in high demand, potentially leading to increased prices for these services. However, based on the size of the Project workforce relative to the pool of locally available resources, the Project is not expected to have an adverse effect on the availability of labour for other initiatives. On the contrary, the employment and business opportunities provided by the Project will increase the overall capacity of the community to benefit from future undertakings.

8.11.5.3 Mitigation Measures

Mitigation measures identified to address demands on specific Local Resources that may be affected by the Project are as follows:

- Electricity Use – The Project Team is exploring opportunities to reduce the quantity of diesel-generated electricity that might be required by the Project. The Project Team will also consider making arrangements with NTCL to cover any incremental costs in the event that electricity required by the Project would otherwise result in cost increases for other users.
- Human Resource Use – The Project Team will be instituting procurement procedures to encourage employment, business and training opportunities for Aboriginal, local and northern residents.

8.11.5.4 Residual Effects

With mitigation measures in place, the Remediation Project is not anticipated to result in adverse residual effects on Local Resources.

Table 8.11.5 Assessment of Potentially Adverse Effects to Local Resources

Activity	Project Phase(s)	Description of Interactions and Effects	Analysis of Effects	Mitigation	Residual Effects	Is Further Consideration Required? When?
Community Effects						
Freeze plant operation and active freezing & Water management	Remediation Long-Term Operation & Maintenance	It is currently anticipated that the majority of electricity used by the Project will be generated by the NTPC and distributed through the regional grid. While the active freeze system represents the greatest source of demand, other activities such as water management (including de-watering of the mine and water treatment) will also contribute to the total electricity demand of the Project. If the incremental demand exerted by the Project were to exceed the current generating and distribution capacity of the NTPC, additional capacity would be required to meet the needs of all users within the LSA (including the Project). Depending on the magnitude of requirements for additional capacity, cost increases could also occur. In addition, if the incremental demand associated with the Project is met through the use of diesel-fired generators, increased atmospheric emissions could also occur.	NTPC has indicated they have sufficient spare capacity to meet the electricity requirements of the Project without straining their generating or distribution systems. A combined generation capacity of 46.5 megawatts is available, of which 70% is from hydroelectricity and 30% from diesel-powered thermal plants. In recent years, since the end of gold mining in Yellowknife, the hydroelectric plants have met close to 100% of demand. For the active freezing operation, electricity demands will be at their greatest in year 2, when annual demand from the Project is predicted to be 57.1 GW.h. This incremental consumption will increase the total demand on the NTPC system to 246.7 GW.h. Of this total, diesel thermal plants are anticipated to provide 10.9% of the supply. To be conservative, the analysis of potential air quality effects associated with the remediation project (Section 8.6.2) assumed that all of the electricity required by the Project would be produced by diesel-fired generators at the NTPC Jackfish Plant in Yellowknife. Under this worst-case scenario, the emissions associated with electricity generation are not anticipated to result in adverse air quality effects. After year 2, there will be a progressive reduction in the electricity requirements of the Project until year 9 when passive freezing commences. Electricity demands will reduce further during the Long-Term Operation and Maintenance Phase when minewater management and treatment are expected to dominate electricity requirements. Current electricity requirements of care and maintenance activities at Giant Mine provide some indication of long-term demands. For example, during the past few years, Giant Mine's annual consumption has been in the order of 5.0 GW.h annually. However, following the freezing of the arsenic chambers, the underground water will be allowed to rise to approximately the 100 level of the mine. Water pumping from this level will be less energy-intensive compared to the current situation where water is being from the 750 level. As such, long-term electricity requirements associated with pumping are expected to be lower than current levels.	The Project Team is exploring opportunities to reduce the quantity of diesel-generated electricity that might be required by the Project. For example, operating during off-peak times, or extending the freeze period may result in minimal requirements for diesel-generated electricity. The Project Team will also consider making arrangements with NTCL to cover any incremental costs in the event that electricity required by the Project would otherwise result in cost increases for other users.	No adverse residual effects are anticipated.	No.
Borrow extraction and backfilling	Remediation	Based on current estimates, the implementation of the Project will require approximately: • 47,000 m^3 of rip rap/waste rock • 610,943 m^3 of coarse borrow (sand to gravel) • 745,982 m^3 of fine borrow (silt to silty clay) The Project's requirements for borrow materials will result in a reduction of readily available materials for other potential users in the LSA. Depending on the magnitude of this reduction, material shortages and/or higher prices may result.	The Project Team has undertaken a series of assessments to determine the availability of borrow materials within the Giant Mine lease boundary. To date, the following resources have been identified: • 324,670 m^3 of rip rap/waste rock • 1,558,526 m^3 of coarse borrow (sand to gravel) • 710,200 m^3 of fine borrow (silt to silty clay) Based on the above estimates, the Project has a relatively minor deficit (< 40,000 m^3) of fine borrow material. It is anticipated that this additional requirement will be met by yet to be identified on-site sources (e.g., fine material present in the C1, A1 Pit and A2 Pit overburden piles). In the unlikely event sufficient fine borrow material is not identified in on-site sources, other options within the LSA are available. The required quantity is considered to be very small relative to the assumed inventory of granular materials available in the LSA. Subject to land use restrictions, large quantities of coarse granular material located within the lease boundary will become available to other users following the completion of the Remediation Phase. Depending on the success of further investigatory work, new sources of fine material may be available as well.	No mitigation is applicable.	No adverse residual effects are anticipated.	Yes. Further investigatory work is required to identify additional sources of fine material within the lease boundary.

Table 8.11.5 Assessment of Potentially Adverse Effects to Local Resources (Cont'd)

Activity	Project Phase(s)	Description of Interactions and Effects	Analysis of Effects	Mitigation	Residual Effects	Is Further Consideration Required? When?
Fuel Management	Remediation	Substantial quantities of diesel fuel will be required for implementation of the Project. Fuel and associated storage requirements will be attributable to increased requirements for diesel powered electricity and heavy equipment operation. If insufficient fuel storage capacity is available within the LSA, demand for fuel storage may result in increased costs for other users.	RTL Robinson Enterprises Ltd and Esso (Imperial Oil Limited) are the two businesses in the LSA which have major fuel storage facilities. RTL Robinson Enterprises Ltd has a 160 million litre capacity for diesel, of which 100% is booked by the operating mines in the NWT. Esso has a diesel fuel storage capacity of 42 million litres, of which only a 3 million litre tank is currently in use. There are 6 other tanks with a total storage capacity of 39 million litres that are currently not in use and could be commissioned if there was a need. Although the total projected quantity of fuel to be used by the Project has yet to be determined, current conditions suggest there is sufficient surplus storage capacity in the LSA. In addition to commercially available fuel storage, the Remediation Contractor may also establish its own tank farm at the Giant Mine site.	None required.	No adverse residual effects are anticipated.	No.
All activities	Remediation	The implementation of the Project will require the deployment of human resources in a number of areas, such as heavy machinery operation, logistics, construction, drilling and environmental services. Depending on the extent of local involvement, the Project could influence the supply of human resources that are available to other initiatives in the Local and Regional Study Areas. Any reductions in the availability of human resources might, in turn, lead to labour scarcity and higher costs for labour/professional services.	It is unlikely that the level of activity associated with the Project will lead to human resource scarcity for the following reasons: • The estimated 120 persons required for the Remediation Phase represents approximately 1% of the available workforce of the LSA. • The available workforce within the LSA is anticipated to be sufficiently large and diverse to provide skilled and unskilled workers in the numbers required during the Remediation Phase without leading to local skill shortages. • Remediation activities may entice skilled workers from other projects, such as the diamond mines, due to the opportunity to work within their home communities.	The Project Team will be instituting procurement procedures to encourage employment, business and training opportunities for Aboriginal, local and northern residents.	No adverse residual effects are anticipated.	Yes. Preparation of a comprehensive procurement strategy that optimizes employment, business and training opportunities for Aboriginal, local and northern residents

9 Effects of the Environment on the Project

9.1 Overview

The current chapter presents an analysis of credible natural hazards or environmental trends that could affect the Giant Mine Remediation Project. Specifically, Section 9.2 focuses on the identification and evaluation of interactions between the *natural environment* and the Remediation Project. Within this context, adverse effects on the Project have the potential to occur in situations where the natural environment partially or completely prevents one or more Project components from performing as intended. This could, in turn, lead to adverse effects on the environment.

In addition to natural phenomena, Giant Mine has a number of man-made physical hazards that could affect the implementation of the Project under certain upset scenarios. These hazards include existing site features such as unstable crown pillars (Section 5.1.4) and underground bulkheads (Section 5.1.5), both of which are at risk of failure. As described in Chapter 6, the Remediation Plan has identified specific remedial measures to address these risks. However, should the risks materialize prior to implementation of the remedial measures, the effectiveness of the Remediation Project may be compromised.

The potential for existing physical hazards to have an adverse effect on the Remediation Project is evaluated in Section 9.3. In some respects, the upset events involving existing site hazards are similar to the Accidents and Malfunctions examined in Chapter 10. However, the analysis of Accidents and Malfunctions deals with those upset events that might occur *as a consequence* of Project implementation (e.g. spills), whereas, scenarios involving existing site hazards can occur independently of the Remediation Project.

9.2 Effects of the Natural Environment on the Project

The approach used to evaluate effects of the natural environment on the Remediation Project was generally similar to the methodology for the assessment of Project effects on the environment (as described in Chapters 3 and 8). The specific steps included:

- Identifying potential interactions between the environment and the Project (Section 9.2.1);
- Evaluating the potential effects of interactions between the environment and the Project (Section 9.2.2); and
- Selecting mitigation measures to prevent or minimize adverse effects that could be caused by environmental phenomena (Section 9.2.3).

9.2.1 Potential Interactions of the Environment with the Project

The following categories of environmental phenomena were identified as potentially interacting with the Remediation Project:

- Seismic events;
- Climate change; and
- Severe weather & flooding.

Table 9.2.1 identifies potential interactions between these environmental phenomena and the activities associated with the Site Remediation and Long-Term Operation and Maintenance phases of the Project. In situations where potential interactions have been identified, they are discussed further in Section 9.2.2.

Table 9.2.1 Potential Interactions of the Environment with the Project

Project Component	Seismic Events	Climate Change	Severe Weather and Flooding
Site Remediation Phase			
Installation & Operation of Freeze System	No interaction. The maximum credible seismic event in the Giant Mine area falls within the range of 5 to 6 on the Richter scale. A seismic event of this magnitude is not anticipated to have an effect on this Project activity. The same rationale applies to other activities within this column noted as having "no interaction".	No interaction. The Project's remediation phase is scheduled to extend from 2012 to 2027. This period is considered too short to result in measurable effects of climate change on the Project. The same rationale applies to other activities within this column noted as having "no interaction".	No interaction. Severe weather and flooding could result in temporary delays in Project implementation. However, any delays would be short relative to the entire Project duration. The same rationale applies to other activities within this column noted as having "no interaction".
New Underground Development	Potential interaction. A seismic event could lead to an underground failure within areas required to implement the Project. This could delay Project implementation.	No interaction.	Potential interaction. Flooding could result in a delay in Project implementation while the underground workings were being dewatered sufficiently to continue activities and potential damage to equipment.
Earthworks	No interaction. Although a seismic event could affect existing earthworks (e.g., B2 Dyke), this would not affect the implementation of new earthworks associated with the Project.	No interaction.	Potential interaction. Severe weather and flooding could lead to localized erosion of unconsolidated surficial material around earthworks, such as during tailing cover construction, or quarrying. This may lead to increased turbidity and potential mobilization of contaminated materials.

Table 9.2.1 Potential Interactions of the Environment with the Project (Cont'd)

Project Component	**Seismic Events**	**Climate Change**	**Severe Weather and Flooding**
Construction of Surface Infrastructure	No credible interactions identified.		
Demolition of Surface Infrastructure	No credible interactions identified.		
Water Management	No interaction.	No interaction.	Potential interaction. Severe weather and flooding will affect the volume and quality of water requiring treatment.
Transportation	No credible interactions identified.		
Miscellaneous	No credible interactions identified.		
Long-Term Operation and Maintenance Phase			
Passive freezing (maintenance of frozen block)	No interaction.	Potential interaction. The 25-year temporal scope of assessment is too short to result in measurable effects of climate change on the performance of the Project.	No interaction.
Storage of contaminants/waste	Potential interaction. Potential damage of structures used to store contaminated materials (e.g., tailings dams).	Potential interaction. Climate change could be a contributing factor to severe weather and flooding events that have the potential to affect tailings covers. A long-term warming trend and/or changes in precipitation could have an effect on vegetation that is to be incorporated as part of the tailing cover design.	Potential interaction. Flood events have the potential to result in increased erosion of earth structures (e.g., tailings dams and covers).
Water management	No interaction.	Potential interaction. Climate change could affect the volume and quality of water requiring treatment.	Potential interaction. Severe weather and flooding could affect the volume and quality of water requiring treatment.
Maintenance	No credible interactions identified.		
Monitoring	No credible interactions identified.		

9.2.2 Evaluation of Potential Effects of the Environment on the Project

9.2.2.1 Potential Seismicity Effects

As described in Section 7.2.2.7, the Yellowknife area is situated within a zone of low seismic hazard. Seismic events in the Yellowknife area are dominated by earthquakes of a magnitude 6 or less, at distances of greater than 60 km. Based on the seismic history of the area, the likely adverse effects to any Project components as a result of a credible earthquake scenario are anticipated to be negligible or very minor.

Earthquakes would have no effect on the frozen arsenic trioxide dust storage areas. Once fully formed, the frozen blocks will not be susceptible to deformations that could result in a release of arsenic trioxide. Similarly, the active and passive-freezing infrastructure will be resilient to credible seismic events. All buildings, including the freeze plant and water treatment plant, will be designed to meet applicable seismicity standards in the National Building Code. In the unlikely event that surface infrastructure is damaged by an earthquake, repairs would be implemented and the potential for adverse environmental effects would be minimal.

Notwithstanding the conclusions noted above, two potentially adverse interactions between seismicity and the Remediation Project were identified in Table 9.2.1. These interactions include.

- New Underground Development (remediation); and
- Storage of Contaminants / Waste (long-term operation & maintenance).

Descriptions of these interactions and their potential to cause adverse effects on the Remediation Project are provided below.

New Underground Development

As noted in Table 9.2.1, a seismic event could lead to an underground failure within areas required to implement the Remediation Project (e.g., new underground development). The main consequence of such an event would be a delay of Remediation Project implementation until the failure could be addressed. This would not compromise the overall performance of the Remediation Project.

Storage of Contaminants / Waste

Regarding the tailings containment areas, the implications of credible seismic events has been formally evaluated. Specifically, the potential for liquefaction of materials underlying portions of selected tailings dams has been determined (Naesgaard and Amini in SRK 2008). In the modelling, silts and tailings were assumed to have "sand-like" behaviour and, thus, to be susceptible to liquefaction. The modelling showed that the soils would not liquefy where they are covered by a minimum of 2 m of rockfill. It is possible that very loose material may exist in some areas at the toes of some dams where the rockfill would be less than 2 m. Under such circumstances, small, localized failures may occur during seismic events. However, they would not threaten the structural integrity of the dams and would be repaired as part of routine maintenance activities (SRK 2008).

Based on this information, it is anticipated that seismic events will not cause adverse effects that would compromise the overall performance of the Remediation Project. As a precautionary measure, the occurrence of an earthquake with a magnitude of 5.0 or greater will prompt a geotechnical inspection of the tailings covers, dams, conveyance channels and other potentially vulnerable structures.

9.2.2.2 Potential Climate Change Effects

Given the temporal scope set for the assessment (i.e., a total of 25 years), it is difficult to make definitive conclusions regarding how climate in the Yellowknife region will change within this period. Similarly, there is uncertainty regarding how any predicted climate changes will affect the performance of some Project components.

In general, the long-term meteorological data set for Yellowknife shows trends toward milder temperatures and more precipitation. This trend is confirmed in the work carried out by the Canadian Climate Change Scenarios Network (CCCSN), which has produced a summary of findings from the most recent IPCC (2007) modelling assessment for Canada for future conditions (CCCSN 2009). A summary of the predicted trends for temperature and precipitation is presented in Table 9.2.2. The results represent three levels of projected climate change for the 2050s period (2041-2070) in relation to the baseline period of 1961-1990 for 'low', 'medium' and 'high’ scenarios.

Table 9.2.2 Predicted Changes in Climate for the Yellowknife Area (2050s period)

	Low	Medium	High
Temperature			
Annual Temperature	+2.5°C	+2.9°C	+3.3°C
Spring Temperature	+2.2°C	+2.6°C	+2.9°C
Summer Temperature	+1.7°C	+1.9°C	+2.2°C
Fall Temperature	+2.5°C	+2.8°C	+3.1°C
Winter Temperature	+3.8°C	+4.2°C	+4.8°C
Precipitation			
Annual Precipitation	+10.48%	+11.89%	+12.75%
Spring Precipitation	+10.19%	+11.80%	+13.92%
Summer Precipitation	+7.62%	+9.10%	+9.46%
Fall Precipitation	+12.98%	+13.86%	+14.43%
Winter Precipitation	+12.81%	+14.64%	+15.37%

Source: CCCSN 2009

Taking into consideration the anticipated long-term trends in climate, the following three potential interactions between climate change and the Remediation Project were identified in Table 9.2.1:

- Passive Freezing (long-term operation & maintenance);
- Storage of Contaminants / Waste (long-term operation & maintenance); and
- Water Management (long-term operation & maintenance).

Descriptions of these interactions and their potential to cause adverse effects on the Remediation Project are provided below.

Passive Freezing

Average ambient temperatures will be a key determinant in the performance of the frozen block method. In particular, any temperature changes associated with climate change have the potential to influence the effectiveness of the Remediation Project and its ability to protect the environment. The potential influence of temperature increases on the frozen block method has been considered in detail in Section 6.2.8.2. It was concluded that climate change is not anticipated to have an adverse effect on the performance of the frozen block method.

Storage of Contaminants / Waste

In addition to arsenic trioxide stored within the frozen blocks, the Remediation Project will involve the long-term storage of other contaminants and waste. A consideration of potentially adverse effects that climate change may have on this Project activity is therefore warranted. Materials stored on surface, particularly tailings, are considered to have the greatest potential to be affected by climate change.

With the exception of potential severe weather and flooding, which are evaluated in the following section, the effects of climate change in the Yellowknife area are anticipated to include increased average annual temperatures and precipitation. Due to the site's semi-arid and cold climate, the warmer temperatures and increased precipitation associated with climate change are expected to promote vegetation growth. In this regard, the predicted climate trend is likely to be beneficial to the establishment of vegetation on tailings covers and all other areas proposed to be revegetated (e.g., restored borrow pits). On this basis, climate change is not expected to have an adverse effect on revegetation efforts.

Water Management

Regarding the potential for increased requirements for the management of contaminated water (i.e., water treatment), Table 9.2.2 indicates that total annual precipitation would increase by a maximum of approximately 13%. The proposed water treatment plant has sufficient residual capacity to manage an equivalent increase in the total annual volume of contaminated water requiring treatment. As a consequence, increased precipitation is not expected to have an adverse effect on the water management requirements of the Remediation Project.

9.2.2.3 Severe Weather and Flooding Effects

Severe weather typically includes conditions of high winds and extreme rainfall leading to the potential of flooding. High winds are not anticipated to have an effect on the Project. As previously noted in Chapter 7, extreme wind events are fairly rare in Yellowknife and there are no credible scenarios in which wind damage might result in the kind of structural damage that would threaten the objectives of the Project. There are, however, several interactions by which extreme rainfall and flooding could result in potential effects on the Remediation Project. As noted in Table 9.2.1, these interactions include:

- New Underground Development (remediation);
- Earthworks (remediation);
- Water Management (remediation and long-term operation & maintenance); and
- Storage of Contaminants / Waste (long-term operation & maintenance).

Descriptions of these interactions and their potential to cause adverse effects on the Remediation Project are provided below.

New Underground Development

Depending on the nature of flooding, modifications to elements of the Remediation Project could become necessary. If such flooding were to occur, the implementation of several Project works and activities could be affected. A delay in the implementation of the Remediation Project could result while the mine workings were dewatered sufficiently and damaged equipment repaired or replaced.

Flooding from Baker Creek is the primary mechanism by which the underground mine could become inundated. As described further in this section under Storage of Contaminants, the probability of a major flood that could cause extensive flooding in the underground workings is quite low, especially for the period required to carry out the freeze process.

Earthworks

Large precipitation events and/or rapid thaw of the snow pack could lead to localized erosion of unconsolidated surficial material around earthworks (e.g., during tailing cover construction or excavation of borrow material). This may lead to increased turbidity and the mobilization of contamination.

As described in Chapter 8, erosion and sedimentation prevention techniques will be implemented during all earthworks activities. Earthwork activities will be scheduled to limit the amount of exposed surficial materials that could be subjected to erosion. As a further means to mitigate the effects of an extreme rainfall event, work stoppages will be implemented when remediation activities that could threaten water quality or the aquatic environment are being carried out. Taking mitigation measures into consideration, increased erosion caused by severe weather and flooding is not anticipated to have an adverse effect on the overall performance of the Remediation Project.

Water Management

As described in Section 6.8.4, surface water exceeding the applicable discharge criterion for arsenic will be collected and treated prior to discharge. Although flood events would result in a temporary increase in the volume of water requiring treatment (e.g., due to increased run-off from the tailings areas), there is sufficient storage capacity within the mine to accommodate these volumes. Under such a circumstance, the water levels within the mine would increase following a storm event. These levels would gradually be lowered to preferred operational conditions by temporarily increasing the volume of minewater treated by the water treatment plant. As noted previously, the water treatment plant has sufficient residual capacity to manage such increases. On this basis, severe weather and flooding are not anticipated to have an adverse effect on water management activities associated with the Remediation Project.

Storage of Contaminants

The discussion of potential effects that severe weather and flooding might have on the storage of contaminants has been divided into two major categories: i) arsenic trioxide dust; and ii) tailings.

Arsenic Trioxide Dust

Until the frozen block has been fully implemented, the greatest risks from severe weather are associated with the potential for flooding of the underground mine, specifically the areas where arsenic trioxide is stored. If such flooding were to occur, the implementation of several Project works and activities could be affected. Depending on the nature of flooding, modifications to elements of the Remediation Project could become necessary.

Flooding from Baker Creek is the primary mechanism by which the underground mine could become inundated. The existing Baker Creek configuration has adequate capacity to safely convey most flood events. For example, the majority of the creek is currently capable of conveying a one in 500-year flow (25 m^3/s) without flooding. The main exception is Reach 1, where flows greater than a one in 370-year event (22 m^3/s) would overtop the A2 Pit. A potential contributing factor to flooding is ice and debris jamming. Such blockages could greatly influence upstream water elevations and the potential for overtopping of the creek banks. To mitigate this potential risk, Baker Creek is monitored when such conditions are prevalent.

Although designs for Baker Creek have yet to be finalized, the capacity of the realigned channel will be equal or greater than the current channel. Overall, the probability of a major flood that could cause extensive flooding in the underground workings is quite low, especially for the period required to carry out the freeze process.

Following the completion of the remediation phase, the potential risk from flooding events is anticipated to greatly diminish. The frozen arsenic trioxide stopes and chambers will not be affected by any flooding event.

Tailings

Any contaminants stored on surface have the potential to be affected by severe weather events. The tailings areas represent the primary concern in this regard due to the risk that severe precipitation events and/or flooding could jeopardize the structural integrity of tailings covers.

The tailings covers will be constructed with conveyance channels and spillways to convey surface flows. The design criterion for the tailings covers was based on a probable maximum precipitation (PMP) event over a 24-hour period, falling as rainfall on a melting snowpack. The site-specific PMP was calculated to be 318 mm with a peak snowmelt rate of 40 mm/day (SRK 2005g). For comparison, the record daily rainfall at the Yellowknife Airport is 82.8 mm.

Additional design criteria were as follows:

- For spillways through bedrock, the base dimension was set at 6 m wide. This was to allow ease of construction using conventional earth moving equipment. Side slopes through bedrock were set at 80% with 3 m wide benches every 5 m. These spillways require no additional armouring.
- For spillways directly in tailings, the base dimension was set at 6 m wide, again allowing construction with conventional earth moving equipment. Side slopes through tailings were set at 33%, with no benches. This slope was selected as the steepest grade at which equipment could effectively work. These spillways will be constructed on top of the final closure cover, and will be armoured with rip-rap.

Based on these design criteria, and using the calculated flood peaks, all spillways and conveyance channels are oversized. One exception to the conveyance channel design will be the Central Pond channel. This channel will be shaped to reflect a natural swale, and will receive armouring on either side of the channel centerline.

The engineered spillways and conveyance channels will require maintenance to ensure that they perform in accordance with their design intent. This maintenance requirement has been minimized by constructing the spillways and conveyance channels as far as practical through competent bedrock. Where this is not possible, the structures will be armoured with appropriate erosion protection. Annual inspection of these structures will be carried out by a qualified geotechnical engineer.

While climate change could result in more intense and frequent precipitation events, the overbuilt preliminary design for the spillways and conveyance structures is anticipated to be sufficient to accommodate any changes that may occur.

9.2.3 Mitigation Measures

Mitigation measures to address potential effects of the environment on the Remediation Project have been incorporated directly into the remedial strategy for the site. Although additional details are presented in Chapter 6 (Remediation Project Description), the "built-in" mitigation measures that will be implemented to address the effects of the environment on the Remediation Project are summarized as follows:

Seismic Events

- Free standing structures will be designed and built to meet applicable earthquake standards in the National Building Code.

Climate Change

- The freeze system (active and passive) will be designed to remain effective under "worst case" climate change scenarios; and
- Any changes to the volume and/or quality of water requiring treatment associated with increased precipitation can be managed by the new water treatment plant.

Severe weather/flooding

- Appropriate erosion and sediment control measures will be put in place for all activities during the Remediation Phase (refer to Section 8.4.2.4);
- Sufficient storage capacity will be available within the mine to store contaminated waters generated during severe weather and flooding events. The water treatment plant will have sufficient capacity to treat contaminated water associated with such events;
- Taking into consideration other design limitations, the realigned Baker Creek will be designed to maximize the return period for flood events; and
- Surface drainage in remediated tailings areas will be designed to convey the selected PMP event.

In addition to the built-in mitigation measures described above, regular inspection, maintenance, and monitoring programs during the remediation and long-term operation and maintenance phases will be implemented to detect and respond to potentially adverse effects caused by natural events.

9.3 Effects of Existing Site or Engineering Hazards on the Project

Chapter 5 identifies a number of physical and engineering hazards at Giant Mine. The Remediation Plan has identified strategies to manage all of these hazards. However, as indicated in Section 9.1, some of these hazards have the potential to compromise the effectiveness of Project, if they were to occur prior to full implementation of the Remediation Plan.

Chapter 10 (Accidents and Malfunctions) evaluates situations where an activity associated with the Remediation Project could trigger the realization of an existing site hazard. The current section deals with a separate type of effect, specifically those situations where an existing site hazard could materialize independent of the Remediation Project. These hazards are presented in the following upset scenarios. While the consequences of such scenarios on Project implementation are described, because these events could happen independently of any Project activity that might trigger the event, they have not been analyzed through an effects assessment methodology.

Collapse of Crown Pillar

Although is it a highly improbable scenario, the collapse of a crown pillar could partially expose an arsenic chamber to the surface. If this were to happen, it would necessitate the backfilling of whatever cavity remains to surface to permit the frozen block method to be implemented.

Bulkhead Failure

The failure of a bulkhead could affect the proposed remediation strategy should a large quantity of arsenic trioxide escape into the lower mine workings. As a result of such a failure, water treatment would become a more important element of the Project and a scaling up treatment would be required. An increase in the volume of sludge generated by the project would be expected with associated requirements to permanently dispose of the sludge on site.

10 Assessment of Accidents and Malfunctions

10.1 Objectives

This section presents an assessment of the possible environmental effects of accidents and malfunctions, both during and after completion of remediation activities. The assessment was undertaken to ensure that:

- Credible upset events that have the possibility of occurring are identified and considered prior to implementation;
- Available means to prevent the occurrence or mitigate the possible effects of such events are incorporated in the Project design; and
- The residual effects of such events after mitigation do not pose significant risks.

By inference, accidents and malfunctions are upset occurrences that are beyond the range of normal project activities. For the purpose of this assessment, an *accident* is defined as an unplanned event that has the potential to result in adverse environmental or public health and safety consequences. A *malfunction* is defined as the failure of a system or piece of equipment to function in a manner for which it was intended.

Both accidents and malfunctions may be the result of various *initiating events* which fall into the following three categories: natural events (e.g., lightning strikes, extreme weather, floods, earthquakes), technological causes (e.g., power outage, equipment failure), and human error. A *credible event* is defined as one that has a reasonable probability of occurrence based on professional judgment in the context of project-specific conditions.

It is possible that individual events may occur at the same time and affect the same part of the environment. The result would be a *bounding scenario*. A *bounding scenario* is one that is likely to encompass the full range of potential adverse environmental effects, compounding events, associated with other similar events. Bounding scenarios have been taken into consideration for the Project.

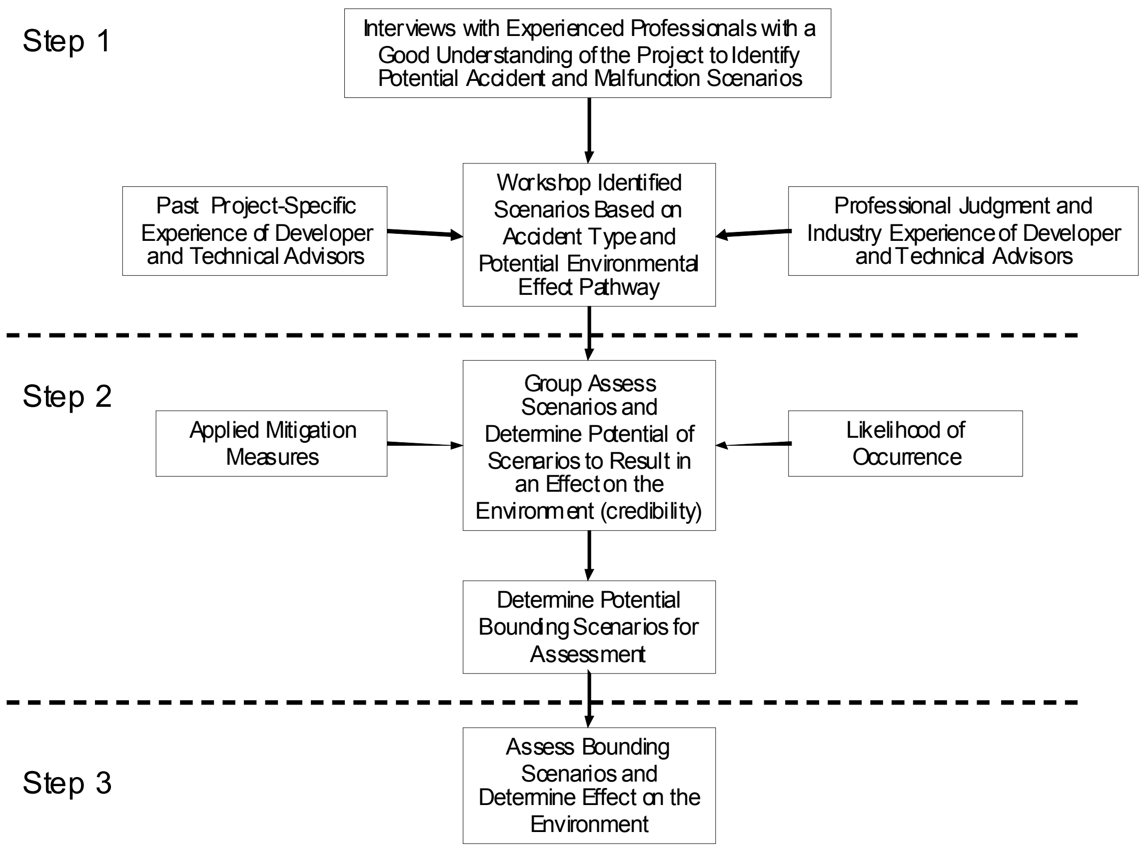
Many of negative effects of the historic operation continue to exist today and, if left unmanaged, have the potential to increase in the future. The greatest risk to the environment and the success of the Project is, therefore, not implementing the Remediation Plan.

10.2 Assessment Methodology

The methodology employed in the accidents and malfunction assessment is summarized in Figure 10.2.1 and consists of the following steps:

1. Identifying credible events;
2. Screening of each credible event to establish if it could result in an adverse environmental or public health and safety consequence that should warrant further consideration; and
3. Advancing for further evaluation those events that were determined to potentially result in an adverse consequence.

Figure 10.2.1 Accident and Malfunctions Assessment Methodology



The focus of the assessment is on those events that are considered credible in the context of the specific project and could occur due to work or actions taken as part of the remediation process. The possibility of an accident or malfunction relating to the frozen block method was discussed in detail in Section 6.2.8.2 and has not been repeated in this section.

The assessment of accidents and malfunctions must be carried out at a somewhat conceptual and speculative level for two main reasons. First, past performance by the site operators does not reliably indicate future performance because, following any accident, the Project Team and its site management contractors evaluate the cause of the event and implement changes to procedures, or improvements to facilities, to prevent the same or similar event occurring again.

Second, the timing of future events cannot be predicted; if an accident can be predicted with any certainty, the Project Team and its contractors would take the necessary steps to prevent it from occurring.

In identifying and evaluating the potential accidents and malfunctions, the *experienced professionals* referred to in Figure 10.2.1 are defined as those people with a good understanding of the Remediation Project, as well as firsthand knowledge of similar situations elsewhere and the state of industry practice, with the ability to make judgements on the likelihood, potential consequence, and possible mitigation measures that would apply to the recognized issues.

10.3 Identification of Credible Accidents and Malfunctions

As the first stage of work to prepare an assessment of credible accidents and malfunctions, participants in the Remediation Project were interviewed by a third party risk assessment facilitator and a list of accident and malfunction events was developed. The Project Team then attended a workshop during September 29 to October 1, 2009. Accident and malfunction events that were specifically identified in the EA *Terms of Reference*, notwithstanding their likelihood, were considered in the assessment. Any other accident or malfunction events suggested in the interviews or by the workshop participants were also assessed. Table 10.3.1 summarizes the accident and malfunction events identified as being relevant during various activities for the site remediation phase and the long-term care and maintenance phase of the Project.

Table 10.3.1 Postulated Accidents and Malfunctions

Project Work or Activity	Postulated Initiating Event
Site Remediation Phase	
Installation & Operation of Freeze System	• Drilling accident or malfunction results in release of arsenic trioxide dust to surface • Drilling results in an accidental release of drill mud to Baker Creek • A lower bulkhead fails during freezing, resulting in a release of arsenic trioxide to deeper underground mine workings • Collapse of a crown pillar near Baker Creek during freshet results in the creek flowing into the mine and reduces flow to the downstream reaches of the creek • Release of freeze coolant due to rupture caused by accident or environmental factors
Earthworks	• Flooding of the mine with surface water due to failure of new channel or diversion resulting in contaminated mine water being released to the environment
New Underground Development	• Mine development activities result in an injury to a worker
Construction of Surface Infrastructure	• Construction activities result in an injury to a worker
Demolition of Surface Infrastructure	• Worker error causes an uncontained collapse of the Roaster Complex, releasing a dust plume of arsenic trioxide and asbestos • Ongoing deterioration of the Roaster Complex leads to uncontrolled loss of containment and release of arsenic trioxide into the environment
Water Management	• Failure of a mine water pipe on surface leads to the discharge of untreated mine water above allowable discharge criteria • Human error results in partially treated mine water being released to the environment • Accidental release of water treatment sludge during handling and disposal • An accident results in a spill of chemicals used in water treatment
Transportation	• Traffic accident involving vehicles engaged in remediation activities • Transportation vehicle upset causes release of arsenic contaminated materials
Security Events	• Fire started in surface infrastructure due to accidental or deliberate causes • Deliberate destruction of freeze system components by vandals • Accident in underground workings by either curious unauthorized parties or vandals intent on damaging freeze system. • Accidental fall in and around open pits or raises
Long-term Operation and Maintenance Phase	
Passive Freezing (maintenance of frozen block)	• Wildfire leading to damage of freeze plant infrastructure or thermosyphons • Human error leads to accidental shearing or rupture of thermosyphons
Storage of Contamination/Waste	• Vegetation penetrates through the tailings cover resulting in arsenic uptake by plants and introduction into the terrestrial food chain
Water Management	• Failure of a mine water pipe on surface leads to the discharge of untreated water above allowable discharge criteria • Accidental release of water treatment sludge during handling and disposal • An accident results in a spill of chemicals used in water treatment
Maintenance	• Traffic accident involving maintenance related vehicles • Failure to perform maintenance prior to a prolonged precipitation results in erosion of tailings cover or perimeter dams and release of tailings to surface water • Collapse of a non-arsenic stope crown pillar near the highway resulting in a fatality
Monitoring	• Failure to monitor the re-aligned Baker Creek channel near C1 pit results in unchecked degradation of the ground between the creek and pit resulting in loss of containment of Baker Creek and mine flooding

The accidents and malfunctions events identified were further characterized by considering the following:

1. Past upset events such as accidents and spills, to the extent that they are relevant to the current assessment;
2. Representative (hypothetical) accidents and malfunction events that have a reasonable probability of occurring during the 25-year period established by the Review Board as the temporal scope for the environmental assessment;
3. The "built-in" administrative, procedural and design controls that are part of site management; and
4. The sources, quantities and characteristics of any contaminants that may be released to the environment during an upset event.

10.4 Effects Assessment

The events identified in Table 10.3.1 were grouped if they were of the same nature, or would result in an effect via the same pathway, in order to develop bounding scenarios for assessment. Each group of events identified was screened to determine if it could reasonably be expected to result in a potentially measurable adverse environmental or human health and safety effect, given the implementation of preventative and mitigative measures inherent in the Project design. Table 10.4.1 presents a brief description of each postulated event, mitigation measures and the resulting screening decision.

Table 10.4.1 Screening of Accidents and Malfunctions Events

Event	Screening Evaluation	Screening Decision
Release of Arsenic		
Accidental release of arsenic trioxide dust to surface during drilling	Drilling is required in order to install the freeze pipes for the containment of the arsenic trioxide in the underground chambers. The drill holes are expected to be approximately 150 mm (6 inches) in diameter. Additional vertical holes will be drilled from the surface to install freeze coolant feed pipelines and instrumentation cables. Drilling from the surface could potentially result in a release of arsenic trioxide dust from the boreholes, as a result of a blow-out through an open drill hole. To prevent this possibility, all drill holes will be capped on completion of the drilling activity. Another possibility is the accidental release of drill mud on surface. To prevent or mitigate the accidental discharge of drill mud into surface water, the Project Team will require that: • Standard diamond drilling mitigation measures be implemented to contain drill mud within a perimeter ringed off area at the drill rig site; and • Spill contingency plans to be in place.	No further assessment required
Failure of an inaccessible lower bulkhead prior to or during freezing results in a release of arsenic trioxide to deeper mine workings	While it is unlikely that the Remediation Project will induce the failure of a lower bulkhead, a concern has been identified regarding the physical stability of the existing dust storage areas. Several of the bulkheads below the chambers and stopes have been identified as having moderate to high failure risks, potentially releasing arsenic dust into the lower mine workings. Failure is most likely to occur during the period where the ground is in the initial process of freezing. This risk will no longer be in place once the shell is frozen. Currently, there are 26 lower bulkheads that are directly holding back dust, 12 of which are inaccessible. The accessible bulkheads have been subject to regular inspections and non-destructive examinations. Stabilization and reinforcement measures are being planned or implemented where required. Out of the 26 bulkheads, 11 were identified as posing a moderate risk of failure, which could result in a release of dust to deeper mine workings.	As a risk was identified for this event to occur, the event was forwarded for further assessment and identification of a bounding scenario.
Flooding of the mine with water resulting in contaminated water being released to the environment	Normal pathways for water to enter the mine include runoff flowing into the open pits, seepage from Baker Creek, seepage from the tailings containment areas, infiltration through soils and bedrock in the mine area and inflow from groundwater into the underground mine workings. As such, infrastructure is in place for the collection of water flowing into the mine to prevent releases to the environment. All water entering the mine ultimately drains into the main dewatering systems in the northern part of the mine through mine openings and an underground drainage and dewatering system. The system is designed to handle a flow rate of more than 4000 m^3 per day. Because the mine drainage and dewatering systems will maintain water levels below the local groundwater table during the Project (as described in Section 6.8.3) the groundwater will continue to be drawn towards the workings, thus preventing the escape of contaminated mine water. As this water will not be directly released to the environment without treatment and testing to confirm it meets the discharge limits, no adverse effect is anticipated as a result of this event.	No further assessment required

Table 10.4.1 Screening of Accidents and Malfunctions (Cont'd)

Event	Screening Evaluation	Screening Decision
Collapse of a crown pillar near Baker Creek during freshet results in the creek flowing into the mine and dewatering the downstream reaches	A concern has been identified regarding the physical stability of the existing crown pillars above the dust storage areas. The Remediation Project has been developed to mitigate the risk of a crown pillar failure resulting in Baker Creek flowing into the underground workings. As discussed in Sections 5.1.4 and 6.2.4, investigations to evaluate whether the chambers and stopes containing arsenic trioxide dust will remain stable while the remediation plan is being implemented identified the C212 crown pillar at risk. The risk of Baker Creek quickly inundating the mine in the event of a failure was reduced in 2006 by the relocation of Reach 4 of Baker Creek. Remedial plans call for work inside and on top of several of the stopes, including stabilizing the crown pillar of several stopes by drilling through and filling the void above the dust to support the crown pillar. These tasks will have to be managed to avoid significant loading to the crown pillars. In addition, following freezing, all crown pillars will be supported by the frozen dust, ice, or fill placed prior to freezing.	No further assessment required
Unplanned collapse of the Roaster Complex, releasing a dust plume of arsenic trioxide and asbestos	The Roaster Complex consists of seven main structures and contains a combination of arsenic trioxide dust, asbestos and residual chemicals in vessels, tanks and containers. An exposure control plan will be in place and all work within the Roaster Complex will be conducted in conformance with this plan. Access to the Roaster Complex area is restricted by fencing and the site maintains 24 hour security. In the case of an unplanned collapse caused by the demolition process, atmospheric releases of arsenic trioxide dust and asbestos may occur. During demolition, the Project Team will require the following: • Demolition workers will have completed appropriate training and certification for safe operation and maintenance of equipment; • Only operators with specialized skill in demolition of contaminated structures will operate heavy equipment; • No visitors will be able to enter the area without the proper training and proof of training will be required; and • Engineering controls and work practices including visual inspections will be performed to identify and mitigate specific risks. The Remediation Project has been developed to mitigate this risk. Building integrity will be monitored and stop work orders will be issued until the risk has been mitigated or reduced to acceptable levels.	No further assessment required
Surface discharge of untreated or partially treated water	A new mine water treatment plant will be constructed as part of the Remediation Project. The feed water (untreated water from the mine) will be pumped from a point(s) close to the water treatment plant, so although the length of pipe involved will be minimized, a pipe rupture could release untreated mine water on surface. The treated mine water will be discharged to a diffuser constructed in Yellowknife Bay. Treated water will be held in a holding system for monitoring prior to discharge. Any treated water that fails to meet the discharge quality criteria will be recycled through the treatment plant or returned to underground storage. To prevent or mitigate an accidental release of partially treated water, the Project Team will require that: • The mine water pipe line is equipped with pressure sensors to detect changes in pressure that might	Failure of a water treatment pipe on surface is determined to be a credible event. This event is forwarded for further assessment.

Table 10.4.1 Screening of Accidents and Malfunctions (Cont'd)

Event	Screening Evaluation	Screening Decision
	be attributed to pipe failure. This design feature will provide operators with an early warning of a potential problem; • The pipeline will be inspected regularly for evidence of leaks; and • Spill contingency plans will be developed for the water treatment system.	
Accidental release of sludge from the water treatment plant during handling and disposal	One of the products of the proposed new water treatment plant will be a chemical sludge, comprised of approximately 30% solids, which will contain iron hydroxide with ferric arsenate, ferric antimonite, calcium carbonate and any residual suspended particulate matter present in the raw water. In the short-term, the quantity of sludge is great enough to warrant on-site disposal (550 m^3/yr), though the quantity of sludge is expected to decrease substantially in the long-term to 30 m^3/yr. The sludge will be discharged to a storage silo and then transported in batches by truck to an on-site or off-site sludge disposal facility. A possible spill event would be the loss of sludge from the truck transporting the sludge to the ground surface, or a leak in the piping connecting the storage silo to the water treatment facility. The pipe connections are expected to have suitable secondary containment where applicable, and will undergo regular visual inspections to identify any potential leaks prior to substantial releases. Therefore, a loss of the pipeline resulting in a release of sludge is not considered further. If a truck accident were to occur that resulted in a loss of the sludge contents from the truck, emergency response procedures would be in place to begin rapid clean-up of the spilled material. It is expected that, at a solids content of about 30%, it will be possible to remediate any spills using shovels or excavators, as the consistency of the sludge will be fairly dry. Additionally, due to the consistency of the sludge, it is not anticipated that the full contents of the truck would be lost during a vehicle accident. Given the chemical stability and semi-solid composition of the sludge complete remediation of a spill is anticipated.	No further assessment required
Release of Other Contaminants		
Spill of chemicals used in water treatment	As part of the water treatment process, hydrogen peroxide, ferric (iron) sulphate and lime will be used. The water treatment plant will be located in a process building that will have a sump or similar collection system to collect spills of water treatment chemicals, which will be stored inside the building. In addition, the design will take into consideration measures such as the requirement for secondary containment around chemical storage tanks and process lines. Spill contingency plans will be developed for the water treatment plant to manage spills that are not mitigated through the measures inherent in the design of the plant. Therefore, no residual environmental effects are anticipated as a result of spilled water treatment chemicals.	No further assessment required
Rupture of coolant pipe results in release of coolant	Primary coolant is used in a freeze plant to cool secondary coolant, which is then transferred through the coolant distribution pipes to the region requiring cooling. The primary coolant would be contained within the freeze plant and any spills would be collected in building sumps and treated or cleaned up prior to being released to the environment. The freeze system will have a substantial network of coolant distribution pipes to circulate coolant through the freeze pipes on surface and underground. As the distribution pipes will be installed on surface, they will be exposed to the elements, construction traffic, and possible vandalism. Given the quantity of distribution	A rupture of a freeze-pipe underground resulting in the release of coolant is determined to

Table 10.4.1 Screening of Accidents and Malfunctions (Cont'd)

Event	Screening Evaluation	Screening Decision
	pipes to be installed, there is sufficient possibility for one or more of the pipes to rupture due to an accident involving heavy equipment, winter temperatures or vandalism. In either case, a quantity of coolant could be released. The coolant currently proposed to be used is an organic, non-toxic and biodegradable brine solution with very low toxicity and not classified as a Transportation of Dangerous Goods (TDG) substance. Spills of other contaminants greater than 100 L are reportable quantities (INAC 2007). A spill resulting from the rupture of one pipe could conceivably release more than 100 L of coolant. To prevent or mitigate the accidental discharge of brine, the Project Team will require the following: • Distribution pipes are composed of weather-resistant material and insulated; • Regular inspections are carried out of the distribution pipe network; • Pressure and flow monitoring gauges are installed on each distribution pipe to detect ruptures; • Site security patrols and fencing will be used to prevent access to pipes; and • Contingency plans will include response for leaks of coolant. Given mitigation measures, the minimal ecological risk of the brine solution and the containment of the primary coolant, no residual surface environmental effects are anticipated. Besides the event noted above, an uncontained release of coolant underground caused by a rupture in a freeze-pipe is a real possibility. Such an occurrence could inhibit the freezing of the ground in that area. Instrumentation on the freeze pipes will include temperature, pressure and flow monitoring on both supply and return lines in order that any leakage of secondary coolant will be immediately detected and corrective action can be taken.	be a credible event. This event is forwarded for further assessment.
Construction Accident and Malfunction Events		
Potential personnel injury during construction activities	Medium and large scale construction activities and mine work could result in personnel injuries and lost time incidents. According to the Canadian Ministry of Labour, for the years 2001 to 2005, the average rate of lost time injuries claimed was less than 3 per 100 covered workers. Since the Project Team assumed responsibility for Giant Mine in 1999, workplace safety has consistently been good and improvements to health and safety practices are continuously occurring. All future site contractors will be required to meet the health and safety standards currently in place. For the purpose of this assessment, it is assumed that good performance and improvements in worker safety will continue during the implementation of the Project. Assurance for this conclusion is also supported by the fact that operational health and safety practices at the Giant Mine site are monitored and regulated by the *Workers' Safety and Compensation Commission* through the office of the Chief Mine Inspector. As a result, it is not expected that the risk of personal injury from the Project will be incrementally different from that at any other similar construction or mine site, and would likely be better due to the controls in place and historical performance. Therefore, no residual effect is expected from this event.	No further assessment required

Table 10.4.1 Screening of Accidents and Malfunctions (Cont'd)

<table>
<tr><th>Event</th><th>Screening Evaluation</th><th>Screening Decision</th></tr>
<tr><td colspan="3">Other Accident Events</td></tr>
<tr><td>Vehicle or construction equipment accident</td><td>Vehicle accidents involving construction equipment or transport trucks have the potential to result in spills of fuel, lubricants or materials being carried or personnel injury. Such accidents can be initiated as a result of driver error, adverse road conditions or bad weather.
Approximately two dozen trucks and other mobile heavy equipment are expected to be employed during remediation. The majority of these vehicles will be used to haul aggregate or transporting personnel and will not spend significant amounts of time on public roads.
To minimize the potential for traffic accidents, both on-site and off-site, the Project Team will require the following:
• Remediation contractors will observe all applicable public safety requirements and transportation regulations when using public roads;
• Where work requires that slow moving heavy equipment use public roads, additional safety measures to alert other road users, such as signage, or the stationing of workers to control traffic will be implemented where applicable;
• Vehicles will be inspected regularly and maintenance performed as needed; and
• Only accredited drivers will be allowed to operate heavy machinery and other vehicles on public roads.

Roaster demolition debris will be containerized into sea cans for disposal within a frozen block underground. Transportation of the containers across Baker Creek may be required.
To prevent or mitigate an accidental release of arsenic from the containers into the creek, the Project Team will require the following:
• The sea cans used to transport the contaminated materials will be double lined with reinforced polyethylene and of durable construction material;
• Development of a spill response plan;
• Applicable spill response training; and
• Contaminated soil and/or water will be remediated rapidly to limit the potential effects of the spill on the environment.

Fuel required by the construction equipment during remediation will be stored in a secure area in double lined tanks. Fuelling stations will be equipped with drip trays and kits for cleanup of spills should that occur. Operators of fuel trucks used to refuel heavy equipment will receive appropriate training for cleanup procedures in the events that small quantities are spilled during refuelling. Should an accident involving a fuel truck result in a fuel spill, an emergency response team will be deployed to contain and remediate the affected area.</td><td>The potential for a spill of arsenic containing material or fuel was identified as a credible event and is forwarded for further assessment.</td></tr>
</table>

Table 10.4.1 Screening of Accidents and Malfunctions (Cont'd)

Event	Screening Evaluation	Screening Decision
Damage of freeze plant infrastructure or thermosyphons	Should the buildings, equipment or thermosyphons be damaged by accident, vandals or wildfire, the Project Team will require that they are replaced prior to the outer limit of the dust actually beginning to thaw, which is expected to take several years. A combination of methods may be used for the freezing activities including the use of pipes with circulating cold liquid or the installation of thermosyphons. The circulating coolant method will require active components such as pumps and compressors in order for the system to operate. If damage of the infrastructure or components of the freeze plant were to occur, there would be an interruption in the transfer of coolant to the pipes. To prevent damage from occurring, fire suppression equipment and fire breaks will be utilized to protect the freeze plant infrastructure and thermosyphons. As discussed in Section 6.2.8.2, in the event where all of the thermosyphons were suddenly made ineffective it was predicted to take ten years before the arsenic dust warmed to -5°C, and between twenty and more than fifty years before the outer limit of the dust actually began to thaw. During this time, mitigation measures would be put in place to repair the thermosyphon system in order to prevent the thawing and release.	No further assessment required
Potential injury to public by an accidental fall into the open pits or unauthorized entry underground	The Project Team will require that site security be maintained during the remediation project to prevent inadvertent access to open pits and the underground workings. Fences, berms and other barricades will secure the perimeter of the open pits following remediation. Mine openings will be secured or permanently sealed to prevent access following remediation.	No further assessment required
Vegetation penetrates through the tailings cover resulting in arsenic uptake by plants and into the terrestrial food chain	To prevent or mitigate vegetation penetrating the tailings cover, the Project Team will monitor the revegetation of the tailings and sludge areas, including the chemical uptake of plants during the temporal scope as defined by the Review Board. As discussed in Section 6.6.6, studies are ongoing to determine the optimal cover design.	No further assessment required
Collapse of a non-arsenic stope crown pillar near the highway	Land use restrictions will be put in place to limit future development in the vicinity of areas with a risk of crown pillar failure.	No further assessment required
Failure to perform maintenance prior to a prolonged precipitation causes erosion of tailings cover or perimeter dams release tailings to surface water	To prevent or mitigate reduced cover performance and deterioration, the Project Team will require that the covers and dams are monitored and maintained within the temporal scope as defined by regulatory authorizations.	No further assessment required
Failure to monitor the new alignment around C1 pit results in unchecked degradation of the ground and loss of containment of Baker Creek	To prevent or mitigate deterioration of Baker Creek and the C1 pit wall, the Project Team will require that the stability of the creek and pit walls are monitored and maintained within the temporal scope as defined by regulatory authorizations.	No further assessment required

10.5 Development of Bounding Scenarios

The selection of a bounding scenario is used to provide a "worst case" assessment for accidents and malfunctions. Table 10.5.1 summarizes the scenarios in each category from Table 10.4.1 that were forwarded for further assessment and identification of the bounding scenarios.

Table 10.5.1 Accidents and Malfunctions Forwarded for Assessment

Identified Accident or Malfunction Scenario	Description of Scenario for Assessment
Lower bulkhead failure	This scenario involves the release of arsenic trioxide dust slurry into the lower mine workings beyond the designed frozen block limits.
Failure of water treatment pipe on surface	This scenario involves the rupture of a water treatment pipe resulting in the release of contaminated water on surface and flows into Baker Creek.
Rupture of a freeze-pipe underground	This scenario involves the rupture of a freeze-pipe resulting in the release of a significant quantity of brine into an area proposed to be frozen.
Vehicle or construction equipment accident	This scenario involves a vehicle accident resulting in a spill of arsenic containing material to Baker Creek. The material is assumed to be waste/debris from the demolition of the Roaster Complex and will be packaged in double-lined 2.72 m^3 hazardous material containers. A second scenario involves a fuel truck accident resulting in a spill of fuel in close proximity to Baker Creek.

After reviewing the events identified for further consideration, it was determined that the events are all unique in nature and the development of bounding scenarios was not possible. Therefore, the four events identified in Table 10.5.1 are all forwarded for an assessment of environmental effects in Section 10.6.

10.6 Assessment of Bounding Scenarios

10.6.1 Lower Bulkhead Failure

As identified in Table 10.4.1, there is concern regarding the current physical stability of the dust storage areas. Of the 26 lower bulkheads below the chambers and stopes, 11 have been identified as having moderate to high failure risks, potentially releasing arsenic dust into the lower mine workings as a flow of slurry.

An ongoing monitoring and maintenance program is conducted to reduce the risk of bulkhead failure beyond that which is currently identified. This program consists of regular visual inspections of accessible bulkheads, pressure monitoring at the bulkheads where possible, and other measures to reduce the loads on the bulkheads and mitigate against potential failure.

Although remedial works could cause a slight increase in the possibility of failure due to water pressure when dust saturation begins, the potential increase is not considered to be significant, due to mitigation and reinforcement measures planned as part of the Project.

If a lower bulkhead were to fail, the released arsenic would remain within the mine water collection system. The primary consequence would be an increase in the arsenic concentration in the mine water and a requirement for prolonged operation of the mine water treatment plant.

Infrastructure is in place for the collection of water flowing into the mine to prevent direct releases to the environment, and similar infrastructure will be maintained throughout the implementation of the Project. Therefore, as all water pumped from the mine will be treated and tested for acceptable quality prior to release to the environment, no adverse environmental effect is anticipated as a result of this scenario. However, cost implications would be very significant.

10.6.2 Mine Water Pipeline Rupture

A rupture of a mine water pipeline connecting the mine water pumps to the treatment plant has the potential to result in the release of contaminated water to the ground or to Baker Creek. Several project design features and operational measures will be used to prevent such releases or mitigate their environmental effects. These will include flow and pressure sensors in the pipeline connected to an alarm system to warn people of a sudden change in the flow rate or pressure, routine pipeline inspections, and spill containment facilities.

10.6.3 Freeze-Pipe Rupture Underground

A rupture of a freeze-pipe underground has the potential to result in the release of coolant to the ground and inhibit the development of a frozen block. This will be a concern when the freeze system is first activated and before the grout and rock surrounding the pipe is not yet frozen.

Modern ground freezing systems are heavily instrumented and monitored to allow for immediate detection of leaks or other problems to limit the loss of secondary coolant to the ground. Instrumentation on the coolant distribution and freeze pipes will include temperature, pressure and flow monitoring on both supply and return lines. Coolant flow into individual pipes can be stopped with isolation valves. Additionally, operational policies and procedures will be in place to reduce the likelihood of spills from occurring.

10.6.4 Vehicle or Equipment Accident

The potential for accidental spillage of contaminated soil or hazardous materials while being transported on site cannot be eliminated. As these materials have solids characteristics, cleanup of spills on land can be undertaken with minimal risk of adverse effects. Spills to Baker Creek could pose some risk of effect on the aquatic ecosystem. However, with proper emergency response training, any effects can be mitigated through containment and removal of the spilled material. It is also noted that hazardous materials removed from the Roaster Complex (e.g. arsenic trioxide dust removed from piping and equipment in the building) will be handled in lined sea cans so the likelihood of spillage on the land or to Baker Creek is quite low.

Any spillage of fuel on land on the Giant Mine site during the remediation phase will be mitigated by removal and management/disposal of contaminated soil with other hydrocarbon contaminated soil. In the event of a fuel spill potentially reaching Baker Creek, workers trained in emergency response procedures would be immediately deployed to isolate and contain the spill and implement clean-up procedures. While it is unlikely that the effects of a spill to Baker Creek can be entirely mitigated, it is anticipated that adverse effects on the aquatic ecosystem can be minimized.

10.7 Emergency Preparedness

The Remediation Project will be designed in accordance with strict safety standards to confirm that personnel, members of the public and the surrounding environment are protected from the effects of abnormal events that might occur during the implementation of remedial measures and the long-term operation and maintenance phase.

The overall responsibility to review and ensure implementation of emergency response plans remains with the Project Team as with other abandoned mine remediation projects in the north. As indicated in Section 6.13, the final mechanism of Project delivery has yet to be finalized. However, the Project Team may choose to contract an overall site operator, as is currently the case, and establish through contract the responsibility for coordinating emergency response actions. On-site emergency response plans will be a contractual obligation for all contractors hired to implement the Project.

The Project Team's minimum requirements for the emergency response plans will include measures to address:

- Fire, Flood, Spills, Accidents and Fatalities, Vandalism, Equipment Failure or Malfunction;
- Communications protocols for the notification of the City of Yellowknife, the Yellowknives Dene First Nation and other interested parties.

10.8 Risk Communication

In addition to the communications procedures identified in the site emergency response plan, the Project Team commits to meet with the City of Yellowknife, the Yellowknives Dene First Nation and any other interested parties to discuss the coordination of emergency response plans, and any other concerns about the risks arising from remediation or care and maintenance activities. Risk communication will include media releases and public sessions to communicate risk and consequences to the public, as described further in Section 13.

11 Assessment of Cumulative Effects

11.1 Objectives and Approach

This chapter provides an evaluation of the potential cumulative effects associated with the Giant Mine Remediation Project. The evaluation has taken into consideration consultation conducted during the development of the Remediation Plan and preliminary engagement sessions with Aboriginal Communities on the implementation of the Project conducted in the spring of 2010. While this engagement has provided valuable input, there remains a need for on-going involvement of Aboriginal Communities as the Project advances through the regulatory and detailed design phases. In particular, this input is required to finalize the analysis of cumulative effects.

In Section 3.7 of the *Terms of Reference*, the Review Board outlined its expectations for the conduct of a cumulative effects assessment (CEA). It requested that the DAR consider the manner by which any adverse effects of the Project will incrementally combine with the effects of other past, existing and reasonably foreseeable future developments[30]. The approach used to carry out the CEA was based, in part, on the following sources of guidance:

- Appendix H of the Review Board's *Environmental Impact Assessment Guidelines* (2004); and
- The Canadian Environmental Assessment Agency's (CEAA) *Cumulative Effects Assessment Practitioners Guide* (1999).

As presented in the *Cumulative Effects Assessment Practitioners Guide*, a CEA should involve the following steps:

1. A determination of whether the Project has the potential to result in residual adverse effects. This step was completed in the evaluation of Project-specific effects on the environment, as presented in Chapter 8;
2. In situations where the Project is likely to result in residual adverse effects, the CEA should evaluate those effects in combination with the effects of other past, existing and reasonably foreseeable developments. Where necessary and appropriate, measures to mitigate potential adverse effects are to be identified. This evaluation of cumulative effects is presented in the current chapter; and

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[30] The Review Board guidance applies the term "development", however this term is considered interchangeable with the term "action" used in by the Canadian Environmental Assessment Agency.

3. In situations where cumulative effects are anticipated to occur, the significance of any residual effects (i.e., after mitigation) should be determined. The significance of residual effects associated with the Remediation Project is evaluated in Chapter 12.

A key assumption in both the Project-specific and the cumulative effects assessments is that the Project will have a long-term net positive effect on the biophysical environment. Although some adverse effects may occur, such effects are expected to be minor in comparison to the overall benefits of the Project. Where adverse effects are predicted to occur, it is anticipated that, with few exceptions, they will be mitigated through standard environmental management practices or in-design mitigation.

11.2 Methodology for Cumulative Effects Assessment

The framework used for the CEA is presented in Table 11.2.1. In many respects, the framework is similar to the approach that was used to evaluate Project-specific effects in Chapter 8.

Table 11.2.1 Cumulative Effects Assessment Framework

Basic CEA Steps	Required Tasks
Scoping	• Identification of cumulative effects issues of concern • Selection of VCs appropriate for the CEA • Delineation of spatial and temporal boundaries • Identification of other developments that may affect the VCs for the CEA
Analysis of Cumulative Effects	• Identification of Project-specific residual adverse effects that are relevant to the cumulative effects issues of concern • Analysis of potential cumulative effects • Identification of mitigation for cumulative effects • Evaluation of significance for residual cumulative effects
Cumulative Effect Monitoring	• Development of a monitoring program for cumulative effects

11.3 Scoping

The framework for assessment of cumulative effects identifies four tasks that are to be completed during the scoping phase for the CEA: issue identification, selection of VCs, setting of assessment boundaries and the identification of other developments that may contribute to cumulative effects. These tasks are summarized in the following sections.

11.3.1 Identification of Cumulative Effects Issues of Concern

Not every predicted adverse effect of a development under assessment necessarily requires an examination from a cumulative effects perspective. As a means of ensuring that a CEA is relevant and manageable, emphasis is typically placed on a set of important issues that are applicable to the given development. The geographic location of the proposed development is an important factor in this regard. In the case of the CEA for the Remediation Project, the historic effects of municipal and industrial development in the Yellowknife region, as well as local and regional environmental and social trends, were the primary determinants for selecting the key issues that are the focus of the CEA. These "Cumulative Effects Issues of Concern", which are described below, were selected on the basis of the Project Team's understanding of the environmental issues affecting the Yellowknife region.

<u>Contamination of Water by Arsenic</u>

Historic mining operations have resulted in arsenic concentrations in surface water that are elevated above natural levels (e.g., within Baker Creek and Yellowknife Bay). The effect of these elevated concentrations on water quality in the Yellowknife area has been a long-term concern for local residents going back over 50 years. Although the Remediation Project will result in a reduction of arsenic loadings to the environment, the implementation of the Remediation Project has the potential to result in localized and minor releases of arsenic to surface waters.

<u>Arsenic Contamination of Fish</u>

Fish constitutes an important component of the diet of persons living in the Yellowknife area, particularly Aboriginal residents. There are long-standing concerns that the elevated concentrations of arsenic in local water bodies has resulted in fish with correspondingly high levels of arsenic in their tissue, and that this may represent a risk to human health. Similar to water quality, the Remediation Project will result in an improvement of environmental quality and, by extension, any effects on fish will reduce. However, due to potential effects to the environment during implementation of the Remediation Project, cumulative effects on fish warrant consideration.

<u>Arsenic Contamination of Terrestrial and Semi-Aquatic Wildlife</u>

In addition to fish, concerns have been voiced regarding the potential contamination of locally harvested terrestrial and semi-aquatic wildlife. While the environment as a whole will be improved, implementation of certain Project activities has the potential to introduce new sources of arsenic into the environment which, under extreme circumstances, could serve as a pathway to higher concentrations of arsenic in the tissue of local wildlife species.

<u>Loss and Degradation of Habitat</u>

Various developments in the Yellowknife area and the larger North Slave region have cumulatively reduced the quantity and quality of habitat for terrestrial wildlife. Of particular concern are the habitats for species that are harvested for food, fur and cultural practices.

Notwithstanding its positive effects, the Remediation Project may have minor and localized effects on the overall quantity and quality of wildlife habitat for a short duration.

Traditional Land Use

Various developments in the Yellowknife area and the larger North Slave region have cumulatively reduced the amount of land on which local Aboriginal people can practice traditional land use activities. Given that traditional land use practices such as hunting and fishing require ecologically intact and productive lands, any further development in the area has the potential to result in adverse cumulative effects on traditional land use.

11.3.2 Selection of VCs Appropriate for the Cumulative Effects Assessment

VCs that are directly relevant to the Cumulative Effects Issues of Concern were selected for the CEA. The selection of these VCs, which are presented in Table 11.3.1, was influenced in part by the Review Board's *EIA Guidelines* which suggest that VCs for CEA can be a subset of those components examined in the Project-specific effects assessment. On this basis, a number of the Project-specific VCs were aggregated into single VCs, reflecting the fact that the CEA was carried out on a broader local or regional scale than the Project-specific assessment. For example, caribou, moose, bear and muskrat, which were VCs in the Project-specific assessment, have become indicators of the Hunted and Trapped Species VC for the CEA.

Table 11.3.1 Issues, Valued Components and Indicators for the CEA

Cumulative Effects Issues of Concern	Environmental Component	VCs for the CEA	Examples of Indicators
Contamination of Water by Arsenic	Surface Water Environment	Water Quality	Water quality guidelines (CCME-FAL)
Arsenic Contamination of Fish	Aquatic Environment	Edible Fish Species (e.g., northern pike, Arctic grayling, lake whitefish)	Arsenic concentrations in fish tissues
Arsenic Contamination of Terrestrial and Semi-Aquatic Wildlife	Terrestrial Environment	Hunted and Trapped Species	Caribou, moose, bear, muskrat
Loss and Degradation of Habitat	Terrestrial Environment	Hunted and Trapped Species	Caribou, moose, bear, muskrat
Traditional Land Use	Aboriginal Interests	Traditional Land Use	Amount and quality of land available for Traditional Land Use

11.3.3 Spatial and Temporal Boundaries for the CEA

The spatial and temporal boundaries used in the assessment of Project-specific effects (Chapter 8) are expected to encapsulate all potential cumulative effects associated with the Project. Those boundaries were therefore used in the cumulative effects assessment (refer to Section 3.4 for detailed descriptions of these boundaries). To facilitate the CEA, the temporal boundaries were divided into the following categories:

- Past: developments that have already occurred but may still cause effects of concern;
- Present: currently active developments; and
- Future (reasonably foreseeable): developments that may yet occur.

While past and existing developments are relatively easy to identify and assess, the selection of future or reasonably foreseeable developments is more challenging. For this CEA, reasonably foreseeable developments are those projects or activities that have formally entered into the permitting or assessment stage such that they are pending approval from decision-makers. Several more speculative developments have also been included in the CEA based on factors such as being part of government strategic planning or land use plans.

11.3.4 Identification of Other Developments that May Affect the VCs for the CEA

Using the temporal and spatial boundaries noted in Section 11.3.3, other past, present and reasonably foreseeable developments that might affect the VCs selected for the CEA were identified. These developments are summarized in Table 11.3.2. It should be noted that the table does not identify the historic operation of Giant Mine as a past development. The rationale for this decision is that the environmental effects associated with the historic operation of the mine are reflected in baseline environmental conditions (as described in Chapter 7). The environmental effects of historic mining at Giant Mine have, therefore, been considered in the CEA through their inclusion as the baseline against which Project-specific effects were evaluated in Chapter 8.

Table 11.3.2 Past, Present and Reasonably Foreseeable Developments Considered

Past and Present Developments		
Project Activity	**Geographic Scope**	**Rationale**
On-going industrial, residential and recreational use of Highway 4	SSA	Highway 4 bisects the SSA and serves as the primary access route to Dettah (summer), mining developments (winter) and recreational use of areas adjacent to the highway.
Community operations	LSA	Communities in the LSA (Yellowknife, Dettah and N'dilo) affect the environment in various ways. Examples include atmospheric emissions, water discharges to Great Slave Lake (stormwater and wastewater) and generation of solid waste.
Resource harvesting	LSA	Some resource harvesting occurs in the LSA (mainly recreational fishing).
Quarry operations	LSA	Quarrying currently occurs in the LSA (between the SSA and the municipal solid waste landfill).
Solid waste landfill operations	LSA	The City of Yellowknife operates its solid waste landfill to the south of the SSA.
Transportation (air)	LSA	Air traffic in the vicinity of Yellowknife is extensive, resulting in noise and combustion emissions.
Decommissioning of Con Mine	LSA	The Con Mine is currently undergoing remediation, including extensive earthworks and the demolition of surface buildings.
Mineral/diamond exploration and mining	RSA	Biophysical cumulative effects are unlikely due to an absence of spatial overlap of effects. However, socio-economic cumulative effects are possible.
Oil and gas exploration and development	RSA	
Reasonably Foreseeable Projects and Activities		
Project Activity	**Geographic Scope**	**Rationale**
Re-routing or upgrading of Highway 4	SSA LSA	In addition to the 1.5 km stretch of Highway 4 that will be moved to facilitate the implementation of the Remediation Project, various alternatives are currently under evaluation by the GNWT for the re-routing of a much larger portion of the highway. Effects are expected to be typical of road construction activities and similar to the major earthworks associated with the Remediation Project.
Highway 4 extension	RSA	The territorial government and other parties are considering the extension of the "all weather" portion of Highway 4 to facilitate access to mineral developments in the Slave Geological Province. The development is currently at a conceptual level.
Potential re-development of former Giant Mine town-site and adjacent areas	SSA	The City of Yellowknife is evaluating options for the future use of the former Giant Mine town-site, for which the City now holds a lease. The NWT Mining Heritage Society is planning to build several structures and exhibits near and on the mine site. The Yellowknife Cruising Club is believed to be considering expansion of its facilities.
Future municipal development	LSA	The average annual growth rate for the City of Yellowknife has been under 1% for the last ten years and growth is expected to continue at a similar pace. Any incremental environmental effects associated with population increases are likely to be off-set by improvements in environmental performance.
Solid waste landfill expansion	LSA	The City of Yellowknife is evaluating options to expand the capacity of the municipal solid waste landfill.

11.4 Analysis of Cumulative Effects

11.4.1 Project-Specific Residual Effects

Table 11.4.1 provides an overview of the anticipated Project-specific residual effects (as identified in Chapter 8). As noted in the table, several types of residual adverse effects have been identified, only some of which are relevant to the Cumulative Effects Issues of Concern. Table 11.4.2 presents a summary of the types of residual Project-specific effects and how they relate to the Cumulative Effects Issues of Concern.

11.4.2 Identification and Analysis of Potential Cumulative Effects

Cumulative effects will occur only if the residual effects of the Giant Mine Remediation Project and the effects of another development meet each of the following conditions:

1. The effects are similar in nature;
2. They overlap spatially; and
3. They overlap temporally.

Table 11.4.3 evaluates the extent to which these conditions have been met using the following symbols: similar effects (●), temporal overlap (✓) and spatial overlap (■). In situations where a potential cumulative effect has been identified (i.e., all three conditions have been met) the symbols have been highlighted (cells shaded) for further analysis. This concept is illustrated in Figure 11.4.1.

Table 11.4.1 Project-Specific Residual Adverse Effects

Environmental Component	Environmental Sub-Component	Activity	Type of Adverse Effect	Description of Residual Effect	Effect Boundaries	
					Spatial	Temporal
Surface Water Environment	Hydrology	No residual adverse effects are anticipated.				
	Surface Water Quality	Surface drilling and freeze pipe installation	Minor Operational Releases	A small quantity of drilling fluids, potentially contaminated with arsenic, may enter surface waters.	SSA	Remediation
		Decontamination (of surface infrastructure)	Minor Operational Releases	A small quantity of wash water from the decontamination of buildings, potentially contaminated with arsenic, may enter surface waters.	SSA	Remediation
		Earthworks (all activities)	Increased Turbidity in Water	A temporary increase in turbidity as a result of earthworks activities.	SSA and LSA	Remediation
		Construction of Yellowknife Bay outfall / diffuser	Increased Turbidity in Water	A temporary increase in turbidity during the construction of the water treatment outfall and diffuser.	LSA	Remediation
		Earthworks (all activities, excluding Borrow and backfill, and Bedrock modification on surface).	Mobilization of Contaminants	Minor mobilization of contamination (e.g., soils and sediments) as a result of earthworks.	SSA and LSA	Remediation
		Construction of Yellowknife Bay outfall / diffuser	Mobilization of Contaminants	Minor mobilization of contamination (e.g., sediments and pore water) during the construction of the outfall and diffuser.	LSA	Remediation
		Discharge of treated minewater to Yellowknife Bay	Mobilization of Contaminants	Treated minewater discharged from the diffuser will exceed the CWQG – FAL guideline for arsenic within a small volume of water. The discharge of treated minewater will alter the thermal conditions of the water column in the vicinity of the diffuser.	LSA	Remediation Long-Term Operation & Maintenance
	Sediment Quality	Earthworks (all activities, excluding work in previously undisturbed materials)	Mobilization of Contaminants	Mobilization of contaminated soils, sediment and pore water during earthwork activities.	SSA and LSA	Remediation
		Construction of Yellowknife Bay outfall / diffuser	Mobilization of Contaminants	Mobilization of contaminants during construction of the diffuser/outfall.	LSA	Remediation
		Discharge of treated minewater to Yellowknife Bay	Mobilization of Contaminants	Increased contaminant loadings in the vicinity of the diffuser in Yellowknife Bay (Great Slave Lake).	LSA	Remediation Long-Term Operation & Maintenance
Geological and Hydrogeological Environment	Groundwater Flow	No residual adverse effects are anticipated.				
	Groundwater Quality	No residual adverse effects are anticipated.				

Table 11.4.1 Project-Specific Residual Adverse Effects (Cont'd)

Environmental Component	Environmental Sub-Component	Activity	Type of Adverse Effect	Description of Residual Effect	Effect Boundaries	
Geological and Hydrogeological Environment	Soil Quality	Transportation	Minor Operational Releases	Minor Operational Releases of hydrocarbons and arsenic-contaminated materials associated with transportation activities during remediation of contaminated soils	SSA and LSA	Remediation
	Permafrost	Earthworks (all activities, excluding contouring and capping of tailings/sludge ponds)	Permafrost Degradation	Localized loss of permafrost is anticipated.	SSA	Remediation
Atmospheric Environment	Air Quality	No residual adverse effects are anticipated				
	Noise Environment	No residual adverse effects are anticipated				
Aquatic Environment	Aquatic Habitat and Biota	Pathway from the Surface Water Environment	Minor Operational Releases	Potential effects of Minor Operational Releases on the Aquatic Environment may occur through effects to the Surface Water Environment.	SSA	Remediation
		Pathway from the Surface Water Environment	Increased Turbidity in Water	Potential effects of Increased Turbidity on the Aquatic Environment may occur through effects to the Surface Water Environment.	SSA and LSA	Remediation
		Pathway from the Surface Water Environment	Mobilization of Contaminants	Potential effects of Mobilizing Existing Contamination on the Aquatic Environment may occur through effects to the Surface Water Environment.	SSA	Remediation Long-Term Operation & Maintenance
		Baker Creek rehabilitation	Disturbance of Existing Sediments	Aquatic habitat (i.e., sediments and water quality) and some biota (benthos and macrophytes) in Baker Creek will be disturbed as a result of rehabilitation work.	SSA	Remediation
		Construction of Yellowknife Bay outfall / diffuser	Disturbance of Existing Sediments	Construction of the diffuser / outfall in Yellowknife Bay will affect aquatic habitat (sediments) and, therefore, benthos and macrophytes.	LSA	Remediation
		Contouring and capping of tailings beach area (historic foreshore tailings)	Disturbance of Existing Sediments/Tailings	Extension of the cover on foreshore tailings will disturb a small area of sediments, and thus affect aquatic habitat for benthos, macrophytes and fish.	SSA	Remediation
		Baker Creek rehabilitation	Surface Disturbances	Riparian vegetation will be removed as a consequence of surface disturbances along Baker Creek's channel during rehabilitation activities.	SSA	Remediation
Terrestrial Environment	Terrestrial Habitat and Biota	Pathway from the Surface Water Environment Pathway from Soil Quality	Minor Operational Releases	Potential effects of Minor Operational Releases on the Terrestrial Environment would occur only through effects to Surface Water Quality and Soil Quality.	SSA	Remediation
		Pathway from the Surface Water Environment	Mobilization of Contaminants	Potential effects involving the Mobilization of Existing Contamination would occur only through effects to Surface Water Quality.	SSA	Remediation

Table 11.4.1 Project-Specific Residual Adverse Effects (Cont'd)

Environmental Component	Environmental Sub-Component	Activity	Type of Adverse Effect	Description of Residual Effect	Effect Boundaries	
		Earthworks	Surface Disturbances	Earthwork activities will result in surface disturbances that will adversely affect terrestrial habitat.	SSA	Remediation
		Demolition of surface infrastructure	Surface Disturbances	The demolition of existing surface infrastructure and buildings is anticipated to eliminate existing terrestrial habitat.	SSA	Remediation
		Multiple activities	Noise Emissions	Noise emissions will discourage use of the site as terrestrial habitat, particularly during the Remediation Phase.	SSA and LSA	Remediation
Health	Human and Non-Human Biota	No residual adverse effects are anticipated				
Aboriginal Interests	Aboriginal Communities	No residual adverse effects are anticipated (subject to confirmation during future consultation).				
	Traditional Land Use	No residual adverse effects are anticipated (subject to confirmation during future consultation).				
	Aboriginal Heritage Resources	No residual adverse effects are anticipated (subject to confirmation during future consultation).				
Additional Community Interests	Land Use, Visual and Cultural Setting	Demolition and disposal of existing buildings	Community Effects	Buildings and surface infrastructure that may have heritage value may be demolished as part of Project implementation.	SSA	Remediation
	Socio-economic Conditions	No residual adverse effects are anticipated				
	Transportation	No residual adverse effects are anticipated				
	Local Resources	No residual adverse effects are anticipated				

Table 11.4.2 Types of Residual Effects and Relevance to the Cumulative Effects Issues of Concern

Type of Residual Adverse Effect	Relevant Cumulative Effects Issues of Concern	Residual Effect Considered in CEA?
Minor Operational Releases	- Contamination of Water by Arsenic - Arsenic Contamination of Fish - Arsenic Contamination of Terrestrial and Semi-Aquatic Game	Yes (due to potential for arsenic releases)
Increased Turbidity in Water	- The residual effects that were identified are not relevant to the Cumulative Effects Issues of Concern	No
Mobilization of Contaminants	- Contamination of Water by Arsenic - Arsenic Contamination of Fish - Arsenic Contamination of Terrestrial and Semi-Aquatic Wildlife	Yes (due to potential for arsenic releases)
Permafrost Degradation	- The residual effect that was identified is not relevant to the Cumulative Effects Issues of Concern	No
Disturbance of Existing Sediments	- The residual effect that was identified is not relevant to the Cumulative Effects Issues of Concern	No
Surface Disturbances	- Loss and Degradation of Habitat - Traditional Land Use	Yes (due to habitat disruption during Project implementation)
Noise Emissions	- The residual effect that was identified is not relevant to the Cumulative Effects Issues of Concern	No
Community Effects	- Traditional Land Use	Yes (due to potential concerns related to perceptions of environmental quality)

Figure 11.4.1 Scope of the Cumulative Effects Assessment

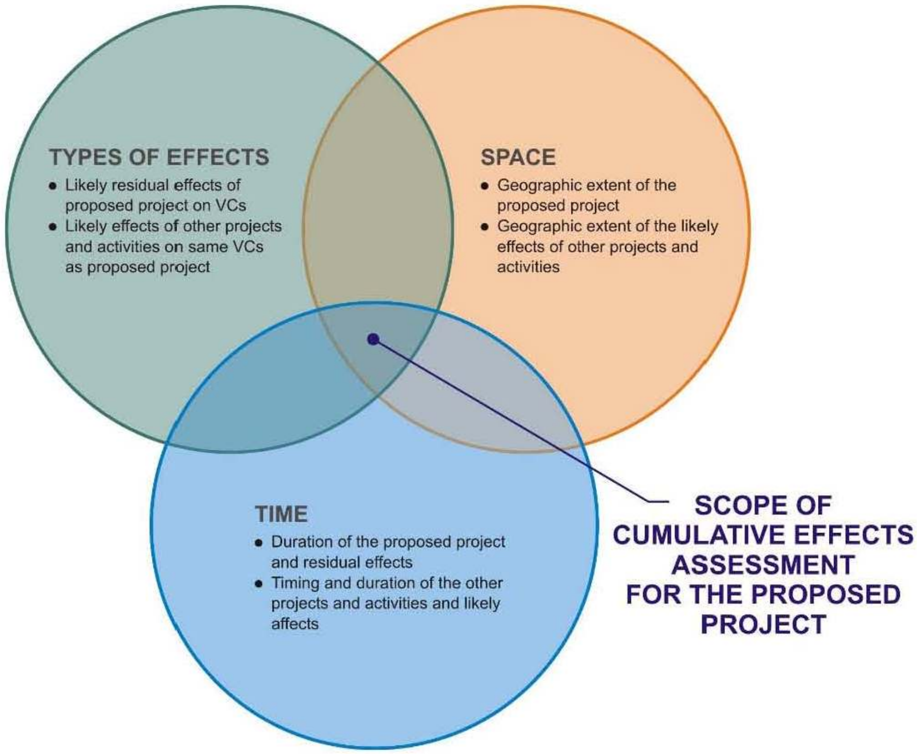

Table 11.4.3 Potential Interaction of Project Effects

Other Developments (refer to Section 11.3.4)	Types of Project-Specific Residual Effects that are Relevant to the Cumulative Effects Issues of Concern (refer to Table 11.4.2)			
	Minor Operational Releases *	Mobilization of Existing Contamination *	Surface Disturbances	Traditional Land Use
Site Study Area				
On-going industrial, residential and recreational use of Highway 4	√ ■	√ ■	● √ ■	● √ ■
Re-routing or upgrading of Highway 4	√ ■	● √ ■	● √ ■	● √ ■
Potential re-development of former Giant Mine town-site and adjacent areas	√ ■	●√ ■	● √ ■	● √ ■
Local Study Area				
Current community operations	√ ■	√ ■	√ ■	√ ■
Future municipal development	√ ■	√ ■	● √ ■	● √ ■
Resource harvesting	√ ■	√ ■	√ ■	√ ■
Solid waste landfill operation and expansion **	√ ■	√ ■	● √■	● √■
Quarry Operations	√ ■	√ ■	● √ ■	● √ ■
Transportation (air)	√	√	√	√
Decommissioning of Con Mine	● √■	● √■	● √	● √
Regional Study Area				
Highway 4 extension	√ ■	√ ■	● √■	● √■
Mineral/diamond exploration and mining	√ ■	√ ■	● √■	● √■
Oil and gas exploration and development	√	√	● √	● √

* Minor Operational Releases and Mobilization of Existing Contamination from other developments would result in similar effects on Cumulative Effects Issues of Concern only if arsenic has the potential to be released.

** Interactions of the Remediation Project with the existing landfill operation and potential landfill expansion are identical. To avoid duplication, the two types of landfill activities have been combined.

Cumulative Effects from Minor Operational Releases

The only additional development with a potential to contribute to an adverse cumulative effect due to Minor Operational Releases (of arsenic) is the decommissioning of the Con Mine. Unlike all other developments presented in Table 11.4.3, the decommissioning of Con Mine may require the management of arsenic contaminated materials. During normal operations, such activities may result in the inadvertent release of arsenic to the environment. However, the decommissioning of the Con Mine is a regulated activity, occurring under the supervision of environmental inspectors, and implemented with substantial environmental protection measures in place to minimize fugitive emissions of arsenic. Additionally, historic mining and milling practices at the Con Mine differed from those of Giant Mine and, as a result, the quantity of extremely contaminated material requiring specialized treatment, such as that found within the Giant Mine Roaster Complex, is not present at the Con Mine.

Taking into consideration the spatial separation of the Giant and Con Mines, as well as the factors noted above, it is unlikely that any cumulative Minor Operational Releases of arsenic would be detectable within the environment that are not already measured in baseline conditions (e.g. arsenic levels in soils and vegetation in the LSA). By extension, adverse cumulative effects to the CEA VCs of Water Quality, Edible Fish Species and Hunted and Trapped Species are not anticipated.

Mobilization of Existing Contamination

As indicated in Table 11.4.3, additional developments with the potential to result in cumulative effects from the Mobilization of Existing Contamination include:

- Re-routing or upgrading of Highway 4;
- Potential re-development of the former Giant Mine town-site and adjacent areas; and
- Decommissioning of the Con Mine.

Under certain development scenarios, the re-routing or upgrading of Highway 4 and the potential re-development of the former Giant Mine town-site may result in the disturbance and mobilization of existing soil contamination. For example, if a decision is made to dismantle the highway culvert over Reach 1 of Baker Creek, the associated earthworks have the potential to cause the mobilization of arsenic present in soil and sediments which could migrate into the downstream aquatic environment. Similarly, although the former Giant Mine town-site will be remediated to industrial standards, future earthworks required for the potential re-development of the site could result in the disturbance of arsenic-contaminated soils.

While the remediation activities occurring at the Con Mine are being undertaken to reduce the long-term risk of contamination, some activities associated with that remediation project have the potential to result in the short-term mobilization of contaminants, specifically arsenic. For example, similar to the Giant Mine Remediation Project, major earthworks in contaminated areas may result in arsenic mobilization within the environment.

In evaluating the potential for cumulative effects associated with the activities noted above, the CEA has been conducted under the assumption that appropriate mitigation measures will be put in place to prevent the mobilization of existing contamination. These measures are expected to be similar in nature to those proposed for the Giant Mine Remediation Project (e.g., use of silt curtains, dewatering or redirection of water bodies during excavation). Additionally, the overall effect of remediating the Giant and Con Mines will be positive by limiting contaminant mobilization.

Based on the conditions described above, it is unlikely that Mobilization of Contamination from the Remediation Project will result in cumulative adverse effects on the relevant CEA VCs of Water Quality, Edible Fish Species and Hunted and Trapped Species. To the contrary, the Remediation Project will result in cumulative positive effects on the environment (e.g., through reduced arsenic loadings to Yellowknife Bay).

Surface Disturbances

There are a number of additional developments that have the potential to result in surface disturbances which, when combined with the Remediation Project, may result in cumulative adverse effects on terrestrial species that are valued for hunting and trapping purposes. In addition, surface disturbances could temporarily affect the quality and abundance of terrestrial habitat. Although there is a theoretical potential that all developments would result in surface disturbances, the developments considered to have the greatest potential to contribute to cumulative effects on terrestrial species and habitat are:

- On-going industrial, residential and recreational use of Highway 4;
- Re-routing or upgrading of Highway 4;
- Potential re-development of the former Giant Mine town-site and adjacent areas;
- Future municipal development;
- Solid waste landfill operation and expansion;
- Quarry operations;
- Highway 4 extension; and
- Mineral/diamond exploration and mining.

The increase in human activity at the local level (e.g. urban development in Yellowknife) and the regional level (e.g. mining and mineral exploration in the Slave Geologic Province) have affected the habitat of certain wildlife species. For example, the role of industrial development and its linkages to the decline of the Bathurst Caribou Herd has become an issue of concern.

The contributions of the Remediation Project to such cumulative effects on terrestrial wildlife will effectively last only for the period of the remediation phase. Further, the residual adverse effects associated with the Remediation Project are considered to be minor relative to the positive effects that will be achieved. Taking into consideration these positive effects, the Remediation Project is not anticipated to contribute to adverse cumulative effects to the Hunted and Trapped Species VC for the CEA.

Community Effects

As noted previously, the evaluation of Community Effects within the CEA focused on the ability of Aboriginal residents to pursue traditional land use activities at the site, local and regional levels. Traditional land use activities are assumed to be pursuits such as hunting, fishing, trapping, camping and the harvesting of berries and medicinal plants. Additional developments with a potential to result in cumulative effects to Community Effects, specifically traditional land use, include:

- On-going industrial, residential and recreational use of Highway 4;
- Re-routing or upgrading of Highway 4;
- Potential re-development of former Giant Mine town-site and adjacent areas;
- Future municipal development;
- Solid waste landfill operation and expansion;
- Quarry operations;
- Highway 4 extension; and
- Mineral/diamond exploration and mining.

Traditional land use by Aboriginal residents has been affected by human activities in the LSA and RSA (e.g., urban growth and mining developments). Reductions in traditional land use can be associated with real changes in environmental conditions, such as the loss of habitat affecting the presence of species that are harvested. In addition to real changes, perceptions of environmental quality are also key determinants in traditional land use practices. For example, even in situations where scientific methods suggest that the risks associated with environmental contamination are minimal, some individuals may alter their traditional land use practices if they perceive that the environment has been degraded. In this regard, any additional human activities that have (or are perceived to have) an adverse effect on environmental quality, could contribute to cumulative adverse effects on traditional land use.

Although the Remediation Project may result in temporary Project-specific adverse residual effects on traditional land use, they are expected to be minor relative to the positive effects that will be achieved through restoration of the site. In this regard, the Remediation Project is expected to result in an overall positive effect on the ability and willingness of Aboriginal residents to pursue traditional land use activities within the LSA and, potentially, within the SSA. Notwithstanding this improvement, certain restrictions against hunting and trapping within municipal boundaries will continue to apply. As well, lands within the SSA may be considered for other land uses that are not fully compatible with traditional land uses (e.g., future development within the SSA by the City of Yellowknife).

The only activity that, when considered in isolation, has a potential to result in a long-term contribution to adverse cumulative effects on traditional land use is the discharge of treated minewater to a new diffuser in Yellowknife Bay. While this activity is not predicted to have a significant adverse effect on the biophysical environment upon which traditional land use depends (as described in Chapter 12) it may constitute a source of concern that could affect land use/harvesting behaviours (e.g., fishing in Yellowknife Bay). However, taking into consideration the important role that the relocation of the discharge point for treated minewater will have in achieving an overall improvement of environmental quality, the Remediation Project is not anticipated to contribute to adverse cumulative effects on traditional land use.

11.4.3 Identification of Mitigation

No measures beyond those already proposed in Chapter 8 to mitigate Project-specific effects are required to address the Project's contribution to cumulative effects.

While it is not a mitigation measure *per se*, the Project Team recognizes the importance of implementing an effective consultation and communications strategy that will, among other things, address public concerns around the Project's potential to contribute to cumulative effects on certain VCs. As described further in Chapter 13, the Project Team will require that a component of such a strategy is specifically directed to local harvesters and others parties that may be concerned by the types of cumulative effects evaluated within the CEA (i.e., the presence or perception of environmental contaminants). The strategy will include provisions for regular updates on Project activities, as well as the sharing of environmental monitoring data.

11.4.4 Evaluation of Significance

The Remediation Project is not anticipated to contribute to adverse cumulative effects. On this basis, no cumulative effects have been advanced for a determination of significance (as presented in Chapter 12).

11.5 Monitoring Plan for Cumulative Effects

Notwithstanding the assessment that that the Remediation Project is not anticipated to contribute to adverse cumulative effects, the Project Team will develop a cumulative effects monitoring plan. The plan will represent one component of the overall monitoring strategy for the Remediation Project. Chapter 14 presents a framework for the monitoring strategy for the entire Remediation Project, including information on the organizational structure and technical scope of the program. Although the cumulative effects monitoring component of the strategy is conceptual in nature, it is envisaged that it will focus principally on the monitoring of contaminant levels in fish, wildlife and plant species that form an important part of the diet of residents within the LSA. The details of the monitoring strategy will be developed and implemented in partnership with representatives of local Aboriginal communities, regulators and other interested parties.

12 Significance of Residual Adverse Effects

12.1 Context for Determination of Significance

The Review Board's *Terms of Reference* requires an evaluation of the significance of any adverse residual effects that may be caused by the Remediation Project. All adverse residual effects identified in Chapter 8 (i.e., Project-specific effects) have, therefore, been advanced to this chapter for an evaluation of significance on the VCs representing the environmental components that may be affected.

In environmental impact assessment, any residual effects identified in cumulative effects assessments are typically forwarded for an evaluation of significance alongside the Project-specific effects. However, as indicated in Chapter 11, the Remediation Project is not anticipated to contribute to the adverse cumulative effects of other past, existing and reasonably foreseeable future developments. In the absence of cumulative effects, a determination of significance for such effects is not required.

Positive residual effects were generally not included in the determination of significance because the Remediation Project has been designed to mitigate, to the maximum extent possible, the effects of decades of mining in the SSA. By its very nature, the Remediation Project will produce beneficial results for the environment and the local population. These benefits were previously discussed in Chapter 8 for each environmental component considered.

12.2 Evaluation Methodology

12.2.1 Residual Effects Criteria

As outlined previously in Section 3.12, residual adverse effects from the Project were evaluated for significance using the following criteria:

Primary Criteria

- Magnitude
- Spatial Extent
- Duration

Other Criteria

- Frequency/Probability
- Reversibility

- Ecological Importance
- Societal Value

Table 12.2.1 presents the evaluation criteria used to evaluate each of the residual effects. The measurement ranges are divided into rankings of low, medium or high.

Table 12.2.1 Criteria for Determining the Significance of Residual Adverse Effects on VCs

Primary Criteria			
Effects Criteria	**Low**	**Medium**	**High**
Magnitude	Effect exceeds baseline conditions; however, is less than reference criteria or guideline values.	Effect will likely exceed reference criteria or guideline values but has limited effect on VC or pathway to VC.	Effect will likely exceed reference criteria or guideline values and may cause an effect on VC or pathway to VC.
Spatial Extent	Effect limited to SSA or immediate surroundings.	Effect limited to LSA.	Effect extends into the RSA.
Duration	Effect is limited to short-term events.	Effect is limited to Remediation Phase.	Effect extends into the Long-term Operation and Maintenance Phase.
Other Criteria			
	Low	**Medium**	**High**
Frequency / Probability	Conditions or phenomena causing the effect are unlikely to occur.	Conditions or phenomena causing the effect may occur on one or more occasions over the project life.	Conditions or phenomena causing the effect may occur at regular and frequent intervals.
Reversibility	Effect is reversible and ceases once source/stressor is removed.	Effect is moderately reversible and persists for some time after source/stressor is removed.	Effect is not readily reversible.
Ecological Importance (of VC)	The VC being affected is common and abundant within the LSA.	The VC being affected is less common and of limited abundance within the LSA.	The VC being affected is recognized as being a threatened or a rare or endangered species.
Societal Value (of VC)	The VC being affected is of limited value to people in the study area.	The VC being affected is of moderate value to people in the study area.	The VC being affected is of high value to people in the study area.

12.2.2 Significance Determination

Table 12.2.2 provides a complete listing of the Project-specific residual effects that were identified in Chapter 8. The significance determination involved evaluating each of the residual effects against the criteria presented in Table 12.2.1.

In performing the evaluation, numerical weights were not assigned to the individual criteria, nor was there an attempt to calculate significance levels mathematically. Instead, professional judgement was used in a structured (methodical) manner to evaluate the residual effect and assign a level of overall significance to it.

Following the evaluation of residual effects, based on the Primary and Other Criteria, one of the following significance levels was allocated to each residual effect:

- *Minor Adverse Effect*: The residual adverse effect is minor or insignificant.
- *Significant Adverse Effect*: The residual adverse effect is significant. Additional or more effective mitigation to reduce the impact of the effect is not considered possible.

The methodology used to determine the level of significance for residual adverse effects consisted of the following two-step process:

Step 1: If any of the Primary Criteria was assigned a "low" ranking, then the residual effect would immediately be considered a minor adverse effect (not significant). However, if a "medium" or "high" rating was assigned for all three of the Primary Criteria, then it would be necessary to proceed to Step 2.

Step 2: If a medium or high rating was assigned to at least one of the Other Criteria, then the residual effect would be considered significant.

For Step 1, the criteria were principally based on the size and extent of the effect. The decision threshold for Step 1 was established so that any residual adverse effect ranked as "low" for any one of the Step 1 criteria would immediately identify the adverse effect as being so minimal that it could not be significant, regardless of the rankings assigned to other Step 1 or Step 2 criteria.

The methodology outlined above was designed to guide and standardize the subjective judgments that must be applied in the analysis.

Table 12.2.2 Summary of Project-Specific Residual Adverse Effects

Environmental Component	Environmental Sub-component	Residual adverse effect
Surface Water Environment	Hydrology	• No residual adverse effects are anticipated
	Surface Water Quality	• A small quantity of drilling fluids, potentially contaminated with arsenic, may enter surface waters • A small quantity of wash water from the decontamination of buildings, potentially contaminated with arsenic, may enter surface waters • A temporary increase in turbidity as a result of earthworks activities • A temporary increase in turbidity during the construction of the water treatment outfall and diffuser • Minor mobilization of contamination (e.g., soils and sediments) as a result of earthworks • Minor mobilization of contamination (e.g., sediments and pore water) during the construction of the outfall and diffuser • Treated minewater discharged from the diffuser will exceed the CWQG –FAL guideline for arsenic within a small volume of water • The discharge of treated minewater will alter the thermal conditions of the water column in the vicinity of the diffuser
	Sediment Quality	• Mobilization of contaminated soils, sediment and pore water during earthwork activities • Mobilization of contaminants during construction of the diffuser/outfall • Increased contaminant loadings in the vicinity of the diffuser in Yellowknife Bay (Great Slave Lake)
Geological & Hydrogeological Environment	Groundwater Flow	• No residual adverse effects
	Groundwater Quality	• No residual adverse effects
	Soil Quality	• Minor Operational Releases of hydrocarbons and arsenic-contaminated materials associated with transportation activities
	Permafrost	• Localized loss of permafrost
Atmospheric Environment	Air Quality	• No residual adverse effects are anticipated
	Noise Environment	• No residual adverse effects are anticipated

Table 12.2.2 Summary of Project-Specific Residual Adverse Effects (Cont'd)

Environmental Component	Environmental Sub-component	Residual adverse effect
Aquatic Environment	Aquatic Biota Aquatic Habitat	• Disturbance of sediments in Baker Creek • Disturbance of sediments during construction of the diffuser / outfall in Yellowknife Bay (Great Slave Lake) • Disturbance of sediments when the cover on foreshore tailings is extended • Removal of riparian vegetation as a consequence of surface disturbances along Baker Creek's channel
Terrestrial Environment	Terrestrial Biota Terrestrial Habitat	• Earthwork activities will result in surface disturbances that will affect terrestrial habitat • The demolition of existing surface infrastructure and buildings is anticipated to eliminate existing terrestrial habitat • Noise emissions will discourage use of the site as terrestrial habitat, particularly during the Remediation Phase
Health	Non-Human Biota Human	• No residual adverse effects are anticipated
Aboriginal Interests	Aboriginal Communities	• No residual adverse effects are anticipated (subject to confirmation during future consultation)
	Traditional Land Use	• No residual adverse effects are anticipated (subject to confirmation during future consultation)
	Aboriginal Heritage Resources	• No residual adverse effects are anticipated (subject to confirmation during future consultation)
Additional Community Interests	Land Use, Visual & Cultural Setting	• Buildings and surface infrastructure that may have heritage value may be demolished as part of Project implementation
	Socio-economic Conditions	• No residual adverse effects are anticipated
	Transportation	• No residual adverse effects are anticipated
	Local Resources	• No residual adverse effects are anticipated

12.3 Results of Significance Determination

The results of the significance determination exercise are summarized in Table 12.3.1. Based on the analysis presented in the table, none of the residual effects are anticipated to be significant.

Table 12.3.1 Evaluation of Adverse Residual Effects

Likely Residual Adverse Effect (After Mitigation)	Potentially Affected Valued Components	Evaluation		Discussion of Significance Result
HYDROLOGY				
No residual adverse effects.				
SURFACE WATER QUALITY				
A small quantity of drilling fluids, potentially contaminated with arsenic, may enter surface waters.	Members of the Public Water quality (intrinsic value) Effects evaluated through potential pathways to: • Aquatic Environment VCs • Terrestrial Environment VCs • Human Health	**Magnitude: LOW** The quantities of any contaminants that would be released are anticipated to be small. **Spatial Extent: LOW** Limited to the SSA, specifically around the construction sites for the freeze pipe collars and adjacent drainage areas. **Duration: LOW** Effect would be short lived as spills will be remediated quickly and any drilling fluids that reach Baker Creek would be rapidly attenuated.	**Step 1:** At least one is low, therefore not significant and Step 2 not needed	**Minor Adverse Effect (Not significant)** The amounts of materials that can be expected to enter surface waters during regular surface drilling are not of a magnitude sufficient to be significant. Accidents and malfunctions involving drilling are a separate matter that has been addressed in Chapter 10. Given the small quantity of materials involved, the assimilative capacity of the main receiving water bodies in the SSA and LSA (Baker Creek and Yellowknife Bay) are large enough that effects to water quality would be temporary and very localized around the point of contact with water. Rapid attenuation is anticipated. The possibility of public exposure is very low and no effects to humans are expected.
		Frequency/Probability: LOW An infrequent occurrence and only possible during drilling activities. **Reversibility: LOW** Any affected water bodies would quickly re-equilibrate to baseline water quality conditions. **Ecological Importance: LOW** The potentially-affected water bodies are not ecologically unique and also have been previously impacted by industrial activity. **Societal Value: MEDIUM** The proximity of the potentially-affected water bodies to Yellowknife increases their social value more than if they were located in a remote location.	**Step 2:** Not needed	

Table 12.3.1 Evaluation of Adverse Residual Effects (Cont'd)

Likely Residual Adverse Effect (After Mitigation)	Potentially Affected Valued Components	Evaluation		Discussion of Significance Result
A small quantity of wash water from the decontamination of buildings, potentially contaminated with arsenic, may enter surface waters.	Members of the Public Water quality (intrinsic value) Effects evaluated through potential pathways to: • Aquatic Environment VCs • Terrestrial Environment VCs • Human Health	**Magnitude: LOW** The quantities of contaminants released are anticipated to be very small, as contaminated waters will be collected and treated before release to the environment. **Spatial Extent: LOW to MEDIUM** Limited to the SSA, specifically around contaminated buildings and adjacent drainage areas. Any wash water that reaches Baker Creek would disperse quickly in the creek and the near-shore area in Back Bay at the mouth of Baker Creek. **Duration: LOW** Effect would be short lived due to rapid attenuation in Baker Creek during the spring and early summer. In the winter, any release would freeze within a short distance of the spill site and be easily remediated.	**Step 1:** At least one is low, therefore not significant and Step 2 not needed	**Minor Adverse Effect (Not significant)** The amounts of materials that can be expected to enter surface waters during regular decontamination of buildings are not of a magnitude sufficient to be significant. Accidents and malfunctions involving building decontamination are a separate matter that has been addressed in Chapter 10. Given the small quantity of materials involved, the assimilative capacity of the main receiving water bodies in the SSA and LSA (Baker Creek and Yellowknife Bay) are large enough that effects to water quality would be temporary and very localized around the point of contact with water. Rapid attenuation is anticipated. The possibility of public exposure is very low and no effects to humans are expected.
		Frequency/Probability: LOW An infrequent occurrence and only possible during the building decontamination program. **Reversibility: LOW** Any potentially-affected water bodies would quickly re-equilibrate to baseline water quality conditions. **Ecological Importance: LOW** The potentially-affected water bodies are not ecologically unique and have been previously impacted by prior industrial activity. **Societal Value: MEDIUM** The proximity of the affected water-bodies to Yellowknife increases their social value more than if they were located in a remote location.	**Step 2:** Not needed	

Table 12.3.1 Evaluation of Adverse Residual Effects (Cont'd)

Likely Residual Adverse Effect (After Mitigation)	Potentially Affected Valued Components	Evaluation		Discussion of Significance Result
A temporary increase in turbidity as a result of earthworks activities.	Water quality (intrinsic value) Effects evaluated through potential pathways to: • Aquatic Environment VCs	**Magnitude: MEDIUM** Relative to current conditions, a moderate increase in turbidity is anticipated in water bodies within the SSA (i.e., Baker Creek).	**Step 1:** At least one is low, therefore not significant and Step 2 not needed	**Minor Adverse Effect (Not significant)** The scale of the earthworks proposed for the Project suggests that a moderate increase in turbidity is inevitable, despite proposed measures to mitigate such an effect. However, the effects are anticipated to be limited to the water bodies of the SSA (Baker Creek) and the near-shore zone in Back Bay at the mouth of Baker Creek. Any increases in turbidity can be expected to attenuate quickly in Back Bay, such that no significant effect is predicted. Turbid waters, while not-aesthetically pleasing, are not considered a health risk to humans.
		Spatial Extent: LOW to MEDIUM Limited to the SSA (Baker Creek) and near-shore area of Back Bay		
		Duration: LOW Periodic short-term episodes of increased turbidity may occur during Remediation Phase earthworks activities.		
		Frequency/Probability: MEDIUM Episodes of elevated turbidity are reasonably probable; however, they are likely to be intermittent.	**Step 2:** Not needed	
		Reversibility: LOW Turbidity will rapidly decrease as suspended particles settle or are diluted in Back Bay.		
		Ecological Importance: LOW The potentially-affected water bodies are not ecologically unique and have been previously impacted by prior industrial activity.		
		Societal Value: MEDIUM The proximity of the affected water-bodies to Yellowknife increases their social value more than if they were located in a remote location.		

Table 12.3.1 Evaluation of Adverse Residual Effects (Cont'd)

Likely Residual Adverse Effect (After Mitigation)	Potentially Affected Valued Components	Evaluation		Discussion of Significance Result
A temporary increase in turbidity during the construction of the outfall and diffuser for treated minewater	Water quality (intrinsic value) Effects evaluated through potential pathways to: • Aquatic Environment VCs	**Magnitude: LOW** Relative to current conditions, increased turbidity is anticipated in close proximity to the outfall. Silt curtains will be employed during construction to limit the magnitude of the effect.	**Step 1:** At least one is low, therefore not significant and Step 2 not needed	**Minor Adverse Effect (Not significant)** A small increase in turbidity in the waters around the outfall/diffuser alignment is predicted. While the proposed measures to mitigate an increase in turbidity should be largely effective, complete retention of suspended sediment is unlikely. Any effects are anticipated to be of low magnitude and limited to the near vicinity of the outfall/diffuser alignment area. Any increases in turbidity can be expected to attenuate quickly in Yellowknife Bay, such that no significant effect is predicted. Turbid waters, while not-aesthetically pleasing, are not considered a health risk to humans.
		Spatial Extent: LOW Limited to the near vicinity of the proposed diffuser/outfall alignment.		
		Duration: LOW Turbid conditions are possible only during the brief period when the diffuser/outfall is being constructed.		
		Frequency/Probability: MEDIUM An increase in turbidity is likely to occur due to the disturbance of fine grained sediments during the construction process.	**Step 2:** Not needed	
		Reversibility: LOW Turbidity will rapidly decrease as suspended particles settle or are dispersed in Great Slave Lake.		
		Ecological Importance: LOW The potentially-affected water bodies are not ecologically unique and the habitat quality is not of high value.		
		Societal Value: MEDIUM The proximity of the affected water-bodies to Yellowknife increases their social value than if they were located in a more remote area.		

Table 12.3.1 Evaluation of Adverse Residual Effects (Cont'd)

Likely Residual Adverse Effect (After Mitigation)	Potentially Affected Valued Components	Evaluation		Discussion of Significance Result
Minor mobilization of contamination (e.g., soils and sediments) as a result of earthworks.	Members of the Public Water quality (intrinsic value) Effects evaluated through potential pathways to: • Aquatic Environment VCs • Terrestrial Environment VCs • Human health	**Magnitude: LOW** Relative to current conditions, a small increase in the amount of contaminants discharged to water bodies within the SSA may occur.	**Step 1:** At least one is low, therefore not significant and Step 2 not needed	**Minor Adverse Effect (Not significant)** The scale of the earthworks proposed for the Project suggests that a slight increase in the mobilization of existing contaminants to water bodies may occur, despite proposed measures to mitigate such an effect. However, any effects are anticipated to be limited to the water bodies of the SSA and the near-shore area of Back Bay at the mouth of Baker Creek. Any contamination that is mobilized is expected to attenuate quickly in either Baker Creek or Yellowknife Bay, such that no significant effect is predicted. Incremental exposure of contaminants (if any) to humans is expected to be negligible.
		Spatial Extent: LOW to MEDIUM Limited to the SSA (Baker Creek) and near-shore area of Back Bay.		
		Duration: LOW Periodic short-term episodes of increased contaminant mobilization may occur during Remediation Phase earthworks activities.		
		Frequency/Probability: MEDIUM Episodes of contaminant mobilization are reasonably probable; however, they are likely to be intermittent.	**Step 2:** Not needed	
		Reversibility: LOW Any potentially-affected water bodies would quickly re-equilibrate to baseline water quality conditions.		
		Ecological Importance: LOW The potentially-affected water bodies are not ecologically unique and have been previously impacted by prior industrial activity.		
		Societal Value: MEDIUM The proximity of the affected water bodies to Yellowknife increases their social value more than if they were located in a remote area.		

Table 12.3.1 Evaluation of Adverse Residual Effects (Cont'd)

Likely Residual Adverse Effect (After Mitigation)	Potentially Affected Valued Components	Evaluation		Discussion of Significance Result
Minor mobilization of contamination (e.g., sediments and pore water) during the construction of the outfall and diffuser.	Members of the Public Water quality (intrinsic value) Effects evaluated through potential pathways to: • Aquatic Environment VCs • Human health	**Magnitude: LOW** Relative to current conditions, a minor increase in the amount of contaminants discharged to Yellowknife Bay from these affected sediments is possible.	**Step 1:** At least one is low, therefore not significant and Step 2 not needed	**Minor Adverse Effect (Not significant)** A small increase in the mobilization of existing contaminants from disturbed sediments into the waters around the outfall/diffuser alignment is predicted. While the proposed measures to mitigate an increase in contaminant mobilization are expected to be largely effective, complete control is unlikely. However, such effects are anticipated to be of low magnitude and limited to the outfall/diffuser alignment area. Any contamination that is mobilized is expected to attenuate quickly in Yellowknife Bay, such that no significant effect is predicted. Incremental exposure of contaminants (if any) to humans is expected to be negligible.
		Spatial Extent: LOW The potentially-affected area is limited to the near vicinity of the outfall/diffuser alignment.		
		Duration: LOW Adverse effects are limited to the construction period for the outfall/diffuser		
		Frequency/Probability: MEDIUM An increase in contaminant mobilization may occur due to the disturbance of fine grained sediments during the construction process.	**Step 2:** Not needed	
		Reversibility: LOW Yellowknife Bay would quickly re-equilibrate to baseline water quality conditions.		
		Ecological Importance: LOW The part of Yellowknife Bay which will be affected by this activity is not ecologically unique, and much of the area covered by the proposed alignment has been previously impacted.		
		Societal Value: MEDIUM The proximity of the affected water bodies to Yellowknife increases their social value more than if they were located in a remote area.		

Table 12.3.1 Evaluation of Adverse Residual Effects (Cont'd)

Likely Residual Adverse Effect (After Mitigation)	Potentially Affected Valued Components	Evaluation		Discussion of Significance Result
Treated minewater discharged from the diffuser will exceed the CWQG – FAL guideline for arsenic within a small volume of water.	Members of the Public Water quality (intrinsic value) Effects evaluated through potential pathways to: • Aquatic Environment VCs • Human health	**Magnitude: LOW** The volume of water in Yellowknife Bay that will exceed the CWQG-FAL guideline for arsenic is very small (<100m^3) relative to the volume of water in North Yellowknife Bay (44,000,000 m^3).	**Step 1:** At least one is low, therefore not significant and Step 2 not needed	**Minor Adverse Effect (Not significant)** The discharge of treated minewater is not expected to result in a significant adverse effect on the water quality of Yellowknife Bay, or other VCs. The diffuser will be designed to encourage rapid mixing of treated effluent with lake water and thus reduce the size of the mixing zone required to meet the CWQG-FAL guideline for arsenic. The activity will not result in an increase of human exposure to arsenic.
		Spatial Extent: LOW The area affected by the discharge of minewater is very small compared to the overall receiving environment.		
		Duration: HIGH Treated minewater will be discharged to Yellowknife Bay for the foreseeable future.		
		Frequency/Probability: HIGH The discharge of treated minewater is a necessary Project activity that is guaranteed to occur.	**Step 2:** Not needed	
		Reversibility: High Not reversible during either phase of the Project.		
		Ecological Importance: LOW The part of Yellowknife Bay which will be affected by this activity is not ecologically unique; there is an abundance of similar areas elsewhere in the bay.		
		Societal Value: MEDIUM The proximity of the affected water-bodies to Yellowknife increases their social value more than if they were located in a remote area.		

Table 12.3.1 Evaluation of Adverse Residual Effects (Cont'd)

Likely Residual Adverse Effect (After Mitigation)	Potentially Affected Valued Components	Evaluation		Discussion of Significance Result
The discharge of treated minewater will alter the thermal conditions of the water column in the vicinity of the diffuser.	Members of the Public Water quality (intrinsic value) Effects evaluated through potential pathways to: • Aquatic Environment VCs	**Magnitude: LOW** The difference in temperature between the discharged minewater and the Yellowknife Bay receiving environment is anticipated to be minor. Similarly, the volume of water discharged relative the overall volume of the receiving environment is very minor.	**Step 1:** At least one is low, therefore not significant and Step 2 not needed	**Minor Adverse Effect (Not significant)** The discharge of treated minewater is not anticipated to pose either a safety risk to human well-being, or to impair the ecological function of Yellowknife Bay. Depending on the selection of the final location, the diffuser will be placed between 8.5 m to 10 m below the surface of Yellowknife Bay. This distance from surface, as well as the relatively small volume of water discharged and the anticipated cold temperature of treated minewater suggests there will be no significant ecological or safety risks associated with the thermal discharge.
		Spatial Extent: LOW The area affected by the discharge of minewater is very small compared to the overall receiving environment.		
		Duration: HIGH Treated minewater will be discharged to Yellowknife Bay for the foreseeable future.		
		Frequency/Probability: HIGH The discharge of treated minewater is a necessary Project activity that is guaranteed to occur.	**Step 2:** Not needed	
		Reversibility: High Not reversible during either phase of the Project.		
		Ecological Importance: LOW The part of Yellowknife Bay which will be affected by this activity is not ecologically unique; there is an abundance of similar habitat elsewhere in the bay.		
		Societal Value: MEDIUM The proximity of the affected water-bodies to Yellowknife increases their social value more than if they were located in a remote area.		

Table 12.3.1 Evaluation of Adverse Residual Effects (Cont'd)

Likely Residual Adverse Effect (After Mitigation)	Potentially Affected Valued Components	Evaluation		Discussion of Significance Result
SEDIMENT QUALITY				
Mobilization of contaminated soils, sediment and pore water during earthwork activities.	Water quality (intrinsic value) Sediment quality (intrinsic value) Effects evaluated through potential pathways to: • Aquatic Environment VCs	**Magnitude: LOW** Sediments in Baker Creek currently contain elevated arsenic levels; hence the effect on downstream sediments from the mobilization of contaminated soils or sediments in the upstream reaches is likely to be small.	**Step 1:** At least one is low, therefore not significant and Step 2 not needed	**Minor Adverse Effect (Not significant)** The scale of earthworks required to implement the Project suggests that contaminated soils and sediments may be mobilized and be deposited downstream in other sediments. However, the extent of mobilization is anticipated to be similar to current conditions. Moreover, the high energy systems of Baker Creek and Yellowknife Bay will preclude the concentrated deposition of any mobilized contaminants to sediments. Taking these factors into consideration, any contaminants that are mobilized are not anticipated to have a significant adverse effect on sediment quality. Rather, gradual improvement of sediment quality throughout the SSA and LSA is expected over time. No effects to humans are anticipated.
		Spatial Extent: LOW Limited to the SSA.		
		Duration: HIGH Effects may extend into the Long-Term Operation & Maintenance Phase.		
		Frequency/Probability: MEDIUM The nature of the earthworks makes it reasonably probable that the mobilization of contaminants will occur. However, such occurrences will be intermittent.	**Step 2:** Not needed	
		Reversibility: HIGH Reversibility through natural processes would take place over an extended period of time.		
		Ecological Importance: LOW The potentially-affected sediments are not ecologically unique and most within the SSA have been previously impacted.		
		Societal Value: LOW Limited and indirect role for societal values.		

Table 12.3.1 Evaluation of Adverse Residual Effects (Cont'd)

Likely Residual Adverse Effect (After Mitigation)	Potentially Affected Valued Components	Evaluation		Discussion of Significance Result
Mobilization of contaminants during construction of the diffuser/outfall.	Water quality (intrinsic value) Sediment quality (intrinsic value) Effects evaluated through potential pathways to: • Aquatic Environment VCs	**Magnitude: LOW** The activity may result in a localized re-distribution of existing dissolved arsenic in the pore water of sediments but the magnitude of the effect is anticipated to be minor overall, although there may be short-term localized exceedances of CWQG-FAL.	**Step 1:** At least one is low, therefore not significant and Step 2 not needed	**Minor Adverse Effect (Not significant)** The area that will be physically disturbed by the installation of the diffuser/outfall pipeline is relatively small. Should contaminants be stirred up as a result of installation, they are likely to quickly settle out again or, in the case of dissolved arsenic species, to disperse quickly in surrounding water in close proximity to the pipeline. No effects to humans are anticipated.
		Spatial Extent: LOW The potentially-affected area is limited to the near vicinity of the outfall/diffuser alignment.		
		Duration: HIGH Effects may extend into the Long-Term Operation & Maintenance Phase.		
		Frequency/Probability: MEDIUM The nature of the activity makes it reasonably probable that the mobilization of contaminants will occur.	**Step 2:** Not needed	
		Reversibility: HIGH Reversibility through natural processes would take place over an extended period of time.		
		Ecological Importance: LOW The potentially-affected sediments are not ecologically unique and have been previously impacted.		
		Societal Value: LOW Limited and indirect role for societal values.		

Table 12.3.1 Evaluation of Adverse Residual Effects (Cont'd)

Likely Residual Adverse Effect (After Mitigation)	Potentially Affected Valued Components	Evaluation		Discussion of Significance Result
Increased contaminant loadings in the vicinity of the diffuser in Yellowknife Bay (Great Slave Lake).	Sediment quality (intrinsic value) Effects evaluated through potential pathways to: • Aquatic Environment VCs	**Magnitude: LOW** The quantity of sediments that could be adversely affected by the discharge of mine water is anticipated to be very small.	**Step 1:** At least one is low, therefore not significant and Step 2 not needed	**Minor Adverse Effect (Not significant)** The diffuser design and location have been selected to minimize potential effects on the receiving environment.
		Spatial Extent: LOW Limited to the near vicinity of the diffuser.		
		Duration: HIGH Treated minewater will be discharged to Yellowknife Bay for the foreseeable future.		
		Frequency/Probability: LOW It is not likely that contaminants emitted from the diffuser will cause an increase in local sediment contaminant concentrations.	**Step 2:** Not needed	
		Reversibility: HIGH Although not predicted to occur, if contaminants do exchange between the water column and sediments, reversibility through natural processes would take place over an extended period of time.		
		Ecological Importance: LOW The sediment in the potentially-affected area of Yellowknife Bay is not ecologically unique.		
		Societal Value: LOW Limited and indirect role for societal values.		
GROUNDWATER FLOW				
No residual adverse effects.				
GROUNDWATER QUALITY				
No residual adverse effects.				

Table 12.3.1 Evaluation of Adverse Residual Effects (Cont'd)

Likely Residual Adverse Effect (After Mitigation)	Potentially Affected Valued Components	Evaluation		Discussion of Significance Result
PERMAFROST				
Localized loss of permafrost	No VC identified. Effects evaluated through potential pathways to: • Surface Water Environment VCs • Aquatic Environment VCs • Terrestrial Environment VCs	**Magnitude: LOW** Areas with naturally occurring permafrost that may be disturbed during Project implementation are small relative to the SSA.	**Step 1:** At least one is low, therefore not significant and Step 2 not needed	**Minor Adverse Effect (Not significant)** While certain Project activities, such as borrow excavation, could trigger a loss of permafrost, the predicted magnitude of the loss is anticipated to be minor and not significant.
		Spatial Extent: LOW Effects to permafrost would be limited to the SSA.		
		Duration: HIGH An extended period would be required for any disturbed permafrost to regenerate.		
		Frequency/Probability: MEDIUM Localized loss of permafrost may occur in areas where earthworks are performed in previously undisturbed ground (e.g., new borrow sources).	**Step 2:** Not needed	
		Reversibility: HIGH Any effects to permafrost are not easily reversible.		
		Ecological Importance: LOW Limited direct role for ecological values.		
		Societal Value: LOW Limited direct role for ecological values.		

Table 12.3.1 Evaluation of Adverse Residual Effects (Cont'd)

Likely Residual Adverse Effect (After Mitigation)	Potentially Affected Valued Components	Evaluation		Discussion of Significance Result
SOIL QUALITY				
Operational releases of hydrocarbons and arsenic-contaminated materials associated with transportation activities.	Member of the public Soil quality (intrinsic value) Effects evaluated through potential pathways to: • Aquatic Environment VCs • Terrestrial Environment VCs • Human Health	**Magnitude: LOW** The quantities of contaminants released from transportation activities would be very small. **Spatial Extent: LOW** Effects would be limited to the SSA. **Duration: LOW** The time frame required to complete soil remediation activities is relatively short hence the duration of the activity is rated as low.	**Step 1:** At least one is low, therefore not significant and Step 2 not needed	**Minor Adverse Effect (Not significant)** The quantity of hydrocarbon or arsenic-contaminated material that may be released to areas with clean soil is not of a magnitude sufficient to be significant. Contaminated soils will be transported over short distances for disposal in the B1 pit. Any spillage that does occur along the haul route will be remediated. No effects to humans are anticipated. Accidents and malfunctions involving contaminants are a separate matter that has been addressed in Chapter 10.
		Frequency/Probability: HIGH It is likely that some hydrocarbons and arsenic-contaminated material will be released through the course of normal transportation activities. **Reversibility: MEDIUM** Contaminants can naturally attenuate or they can be actively remediated. **Ecological Importance: LOW** The areas that may be subject to minor operational releases are, for the most part, areas previously impacted by industrial development (i.e. where earthworks will be concentrated). **Societal Value: LOW** The community is accustomed to this sort of environmental effect and is unlikely to be concerned or raise issues.	**Step 2:** Not needed	
AIR QUALITY				
No residual adverse effects.				
NOISE ENVIRONMENT				
No residual adverse effects on VCs were evaluated. However residual noise effects are evaluated in the Terrestrial Environment sub-section due to the pathway linkages between the Noise Environment sub-component and Terrestrial VCs.				

Table 12.3.1 Evaluation of Adverse Residual Effects (Cont'd)

Likely Residual Adverse Effect (After Mitigation)	Potentially Affected Valued Components	Evaluation		Discussion of Significance Result
AQUATIC BIOTA & AQUATIC HABITAT				
The residual effects previously evaluated in respect of the Surface Water Quality and Sediment Quality environmental sub-components considered effects to Aquatic Environment VCs because the effects pathways link aquatic biota and habitat to the Surface Water Environment. A similar but less critical relationship applies to the residual effects evaluated for the Permafrost and Soil Quality environmental sub-components.				
Disturbance of sediments in Baker Creek.	Baker Creek Aquatic Habitat (intrinsic value) Emergent macrophyte community Benthic invertebrates VC fish species	**Magnitude: MEDIUM** Remediation of Baker Creek is likely to include the disturbance of sediments, which may have a localized and temporary adverse effect on aquatic habitat (e.g., water quality) and aquatic VC species (e.g., benthic invertebrates). **Spatial Extent: LOW** Limited to certain reaches in Baker Creek within the SSA. **Duration: MEDIUM** The aquatic ecosystem is anticipated to recover within a few years of any disturbances.	**Step 1:** At least one is low, therefore not significant and Step 2 not needed	**Minor Adverse Effect (Not significant)** The rehabilitation of Baker Creek will permanently alter some reaches, such that VCs will temporarily lose effective habitat. However certain sections of the creek have been significantly affected by past industrial activity, such that they have limited ecological value. In these cases, rehabilitation will lead to a positive improvement once species start to re-colonize the rehabilitated reaches of the creek. Monitoring of reach 4 of Baker Creek, which was remediated in 2006, has proven to be quite successful and arctic grayling and other fish species have been observed utilizing the creek in the intervening years.
		Frequency/Probability: HIGH There is a high probability that Baker Creek sediments will be disturbed during Project implementation. **Reversibility: MEDIUM** Effects to the aquatic ecosystem are reversible over the span of a few years after disturbances. **Ecological Importance: MEDIUM** The benthic and riparian habitat provided by Baker Creek is not ecologically unique and has been compromised by decades of industrial activity. **Societal Value: MEDIUM to HIGH** Parts of Baker Creek are valued by local residents as recreational fishing locations.	**Step 2:** Not needed	
Disturbance of sediments during construction of the outfall/diffuser in Yellowknife Bay	Yellowknife Bay Aquatic Habitat (intrinsic value)	**Magnitude: LOW** The amount of sediments that might be disturbed by this activity and the footprint of the new outfall / diffuser pipeline will be very small relative to the area covered by Yellowknife Bay.	**Step 1:** At least one is low, therefore not significant and Step 2 not needed	**Minor Adverse Effect (Not significant)** The construction of the outfall/diffuser is likely to result in disturbance of some sediments within Yellowknife Bay. The physical footprint of the

Table 12.3.1 Evaluation of Adverse Residual Effects (Cont'd)

Likely Residual Adverse Effect (After Mitigation)	Potentially Affected Valued Components	Evaluation		Discussion of Significance Result
	Emergent macrophyte community Benthic invertebrates VC fish species	**Spatial Extent: LOW** The disturbance will be limited to the near vicinity of the outfall/diffuser by the employment of silt curtains during construction.		outfall / diffuser may preclude the re-establishment of habitat in a small area. However, the area that may be affected is very small relative to Yellowknife Bay and associated effects are not expected to be significant.
		Duration: LOW Any adverse effects to sediment and habitat quality would be limited as the disturbed sediments have the same characteristics as the surrounding sediments and there is only limited aquatic plant growth along the potential pipeline alignments.		
		Frequency/Probability: HIGH Some disturbance of sediments along the outfall/diffuser alignment is likely to occur as part of Project implementation.	**Step 2:** Not needed	
		Reversibility: LOW Areas affected by sediment disturbance and deposition will recover following completion of construction activity.		
		Ecological Importance: LOW The benthic habitats along the diffuser/outfall alignment are not ecologically unique and similar types of habitat are present throughout Yellowknife Bay.		
		Societal Value: LOW Limited and indirect role for societal values.		
Disturbance of sediments when the cover on foreshore tailings is extended	Yellowknife Bay Aquatic Habitat (intrinsic value) Emergent macrophyte community Benthic invertebrates	**Magnitude: LOW** The amount of sediment/tailings to be disturbed and/or covered will be very small relative to the area of Yellowknife Bay.	**Step 1:** At least one is low, therefore not significant and Step 2 not needed	**Minor Adverse Effect (Not significant)** The extension of the foreshore tailings cover requires that some sediment in Yellowknife Bay be disturbed. However, given the very small area proposed to be covered, the magnitude of the effect is not expected to be significant to applicable VCs. In addition, the covering of the foreshore tailings is anticipated to result in the creation of new habitat that is not compromised
		Spatial Extent: LOW Effect limited to the foreshore area of the SSA.		
		Duration: MEDIUM Associated VCs are anticipated to fully recover within several years (e.g., benthic invertebrates).		

Table 12.3.1 Evaluation of Adverse Residual Effects (Cont'd)

Likely Residual Adverse Effect (After Mitigation)	Potentially Affected Valued Components	Evaluation		Discussion of Significance Result
	VC fish species	**Frequency/Probability: HIGH** Some disturbance of sediments in the area to be covered is likely to occur as part of Project implementation.	**Step 2:** Not needed	by existing contaminants.
		Reversibility: HIGH Any effect to sediments will be irreversible but associated VCs are anticipated to fully recover (e.g., benthic invertebrates).		
		Ecological Importance: LOW The habitat in the foreshore tailings area is not ecologically unique and similar types of habitat are found throughout Yellowknife Bay. Much of this area's ecological value was compromised by deposition of tailings into the bay during the early years of mine operations.		
		Societal Value: LOW Limited and indirect role for societal values as this is not an area that is highly valued by local residents		
Removal of riparian vegetation as a consequence of surface disturbances along Baker Creek's channel	Surface Water Quality and Sediment Quality Baker Creek Aquatic Habitat (intrinsic value) Emergent macrophyte community Benthic invertebrates VC fish species	**Magnitude: MEDIUM** The quantities of vegetation that will be removed during remediation of Baker Creek has yet to be determined. However, it is expected that most riparian areas will not be affected by the Remediation Project.	**Step 1:** At least one is low, therefore not significant and Step 2 not needed	**Minor Adverse Effect (Not significant)** Overall, the quantity of vegetation loss due to the rehabilitation of Baker Creek is of low significance. At the completion of remediation, vegetation in disturbed areas is anticipated to re-establish quickly, particularly if the plan includes transplanting of aquatic plant species to speed up recovery of the aquatic ecosystem.
		Spatial Extent: LOW Limited to the SSA, and then only in certain reaches along Baker Creek		
		Duration: LOW to MEDIUM The proposed disturbance will be limited to the period required to rehabilitate Baker Creek and the time required to re-establish vegetation.		
		Frequency/Probability: HIGH The removal of some riparian vegetation from Baker Creek is required in order to carry out the rehabilitation activities.	**Step 2:** Not needed	

Table 12.3.1 Evaluation of Adverse Residual Effects (Cont'd)

Likely Residual Adverse Effect (After Mitigation)	Potentially Affected Valued Components	Evaluation		Discussion of Significance Result
		Reversibility: MEDIUM Defoliated reaches are expected to fully recover over time.		
		Ecological Importance: HIGH Re-establishment of riparian vegetation along the realigned Baker Creek is important for full recovery of the aquatic ecosystem.		
		Societal Value: LOW to MEDIUM Vegetation along Baker Creek is more of a concern to some local stakeholders then others.		
TERRESTRIAL BIOTA & TERRESTRIAL HABITAT				
NOTE: The residual effects previously evaluated in respect of the Surface Water Quality environmental sub-component have considered effects to Terrestrial Environment VCs because the effects pathways link terrestrial biota and habitat to the Surface Water Environment Component. A similar but less critical relationship applies to the residual effects evaluated for the Permafrost and Soil Quality environmental sub-components.				
Earthwork activities will result in surface disturbances that will affect terrestrial habitat.	Quality of habitat (intrinsic value) Moose and Caribou Black bear Wolf Fur-bearing mammals (including muskrat) Grouse/ptarmigan Mallard, merganser, scaup	**Magnitude: MEDIUM** Potential habitat may be affected during implementation of earthworks and other Project activities. The effect on VCs may be more pronounced in ecologically intact areas, such as the Baker Creek channel.	**Step 1:** At least one is low, therefore not significant and Step 2 not needed	**Minor Adverse Effect (Not significant)** Although the proposed earthwork activities for the Project are extensive, the degree to which they will physically impinge on terrestrial biota and habitat is minimal and not significant. The Giant Mine site has been negatively affected by over five decades of industrial activity that has reduced the quality of habitat through past land disturbances and contamination. While some VCs could be affected by short-term earthwork activities, the overall long-term effect will be positive as new habitat will be created (e.g., revegetation of tailings covers), and current habitat will be improved through the
		Spatial Extent: LOW Limited to the SSA.		
		Duration: LOW to MEDIUM Physical disturbances to existing terrestrial habitat as a result of earthwork activities are considered permanent. However, replacement habitat of a better quality will be established along Baker Creek and on the contaminated soils and tailings areas.		
		Frequency/Probability: MEDIUM Project implementation will result in the disturbance of some terrestrial habitat.	**Step 2:** Not needed	

Table 12.3.1 Evaluation of Adverse Residual Effects (Cont'd)

Likely Residual Adverse Effect (After Mitigation)	Potentially Affected Valued Components	Evaluation		Discussion of Significance Result
	VC raptor species Berries and medicinal plants Browse	**Reversibility: MEDIUM** Some existing (and environmentally compromised) habitat will be permanently lost. However, all losses will be compensated through a general improvement in environmental quality.		removal of contaminant "hotspots" (e.g., Baker Creek rehabilitation and contaminated soils around the mill and roaster facilities). Disturbance of terrestrial habitat in borrow areas will be offset by reclamation of vegetative cover on these areas.
		Ecological Importance: LOW The potentially affected habitat is not ecologically unique. There is sufficient equivalent habitat within and beyond the LSA. While some of the potentially affected areas serve as habitat for muskrat and semi-aquatic birds, much of the site has been previously impacted by industrial development.		
		Societal Value: LOW Limited and indirect role for societal values.		
The demolition of existing surface infrastructure and buildings may eliminate existing terrestrial habitat.	Quality of habitat (intrinsic value) VC raptor species	**Magnitude: LOW** Very few buildings on site provide adequate habitat for potentially-affected species. Such habitat is considered sub-standard relative to natural environments.	**Step 1:** At least one is low, therefore not significant and Step 2 not needed	**Minor Adverse Effect (Not significant)** Given that such structures may pose a potential physical and chemical risk to wildlife that nest in them, the elimination of wildlife habitat through the demolition of surface infrastructure and buildings will not result in a significant adverse effect.
		Spatial Extent: LOW Limited to buildings within the SSA.		
		Duration: HIGH The elimination of habitat is a permanent effect.		
		Frequency/Probability: HIGH The demolition of buildings is a key part of the Project implementation.	**Step 2:** Not needed	
		Reversibility: HIGH The demolition of buildings is irreversible.		
		Ecological Importance: LOW There are many alternate human structures and natural formations within the LSA that can provide similar and superior alternate habitat for potentially-affected VCs.		
		Societal Value: LOW Limited and indirect role for societal values.		

Table 12.3.1 Evaluation of Adverse Residual Effects (Cont'd)

Likely Residual Adverse Effect (After Mitigation)	Potentially Affected Valued Components	Evaluation		Discussion of Significance Result
Noise emissions will discourage use of the site as terrestrial habitat, particularly during the Remediation Phase.	Quality of habitat (intrinsic value) Moose and Caribou Black bear Wolf Fur-bearing mammals (including muskrat) Grouse/ptarmigan Mallard, merganser, scaup VC raptor species	**Magnitude: MEDIUM** Activities throughout the Remediation Phase are expected to generate increased noise levels relative to current conditions. However, noise levels are not expected to be greater than during the operational phase of the mine. **Spatial Extent: LOW** Disturbances will be largely limited to the SSA. **Duration: MEDIUM** The disturbance will last until the end of the construction period within the Remediation Phase.	**Step 1:** At least one is low, therefore not significant and Step 2 not needed	**Minor Adverse Effect (Not significant)** Although noise levels within the SSA are anticipated to increase during the Remediation Phase, the effect is considered minor and not significant. Many of the species that are typically considered resident species, such as muskrat, are expected to habituate to higher ambient noise levels. Species that are considered more sensitive to noise, such as moose and caribou, are not currently found at the site due to current conditions.
		Frequency/Probability: HIGH Noise is an unavoidable consequence of Project implementation. **Reversibility: LOW** Effect is completely reversible once activities that generate noise are complete. **Ecological Importance: LOW** For the most part, the SSA does not have a high ecological value given that much of the area has been affected by past industrial activity and contamination. There is sufficient high quality habitat within and beyond the LSA. **Societal Value: LOW** Limited and indirect role for societal values.	**Step 2:** Not needed	
NON-HUMAN BIOTA HEALTH & HUMAN HEALTH				
No residual adverse effects.				
ABORIGINAL COMMUNITIES				
No residual adverse effects anticipated (subject to confirmation during future consultation)				
TRADITIONAL LAND USE				
No residual adverse effects anticipated (subject to confirmation during future consultation)				
ABORIGINAL HERITAGE RESOURCES				
No residual adverse effects anticipated (subject to confirmation during future consultation)				

Table 12.3.1 Evaluation of Adverse Residual Effects (Cont'd)

Likely Residual Adverse Effect (After Mitigation)	Potentially Affected Valued Components	Evaluation		Discussion of Significance Result
LAND USE, VISUAL & CULTURAL SETTING				
Buildings and surface infrastructure that have heritage value may be demolished as part of Project implementation.	Recreational and community features/resource use Visual aesthetics and physical resources Built heritage features and cultural landscapes	**Magnitude: LOW** Out of more than 100 buildings very few have been identified as having heritage value worth preserving. The loss of such structures is fully offset by the positive effects associated with implementing the Remediation Project. **Spatial Extent: LOW** The buildings and surface infrastructure in question are exclusively located within the SSA. **Duration: HIGH** Demolition of buildings is a permanent effect.	**Step 1:** At least one is low, therefore not significant and Step 2 not needed	**Minor Adverse Effect (Not significant)** Certain stakeholder affiliations, particularly the NWT Mining Heritage Society, have articulated their preference to preserve the structures that would otherwise be destroyed as part of Project Implementation. For its part, the Project Team must balance other societal interests when considering if and how to preserve these potential heritage features. Key among these concerns is the cost associated with preservation. The Project Team is generally supportive of the goals of those stakeholders who would like to preserve the structures, and continues to work with them towards finding a mutually acceptable outcome. However, this support cannot come at the expense of achieving the key objectives of the Giant Mine Remediation Project. Therefore it is the opinion of the Project Team that in the event it becomes necessary to demolish the structures in question, this would be an acceptable outcome that would appropriately balance the varied interests of society.
		Frequency/Probability: HIGH There is a high probability that the structures will be demolished. **Reversibility: HIGH** The demolition of buildings is irreversible. **Ecological Importance: LOW** No effect predicted. **Societal Value: MEDIUM** Certain members within the Yellowknife community value built heritage features at the Giant Mine site.	**Step 2:** Not needed	
LOCAL RESOURCES				
No residual adverse effects.				
TRANSPORTATION				
No residual adverse effects.				
SOCIO-ECONOMIC CONDITIONS				
No residual adverse effects.				

13 Consultation and Engagement

13.1 Objectives and Overview

This Chapter outlines the Project Team's approach to engagement and consultation on the Giant Mine Remediation Project. It includes a summary of consultation conducted in the past, both historically and recently; describes efforts to simplify and improve this engagement; describes future plans to engage and inform; and outlines how the Project Team will collect and follow-up on feedback received from Aboriginal communities and the public. Consistent, clear and transparent Aboriginal group and public involvement will be a significant aspect of moving forward on the Remediation Project. Future engagement and consultation will be informed by past engagement activities and will be subject to change and growth, based on lessons learned and feedback received. The Project Team's plan for future consultation and engagement during and beyond the EA is outlined in this Chapter.

Very generally, engagement and consultation are inclusive approaches to dealing with complex problems. They are useful in bringing disparate parties towards a common understanding of an issue, which in turn can facilitate arrival at a solution. As identified by the Public Policy Forum, public engagement is a "*way of thinking about how government works together with stakeholders and ordinary citizens to achieve a wide range of goals that it cannot achieve alone*"[31]. Any major policy decision, including decisions on a large and complex undertaking such as the Giant Mine Remediation Project, increasingly depends on how well it reflects the underlying values of those with a stake in the outcome. Meaningful engagement and consultation can lead to improved public trust and confidence, and, in this case, a well-constructed and carried out public engagement process is important in strengthening the effectiveness of the Remediation Project.

Common methods used to engage and consult include public meetings, open houses, workshops, focus groups, surveys and interviews; all of these are being used in the Giant Mine Remediation Project consultations. The ongoing input of Aboriginal groups and the public is essential to dealing with the contaminants and environmental risks on site, and to help ensure that the Remediation Project is designed to reflect the interests of those who will use and reside around the site in the future. The remediation of contaminated sites such as Giant Mine can also introduce a focus on matters beyond remediation of the environment - as a result of the relatively large potential for training, jobs and economic opportunities associated with a large remediation program.

[31] Public Policy Forum Web Site (http://www.ppforum.ca/engagement-community). As viewed online in September 2010.

Given the close proximity of the site to Dettah, N'dilo and Yellowknife, the remediation of Giant Mine has always had a high profile and been under the close scrutiny of these three communities. This will only increase over the next years of EA, regulatory review and implementation of the Remediation Project.

The timing for public engagement on the Remediation Project is coming to a critical juncture. Plans are advancing such that there are now options for the detailed design, particularly for surface remediation, on which the Project Team can effectively ask Aboriginal communities and the public for meaningful feedback.

13.2 Review Board Directions to the Giant Mine Remediation Team

In Section 3.2.6 of the *Terms of Reference* for the EA, the Review Board described the purpose of public consultation as providing "*those individuals who may be affected by the development, an opportunity to effectively participate in the environmental assessment*." The Review Board expressed the need for a thorough understanding of the Project Team's efforts to consult with the public, in order to consider whether potentially affected individuals have been able to participate in the process. The following items, taken directly from the *Terms of Reference*, are required for consideration of public and Aboriginal consultation:

1. For each consultation activity, identify dates and locations, participants in consultation activities, methods of consultation and discussion topics. Additionally, identify:
   a. All public methods used to identify, inform and solicit input from potentially affected parties;
   b. All commitments and agreements made in response to issues raised by the public during these consultations and how these commitments altered the planning of the proposed development;
   c. All issues that remain unresolved, and document any further efforts envisioned by the parties to resolve them.
2. Identify any plans, strategies or commitments that the developer is contemplating to ensure that individuals or groups that may be affected by the development will continue to be consulted over the term of this environmental assessment and over the life of the project.
3. Describe the membership and activities of the Giant Mine Community Alliance.
4. Discuss any efforts that the developer will be making to simplify the complex information contained within the development public registry and to more effectively communicate aspects of the development, including any efforts that will specifically address concerns that the developer may have heard from participants in previous consultation activities or during this environmental assessment.
5. Discuss how the developer intends to engage with traditional knowledge holders in order to collect relevant information for the prediction of possible impacts, as well as the development of mitigation methods, adaptive management plans and monitoring program planning.

6. Describe any plans the developer has to continue public consultation and involvement during implementation of the project and afterwards, with particular regard to reporting monitoring results and adaptive management, and a description of how public complaints will be addressed and the dispute resolution process.

13.3 Looking Back: A History of Consultation Activities

The historic operation of Giant Mine has had a profound effect on the economy, the land and the people in the surrounding communities of Dettah, N'dilo, and Yellowknife. While approximately 220,000 kilograms of gold were produced during the five-decades of operations, the gold roasting process has left a legacy of 237,000 tonnes of toxic arsenic trioxide which is stored in underground chambers at the mine site. Following the economic failure of Royal Oak Mines, the courts transferred control of Giant Mine to INAC, with the department becoming the caretaker for the existing conditions at the site, including the arsenic trioxide dust stored underground; and ultimately, in partnership with the GNWT, its remediation. More detail on the history of Giant Mine is provided in Chapter 4 of this DAR.

In determining the best option for long-term storage of the arsenic trioxide dust, a Technical Advisor undertook an Alternatives Assessment of 56 methods. The work of the Technical Advisor was evaluated by an Independent Peer Review Panel (IPRP) of nine experts. The assessment involved three years of studies from 2001-2003 and over 40 public consultations including three major workshops. The first workshop narrowed down the alternatives to 12 methods for more detailed assessment, and the two best options were presented at a second public workshop. The participants were divided over whether to keep the arsenic dust stored underground or remove it and, based on the public feedback, a third option was included in the final workshop. The Technical Advisor recommended the frozen block method to the Project Team, on the basis of scientific studies, public feedback, and support from the IPRP as an environmentally effective option with the least health and safety risks for the workers. It is not, however, the least costly option.

All engagement and consultation activities from 1997 – 2007 are captured in a report entitled "*Supporting Document P1, Giant Mine Remediation Plan Public Consultation and Communications*" which is provided in Appendix B to this DAR. Over the years, INAC has held numerous public information sessions and workshops and led a large number of tours of the Giant Mine site. Each of these tools and the input received from the public has contributed to the development of the Remediation Plan.

The responsibility for cleaning up the site rests with the Federal and Territorial governments. INAC and the GNWT are joint proponents (also referred to as the Project Team) for the implementation of the Giant Mine Remediation Project. On October 19, 2007, INAC submitted an application for a water licence to the Mackenzie Valley Land and Water Board (MVLWB).

The application was to complete the reclamation of the Giant Mine site over a period of up to ten years. On March 31, 2008 the City of Yellowknife referred the Giant Mine Remediation Plan to an EA under section 126(2) (d) of the *Mackenzie Valley Resource Management Act*. The Review Board began its environmental assessment of the remediation project on April 7, 2008 and on May 12, 2009 issued its *Terms of Reference* for the Environmental Assessment and production of this DAR. The *Terms of Reference* include directions to the Project Team for conducting and reporting on their public consultation.

After the submission of the Remediation Plan, the Project Team began to work towards the detailed design of the project. In the period between 2007 and 2010, information was shared with Aboriginal groups and the public on the direction the detailed design was heading. A summary of public engagement activities implemented between submission of the Remediation Plan in July 2007 and September, 2010 is presented in Appendix C.

13.4 Looking Back: Recent Consultation Activities

In September 2009, the Project Team hosted public tours of Giant Mine. The intent of the tours was to inform the Yellowknife community about the Remediation Plan and future plans for the overall site. During the tours, attendees were asked what concerned them most and what should the Project Team focus future consultation activities on.

From the responses received during the tours, the Project Team designed and hosted six engagements with Aboriginal leaders and other parties interested in the Remediation Project in the spring of 2010. The engagements focused on: 1) the Frozen Block; 2) Surface Remediation including Baker Creek; and 3) Environmental Site Quality (see Table 13.4.1 for details). The intent of the first session was to engage the Yellowknife City Council. The next three public sessions were hosted by the Community Alliance and targeted the general public of Yellowknife, although there were also participants from Dettah and N'dilo. Each day included a lunch time 'meet-and-greet' open house followed by a specific theme-oriented evening session. In May 2010, the Project Team hosted two evening engagement sessions, in Dettah and N'dilo, with members of the Yellowknives Dene First Nation (YKDFN). Members of the Project Team also held a meeting with leadership from the Tlicho Government and traveled to Hay River in June 2010 to engage the Northwest Territory Métis Nation (NWTMN) in the development of the Remediation Project.

Table 13.4.1 Recent Consultation Activities

Participants	Location	Presentation Topic	2010 Dates	Time	Public Attending	Remediation Team Participants
Yellowknife City Council	City Hall	Giant Mine Remediation Plan	April 19	11:00 – 12:00	Mayor, 7 Council Members, and 9 City administrative staff	11
Residents of Yellowknife, Dettah, and N'dilo	Tree of Peace Friendship Centre	Freezing the Arsenic Trioxide	April 20	11:00 – 13:30	10	19
				19:00 – 21:00	6	
		Surface Remediation	April 27	11:00 – 13:30	29	21
				19:00 – 21:00	19	
		Environmental Quality and the DAR	April 29	11:00 – 13:30	53	20
				19:00 – 21:30	21	
Yellowknives Dene First Nation Members	Chief Drygeese Conference Centre, Dettah	Freezing the Arsenic Trioxide; Surface Remediation; Environmental Quality and Risk Assessment	May 25	18:00 – 23:30	Chief Edward Sangris and approximately 35 YKDFN members	13
	N'dilo Gym, N'dilo		May 26	18:00 – 22:00	Chief Ted Tsetta, Chief Edward Sangris, MLA Bob Bromley, and approximately 60 YKDFN members	14
Tlicho Government	Yellowknife	Freezing the Arsenic Trioxide; Surface Remediation; Environmental Quality and Risk Assessment	May 17	14:00 – 16:15	Grand Chief Joe Rabesca, Chief Edward Chocolate, Chief Charlie Football, Executive Assistant Laura Duncan	4
Northwest Territory Métis Nation	Hay River	Freezing the Arsenic Trioxide; Surface Remediation; Environmental Quality and Risk Assessment	June 30	09:00 – 14:30	President Betty Villebrun and 12 other NWTMN members from Fort Smith, Fort Resolution, and Hay River	6

The Review Board's directions for conducting and reporting on public consultation in the DAR *Terms of Reference* formed the underpinning for the engagement sessions. Full reporting on the April and May 2010 sessions is provided in three publically available documents:

1) *Giant Mine Remediation Plan: Summary of April 2010 Public Engagements-Yellowknife. July 2010.* 50 pages plus Appendices.
2) *Giant Mine Remediation Plan: Summary of May 2010 Yellowknives Dene Engagements – Dettah and N'dilo. July 2010.* 47 pages plus Appendices.
3) *Giant Mine Remediation Plan: Yellowknives Dene May 2010 Engagements: Themes and* Concerns. July 2010. 17 pages plus Appendices.

As stated by the Review Board, the purpose of public consultation is to provide those individuals who may be affected by the Remediation Project an opportunity to participate effectively in the EA. During the engagements, the Project Team shared information about the Remediation Plan, the options for future land use, and the methods proposed for information collection and analysis. Information was shared through oral presentations with accompanying PowerPoint slides and visually by using three-dimensional models and wall posters (see Section 13.8). The question and answer periods provided an opportunity for the Project Team to expand on details of the Remediation Plan and for participants to share opinions and concerns. Feedback was also solicited with an event evaluation form (see Report 1 and 2 above for details of the evaluation).

13.5 Resulting Commitments

Commitments

In the April and May 2010 engagement sessions, the Project Team committed to the following:

- Consider keeping in place all the equipment needed to return the frozen block system to an active freezing system for a period of time after completion.
- Give priority to the City of Yellowknife demands for power from the grid over Giant Mine remediation or maintenance power demands - by reducing remediation consumption if needed.
- Identify the archaeological and burial sites of the Yellowknives Dene within the remediation area before any work occurs.
- Work cooperatively with YKDFN to make sure appropriate respect is shown throughout the development of the Remediation Project.
- Ensure government department reviews of the Human Health and Ecological Risk Assessment which was prepared for the Remediation Project are made publicly available.
- Hold a public meeting on the Monitoring Framework for the Remediation Project.
- Work with the YKDFN to make the cleanup a success.

- Although not part of this Remediation Project, raise with INAC senior management the question of compensating YKDFN members for historic damages associated with Giant Mine.
- Work on gathering and incorporating traditional knowledge into the cleanup project.
- Provide a summary report of the meeting discussions to the YKDFN (the report was shared and a follow-up meeting is planned for the fall of 2010), MLA Bob Bromley, and Great Slave Cruising Club Officer Terry Brookes.

13.5.1 Summary of Feedback

The engagement sessions delivered by the Project Team were generally well received. During the sessions there was both criticism and support levelled at the Project Team and many lessons learned. This experience will help inform plans for engagement and consultation in the future. This section summarizes feedback received during the question and answer period, and event evaluations from recent engagements with the YKDFN, Tlicho Government, the NWTMN, and the general public (Aboriginal and non-Aboriginal residents) of Yellowknife.

Common Concerns

Some of the feedback expressed most frequently during the engagement sessions was:

- The approach used in the past to develop the site and to engage Aboriginal groups and the public was inadequate; there is a critical need for more regular and direct communication between the Project Team and the YKDFN, other NWT Aboriginal groups and the Yellowknife public.
- Yellowknives Dene First Nation has grievances about how its land was used and misused; participants at several engagements demanded that these grievances be addressed by the government.
- Old burial sites, archaeological remnants, and cultural sites in and near the mine site need to be identified.

> *I have read many materials but I don't believe that to this day many of the hearings that we had in the community, many of the points and issues that we brought forward have been properly looked in to. And I still don't hear it today. One issue is old burial sites in the area. We raised this concern many years ago and I still haven't heard anything today. Those burials and graves need to be identified and taken care of properly. In 1940's when Giant Mine was in operation, the mine company went to the community of Dettah and asked the family members to remove the graves. In my culture when we put a person to rest in an area that is the chosen place for the remainder of their burial. We don't move burials.* - Fred Sangris, N'dilo.

- The views and concerns of YKDFN and Yellowknife stakeholders must be carefully considered by the Project Team and followed wherever possible. When public advice and recommendations are not followed, the Project Team must explain why in a clear and timely manner.
- There remains confusion about the toxicity and mobility of different forms of arsenic (i.e., arsenopyrite, arsenic trioxide, and dissolved arsenic in water) and the Project Team should continue its efforts to clarify this.

> *My final question is one thing I hoped to get out of all this is I cannot figure out all the different types of arsenic. There is arsenic in rocks and arsenic that is organic and not at all poisonous…it all sounds the same to me.* - Andrew Robinson, Yellowknife

- Some concern remains about the effects a warming climate or earthquakes may have on the safe storage of arsenic trioxide and that the Project Team must fully address the concerns and commit to ensuring sufficient freezing capacity is installed to keep the ground frozen if the worst case scenario climate predictions occur.

> *My biggest concern is climate change. Will we be able to keep it [the arsenic trioxide chambers] frozen forever? Now climate is changing everywhere, which is something we need to consider.* - Chief Edward Sangris, Dettah

- There were conflicting views and preferences about several details in the Remediation Plan that are still open for debate and modification, such as the relocation of the Ingraham Trail, the type of vegetative cover for remediated tailings, future land use of the mine site, and whether contaminated sediments in Baker Creek should be removed or undisturbed.

> *You talked about fencing the mine property. As a First Nation person, I would like to see the whole mine site enclosed to keep everyone out of there. With everyone out there on 4x4s and who knows what else, there is already enough noise and disturbance for the wildlife. I would like to see every old mine site enclosed and not developed. We don't want anything else developed on there. If we can't have it we don't want anyone else to have it and we don't want it.* - Diane Betsina, N'dilo

- The power demands for the project were of concern. The audience in the Yellowknife engagements questioned the effects the project may have on the city supply of power whereas the YKDFN audience was concerned about the investment in electrical power while their requests for compensation were not met.

> *And who is paying for the power to run that giant refrigerator. If you have the money to pay for the power then you should have enough to pay the Elders for compensation that they never received. If you have money to give to the City's Northland Utilities then I think the Elders should get some kind of benefit that they have been asking for over many years now.* - Muriel Betsina, N'dilo

> *What are the proposed power sources for the mine? Will it be hooked up to the city grid or obtain its own power source?* - Mark Heyck, Yellowknife City Councillor

- There remains concern about arsenic contamination outside the mine site impacting the well-being of YKDFN members and residents of Yellowknife. Although outside the scope of this project, the Giant Team committed to informing senior government managers about this sentiment.
- A workshop participant said that, "*We like some of the tools and the ways in which you are now engaging with us and we encourage you to continue to speak often, honestly, and in ways that we can understand.*"
- There was recognition of the effort to share the status and plans for the cleanup and for bringing all of these Project Team members to the engagements; and a request to continue doing this.

<u>Yellowknives Dene First Nation Specific Feedback</u>

Members of the YKDFN indicated that, since the discovery of gold in the Yellowknife region, their people have been greatly impacted by Giant Mine which is located within their traditional territory. There were concerns and demands unique to the engagements in Dettah and N'dilo. The input provided by members of the YKDFN has been grouped into the following themes:

1. Health: Human
    - The impact of past mining pollution and present environmental contamination on community members' health has been inadequately studied and communicated, so this remains highly contentious.
2. Health: Animals, Fish and Environment
    - Aboriginal people were and still are impacted by changes in the quality and availability of traditional food and land.

> *I am 97 years old. When I was a young child hunting in this area - I went hunting for ducks, rabbits. We used to go by the shore and take a cup of water and drink it, today we can't do that. We are so scared of drinking water by the shore... A lot of people do not drink water within a 30 mile radius of the mine site.* - Michel Paper, Dettah Elder

3. Surface: Leaving Buildings

   - In contrast to engagements in Yellowknife, members of the YKDFN were not necessarily supportive of preserving any buildings on the mine site.

> *You mentioned at the beginning of your presentation that some of the buildings will be left for their historic values. But who in their right mind would want to keep a reminder about murder and destruction of the land? That roaster should be torn down and shipped out of here.* - Chief Ed Sangris, Dettah

4. Local Knowledge and People for Monitoring

   - Participants were eager to provide traditional and local knowledge about changes to Giant Mine and neighbouring ecosystems. The YKDFN want to be active in the future monitoring activities to ensure that the proper data is collected by people with local knowledge and respect for the land.

> *Some of these Elders have been around this area for a long time and they know the animals' movements and populations very well. We know that the animals, especially small mammals, do not use the mine site area as much as the surrounding lands. You should hire a First Nation person to do the wildlife monitoring and collect samples for your studies.* - Alfred Baillargeon, Dettah Elder and Band Councillor

5. Traditional Knowledge

   - Members of the YKDFN hold the traditional knowledge of the Giant Mine land and surrounding area. This knowledge needs to be recorded and considered in the Remediation Plan. Participants expressed a strong desire for a comprehensive collection and utilization of this knowledge.

> *[Our] concerns and questions need to be compiled and studied so that we can be given the proper answer. There are many stories from the past that the Elders know and they have not been recorded. We need to [ask]*

the Elders because their knowledge goes way back.
- Liza Pieper, N'dilo

6. Communications with Leadership

   - Although participants were positive about building better partnerships in the future, there was still concern expressed by many that communication has been inadequate between YKDFN and the government on important issues. This has continued as recently as the spring 2010 incident involving accidental release of air from an arsenic trioxide chamber following experimental drilling.

     We have not been given a proper presentation to inform us about what is going on over at the mine. We don't know what activities are going on over there. The communication efforts so far have not been adequate because we still don't know and understand a lot of the details. - Alfred Baillargeon, Dettah Elder and Band Councillor

7. Compensation and Apology

   - There was a recurring theme, expressed by many participants, about the strong need for the community to be compensated for the loss of its land and resulting damages to the wildlife, fish, drinking water, cultural activities, human health, and peace of mind. Although outside the scope of this project, the Project Team committed to informing senior government managers about this sentiment.

8. Awarding Contracts for Site Remediation

   - Chief Tsetta made one point perfectly clear: "*that what has been happening in our homeland over the last 50-70 years has to stop.*" He and others stated that contracting the cleanup work to the YKDFN is very important. "*We are not against development and we can do the job…we have drills; we are ready to do business.*" It was suggested by members of the YKDFN that in the bidding process the Yellowknives Dene have to be given the first priority and that the First Nation will not be satisfied if the YKDFN and their corporation Deton' Cho do not receive the contract for the cleanup work, either as a sole source contract or through the competitive bidding process.

Yellowknife Public Sessions Specific Feedback

Below is some feedback received from the four engagements in Yellowknife through the question and answer sessions, the lunch time meet and greet, and the written event evaluations:

- Members of the Great Slave Cruising Club voiced their concerns and interests in the Remediation Plan at the Yellowknife engagements. They sought feedback on the effects the project would have on the operation of their club and the current contamination at the marina, and requested they be informed about developments that will affect their club.

> *There is also the Giant Mine cruising club and other identified Heritage Site buildings. I guess the old buildings will be removed and treated in some manner. There are probably some asbestos and other contaminants. The marina has a history that might have hidden contamination too. I am asking again what your priority is for the cleanup. We are an active club and would like to work with you.* - Terry Brookes, Great Slave Cruising Club

- Residents of Yellowknife were interested in the site surface remediation plans and understanding what the land use limitations will be. Some participants would like to see the site remediated to residential standards so that future housing developments might occur on the former mine site.

> *Remediation is targeted to reach industrial standards. You mentioned that if you cover tailings then you cannot dig into them, so if the land is remediated to industrial standards would there not be limitations on industrial activities?* - David Wind, Yellowknife City Councillor

> *Have you estimated how much it would cost to remediate the town site area to residential standards? If you haven't, we would like you to estimate because either the city has to do it or INAC/GNWT will have to do it at some point.* - Kevin O'Reilly, Yellowknife

- There was feedback from Yellowknife participants that they would like to see the Remediation Project advance faster and that structures of historic value on the site be preserved.
- There were concerns about the safety of water and fish. The Human Health and Ecological Risk Assessment was described in the presentation but many of the complexities require continued communication.

13.6 Who Do We Talk To?

When planning meetings, events, or seeking feedback for ongoing activities throughout the course of the EA and beyond, the following audiences will be considered. This list has developed as a result of communication and consultation efforts made by the Project Team over the past decade. It is in no way an exhaustive list and will be updated as new information emerges.

13.6.1 Primary Audiences

The primary audiences are the Aboriginal groups and regional stakeholders.

- Yellowknives Dene First Nation;
- Tlicho Government;
- Akaitcho First Nation;
- Northwest Territory Métis Nation;
- North Slave Métis Alliance;
- Local residents in Yellowknife;
- Aboriginal-owned businesses;
- Local media (Aboriginal, Yellowknife, NWT);
- Local non-governmental organizations (e.g., Ecology North, Canadian Parks and Wilderness Society – NWT Chapter, Nature Conservancy, Pembina Institute);
- Giant Mine Community Alliance;
- City of Yellowknife (councillors, municipal government managers, employees);
- GNWT Legislative Assembly (MLAs);
- Yellowknife secondary and post-secondary educators and students;
- Interested service organizations (e.g., NWT Mine Heritage Society, Rotary Club); and
- Local, regional and northern industries who may be interested in bidding on contract opportunities.

13.6.2 Secondary Audiences

The secondary audiences are stakeholders who may be directly consulted but with whom consultation and engagement are often indirect such as through newspaper articles, displays, pamphlets or radio coverage. The Project Team will be responsive to any requests from these audiences.

- INAC NWT Region employees and GNWT employees;
- NWT and Nunavut Chamber of Mines;
- NWT Construction Association;
- NWT educators and students;
- Potential industry partners, trade show participants;

- National non-governmental organizations and science groups; and
- All Canadians (via national media).

13.6.3 Media

The Giant Mine Remediation project is a large and complex undertaking that will continue to generate interest across the Northwest Territories and Canada. There is also a long history on Giant Mine dating back to the 1930s and the Mine has been very prominent in the lives of Yellowknifers and other NWT residents in Dettah, N'dilo and elsewhere. For the past decade, the attention of the public and the media has appropriately been on the management of arsenic trioxide dust, and the efforts to remediate the mine site. INAC and GNWT have developed relationships with local and Territorial media over the decade. In 2009 alone over 100 media reports were produced on all aspects of the mine. Building and maintaining positive relationships with local media will help the Project Team to communicate news about the project and opportunities for public engagement. The following media outlets are actively engaged:

- Yellowknifer;
- News North;
- L'Aquilon;
- Radio Taïga;
- CKLB;
- CJCD;
- CBC Radio;
- APTN; and
- CBC North.

The internet is an extremely effective media for sharing information. The Remediation Project website (see Section 13.8.4) indicates a contact for viewers to receive a response to unanswered questions and concerns. This helps the Project Team stay informed about public opinion and preferences regarding the Remediation Plan.

13.7 Giant Mine Community Alliance

The Remediation Project has an external avenue of public consultation through the Giant Mine Community Alliance. The Community Alliance was established in 2003 to respond to the need for community participation in feedback and recommendations about the management of Giant Mine.

The Community Alliance is made up of a group of residents, representing various facets of the communities with interests in the Remediation Project. Its membership includes: Northern Territories Federation of Labour, North Slave Métis Alliance, the Yellowknife Chamber of Commerce, the NWT Mining Heritage Society, the City of Yellowknife, and a Health Representative. The Yellowknives Dene First Nation has chosen to participate in the Community Alliance as observers and have the invitation to join as a member if they wish to do so.

The Community Alliance was created to function independently of government and industry and to play a communication and liaison role between the Project Team and the public. Guided by its Terms of Reference, the Community Alliance is intended to bring together people and organizations from the community to share information and ideas. The group's mandate is to act as a body to assist affected parties including those in the communities of N'dilo, Dettah and Yellowknife in providing input and feedback into decisions about the remediation and future use of the site.

The Community Alliance meets once a month with the Project Team to relay public concerns and discuss the status of the Remediation Project. Minutes from each meeting are recorded, and, after they are reviewed by all members, are stored in the Giant Mine Public Registry. Meetings of the Community Alliance are open to the public upon contact with the Chair. Membership as well is open to the public. Members of the general public can contact the Community Alliance via email GMCA-ACMG@inac-ainc.gc.ca to enquire about the possibility of becoming a member of the Alliance or about participating in meetings.

In accordance with the Terms of Reference, the Alliance works with Aboriginal groups and the public to better understand their information needs. The Community Alliance identifies gaps in information and works with the Project Team to address those gaps. INAC provides the necessary financial resources to the Community Alliance to ensure its operation.

The Community Alliance has undertaken public outreach work including hosting public information sessions and conducting surveys. The group may host additional open houses throughout the regulatory process. They will likely invite INAC and the GNWT to present and to answer questions from the public.

13.8 Efforts to Simplify Information and Material

In addition to the public registries relating to the ongoing EA and regulatory process, there is a Giant Mine Public Registry at the Giant Mine Remediation Project Office. This registry contains numerous documents regarding Giant Mine, both historical and current, and provides the public with the opportunity to review technical project information. The Giant Mine Public Registry is located in the Waldron Building in Yellowknife and is available from 0900 – 1600 hours Monday to Friday.

As previously stated, in order to gather meaningful feedback, the public and Aboriginal groups need to have a good understanding of the Remediation Project. While the Giant Mine Public Registry is an extensive resource, it is recognized that not all interested parties can effectively utilise the information contained in it because of the volume and specialized nature of information captured there.

During the April and May 2010 public and Aboriginal engagements, the Project Team (see lists in Summary of April and Summary of May Engagements) shared information through oral presentations and through visual displays[32]. The content of the presentations was specific to each event but the same models and posters were on display at each engagement session.

Some of this material had been used in earlier years, but the inventory of Remediation Project materials is becoming more extensive and designed specifically for reaching a broad audience. To facilitate and improve communication with the public, the Project Team will continue to revise and develop tools for the public to understand what is happening at Giant Mine. This includes:

13.8.1 Printed Materials

Plain language, printed materials will help explain all aspects of the Remediation Project in relatable terms. Visual tools will help illustrate these points, for example by comparing the aerial extents to relatable areas such as football fields. Materials will be distributed at events, through direct mail, and be on hand at the Giant Mine Remediation Project Office.

13.8.2 Presentations

To further disseminate the complex information found in the public registry, audience-specific presentations will be prepared, depending on the party and their areas of interest. These presentations will explain in plain language the technical aspects of the project and will use comparisons that draw upon real-world examples. Again, visual tools will be used to help illustrate these points.

13.8.3 Information Products and Displays

In 2002, the Project Team produced a display module, which was placed in Centre Square Mall in Yellowknife. This display includes a timeline of Giant Mine, photos, scale models and printed handouts. The same type of module system may be used again for future phases of the project.

[32] The April 19 session with City Council did not involve any visual displays

13.8.4 Giant Mine Website

The Remediation Project website, http://nwt-tno.inac-ainc.gc.ca/splash/giant.asp or www.giant.gc.ca is an online resource for public information on the technical aspects of the Remediation Project, the site's history, involved parties, the frozen block method, contact information and how to access the Giant Mine Public Registry. The website also includes photos of the site and frequently asked questions. The website is updated as necessary and is available in both French and English.

13.8.5 Tours

In the past, the Project Team has offered tours to Aboriginal groups and the public so they can ask the experts questions and see firsthand the challenges at site. Feedback received for tours has been very positive. Participants have expressed that they gained a better understanding of the Remediation Project after the tour, and appreciated the opportunity to meet the Project Team. The approach of showing and sharing aspects of the site with people will continue to be an important part of the Project Team's focus.

Using the tools above, the Project Team will be able to help the public to better understand the Remediation Project. An elaboration on how the Project Team will help to simplify the information contained in the Giant Mine Public Registry is presented in the following section.

13.9 Using Appropriate Media

This section identifies mechanisms for engaging and consulting with Aboriginal communities and the public. Some of the tools, such as workshops and public meetings, have been tested over the past decade and even longer. Others, like videos and three dimensional models, have been developed and used more recently. The communication tools become extremely important because of the sheer size of the Remediation Project, as well as the fact that much of the mine and the environmental issue is out of sight underground.

The Project Team recognizes the importance of ensuring that all information is communicated in a form that is understandable to a wide variety of audiences. Visual aides are particularly effective in this regard and the Project Team has developed posters and models to display at public meetings. In past consultation activities, these tools have proven to be an effective way to draw people in and stimulate discussion about aspects of the Remediation Project. During the public sessions in Yellowknife, Dettah and N'dilo in 2010, the Project Team examined the effectiveness of the various tools and asked attendees to evaluate what methods and tools worked best. The input is reflected in this chapter and will inform future engagement activities.

The visual tools that the Project Team currently uses are as follows:

13.9.1 Models

- **Mine Site Surface and Underground Arsenic Chambers –** A 3D model is used to present the relative scale and locations of pits and underground chambers. In addition, the model also shows mine structures on the surface above the underground arsenic chambers, the access ramps, drifts, C-Shaft, and service raises.

- **Sizes and Configuration of the Arsenic Chambers** – The arsenic chambers were built at different times and in a variety of geometrical shapes. Some are box-like while others are very complex in shape. The model shows the locations of all the bulkheads which are much easier to envision in 3D as there are bulkheads on the top but also on the sides and lower levels of the chambers. Some of the bulkheads are accessible for maintenance and monitoring and others are not.

- **Section profile of a typical arsenic chamber with freeze pipes –** The proposed frozen block method is well illustrated in this model. The pipes required to freeze each chamber are depicted and reach from the bottom of the chambers to the surface. This cross-sectional diagram has the surrounding earth frozen with water that was allowed to flood into the crevices and cracks around the chamber to effectively seal up the block.

- **Mine property after remediation** – This model depicts the site surface after remediation as anticipated in the current plan.

13.9.2 Posters

- **Giant Mine Site Surface Plan** – Shows an aerial view of the mining lease lands as they are now so it may be compared to various remediation options.

- **Underground Arsenic Storage Locations** – Shows the locations of the 15 chambers containing arsenic trioxide, the location of the bulkheads, and how they can be accessed by drifts, ramps, or tunnels are portrayed. The chambers are marked red or black to indicate whether they are currently accessible for monitoring or not accessible.

- **Arsenic Chamber Freezing –** Illustrates the numerous pipes that will be required to surround each chamber for the active and passive freezing process. It also shows a view from above of the area of land around each chamber that will be allowed to flood and freeze to create the "frozen block". The poster includes a graph of the temperature profile by depth underground after active freezing and a table of the predicted time to thaw the frozen block if the active or passive freezing system is no longer operating.

- **Giant Mine Longitudinal Projection –** Displays a longitudinal section view of the mining lease lands. The illustration shows the water levels throughout the past in relation to the depth of the chambers. The chambers containing arsenic trioxide are up to 250 meters below surface level, while an active pumping system currently keeps the water level in the area around 750 meters below the surface.

- **Arsenic at Giant Mine: Where Did It Come From –** Explains the chemical and physical process for how arsenic was released from the mineral arsenopyrite during the roasting process to extract gold. The 237,000 tonnes of arsenic trioxide that was released is given perspective by providing an illustration showing how seven and one-half of the 11-storey downtown Yellowknife building known as the Precambrian Building would be needed to contain all of the dust.

- **Existing Tailings Containment Areas** – Displays the four tailings ponds, the polishing pond and the settling pond that exist on the Giant Mine site. The diagram gives a sense of the size and topography of the four tailings ponds.

- **Giant Mine Remediation Plan Tailings Areas** – Illustrates the proposed process for remediating the tailings areas. A diagram shows the proposed coarse layer that would be placed over the tailings ponds followed by finer sediment where vegetation could take root.

- **What will the site look like after remediation**? – Depicts the same landscape shown in 3-D by the model "Mine Property after Remediation".

- **Conceptual Pathway Model** – Explains the various modes of transporting contaminants in an ecosystem. The model can help viewers understand the connection between arsenic in the water system and then entering the food system, and so on.

- **Giant Mine Community Alliance** – Describes the activities of the Community Alliance and illustrates some of the hands-on education it has provided with site visits and information sessions on site.

- **Giant Mine Tours** – An arrangement of photographs of various groups from school children to the Geological Society visiting the Giant Mine site.

In addition to the tools mentioned above, the Project Team will use video footage, maps and tours to in future to facilitate understanding of the Remediation Project.

13.10 Efforts to Address Specific Concerns and Unresolved Issues

Over the years since INAC assumed responsibility for remediation of Giant Mine, including during the most recent Aboriginal and public sessions, the Project Team has heard a number of concerns and requests for more information. Some of the public engagement, and particularly that undertaken in the early 2000s associated with choosing a viable option for the management of arsenic trioxide dust was quite intense and took place over a lengthy period. Nonetheless, and as identified by the Review Board, "*although the developer in this case has held numerous public information sessions and workshops over the many years spent designing the development, one issue identified during the scoping phase of this environmental assessment was a lack of effective public consultation" (Review Board Terms of Reference Section 3.2.6).* This may be due to the complexity and volume of information associated with the remediation, the long time frame (over a decade) since the initial engagement and the considerable amount of research and planning undertaken by INAC over the past few years towards remediation of the site.

During the consultation and engagement sessions this year there was considerable public interest and there were a few consistent and recurring themes under which most of the concerns expressed can be captured. These are:

- Frozen Block Method;
- Surface Remediation;
- Public Health and Safety;
- Restoration of Baker Creek;
- Environmental Monitoring; and
- Procurement and Economic Opportunities.

Through the public meetings in Yellowknife, Dettah and N'dilo in 2010 and the related evaluations, the Project Team determined some of the information being sought, and received advice on how to present that information and go about seeking input. The advice is being used to inform future consultation and engagement activities including design of the consultation and engagement plan described below. There were also issues raised which are beyond the geographic and project scope of the Giant Mine Remediation Project, such as concerns regarding the extent of arsenic contamination beyond the bounds of the Giant Mine site. Members of the YKDFN also expressed an interest in compensation for the use (and "misuse" as some First Nations people suggested) of the lands on and surrounding the Giant Mine site. These issues are mentioned briefly herein and described in more detail in the supporting consultation documents.

In the recent past, the Project Team has focused mainly on providing information on the Remediation Project through delivery mechanisms such as open houses, displays and presentations. These methods are useful for informing the public about specific issues, however, they must be complemented by other activities that are designed to gather individual feedback and address concerns. Going forward, the Project Team plans initially to focus on the themes above, and will collect and track feedback so that specific concerns can be addressed and the delivery program modified as appropriate. The Project Team acknowledges that there is still much work to be done, including work to be undertaken during the timeframe of the EA process. Throughout the phases of the Remediation Project there will be further opportunities to build relationships with the public and Aboriginal groups through meaningful two-way dialogue. The Project Team will endeavour to seize and create those opportunities. Information on moving forward on specific concerns is summarized below in Section 13.13 and Table 13.13.1 (Future Consultation and Engagement Activities and Timelines).

13.11 Addressing Concerns Associated with Implementation

The overall responsibility for environmental management in relation to the Remediation Project rests with the Project Team. This includes representation from both INAC and the GNWT at a senior level by a Project Oversight Committee established through *The Cooperation Agreement for the Remediation of the Giant Mine Site.* The Oversight Committee has overall responsibility for providing direction to the Giant Mine Remediation Project Team.

Through this committee, INAC and the GNWT are jointly responsible for ensuring success of the Remediation Project - including meeting all environmental commitments, licensing and regulatory requirements. This includes putting a monitoring program in place that will be capable of detecting arsenic trioxide leaks from the frozen block, and will protect human health and safety and the integrity of the local ecosystem.

The Oversight Committee will be supported by a GNWT-Government of Canada Giant Mine Remediation Intergovernmental Working Group as described in Chapter 14. The role of the Working Group will be to ensure that the activities of federal and territorial departments contributing to the remediation of the Giant Mine site are integrated to the greatest extent possible, and that information is shared to support overall due diligence in the remediation of the site.

Central to the role of the Oversight Committee in ensuring an effective monitoring program is in place is to develop a Project Environmental Management System which will establish the blueprint for how environmental issues will be managed throughout the stages of development. The Environmental Management System will identify how public complaints will be addressed, and as appropriate, dispute resolution processes. The system and associated environmental management plans and tracking systems will be supported by ongoing Aboriginal and public consultation. For more information on the Environmental Monitoring and Evaluation Framework the reader is referred to Chapter 14.

13.12 Looking Forward: Future Consultation Efforts

Input from Aboriginal communities and the public will continue to be sought throughout the life of the Remediation Project. Direct consultation with Aboriginal communities will build upon that undertaken in 2010. The Project Team recognizes that Aboriginal communities will be important partners in ensuring that sound environmental management objectives for the Remediation Project are both established and met. They also appreciate the need to review and periodically amend or create new systems in the interest of Aboriginal communities. The Project Team will lead on work with local Aboriginal communities and organizations to create the mechanisms to support a direct and distinct Aboriginal role in the planning and implementation of monitoring and evaluation activities throughout the life of the Remediation Project.

It is critical to apply lessons learned from the extensive engagement on the Remediation Project over the past decade. For example, there were some very successful aspects of the First Nation and public sessions in the early 2000s and again in 2010. These will be repeated and will be strengthened wherever possible. There was also advice and criticism from the public, including from the Yellowknives Dene First Nation who suggested some ways to engage in a more meaningful and helpful manner. The Project Team will do its best to follow that advice.

Below is a description of a number of ways the Project Team will communicate and continue to engage with Aboriginal peoples and the rest of the public, both over the remaining timeframe of the EA process and in the ongoing planning and implementation of the Remediation Project.

13.12.1 Environmental Monitoring and Evaluation

The Project Team recognize that Aboriginal communities will be important partners in ensuring that sound environmental management objectives are established and met. As stated in Chapter 14, the Project Team will work with local Aboriginal communities and organizations to create the mechanisms to support a direct and distinct Aboriginal role in the planning and implementation of monitoring and evaluation activities for the Remediation Project. Regular engagement and re-engagement of communities in response to monitoring results is anticipated throughout the life of the project. Aboriginal communities and the public will also have an ongoing role in shaping specific environmental monitoring activities as the Remediation Project moves from stages of EA, water licensing and full site remediation.

As noted previously, Chapter 14 of the DAR provides further detail on designing an Environmental Monitoring and Evaluation Framework (EMEF). The focus of Aboriginal and public engagement through 2010-2011 with respect to the EMEF will be for the development of the Remediation Project's Environmental Management Systems and Plans. This will be accomplished through public sessions and workshops, and meetings with Aboriginal communities in a format agreed upon with each community. Input from the public and Aboriginal communities will also be sought in shaping specific environmental monitoring. As the Remediation Project advances, and in response to monitoring results, the public and Aboriginal communities will continue to be engaged in the review of monitoring results and the identification of adaptive management approaches needed to address any environmental issues identified through the monitoring program.

Details of the EMEF provided in this DAR include a description of elements of a proposed long-term environmental monitoring program including monitoring of such things as ground temperatures, water quality and surface water runoff, as well as aquatic ecology by monitoring fish and wildlife, vegetation and cumulative effects. Some of the programs which will benefit most from public involvement, and in particular from Aboriginal engagement and traditional knowledge, are summarized below.

Cumulative Effects Monitoring

To address public concerns about impacts of the Remediation Project and historic contamination on the receiving environment, the Project Team will work with members of the Aboriginal community and others to develop a cumulative effects monitoring plan. It is envisaged that the program would include monitoring of contaminant levels in fish, wildlife and plant species that form an important part of the diet of the people living in the Local and Regional Study Areas. Specimen samples collected by hunters and fishermen near the site, as well as remote to the Giant Mine site would be submitted to a certified laboratory for testing.

Fish and Wildlife Monitoring

Long-term monitoring of fish will include Baker Creek and Yellowknife Bay on Great Slave Lake focused on two areas: in Back Bay and the south end of Yellowknife Bay, offshore from the communities of N'dilo and Dettah, respectively. Fish health assessments and tissue analyses will be conducted. The first wildlife survey should occur as soon as possible in the pre-remediation period (Year 0), prior to the initiation of any remediation work, in order to establish current baseline conditions. Other surveys will be conducted during and after the remediation efforts. The wildlife surveys will focus on observations of presence/absence and area usage by small and large mammals and bird species.

Vegetation Monitoring

There will be long-term monitoring of aquatic, emergent and terrestrial vegetation. Sampling of terrestrial vegetation will focus on plant species such as medicinal plants with cultural significance (e.g., Labrador tea, berries) and forage species. There will be opportunistic sampling of edible berries and sampling of plant species such as birch and willow which are known to accumulate inorganic contaminants from contaminated soils in terminal leaves and twigs, and may serve as exposure pathways to browsing wildlife.

Reporting

Two levels of monitoring reporting are planned:

- *Annual Report(s)* - prepared annually to summarize and review all operational and environmental data collected in the one-year reporting period; and,
- *Status of the Environment (SOE) Reports* - prepared every three years during the initial 15-year remediation period and every five years thereafter, to summarize, review and interpret the data collected and to provide recommendations for modifications to the monitoring program or site operations.

The reporting requirements will provide a mechanism of ongoing feedback to Aboriginal communities and the public regarding monitoring activities and the effectiveness of the remediation. It will also help the project Oversight Committee and regulators, with the public, to assess the effectiveness of remediation and modify existing programs or add new components.

13.12.2 Aboriginal and Government Body

INAC will take the lead within the Project Team for working with local Aboriginal communities and organizations to create clear mechanisms to support a direct and distinct Aboriginal role in the planning and implementation of monitoring and evaluation activities for the Remediation Project.

The meaningful involvement of Aboriginal people in the planning and remediation of Giant Mine has a very high and immediate priority. It is important for the future of the Remediation Project planning and implementation, and in particular for dealing with issues and concerns such as traditional knowledge, monitoring and dispute resolution.

The Project Team is prepared to make the formation and support of a partnership with YKDFN and other relevant Aboriginal groups a high priority, and to act immediately to institute and fund such a Giant Mine Remediation Aboriginal and Government Body.

13.12.3 Traditional Knowledge Holders

During the Aboriginal consultation sessions held in N'dilo and Dettah, as well as during the earlier Yellowknife Consultation sessions, there was considerable concern expressed about traditional knowledge not forming a significant part of the Giant Mine Remediation research or planning. Elders in both Dene communities were strong and very articulate about the limited involvement of their people on issues related to the Giant Mine in general, and specifically about the lack of consideration of traditional knowledge. Some Elders and Chiefs questioned the results of prior studies, including the Giant Mine Environmental Risk Assessment, because of the limited use of traditional knowledge.

Members of the Project Team have also held meetings with Aboriginal groups including YKDFN leadership, Tlicho and Métis. In those meetings as well the leadership emphasized the importance of Aboriginal involvement and the role of traditional knowledge. During the 2010 engagement sessions INAC and the technical advisors to the Project Team were very receptive to involving traditional knowledge holders in the future and welcomed a mechanism that could ensure the use of traditional knowledge and western science.

As noted above, the Project Team has proposed to form an Aboriginal and Government Body comprised of Aboriginal and Government representatives, who will be responsible in part for supporting the collection and consideration of traditional knowledge in future decisions related to the Remediation Project. Details of the form and composition of this group are yet to be worked out. However, the Project Team will support the collection and incorporation of traditional knowledge into future Remediation Project research, planning and implementation. The YKDFN and other Aboriginal people should determine, in partnership with the Project Team, the best ways to collect and incorporate traditional knowledge.

13.12.4 Open Houses, Community Meetings and Workshops

The Project Team commits to providing the Aboriginal groups and the general public with multiple avenues to participate in the planning of detailed design, monitoring and long-term remediation plans for Giant Mine. These activities, outlined in the table below, are part of the larger commitment to provide opportunities for meaningful participation by Aboriginal people and public groups.

Past consultations, beginning in 1999, focused largely on informing the public on the options and detailed design of the underground "frozen block method" for storage of arsenic trioxide. Since the completion of the Remediation Plan in 2007, and particularly in the spring of 2010, the Project Team has engaged the public of Yellowknife, Dettah and N'dilo on three main themes:

1. The Frozen Block Method;
2. Surface Remediation; and
3. Environmental Quality and Project Effects.

The Remediation Project is now coming to a critical juncture for engaging the public and Aboriginal groups in the detailed designs. While the EA and regulatory phases of the Remediation Project proceeds, public participation on design aspects within the scope of the

Project will become a focus of the Project Team. The nature and focus of that engagement will change during implementation and monitoring.

Consultation sessions will be focused on particular topics. This will provide the Aboriginal groups and the public with specific options and issues, and the opportunity to share their views and provide meaningful input. It will also provide the Project Team with the ability to collect and apply meaningful public input. Themes planned to be the focus of workshops and focus groups over the next year or so are presented in Table 13.12.1.

Table 13.12.1 Themes of Future Open Houses, Community Meetings and Workshops

Monitoring	Monitoring Framework: Defining the context for long-term monitoring
	Creation of management plans
	Monitoring air quality and dust fall
	Water quality monitoring
	Fish: Aquatic effects monitoring
	Wildlife: monitoring plans for wildlife
Baker Creek Remediation and Water Treatment	Baker Creek remediation options including sediment management
	Water treatment plant
	Effluent diffuser design and location
Surface Remediation and End Use of Land	Revegetation of tailings covers
	Demolition of remaining Giant Mine structures
	Location of fencing
	Treatment of pits
	Mining heritage
Socio-Economic Matters	Training
	Employment opportunities
	Business opportunities for Aboriginal and regional businesses

Some of the strengths identified from previous open houses and workshops included: having a large and strong presence of the Project Team available on site; having the three dimensional models, posters and videos displayed such that members of the public could either visit the displays alone, or ask questions of the Project Team members; and using methods of advertising and public engagement that were successful in drawing out a large contingent from the public who, once attracted to the displays, were interested and receptive to technical and policy information available and presented by the team.

Open houses should continue to be used on a regular basis throughout the EA and regulatory review phase and beyond into the various stages of site remediation. The nature of the open houses may change over time as the focus changes (e.g., from arsenic trioxide freezing to restoration of the surface).

The Project Team will continue to use open houses and community meetings as a means of informing and engaging Aboriginal people and other members of the public. The Team will use workshops with a particular focus on remediation options to inform the public and solicit input. Models and displays will continue to be used in order to reach a broader public, and to assist team members in explaining concepts, proposals and options.

As explained previously, the Project Team has used a variety of consultation techniques over the years, and particularly during the three-year review of techniques for the removal or storage of arsenic trioxide, which resulted in selection of the frozen block method. Areas where there is Aboriginal and public interest in using similar workshops to focus on specific designs and options include those listed in Table 13.12.1 above.

Throughout the remaining timeframe of the EA and beyond, the Project Team will continue to engage the public through workshop-like sessions focused on specific remediation subjects and options. These workshops will be used for sharing information, reviewing remediation options and soliciting input to help make project decisions.

13.12.5 Sharing Information Visually (Models, Posters and Videos)

The remediation efforts planned for Giant Mine are complex and can be difficult to visualize. This is in part because some of the most important components, including the arsenic trioxide storage chambers, are located underground. Because of this, the non-verbal tools used at the City of Yellowknife and YKDFN Community sessions in 2010 were very effective. For example, it seemed that for many members of the public, the three dimensional models helped them to understand. The models, posters and videos also served as excellent platforms around which informed technical members of the Project Team could engage members of the public. The Project Team will continue to use these tools and create more such tools.

The Project Team will continue to use the existing three-dimensional models and to gradually develop more models specific to the issue or option to be discussed (e.g., routing of roads, or fencing parts of the Giant site).

The Project Team will continue to use the existing posters and to develop more posters specific to the issue or option to be discussed (e.g., routing of roads, revegetation, or fencing parts of the Giant site).

13.12.6 Information Management

The sheer size of the Remediation Project, combined with the plans to move through a series of EA, regulatory and implementation phases, demands a solid and reliable information management system. A robust information system should also function well, if necessary, without continuity of Project Team personnel given the long-term nature of the Remediation Project and the inevitability of team changes over a decade and beyond.

An important tool to include in an information management system is a tabular summary of issues and concerns with associated responses from the Project Team. This task has begun through preparation of the various table summaries as well as the two Summary Reports from community engagement activities conducted in April and May, 2010. Those documents record, in verbatim quotes, the concerns expressed by Yellowknife residents as well as YKDFN residents of N'dilo and Dettah. Further information can be found in the following documents which are available on the Review Board's public registry:

- *Giant Mine Remediation Plan: Summary of April 2010 Public Engagements-Yellowknife. July 2010.* 50 pages plus Appendices.
- *Giant Mine Remediation Plan: Summary of May 2010 Yellowknives Dene Engagements – Dettah and N'dilo. July 2010.* 47 pages plus Appendices.

Tabular summaries of issues and concerns by theme will be applied retroactively to those public engagement meetings. As directed by the Review Board, the Giant Consultation reports noted above contain categories which should be tracked over time as an indicator of the responsiveness of the Project Team and of project changes made in direct response to public and Aboriginal concerns. This includes categories (as outlined in the DAR *Terms of Reference*) including all commitments and agreements, and any issues that remain unresolved.

The Project Team will select an information management system; populate that system with all available information from engagement on the Remediation Project, including that obtained in the 2010 engagement sessions; and be vigilant in using and adapting the information system as an ongoing tool. All information will be made available to the public.

As indicated in Section 13.8.4, one of the available communication tools is a website devoted to the Remediation Project which forms part of the INAC NWT Region's Website. The Remediation Project website www.giant.gc.ca is an online resource for public information on the technical aspects of the Remediation Project, the site's history, involved parties, the frozen block method, contact information and how to access the public registry. The website also has photos of the Giant Mine site, answers to frequently asked questions and includes some informative material written in plain language. The site is updated as needed and is available in both French and English.

The Project Team will consider ways to expand the existing website to include the information management system and other updates as a vehicle to keep the public and Aboriginal communities informed of the remediation status, proposals and options.

13.12.7 Tours of the Giant Mine Site

Since inheriting responsibility for the Giant site in 1999, the Project Team has hosted many visits by interested parties ranging from technical specialists to senior government officials and Ministers. During the 2010 consultations, an arrangement of photographs of various groups visiting the Giant Mine site (including staff, school children, the Geological Society, government employees and non-governmental organizations) was used to provide a "feel for the site".

The Project Team will work to expand the availability of site tours, particularly to members of the public of Yellowknife, N'dilo and Dettah.

13.12.8 Matters Outside of the Scope of the Remediation Project

During the community consultations in Yellowknife, Dettah and N'dilo, there was considerable concern expressed about two matters which are outside the scope of the Remediation Project and beyond the mandate of the Project Team. These concerns include the off-site contamination from historic operation of the mine (e.g., aerial dispersion of arsenic in early roaster stack emissions) and compensation for historic impacts. The Project Team, including the senior INAC spokesperson, acknowledged these concerns but also made it clear that these matters could not be addressed by the Project Team or as part of the Remediation work. Nonetheless, these concerns have been passed on to senior managers within INAC and the GNWT.

13.13 Looking Forward: The Consultation and Engagement Plan

1. Purpose: The Remediation Project Consultation and Engagement Plan, as set out in Table 13.13.1, identifies activities to obtain input from Aboriginal groups and the public. The plan will support the EA and regulatory processes and continue throughout implementation of the Remediation Project.

2. Administration: The Project Team will lead and manage the Consultation and Engagement plan, including planning, implementation, evaluation, follow up, and information management.

4. Time Frames: The Remediation Project Consultation and Engagement plan will cover the EA and regulatory processes and will be updated annually. A revised plan will be created for implementation.

5. Audiences: See Section 13.6**.**

6. Evaluation: Evaluation methods will be used on an ongoing basis to assess and improve the plan as it moves forward. Evaluation forms and feedback will be stored in the Remediation Project Public Registry.

7. Reporting: An important aspect of the engagement plan is to report back to the public on what input has affected decisions on the Remediation Project, which ideas were not used and why.

8. Deliverables: A consultation database will continue to be maintained in the Giant Mine Public Registry which will include detailed records of engagement activities and assist the team to track follow up actions.

Table 13.13.1 Looking Forward: The Consultation and Engagement Plan

PROJECT PHASE	PROJECT MILESTONE	ACTION	OBJECTIVES	AUDIENCES	TIME LINE ESTIMATE
ENVIRONMENTAL ASSESSMENT		Industry Day	**Socio-Economic Matters:** Inform Aboriginal, local, regional and Northern businesses of the opportunities for work and contracts for the Remediation Project.	Aboriginal, local, regional and Northern Business	Fall 2010
	Developer submits DAR to the Review Board				Fall 2010
		Workshop	**Monitoring Framework[33]:** To define the context in which long-term monitoring will occur for the Remediation Project. This will include the design of cumulative effects monitoring.	Aboriginal, local government, regulatory authorities, and public	
		Meeting with NWT Mining Heritage Society	**Surface Remediation:** To inform and solicit views particularly on surface remediation and demolition of buildings	NWT Mining Heritage	
		Meetings	**Aboriginal Involvement and Traditional Knowledge:** The Project Team meets with YKDFN and other Aboriginal groups to discuss traditional knowledge and its role in research, monitoring and remediation and to explore formation of an Aboriginal-Government Body	Communities of Dettah, N'dilo and Aboriginal Groups	
	Review Board holds Technical Meetings				Winter 2011
		Workshop	**Baker Creek remediation**: To explore options for Baker Creek, water treatment, effluent diffuser, etc.	Aboriginal, local government, regulatory authorities, and public	
		Workshop	**Monitoring:** Inform and solicit feedback on the monitoring plans for the Remediation Project including: • Monitoring air quality and dust fall • Monitoring water quality • Monitoring fish and wildlife	Aboriginal, local government, regulatory authorities, and public	

[33] The Workshops listed as Action are based on the four themes heard through public engagement meetings. The order and scheduling of such workshops may change based on further input received from the Aboriginal communities and public as well as through the EA and the Regulatory Water Licence processes.

Table 13.13.2 Looking Forward: The Consultation and Engagement Plan (Cont'd)

PROJECT PHASE	PROJECT MILESTONE	ACTION	OBJECTIVES	AUDIENCES	TIME LINE ESTIMATE
	Review Board conducts Public Hearings				Spring 2011
		Workshop	**Surface Remediation:** Inform and solicit input on remediation options including revegetation, treatment of pits and demolition of structures	Aboriginal, local government, regulatory authorities, and public	
	Review Board submits EA Report to Minister				Fall 2011
		Industry Day	**Socio-Economic Matters:** Inform Aboriginal, local, regional and Northern businesses of the opportunities for work and contracts for the Remediation.	Aboriginal, local, regional and Northern Business	
		Workshop	**Baker Creek remediation**: To further explore options for Baker Creek, water treatment, effluent diffuser in advance of Water Licence Hearings	Aboriginal, local government, regulatory authorities, and public	
		Meeting with NWT Mining Heritage Society	**Surface Remediation:** To inform and solicit views particularly on surface remediation and demolition of buildings	NWT Mining Heritage	
		Meetings	**Aboriginal Involvement and Traditional Knowledge:** Aboriginal-Government Body continues to meet to discuss traditional knowledge and its role in research, monitoring and remediation.	Communities of Dettah, N'dilo and Aboriginal Groups	
WATER LICENCE REGULATORY PHASE	Preparation for Water Licence Hearing				Winter 2011
	Conduct Water Licence Hearing				Winter 2012
	Minister approves licence				Winter 2012
REMEDIATION CONTINUES					
		Meetings and Workshop	**Baker Creek Remediation:** To further inform and solicit input on options for Baker Creek rehabilitation.	Aboriginal, local government, regulatory authorities, and public	As needed

Table 13.13.2 Looking Forward: The Consultation and Engagement Plan (Cont'd)

PROJECT PHASE	PROJECT MILESTONE	ACTION	OBJECTIVES	AUDIENCES	TIME LINE ESTIMATE
		Meetings and Workshop	**Surface Remediation:** Further inform and solicit input on remediation options including revegetation, treatment of pits and demolition of structures	Aboriginal, local government, regulatory authorities, and public	" " "
		Meetings	**Aboriginal Involvement and Traditional Knowledge:** Aboriginal-Government Body continues to meet to discuss traditional knowledge and its role in research, monitoring and remediation.	Communities of Dettah, N'dilo and Aboriginal Groups	" " "
		Industry Day	**Socio-Economic Matters:** Inform Aboriginal and local, regional and Northern Business of the opportunities for work and contracts for the Remediation.	Aboriginal, local, regional and Northern Business	" " "
		Workshop	**Monitoring:** Inform and solicit feedback on the monitoring plans for Giant Mine including: • Monitoring air quality and dust fall • Monitoring water quality • Monitory fish and wildlife	Aboriginal, local government, regulatory authorities, and public	" " "

14 Environmental Monitoring and Evaluation Framework and Long-Term Environmental Monitoring

This chapter presents an Environmental Monitoring and Evaluation Framework (EMEF) and a Long-term Environmental Monitoring Program to meet the Terms of Reference established for the Giant Mine Remediation Project EA.

Some forms of monitoring are expected in perpetuity, particularly around the function of the thermosyphons and the treatment of water. Consequently, a system to establish standards, deliver programs and receive and evaluate monitoring results will also exist in perpetuity. The EMEF and Long-term Environmental Monitoring Program, as proposed in this chapter, are expected to serve the Remediation Project over the initial 25 year planning horizon and beyond.

14.1 Environmental Monitoring and Evaluation Framework

The EMEF is intended to be followed for all environmental components of Remediation Project implementation set out in the DAR, as may be determined through the EA approval process and as required by legislation, regulation and licensing. The EMEF establishes the blueprint for how environmental protection and regulatory responsibilities will be managed throughout the stages of development. As such, this framework proposes components for monitoring and evaluation. These include:

- A Giant Mine Remediation Project Environmental Management System;
- An Intergovernmental Working Group;
- Environmental Management Plans;
- Evaluation of Environmental Performance;
- Aboriginal and Public Consultation;
- Adaptive Management;
- A program of Long-Term Environmental Monitoring.

Ultimately, selection of key components for monitoring will be developed through ongoing Aboriginal and public consultation, as outlined in Chapter 13. It is also recognized that the elements and details of monitoring and reporting will be substantially governed by water license requirements established by the Mackenzie Valley Land and Water Board (MVLWB). The

EMEF elements and the Long-Term Environmental Monitoring Program discussed in this chapter are presented as a starting point from which to build through dialogue with Aboriginal communities, the public and regulators.

The overall responsibility for environmental management in relation to the Giant Mine Remediation Project is a shared responsibility between INAC and the GNWT. The two governments are represented at the senior level by a Project Oversight Committee established through the Cooperation Agreement between INAC and the GNWT for the remediation of the Giant Mine site. Through this committee, INAC and the GNWT are jointly responsible for ensuring that a monitoring program is in place for the implementation of the Remediation Project.

The Project Oversight Committee will be supported by a GNWT-Government of Canada Giant Mine Remediation Intergovernmental Working Group, made up of representatives from both federal and territorial departments with advisory roles and regulatory responsibilities with respect to the implementation of the Project. The role of the Intergovernmental Working Group will be to ensure that the activities of federal and territorial departments contributing to the remediation of the Giant Mine site are integrated to the greatest extent possible.

INAC, as the funding department for the Remediation Project, is ultimately responsible for works carried out by contractors. PWGSC is supporting the implementation of the Remediation Project by providing procurement services for INAC. As design for the Remediation Project progresses, it is envisioned that some monitoring and reporting responsibilities will be delivered through PWGSC contracts. Through its relationship with PWGSC, INAC will manage these monitoring and reporting requirements.

Where remediation work is carried out by contractors, appropriate environmental protection and risk reduction measures will be incorporated into contract documents, enforceable under mechanisms established by contract.

14.1.1 Giant Mine Remediation Project Environmental Management System

Central to the EMEF is the development and implementation of an environmental management system (EMS). EMSs are used by governments and companies worldwide to achieve environmental goals through consistent control of operations. Core to the implementation of an EMS is the establishment of objectives and targets, the evaluation of performance through auditing and the implementation of corrective action where targets are not being met. EMSs succeed where there is senior level commitment to corrective action and continual improvement. Both INAC and the GNWT are committed to developing an EMS that is central to the ongoing monitoring and performance improvement of the Giant Mine Remediation Project.

The Remediation Project EMS will form a systematic approach to manage environmental issues across all activities and monitoring that will be undertaken in remediating the Giant Mine site.

The EMS will be developed to be consistent with an internationally recognized EMS standard such as ISO 14001 and requirements to manage identified environmental risks. An audit protocol, including third-party auditing, and review process will be an integrated part of the EMS.

Contractors operating on the Giant Mine site will be required to conform to the requirements of the EMS. Initial development of the EMS and its periodic review and amendment will be done with both public and Aboriginal community involvement.

14.1.2 Environmental Management Plans

Objectives and targets of the EMS will be established as Environmental Management Plans (EMP). EMPs will be developed for major environmental components and will be the primary method of controlling, managing and monitoring environmental risks.

The EMPs will address the environmental and social objectives, targets, and commitments of INAC and the GNWT with respect to the Remediation Project, the application of mitigation and risk reduction measures described in this DAR, the final outcomes of the EA process and as required by regulation and licensing.

EMPs will address implementation and monitoring aspects of the project. As the project progresses, additional plans or amended plans will be developed as required.

Development and amendment of EMPs will require collaboration amongst government specialists, the public, Aboriginal communities and other interested parties.

EMPs are proposed to be initially developed for the following:

- Wildlife and Vegetation;
- Water:
- Noise;
- Air Quality;
- Traffic;
- Cultural Heritage; and
- Public Consultation and Engagement.

As necessary to safeguard the environment and minimize risks, EMPs will be addressed in contract documents to ensure contractors' responsibilities with respect to EMPs are clearly identified.

14.1.3 Evaluation of Environmental Performance

The assessment of environmental performance, and compliance with the objectives and targets of EMPs will be carried out through a regular program of monitoring and evaluation set out in the EMS. Monitoring and evaluation activities will include: (i) collecting, collating, and analyzing data related to environmental conditions; (ii) measuring environmental gains as a consequence of the Remediation Project's implementation; and (iii) evaluating environmental effects within selected systems, such as Baker Creek.

Where actions, objectives or targets are not implemented or achieved in relation to environmental conditions, a response process to correct those matters within an appropriate timeframe will be implemented. An action tracking system will be instituted to ensure traceability of significant audit actions and subsequent resolution. These processes will be further refined with the finalisation of the audit and review sections of the EMS.

14.1.3.1 Proposed Levels of Environmental Performance Evaluation

1st Level Evaluation – Project Management

INAC, through its relationship with PWGSC, will ensure conformance with the management actions contained in EMPs.

Where site monitoring is the responsibility of a contractor, PWGSC, as part of its procurements responsibilities, will oversee the implementation of the contractor's monitoring through regular observation and spot checks. Where contractual non-conformance is detected, corrective actions will be taken through mechanisms established under contracts between PWGSC and the contactor.

The goal of Project Management level evaluations is to ensure that contractor requirements to protect human health and safety and the environment are implemented as planned.

2nd Level Evaluation – Internal Audit

Formal internal assessments of conformance with environmental management plans will be undertaken in accordance with the schedule developed as part of the EMS. Reports generated from such audits will be provided to the Giant Mine Oversight Committee.

3rd Level Evaluation – External Audit

An external auditor will be employed to undertake audits at specified intervals. The external audits will be reported to the Giant Mine Oversight Committee, with findings and recommendations.

14.1.4 Access to Monitoring Data

INAC will facilitate third-party access to data for research and/or analysis, subject to the applicable government legislation, policies and contractual obligations. Whenever possible, this access will be through the Giant Mine Remediation Project website. Comments received from the public on monitoring data will be considered in the development and amendment of EMPs.

14.1.5 Monitoring and Evaluation of Regulatory Requirements

Where activities on site are governed by specific authorities, for example protection of fish habitat under the Fisheries Act as enforced by DFO, INAC will work with such authorities to achieve compliance. Where specific management plans are required by regulatory agencies, the intention is to incorporate them into the EMS as EMPs, as appropriate.

In addition to the environmental performance evaluations set out above, the project will be subject to a number of other internal and external audits. This includes auditing under the Federal Contaminated Sites Action Plan (FCSAP) and Health and Safety audits.

14.1.6 Aboriginal and Public Input and Engagement

As set out in Chapter 13, input from Aboriginal communities and the public will continue to be sought throughout the life of the Remediation Project. The focus of Aboriginal and public engagement through 2010-2011 with respect to the EMEF will be for the development of the project's EMS and EMPs and engagement necessary to meet the requirements of the MVLWB water licensing process. This will be accomplished through public sessions and workshops and meetings with Aboriginal communities in a format agreed to with each community. Input from the public and Aboriginal communities will also be sought in shaping specific environmental monitoring activities as the Remediation Project moves from the EA to the water licensing stage.

As the implementation of the Remediation Project advances, and in response to monitoring results, the public and Aboriginal communities will be engaged in the review of monitoring results and the identification of adaptive management approaches needed to address any environmental issues identified through the monitoring program. This is anticipated to be an annual exercise during the remediation phase of the project.

14.1.6.1 Aboriginal and Government Body

Direct consultation with Aboriginal communities will build upon community meetings held in the spring of 2010. INAC and the GNWT recognize that Aboriginal communities will be important partners in ensuring that sound environmental management objectives for the Remediation Project are established and met and that the need to review and periodically amend or create new systems and objectives in the interest of Aboriginal communities will be necessary. To establish Aboriginal involvement throughout the life of the Remediation Project, INAC will work with local Aboriginal communities and organizations to create the mechanisms to support a direct and distinct Aboriginal role in the planning and implementation of monitoring and evaluation activities, including the formation and funding for a joint Aboriginal and government body in cooperation Aboriginal communities.

14.1.7 Community Alliance

INAC and the GNWT will continue to support the Community Alliance in its role of sharing information about the Remediation Project with the Yellowknife community and relaying public concerns and issues about the remediation of Giant Mine back to INAC.

Established in 2003, the Community Alliance operates independently from the Government of Canada, the GNWT and industry. Membership of the Community Alliance consists of the Yellowknife Chamber of Commerce, Northwest Territories Federation of Labour, North Slave Métis Alliance, NWT Mining Heritage Society, City of Yellowknife, Health Representative, and Public Representative. The Yellowknives Dene First Nation has a standing invitation to increase their participation in the Community Alliance, however currently observes the meetings.

14.1.8 Adaptive Management

Central to this DAR is predicting potentially adverse environmental effects of the Remediation Project and identifying appropriate mitigation measures. This will allow the Project to be implemented without significant adverse environmental effects originating from remediation actions.

Adaptive management is an iterative process of decision making in conditions of uncertainty that reinforces the "predict, mitigate, and implement model" of assessment by including the monitoring of environmental conditions following implementation actions and their prescribed mitigations, and adapting action or mitigations as appropriate based on the environmental monitoring data. As such, adaptive management is based on "predict, mitigate, implement, monitor, and adapt". The aim of this approach is to adjust Project implementation actions and mitigations as necessary so that the execution of the Project does not result in significant adverse environmental effects.

Adaptive management approaches for the Remediation Project have been set out in Chapter 6 for both subsurface and surface components. For the frozen block method in particular, while each component of its implementation is well proven in use elsewhere, the application and combinations needed at Giant Mine will present new challenges. Sufficient monitoring of each step is a guiding philosophy of adaptive management and is central to the implementation of the Remediation Project.

The Project's EMS requirements for monitoring and corrective action will form the basis of incorporating adaptive management processes. Establishing the EMS as the primary mechanism of ensuring that adaptive management is built into critical aspects of the Remediation Project will ensure that continuous improvement in management effectiveness and minimization of environmental effects are core to the delivery of the Project.

Key to effective adaptive management is the link between monitoring and decisions. Consequently, ultimate responsibility for the Project's EMS rests with the Project Oversight Committee. The Project Oversight Committee will be responsible for considering the results of audits in its decision making. The goal is to ensure that the results of monitoring are used to manage site risks and to improve the implementation of the Remediation Project over time, both in its design and execution.

In addition to applying adaptive management to the actions and mitigations identified through the EA process, the monitoring and reporting requirements of the water license, and their consequent incorporation into the EMS, are anticipated to significantly contribute to the knowledge upon which adaptive management for the Remediation Project will be built.

14.2 Long-term Environmental Monitoring

The Giant Mine Remediation Project has been designed to minimize the potential for environmental impacts associated with current site risks. While some risks can be eliminated, others will remain on site indefinitely and will require long-term management (e.g., arsenic trioxide stored in underground chambers). To ensure the effectiveness of efforts to manage these risks, and to ensure that the Remediation Project does not contribute additional significant environmental effects, a long-term monitoring program will be required. Such a program will evaluate both the physical performance of remediation infrastructure (e.g., tailings covers) and environmental quality (e.g. surface water quality) in the Site and Local Study Areas.

Following is a detailed description of the proposed Long-term Environmental Monitoring Program for the Giant Mine site. Environmental components and remediation infrastructure (e.g., tailings covers) requiring monitoring are identified and a detailed design specifying the individual requirements of the program at an operational level (e.g., location of sampling stations, parameters analyzed, etc.) for each environmental or physical component are specified.

In cases where particular requirements of the program could not be defined at the present time, guidelines to develop the requirements later on are provided. For example, the exact timing of certain sampling events or surveys and the specific locations of certain sampling stations will need to be determined as more details of the remediation schedule and the progress of remediation works become available. The Long-term Environmental Monitoring Program will be implemented throughout the duration of the Remediation Project. The first 25 years of monitoring is divided into two sections: an initial 15-year period to complete the ground freezing and immobilize contaminants, and a subsequent 10-year monitoring period to verify that the site has been stabilized. Continued implementation of the program beyond the 25-year duration of the Remediation Project will be considered in the future by the relevant regulatory authorities.

While the requirements of and reporting for many parameters of long-term monitoring will be governed by the water licence, the following two levels of reporting are proposed for data collected throughout the Long-term Environmental Monitoring Program. Ultimately, monitoring and reporting will be adjusted to meet the requirements of the water licence:

- Annual Report(s) - prepared annually to summarize and review all operational and environmental data collected in the 1-year reporting period; and,

- Status of the Environment (SOE) Reports - prepared every three years during the initial 15-year remediation period and every five years thereafter, to summarize, review and interpret the operational and environmental data collected in the reporting period and to provide recommendations for modifications to the monitoring program or site operations that may be affecting environmental quality.

The reporting requirements will provide a mechanism by which on-going feedback regarding the effectiveness of the remediation works and the monitoring activities is provided to the Project Oversight Committee, to regulators, Aboriginal communities, the public and stakeholders. Consistent with adaptive management, periodic reviews of operational and environmental data will help determine the appropriate duration for monitoring particular components of the program, the need to modify existing programs or to add new components, and the need to modify existing site operations that may be affecting a particular environmental component.

Components identified for inclusion in the Long-term Environmental Monitoring Program are frozen ground conditions (integrity of arsenic trioxide chambers); water quality (minewater, groundwater, treated water, and surface water); aquatic ecology (aquatic vegetation, benthic invertebrates/sediments and fish); terrestrial environment (vegetation/soils and wildlife); air quality; cumulative effects; and physical works. The proposed Long-term Environmental Monitoring Program for each component is discussed in the following sections and is outlined in Table 14.2.1.

14.2.1 Frozen Ground Monitoring

A number of instruments will be installed during the construction of the freezing system to monitor ground temperature and heat extraction, including the following:

- A ground temperature monitoring system consisting of thermistors or thermocouples mounted on the freeze pipes and additional devices installed in independent drill holes.
- Monitoring of fluid temperature, flow rates and pressures in active or hybrid system piping.
- Checks of gas pressure and monitoring of heat loss from radiators of passive thermosyphons.

The volume of data produced by these and other instruments in the freeze system is expected to be massive and a suitable data management system to store, manipulate and interpret the data is under development.

Ground temperature will be monitored continuously (as described in the first bullet) throughout the duration of the Remediation Project. During the period of active/hybrid freezing, in-ground monitoring will be supplemented by monitoring of temperatures and pressures in the coolant as it enters and leaves freeze pipes or groups of freeze pipes. This method is commonly used in freezing systems of similar design to ensure that all freeze pipes are functioning correctly.

Once frozen conditions have been established and the active/hybrid freezing system is converted to passive thermosyphons, the performance of each thermosyphon will be monitored by annual checks of gas pressure and monitoring of heat loss from the radiators. Ground temperatures will continue to be monitored using the thermistors or thermocouples mounted on the freeze pipes and in independent drillholes.

The proper functioning of the ground freezing system would imply the absence of arsenic trioxide leaks from the containing chambers. Additional assurance that the system is functioning properly without leaks is provided through the monitoring of minewater and groundwater, which is discussed in Section 14.2.2 – Water Quality Monitoring.

Table 14.2.1 Outline of Proposed Long-term Environmental Monitoring Program

Monitoring Component	Sampling Location	Sampling Station	Sampling Frequency	Analytical Parameters
Frozen Ground Around Arsenic Trioxide Chambers	In-ground	-	Continuously throughout Project	Ground temperature
	Freeze pipes	-	During active/hybrid freezing	Fluid temperatures, flow rates and pressures
	Thermosyphons	-	During passive freezing	Gas pressure and monitoring of heat loss from radiators
Water Quality: Minewater	C-Shaft multi-port well	All flooded zones	Quarterly until modified pumping system is commissioned	Water level and chemistry (general chemistry and total metal parameters)
	Pump discharge to water treatment plant	Pump discharge	Daily grab samples	Arsenic
			Weekly composite samples	General chemistry and total metal parameters
	Inflow to treatment plant	-	Continuously	Flow rate, pH, temperature, conductivity
	Multi-port wells	MP-1 to MP-7	Quarterly	General chemistry and total metal parameters
Water Quality: Groundwater	Shallow wells	Existing wells in mill area, tailings impoundments, historic tailings deposition area below South Pond	Annually during remediation work and for five years thereafter	General chemistry and dissolved metal parameters
	Deep multi-port wells	14 existing wells, all 126 zones	Annually during reflooding and for three years thereafter	Water pressure and level
		14 existing wells, approximately 36 select zones	Annually during reflooding and for five years thereafter	General chemistry and dissolved metal parameters

Table 14.2.1 Outline of Proposed Long-term Environmental Monitoring Program (Cont'd)

Monitoring Component	Sampling Location	Sampling Station	Sampling Frequency	Analytical Parameters
Water Quality: Treated Mine Water	Effluent discharge to Baker Creek from current water treatment plant	SNP station 43-1	Daily or weekly during periods of effluent discharge to Baker Creek until the proposed water treatment plant becomes operational	Daily: Flow, field temperature and pH, total suspended solids, total cyanide, total arsenic, copper and nickel Weekly: total ammonia, total lead and zinc, oil & grease
	Effluent discharge to Yellowknife Bay from the proposed water treatment plant	Outflow to holding system	Daily	Conductivity, pH, temperature, ammonia, total suspended solids, and total metals (arsenic, copper, lead, nickel and zinc)
		Discharge pipe from holding system, just upstream of diffuser	Continuously	Flow
			Weekly	pH, dissolved oxygen,, temperature, major ions, total suspended solids, total metal scan (including arsenic)
			Monthly during first year of operation and quarterly thereafter	Acute lethality tests
Water Quality: Surface Water – Receiving Environment	Trapper Creek	SNP stations 43-15 and 43-16	Monthly during open water season	Field measurements (pH, temperature, conductivity and dissolved oxygen), general chemistry and total metal parameters
	Baker Creek	SNP stations 43-5 and 43-11;	Monthly during open water	Field measurements (pH,

Table 14.2.1 Outline of Proposed Long-term Environmental Monitoring Program (Cont'd)

Monitoring Component	Sampling Location	Sampling Station	Sampling Frequency	Analytical Parameters
		new stations in Reach 1 and 4, immediately downstream of Reach 3, and at outlet of Baker Pond	season	temperature, conductivity and dissolved oxygen), general chemistry and total metal parameters
	Back Bay	New stations downstream of breakwater outside of creek/lake mixing zone and off north-west shore of Latham Island by N'dilo community	Bi-monthly (every 2 months)	Field measurements (pH, temperature, conductivity and dissolved oxygen), general chemistry and total metal parameters
	Yellowknife Bay	New stations at mouth of Yellowknife River, south of Latham Island offshore of Yellowknife, south end of bay offshore from Dettah community, in vicinity of diffuser, between diffuser and station in Back Bay An aquatic effects monitoring program will be developed for Yellowknife Bay and will take into account the location and final design of the diffuser.	(Bi-monthly)	Field measurements (pH, temperature, conductivity and dissolved oxygen), general chemistry and total metal parameters
Water Quality: Surface Water – Runoff and Seepage	On-site	Stations at seepage from Dam 3 and 11; in spillways collecting runoff from North Pond, Polishing Pond and Northwest Pond	Monthly during open water season	Field measurements (pH, temperature, conductivity and dissolved oxygen), general chemistry and total metal parameters
Aquatic Ecology:	Baker Creek	Five locations along Baker	Annually following first	Fish presence/absence,

Table 14.2.1 Outline of Proposed Long-term Environmental Monitoring Program (Cont'd)

Monitoring Component	Sampling Location	Sampling Station	Sampling Frequency	Analytical Parameters
Fish (Note: Fish monitoring programs will be designed to conform to fisheries authorization from DFO.)		Creek from creek mouth to Baker Pond including locations in Reach 1, 3 and 4	three years of remediation of Baker Creek	habitat use and Arctic grayling spawning activity
			Every three years following the first three years of remediation	Health assessments and fish tissue analyses on resident and non-resident
	Yellowknife Bay	South end of bay offshore from Dettah community; in Back Bay west of Latham Island offshore from N'dilo community	Every three years	Health assessments and fish tissue analyses on forage and predatory fish
Aquatic Ecology: Benthic Invertebrates and Sediments	Baker Creek/Yellowknife River	Approximately twelve locations in Baker Creek from creek mouth to Baker Pond including a few stations in Reach 4; one reference location in Yellowknife River	Every three years	Benthic invertebrate identification, calculation of statistics and endpoints; Sediment analysis for particle size, total organic carbon and metals
	Yellowknife Bay	In the vicinity of the effluent discharge from the proposed water treatment plant; Back Bay within breakwater in the vicinity of the Baker Creek inflow; two reference areas (one deep and one shallow) in the Akaitcho embayment offshore from Dettah community	Every three years	Benthic invertebrate identification, calculation of statistics and endpoints; Sediment analysis for particle size, total organic carbon and metals

Table 14.2.1 Outline of Proposed Long-term Environmental Monitoring Program (Cont'd)

Monitoring Component	Sampling Location	Sampling Station	Sampling Frequency	Analytical Parameters
Aquatic Ecology: Emergent Vegetation	Baker Creek/Back Bay	Reach 0 in Back Bay at creek inflow; several locations along Baker Creek from creek mouth to Baker Pond including sites in areas undergoing remediation such as Reach 1, 3 and 4.	Twice: once during the pre-remediation period (Year 0) to establish baseline conditions; once after all remediation work on Baker Creek is completed and emergent vegetation is re-established as determined by the SOE review	Emergent macrophyte distribution; metal analyses on target species consumed by furbearers such as muskrat
Terrestrial Environment: Vegetation and Soil	Giant Mine Lease Property	Previously impacted, remediated and revegetated areas	A single sampling campaign once successful revegetation is reported in remediated areas (tailings areas and contaminated soils areas) as determined by the SOE review	Sampling of pertinent plants such as forage species and ones of cultural significance (e.g., Labrador tea, berries) for moisture content and metal analyses of terminal leaves and twigs; soils for moisture content and metal analyses
Terrestrial Environment: Wildlife	Giant Mine Lease Property		Three sampling campaigns: one during the pre-remediation period (Year 0) to establish baseline conditions; one in Year 5 and one in Year 15 of the remediation period	Observations of wildlife to determine species presence/absence and area usage
Air Quality	Giant Mine Town Site and On-site	Giant Mine Town Site; four on-site locations (two on the east side of the property, one in the area of the mill/roaster complex and one on the west side of the Northwest Pond)	Every 6th day during the summer months (July to September) throughout the 15-year remediation period and every three years thereafter	24-hour composite samples for total suspended particulate matter and <10 μm particulate matter fraction (PM_{10})

Table 14.2.1 Outline of Proposed Long-term Environmental Monitoring Program (Cont'd)

Monitoring Component	Sampling Location	Sampling Station	Sampling Frequency	Analytical Parameters
Physical Works	Giant Mine Lease Property	Spillways, ditches, dams and relocated sections of Baker Creek	Annually for as long as they remain in use	
		Tailings and sludge containment area covers	Annually for five years or until vegetation is fully established and erosion rates are consistent with those in local environment	
		Pit walls, crown pillars, and closed mine entries	Annually for five years and every second year thereafter	
Construction Activities	Giant Mine Lease Property	Drainage from active work areas and Baker Creek upstream and downstream	Daily when flow occurs from active work area	Field measurement of turbidity plus weekly samples for general chemistry and metal analyses
Cumulative Effects	Local Study Area	Fish, game and medicinal plants harvested by residents of N'dilo and Dettah	Once per year	Metal analyses plus moisture content

14.2.2 Water Quality Monitoring

14.2.2.1 Minewater Monitoring

Existing Minewater Monitoring System

Currently, minewater levels and quality are monitored through the C-Shaft. The C-Shaft monitoring system was installed in May 2005 to monitor water level rise in the mine and discrete water chemistry at all mine levels within the C-Shaft during reflooding. Water samples and pressure measurements are obtained through the same type of multi-port system that is used in the deep groundwater monitoring wells (see Section 14.2.2.2 – Groundwater Monitoring). A total of 12 monitoring zones, extending to a depth of approximately 600 m (Mine Level 2000), have been established within the C-Shaft where the mine levels intersect the shaft (see Table 14.2.2). Minewater samples for chemical analysis were collected from zone 1 in June 2005 and zones 1 to 4 in January and September 2006. Sampling of the C-Shaft continued at a quarterly frequency in 2007 at which time zones 1 to 6 were flooded. Samples were taken from all six zones in January and May 2007, but only zones 4 to 6 were successfully sampled in August 2007. This was the last time that water samples were successfully obtained from the C-Shaft due to a number of blockages that developed within the shaft. Efforts are currently underway to regain access to the monitoring ports in the C-Shaft so that minewater sampling may resume. Minewater levels have been monitored at the C-Shaft since 2005; however, this practice may be discontinued as minewater levels are now measured at the newly commissioned Akaitcho 750 Mine Level pumping system (SRK 2009a).

Table 14.2.2 C-Shaft Multi-port Details

Mine Level	Measurement Port Depth (m)	Zone (#)
Surface	0.0	-
100	35.2	12
250	89.1	11
425	138.3	10
575	184.7	9
750	238.7	8
950	298.5	7
1100	344.4	6
1250	390.4	5
1500	454.4	4
1650	500.0	3
1800	551.0	2
2000	607.2	1

Proposed Long-term Minewater Monitoring Program

Minewater quality will continue to be monitored quarterly using the C-Shaft multi-port well or a new monitoring well until water in the mine reaches its long-term level below the frozen zones. Samples collected from the C-Shaft will be analyzed for the general chemistry and total metal parameters listed in Table 14.2.3. Once the long-term water level in the mine is reached, a modified minewater pumping system will be commissioned and samples will be collected from the pump discharge as it is fed to the water treatment plant. Grab samples for total arsenic determination will be collected daily during pumping. Weekly composite samples will also be prepared from the daily samples and analyzed for the parameters listed in Table 14.2.3. In addition, continuous monitoring of conductivity, pH and temperature will be recorded on the inflow to the treatment plant.

Table 14.2.3 Proposed Parameter List for Water Samples

Parameter (Units)	
Group A **General Chemistry Parameters**	**Group B** **Metals**
Alkalinity (mg$CaCO_3$ eq/L)	Aluminum (mg/L)
Conductivity, Specific (S/cm)	Antimony (mg/L)
pH	Arsenic (mg/L)
Solids, Total Dissolved (mg/L)	Barium (mg/L)
Solids, Total Suspended (mg/L)	Beryllium (mg/L)
Calcium (mg/L)	Cadmium (mg/L)
Cation/Anion Balance (mg/L)	Cesium (mg/L)
Chloride (mg/L)	Chromium (mg/L)
Electroneutrality (mg/L)	Cobalt (mg/L)
Magnesium (mg/L)	Copper (mg/L)
Nitrate as Nitrogen (mg/L)	Iron (mg/L)
Nitrite as Nitrogen (mg/L)	Lead (mg/L)
Potassium (mg/L)	Lithium (mg/L)
Sodium (mg/L)	Manganese (mg/L)
Sulphate (mg/L)	Mercury (mg/L)
Ammonia as Nitrogen (mg/L)	Molybdenum (mg/L)
Nitrate + Nitrite as Nitrogen (mg/L)	Nickel (mg/L)
Arsenate (μg/L)	Rubidium (mg/L)
Arsenite (μg/L)	Selenium (mg/L)
Inorganic Carbon, Dissolved (mg/L)	Silver (mg/L)
Organic Carbon, Dissolved (mg/L)	Strontium (mg/L)
	Thallium (mg/L)
	Titanium (mg/L)
	Uranium (mg/L)
	Vanadium (mg/L)
	Zinc (mg/L)

A surface based monitoring system consisting of multi-port (MP) wells (MP-1 to MP-7) will also be installed to monitor minewater in specific tunnels and levels surrounding the frozen arsenic storage areas. The locations of these monitoring wells are shown in Figure 14.2.1. As seen in the figure and Table 14.2.4, the monitoring wells will transverse the length of the main mine area targeting specific source areas and levels within the mine. The wells will be sampled quarterly and analyzed for the general chemistry and total metal parameters listed in Table 14.2.3.

Table 14.2.4 Description of Proposed Minewater Monitoring Wells

Multi-port Monitoring Well	Source Area Targeted	Levels Intersected	Comments
MP-1	A-Shaft (extreme south end of mine)	425, 750	
MP-2	South of AR area	100, 425, 750	
MP-3	Centre of AR area	425, 750	
MP-4	B-Shaft – AR area	100, 425	
MP-5	North of AR area	575, 750	
MP-6	Akaitcho Area (extreme north end of mine and Northwest Tailings pond infiltration)	100, 250	Monitors loading coming from north end on underground workings. No tailings backfill.
MP-7		575, 750, 950	

Quality Assurance/Quality Control (QA/QC) procedures will be applied to all water sample collections and laboratory analyses.

14.2.2.2 Groundwater Monitoring

Existing Groundwater Monitoring Program

Groundwater monitoring at Giant Mine has been carried out since 1999, using a shallow well system designed to monitor potential contaminant movement from known arsenic sources. The system consists of sixteen shallow standpipes that extend to a depth of approximately 10 to 15 m below the ground surface and monitor the tailings ponds, Calcine Pond and Mill Pond. In 2002, five deep multilevel (multi-port) wells extending to a depth of approximately 150 m below the ground surface were established to monitor the deeper groundwater surrounding and above the dewatered mine. The deep well system was augmented in 2004 with the establishment of nine additional multi-port wells. Each multi-port well has between 5 and 12 discrete monitoring zones for a combination of 126 zones. Monitoring zones within the multi-port wells have been positioned to monitor possible lithological and/or structural features believed to impact control on the groundwater flow (SRK 2009a).

Figure 14.2.1 Location of Long-term Mine Workings Monitoring System

The main objectives of the multi-port monitoring system have been to: (a) obtain an understanding of hydrogeological conditions along mine-scale structures and within the bedrock mass on the periphery of the mine site, outside of the mine “envelope”; and, (b) to collect background data on piezometric levels and geochemistry of the hydrogeological system surrounding the dewatered mine. The information has been used to establish baseline groundwater conditions at the site that can be directly compared to changes brought about by the remedial works planned for the site.

The multi-port wells are monitored annually in the late summer (August/September) for piezometric (water pressure and levels) and geochemical data. While pressure data are collected from all multi-port monitoring zones, only 36 of the 126 zones are currently monitored on a routine basis for water chemistry. Zones that are routinely monitored have been chosen because they target particular hydrogeological features of interest such as shallow saturated zones close to surficial arsenic sources (e.g., tailings ponds), fault intersections, high differential pressure zones and open drill holes. Water samples are analyzed for pH, conductivity, hardness, total dissolved and suspended solids, turbidity, phosphorous, major ions and a full suite of metals (dissolved) (SRK 2009a).

The shallow standpipe wells located in the vicinity of the tailings ponds and the former Calcine Pond and Mill Pond are also monitored annually, typically in the late summer, for water level and the same analytical parameters mentioned above for the deep wells. In addition, total and weak acid dissociable cyanide are also measured in groundwater at the Calcine Pond and Mill Pond locations.

Proposed Groundwater Long-term Monitoring Program

The proposed Long-term Monitoring Program includes monitoring of both the shallow and deep groundwater systems. Wells that will be monitored in the Long-term Monitoring Program are shown in Figure 14.2.2. The existing shallow standpipes that are located around the mill area, the tailings impoundments, and at the historic tailings deposition area below the South Pond will be sampled annually during the remediation work and for five years thereafter. The deeper groundwater will continue to be monitored using the existing fourteen multi-level (multi-port) monitoring well systems that collectively monitor 126 discrete zones. Each of these discrete zones will be monitored for piezometric levels every year during reflooding and for three years thereafter. Approximately 36 selected zones will be sampled for water quality annually during reflooding and for five years thereafter. A reduced number of sampling points will be identified for monitoring over the longer-term based on the understanding of the groundwater flow at that time.

Figure 14.2.2 Location of Long-term Peripheral Groundwater Monitoring System

All samples will be analyzed for the general chemistry and metal parameters shown in Table 14.2.3.

Quality Assurance/Quality Control (QA/QC) procedures will be applied to all water sample collections and laboratory analyses. In continuation of the current practice (SRK 2009a), sample collection equipment will be de-contaminated daily using dilute acid and rinsed three times with deionized water, and between monitoring zones by rinsing twice with deionised water. Field parameters will be collected in standard lab-provided containers (including acid-washed when appropriate), and field blanks included in the sample suite submitted for analysis. Total metal concentrations will be determined using Inductively Coupled Plasma – Mass Spectrometry (ICP-MS). Criteria for the assessment of groundwater quality have not been developed.

14.2.2.3 Treated Water Monitoring

Existing Treated Water Monitoring Program

Effluent from the water treatment plant is currently discharged from the Polishing Pond into the Baker Creek drainage area and is monitored at station 43-1 (see Figure 14.2.3). Samples are collected from a stilling well in the discharge pipe. The pipe discharges underwater into a small drainage area on the east side of the Ingraham Trail and flows west through a culvert under the road into an intermittent stream/marsh that intersects the Baker Creek drainage system at a point approximately 300 m from the discharge outlet (Deton'Cho/Nuna Joint Venture 2007).

Water quality monitoring at station 43-1 follows the requirements of the Surveillance Network Program (SNP) that was established under the former water license, as well as Environment Canada's Metal Mining Effluent Regulations (MMER). The SNP requires daily (on week days) or weekly sampling for flow, temperature, pH , total suspended solids, ammonia, cyanide, total metals (arsenic, copper, lead, nickel and zinc) and oil and grease during periods of discharge (typically June to October) (MVLWB 2001; Connell 2007). The MMER imposes limits on releases of deleterious substances including cyanide, metals (arsenic, copper, lead, nickel, and zinc), radium-226, suspended solids, and pH, and prohibits the discharge of effluent that is acutely lethal to fish. Water quality samples at station 43-1 are collected weekly for the MMER program and acute lethality tests [rainbow trout (*Oncorhynchus mykiss*) and water flea (*Daphnia magna*)] are performed monthly on the effluent (Deton'Cho/Nuna Joint Venture 2007). The requirements of the SNP and MMER programs are outlined in Table 14.2.5 and the discharge limits set for deleterious substances in each program are summarized in Table 14.2.6.

Figure 14.2.3 Current (2010) Surveillance Network Program Monitoring Stations

Under the MMER, a national Environmental Effects Monitoring (EEM) program is also implemented to assess the effects of metal mining effluent on fish, fish habitat, and the use of fisheries resources. The EEM requires characterization of the treated effluent, water quality monitoring of exposure and reference areas, and sub-lethal toxicity testing. Water quality samples are collected monthly from three locations under the EEM program:

1. Final Effluent Discharge Point – SNP station 43-1;
2. Exposure Area – Baker Creek at the outlet of Baker Pond; and,
3. Reference Area – SNP station 43-11 in Baker Creek upstream of the mine and the final effluent discharge point.

Effluent is characterized with respect to concentrations of hardness, alkalinity, aluminum, cadmium, iron, mercury, molybdenum, ammonia and nitrate, but all water samples are analyzed for a comprehensive suite of parameters (see Table 14.2.5). Samples for chronic toxicity testing are collected at the beginning of the effluent discharge period and are conducted on water flea (*Ceriodaphnia dubia*), fathead minnows (*Pimephales promelas*), an aquatic plant *(Lemna minor*) and an alga (*Pseudokirchneciella subcapitata*) (Deton'Cho/Nuan Joint Venture 2007). To further satisfy the objectives of the EEM program in assessing the effects of metal mining effluent on fish, fish habitat and the use of fisheries resources, biological monitoring studies are also completed in the receiving environment. These studies include a sentinel fish survey, an invertebrate community survey, water and sediment quality monitoring, and sub-lethal toxicity testing of the treated effluent. The fish and invertebrate studies are completed in the Baker Creek exposure area and a reference area in Yellowknife River (Golder 2008).

Table 14.2.5 Current Water Quality Monitoring and Toxicity Testing - Treated Effluent

Surveillance Network Program (SNP) [1] Station 43-1: Final treated effluent downstream of the Polishing Pond before entering Baker Creek	During periods of treated effluent discharge to Baker Creek, the following parameters are measured daily (on week days): flow, field temperature and pH, total suspended solids, total cyanide and total arsenic, copper, and nickel; total ammonia, lead and zinc and oil & grease are measured weekly.
Metal Mining Effluent Regulations (MMER) [2] Station 43-1: Final treated effluent downstream of the Polishing Pond before entering Baker Creek	During periods of treated effluent discharge to Baker Creek, collection of weekly samples for the measurement of deleterious substances (cyanide, arsenic, copper, lead, nickel, zinc, total suspended solids, radium-226 and pH) and measurement of effluent volumes deposited from the final discharge point. Monthly sampling for acute toxicity tests [using rainbow trout (*Oncorhynchus mykiss*) and water flea (*Daphnia magna*)].
MMER Environmental Effects Monitoring (EEM) [2] Station 43-1: Final treated effluent downstream of the Polishing Pond before entering Baker Creek Exposure Area: Baker Creek at the outlet of Baker Pond Reference Area: Station 43-11 in Baker Creek upstream of the mine and Station 43-1	During periods of treated effluent discharge to Baker Creek, collection of monthly samples for effluent characterization at Station 43-1 and water quality monitoring at Exposure and Reference areas. Samples are analyzed for a comprehensive suite of parameters including physical, major ions, nutrients, cyanide, total and dissolved metals, organic parameters, and radium-226, as well as oil & grease and sulphide at station 43-1. Samples for chronic toxicity tests [using water fleas (*Ceriodaphnia dubia*), fathead minnows (*Pimephales promelas*), aquatic plants (*Lemna minor*) and algae (*Pseudokirchneciella subcapitata*)] are collected at the beginning of the effluent discharge period.

Notes: [1]Mackenzie Valley Land and Water Board Surveillance Network Program (Effective June 30, 1998; updated September 19, 2001; former Water License N1L2-0043) and 2006 Surveillance Network Report (Connell 2007); [2]Giant Mine 2006 Annual MMER/EEM Report (Deton'Cho/Nuna Joint Venture 2007).

Table 14.2.6 Mean Discharge Limits of Deleterious Substances in Treated Effluent

Parameter	Mackenzie Valley Land and Water Board License [1]	Metal Mining Effluent Regulations
	Water License Mean Limit	Schedule 4 Monthly Mean Limit
Ammonia (mg/L)	12	not applicable
Arsenic (mg/L)	0.50	0.50
Copper (mg/L)	0.30	0.30
Cyanide (mg/L)	0.80	1.00
Lead (mg/L)	0.20	0.20
Nickel (mg/L)	0.50	0.50
Zinc (mg/L)	0.20	0.50
Total Suspended Solids (mg/L)	20.0	15.0
Radium-226 (Bq/L)	not applicable	0.37
pH-range	6.0 – 9.5	6.0 – 9.5

Notes: [1]Former Water License N1L2-0043

Proposed Treated Water Long-term Monitoring Program

Minewater and surface run-off from the mine site are currently treated and discharged only during the open water season, as the effluent is discharged to Baker Creek. However, once the proposed water treatment plant is built, the treated minewater will be discharged year-round to a diffuser constructed in Yellowknife Bay, at a location east of the Baker Creek mouth and approximately 500 to 1,500 m offshore under a water cover of 8.5 to 10 m (refer to Section 6.8.6 and Figure 6.8.4).

Once the proposed water treatment plant is operational, water will be pumped directly from the mine to the plant. The proposed water treatment plant is designed to remove arsenic, but will also have an effect on several other constituents (e.g., antimony, zinc and several other heavy metals) that have elevated concentrations. In brief, arsenic will be precipitated with iron and the precipitate will be settled out from the treated water in a thickener, generating a sludge that will be dewatered and disposed of on site, as described in Section 6.8.2. The treated water will be discharged to a holding system where water quality will be monitored prior to discharge to Yellowknife Bay. Any treated water that fails to meet the discharge criteria will be recycled through the treatment plant, or returned to underground storage. Treated water that meets the discharge criteria will be pumped through a pipeline to the outfall diffuser in Yellowknife Bay. The goal of the diffuser system will be to achieve efficient mixing of effluent with lake water and thus reduce the arsenic concentration in the receiving lake water, outside an initial mixing zone, to the Canadian water quality guideline for protection of freshwater aquatic life.

For as long as the current water treatment plant continues to be operated and treated effluent is discharged to Baker Creek during the open water season, the treated effluent will continue to be monitored daily at SNP station 43-1 during periods of discharge to meet SNP and MMER requirements (see Table 14.2.6). When minewater is treated at the proposed treatment plant, treated effluent quality will be monitored at two new locations:

1. In the outflow pipe to the holding system; and

2. In the discharge pipe from the holding system, just upstream of the diffuser.

In addition, water quality will also be monitored in Yellowknife Bay in the vicinity of the outfall diffuser, outside the initial mixing zone (see Section 14.2.2.4 – Surface Water Quality). The outflow to the holding system will be monitored daily for pH, total suspended solids and total arsenic. The discharge to Yellowknife Bay will be monitored continuously for flow and weekly for pH, dissolved oxygen, temperature, major ions, total suspended solids, total arsenic, antimony and other metals. Acute toxicity testing on rainbow trout and Daphnia magna will also be conducted monthly for the first year of operating the proposed water treatment plant and quarterly thereafter. The proposed monitoring schedule and parameters for the treated effluent are shown in Table 14.2.7 while the station locations are shown in Figure 14.2.4.

Table 14.2.7 Proposed Long-term Monitoring Program for Treated Water

Sample Location	Schedule	Parameters
Water treatment plant outflow to holding system	Daily	pH, TSS, total arsenic
Discharge from holding system	Continuous	Flow metering
	Weekly	pH, dissolved oxygen, temperature, major ions, TSS, total metals (including arsenic, antimony, copper, lead, nickel and zinc)
	Monthly in first year and quarterly thereafter	Acute lethality tests

14.2.2.4 Surface Water Monitoring

Existing Surface Water Monitoring Programs

Routine surface water quality monitoring at the Giant Mine site follows the SNP requirements set out in previous water licenses. The SNP includes sampling for a restricted set of parameters (see Table 14.2.8) at a number of stations established within the receiving environment. Monitoring of the receiving environment is currently limited to the Baker Creek watershed, which includes Baker Creek in the vicinity of the mine; Trapper Creek, the main tributary to Baker Creek; and, Back Bay (Great Slave Lake) within the breakwater where Baker Creek flows into the lake. Two additional SNP stations monitor discharge from the underground mine to the Northwest Pond (station 43-17) and to the South Pond (station 43-18). Although both of these stations are currently inactive, samples are collected from Station 43-21.

The SNP for surface water quality is summarized in Table 14.2.8 with respect to sampling stations and frequency and analytical parameters monitored. Locations of SNP stations are shown in Figure 14.2.3. As discussed in Section 14.2.2.3 – Treated Water Monitoring, the EEM program also monitors water quality routinely at station 43-1 (treated effluent discharge) and stations upstream of the discharge point at station 43-11 and downstream of the discharge point at the outlet of Baker Pond.

Monitoring Stations

Baker Creek is monitored in the vicinity of the mine site at two locations (stations 43-11 and 43-5). Station 43-11 is a reference site that is located immediately upstream of the mine and upstream of the current effluent discharge point (station 43-1). Station 43-5 is located at the boiler house utilidor crossing just before the creek discharges to Back Bay (at the mouth of Baker Creek). Water quality is also monitored in Back Bay downstream of the mixing zone at the end of the breakwater at station 43-12. A recent review of the SNP program (SRK 2006) concluded that data collected at station 43-12 are not contributing useful information due to the extreme variations in mixing that occur at this location under different flow and wind conditions, as well as the limited suite of parameters that are monitored.

Two monitoring stations (43-15 and 43-16) have also been established along Trapper Creek, which is the largest tributary to Baker Creek in the vicinity of the mine. The purpose of these stations is to measure the effects, if any, of seepage from the Northwest Pond on water quality in Trapper Creek. Station 43-15 monitors the outflow from Trapper Lake and station 43-16 is located below the tailings dams and above the confluence point with Baker Creek.

Table 14.2.8 Summary of Surveillance Network Program for Surface Water Quality

Station	Description	Frequency	Parameters
SNP 43-5	Baker Creek at boiler house utilidor crossing, prior to discharge to Back Bay (mouth of Baker Creek)	One week prior to the commencement of effluent discharge from the treatment plant and weekly during the period of effluent discharge	Temperature, pH and total ammonia
		Twice monthly during the period of effluent discharge	Total arsenic, copper, cyanide, lead, nickel and zinc and total suspended solids
SNP 43-11	Baker Creek, upstream of mine and effluent discharge point (Station 43-1)	Monthly during periods of flow	Temperature, pH, total ammonia, total arsenic, and total suspended solids
SNP 43-12	Back Bay at the end of the breakwater	One week prior to the commencement of effluent discharge from the treatment plant and weekly during the period of effluent discharge	Temperature, pH and total ammonia
SNP 43-15	Trapper Creek at the outflow from Trapper Lake	Monthly during periods of flow	Temperature, pH, total ammonia, total arsenic, and total suspended solids
SNP 43-16	Trapper Creek, below the tailings dams and upstream of the confluence point of Trapper Creek and Baker Creek	Monthly during periods of flow	Temperature, pH, total ammonia, total arsenic, and total suspended solids
SNP 43-17 (currently inactive)	Discharge from the underground mine to the Northwest Pond	Weekly, including daily flows from the mine	Temperature, pH, total ammonia, arsenic, cyanide, copper, nickel, lead and zinc and total suspended solids
SNP 43-18 (currently inactive)	Discharge from the underground mine to the South Pond	Weekly, when operating	Temperature, pH, total ammonia, arsenic, cyanide, copper, nickel, lead and zinc and total suspended solids

Note: MVLWB (2001); Connell (2007).

Proposed Surface Water Long-term Monitoring Program

Monitoring Stations

The long-term monitoring program will continue to monitor surface water quality in the receiving environment including Trapper Creek, Baker Creek, and Back Bay and Yellowknife Bay in Great Slave Lake at existing SNP stations as well as several new stations. In addition, seepage and surface runoff in the vicinity of the tailings ponds will also be monitored. Figures 14.2.4 and 14.2.5 show the proposed monitoring stations, which are outlined below.

Figure 14.2.4 Proposed Baker Creek Water Quality Monitoring Stations

Figure 14.2.5 Long-term Surface Water Quality Monitoring in Yellowknife Bay

- Trapper Creek: SNP stations 43-15 (Trapper Lake outflow) and 43-16 (above confluence with Baker Creek) will continue to be monitored (see Figure 14.2.4).

- Baker Creek: SNP stations 43-5 (creek mouth) and 43-11 (upstream of mine) will continue to be monitored. In addition, several new stations will be established along the length of Baker Creek including one in Reach 1 adjacent to the A2 Pit, one immediately downstream of Reach 3 that will likely be re-routed to the east side of the C-1 Pit, one in the rehabilitated stretch of Reach 4, and one at the outlet of Baker Pond (where water quality is currently monitored in the EEM program) (see Figure 14.2.4).

- Back Bay (Great Slave Lake): SNP station 43-12 will no longer be monitored. Instead, a new station will be established further offshore from the breakwater and outside of the Baker Creek/Back Bay mixing zone. An additional station will be established in Back Bay off the north-west shore of Latham Island west of the community of N'dilo (see Figures 14.2.4 and 14.2.5).

- Yellowknife Bay (Great Slave Lake): New stations will be established in the north and south segments of Yellowknife Bay. The new stations will include one at the mouth of the Yellowknife River, one south of Latham Island directly east of the City of Yellowknife at the location of the proposed drinking water source for the City, and one at the south end of the bay, directly west of the community of Dettah. Stations will also be established in the vicinity of the diffuser (outside of the mixing zone) where effluent from the new water treatment plant will be discharged and one between the diffuser and the new station monitoring water quality in Back Bay downstream of the breakwater (see Figure 14.2.5). An aquatic effects monitoring program will be developed for Yellowknife Bay and will take into account the location and final design of the diffuser.

- Surface seepage and runoff: Monitoring of seepage from Dams 3 and 11, and surface runoff from the covered North Pond, Polishing Pond, and Northwest Pond (see Figure 14.2.4).

As indicated, water quality will continue to be monitored within the Baker Creek watershed even though the effluent discharge will be diverted from Baker Creek to Yellowknife Bay once the proposed water treatment plant becomes operational. Even without the added arsenic load from the treated effluent, Baker Creek remains a contaminated system from historical operations and continued monitoring of water quality is necessary in order to assess the on-going recovery of the system and any potential effects from remediation works. Proposed Baker Creek remediation works include upgrading the section that flows past the A2 Pit (Reach 1) to decrease the risk of overtopping and flooding the mine; upgrading the culvert or realigning the channel and building a bridge downstream of the A2 Pit at the highway crossing; abandoning the diversion around the

C1 Pit (Reach 3) and building a new channel constructed to the east of the pit along the current highway alignment; and, possibly removing contaminated sediments from various sections of the creek. The long-term monitoring plan proposes the establishment of new monitoring stations immediately downstream of Reach 3 and adjacent to the A2 Pit to help monitor for potential effects from some of these activities on Baker Creek water quality. A station will also be established in Reach 4, which has already been successfully rehabilitated, to monitor the continued recovery of that segment.

Under the proposed remediation plans, the settling and polishing ponds associated with the current water treatment plant will be covered, as will be the South, Central and North tailings ponds. The Northwest Pond will also be covered once the water currently stored in the pond is pumped, treated and discharged. A series of spillways will be constructed around the covered ponds to collect surface run-off, which will be monitored and directed into the underground mine for eventual treatment. This practice will continue until such time that water quality is acceptable for direct discharge into the receiving environment (i.e., Baker Creek). As seen in Figure 14.2.4, new monitoring stations will be established along the spillway from the covered North Pond, Polishing Pond and Northwest Pond. In addition, a new monitoring station will be established at the outlet of Baker Pond to monitor for potential seepage from the covered Polishing and Settling ponds that contain sludge. Seepage from Dam 3 and 11 at the northeast end of the covered North Pond and the south end of the covered South Pond, respectively, will also be monitored and, if required, the seepage waters will be directed underground for subsequent treatment.

Water quality in Yellowknife Bay will need to be monitored routinely as effluent from the proposed water treatment plant will be discharged to the bay (see Figure 14.2.5). Proposed monitoring stations occur in the vicinity of the diffuser (outside the mixing zone) and along the length of the bay upstream and downstream of the effluent discharge point. Stations will be established at the south end of Yellowknife Bay opposite the community of Dettah, and off the west shore of Latham Island in Back Bay opposite the community of N'dilo.

The need to establish additional routine monitoring stations or to modify existing monitoring stations may become apparent as surface flow patterns change with the progression of the remediation works. The annual reports and SOE reviews will help determine such needs.

In the case of the tailings covers, monitoring of suspended sediments in the surface runoff collection system that drains to the spillways previously discussed will continue until erosion rates are shown to be similar to those in natural areas.

Sampling Frequency and Analytical Parameters

Existing SNP stations and new stations monitoring water quality in Baker Creek and Trapper Creek and in surface seepage and runoff will be monitored monthly during the open water season and while flows occur. Stations in Back Bay and Yellowknife Bay will be monitored bi-monthly. Some stations may need to be sampled more frequently when remediation activities are occurring within the catchment area.

Water quality samples collected from all monitoring stations will be sampled for the general chemistry and metal parameters shown in Table 14.2.3. In addition, field measurements will be carried out at the time of sample collection for conductivity, dissolved oxygen, pH and temperature at each monitoring station.

Sampling Methods

Surface water samples collected from all monitoring stations during the open water season will consist of grab samples, but samples from underneath the ice will need to be taken in the winter and likely in the spring from Back Bay and Yellowknife Bay. Also, a depth profile consisting of 4 or 5 samples will need to taken at the station occurring in the vicinity of the diffuser (new effluent discharge point) to ensure that the effluent plume, which will not surface, is captured in the sampling.

QA/QC procedures will be applied to all water sample collections and laboratory analyses.

Water Quality Guidelines

The Canadian Water Quality Guidelines (CWQGs) for the protection of Freshwater Aquatic Life (FAL) (CCME 1999 and updates) are recommended as the most appropriate criteria for assessing surface water quality in the receiving waters of Yellowknife Bay. FAL guidelines are used by provincial, territorial and federal agencies to assess background freshwater quality and are not site-specific. They are meant to be applied to freshwater and to protect all forms of aquatic life, including the most sensitive life stage of the most sensitive species.

Exceedance of CWQG-FAL guidelines however, does not necessarily indicate that there will be negative effects on aquatic organisms. As Baker Creek water quality will not meet CWQG-FAL for some contaminants (and in particular arsenic), monitoring of the health of benthic and fish communities will provide the best measure of long-term effects of the remediated Giant Mine site on recovery of that ecosystem. This is discussed further in Section 14.2.3.

14.2.3 Aquatic Ecology Monitoring

14.2.3.1 Fish

Baker Creek

Reach 4 of Baker Creek, which stretches from the north end of the C1 Pit to the north end of the B1 Pit, was realigned to the west side of Ingraham Trail in 2006. The primary objective of the realignment was to isolate the contaminated Mill Pond from Baker Creek, thereby eliminating a source of ongoing contamination and preventing seepage loss from Baker Creek into areas of the underground mine workings (via the 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. Following the realignment and reconstruction of Reach 4, a 3-year fish monitoring program (2007 to 2009) was implemented to assess Arctic grayling spawning activity and suitable spawning habitat, young-of-the-year use of habitat and food availability for various life stages of Arctic grayling. Other fish species were also assessed during the spring spawning period (Golder 2009). The successful breeding of several species in Reach 4 in 2007 and 2008 indicates that changes made to the creek in previous years improved breeding habitat.

Fish monitoring in Baker Creek, including the rehabilitated segment in Reach 4, will continue with the Long-term Monitoring Program. Proposed remediation works for Baker Creek such as upgrading the section that flows past the A2 Pit (Reach 1), upgrading the culvert or realigning the channel and building a bridge downstream of the A2 Pit at the highway crossing, realigning Reach 3 to the east side of the C1 Pit, and possibly removing contaminated sediments from various sections of the creek, are expected to be completed within the first few years of the Remediation Project. During the initial 3-year period that Baker Creek is undergoing remediation, fish assessments will be conducted annually and will largely resemble the studies that have been completed on Reach 4 (Golder 2009). These studies will assess fish presence/absence and habitat use in the creek and Arctic grayling spawning activity and will focus on capturing and observing migrating adults, eggs, and larvae, and measuring and observing habitat conditions. Methods will include visual observations, snorkelling, seine nets to capture migrating fish and kick-netting to sample eggs. Fish surveys will be completed at five locations spanning the length of Baker Creek from the creek mouth to Baker Pond, including locations in Reach 1, 3 and 4. The surveys will preferably be conducted in May or June in order to maintain consistency with previous studies completed in Reach 4 and to capture spawning periods.

Following the initial 3-year period, once remediation works on Baker Creek have been completed, fish assessments will be completed at a 3-year frequency and will focus on health assessments and fish tissue analyses. The surveys will target at least one resident and one non-resident fish species and fish samples will consist of 10 to 15 individuals of each fish species. All fish will be measured for fork length and weight and subjected to full external and internal health examinations noting all lesions, parasites, discoloured tissues and other irregularities. Depending on the species, otoliths, fin rays and scales should be retained for ageing. Muscle and liver samples are to be collected from each fish for laboratory analysis of metals. If large enough, gut contents should also collected and frozen for subsequent analysis.

Liver, muscle and gut content samples are to be submitted to an accredited laboratory for sample preparation, homogenizing, moisture measurement and the determination of metals by ICP-MS high resolution scan. Fish tissues should also be analyzed for mercury using cold vapour techniques, major ions, and moisture content. All analyses should follow standard analytical protocols (e.g., U.S. EPA Method Number SW846 3050B Revision 2 for metals and U.S. EPA method 7470A for mercury). Methods include analytical blanks, spiked samples, and standard reference materials. The rationale and minimum required procedures for rigorous quality control are clearly defined in documentation supporting the methods. The QA/QC program is designed to ensure data of known quality which can be defended and is deemed suitable for the current project. The proposed analytical parameters for fish tissue include moisture content and the metals listed in Table 14.2.3.

Yellowknife Bay

Long-term monitoring of fish in Yellowknife Bay on Great Slave Lake will focus on two areas; in Back Bay and the south end of Yellowknife Bay, offshore from the communities of N'dilo and Dettah, respectively. A suitable reference area will also be established somewhere within the north arm of Great Slave Lake. Fish surveys, consisting of health assessments and fish tissue analyses, will be conducted at a 3-year frequency and will target fish species representing different ecological niches. It is recommended that at least one predatory fish species (e.g., lake trout or northern pike) and one forage species (e.g., lake chub or lake whitefish) be targeted in the study.

Fish health assessments and tissue analyses will be conducted in the same manner described previously for fish sampled in Baker Creek.

14.2.3.2 Benthic Invertebrates and Sediments

Baker Creek

Periodic assessments of benthic invertebrate communities in Baker Creek have been completed in the past. These assessments have examined several sites within the creek (1998), the creek mouth (2006), and the realigned Reach 4 (2008). The Long-term Monitoring Program for Baker Creek includes a benthic component that will be completed every three years. Several study sites (approximately twelve [2x 6 reaches]) will be established throughout Baker Creek stretching from the creek mouth to Baker Pond, including stations in the realigned Reach 4. A reference area will also be established in Yellowknife River. The exact sampling locations and timing of the sampling events will be determined at a later time to avoid interference with any on-going remediation works. To facilitate comparisons between benthic communities and potential contaminant concentrations, sediment samples will also be collected at all benthic sites at the time of sampling.

Benthic Invertebrate Sampling

Sample collection techniques for benthic surveys are to follow the same methods described for sediments (see below). At each sampling station, five replicate benthic samples should be collected, with each of these samples consisting of a composite of 10 Ekman (or equivalent) dredges, as per the Metal Mining Guidance Document (Environment Canada 2002) for Environmental Effects Monitoring. The five replicate benthic samples should be spaced approximately 20 m apart. Samples of benthic organisms are to be preserved in 10% buffered formalin solution. Immediately following collection, the benthic samples should be placed in a field cooler and kept as cool as possible until shipment for laboratory analysis.

Similar to sediments, all methods for analysis of benthic invertebrates should follow protocols recommended in the Metal Mining Guidance Document noted above (Environment Canada 2002). Benthic invertebrates should be identified to the genus and species level, whenever possible. Basic statistical analysis should be carried out on the invertebrate data collected during the invertebrate survey. Arithmetic mean, median, standard deviation, standard error and minimum and maximum values are to be calculated for a number of endpoints including Taxon Richness, Total Density, EPT (number of taxa of *Ephemeroptera, Plecoptera*, and *Tricoptera*), and the density of major taxonomic groups (*Oligochaeta, Crustacea*, etc.) and taxon presence/absence. These endpoints are simple and useful in condensing complex benthic data and are easily interpretable.

Sediment Sampling

Sediments collected from the benthic sampling sites will be analyzed for moisture content, particle size distribution, total organic carbon and a full suite of metal parameters listed previously in Table 14.2.3. Sediment collections will employ a standard sampling apparatus such as an Eckman (or equivalent) dredge. The recommended sediment sampling protocol involves the use of clean latex gloves for sub-sampling and thorough rinsing of all sampling equipment (e.g., dredge and sub-sampling receptacles) to avoid cross-contamination between samples. To reduce any bias associated with non-homogeneous concentrations, samples for metals analysis are to be collected in triplicate from each station using separate dredge grabs. Metal concentrations should be evaluated based on the average of the triplicate results.

The recommended analytical technique for metals is ICP-MS following a high temperature nitric acid digestion as described by the U.S. EPA method 200.8.

Yellowknife Bay

Benthic communities in Yellowknife Bay were assessed in 1976 when effluent from Giant Mine contributed to elevated concentrations of arsenic and other metals in the bay and more recently in 2004 in a survey of chemical, physical and biological characteristics of sediments from Latham Island to the mouth of Yellowknife River (Golder 2005a). The Long-term Monitoring Program will assess benthic communities in Yellowknife Bay every three years in the vicinity of the treated effluent discharge point from the proposed water treatment plant (see Figure 14.2.5) and in Back Bay within the breakwater in the vicinity of the Baker Creek mouth. In addition, a reference area will be established in the south end of Yellowknife Bay in the embayment located offshore from the Dettah community. Sediment samples will also be collected from these locations during benthic sampling.

14.2.3.3 Aquatic Vegetation

Several studies have documented the distribution of vegetation within Baker Creek due to the importance of emergent macrophytes as a food source and habitat for wildlife species (e.g., muskrat) as well as a cover and food source for young fish. Past disturbances of the Baker Creek stream banks during mine development and construction of Highway 4 caused the loss of much of the natural vegetation in some areas. The proposed remediation works on Baker Creek are also expected to cause some short-term disturbances to the emergent vegetation.

In the Long-term Monitoring Program, it is proposed that emergent vegetation in Baker Creek be sampled on two occasions. The first sampling campaign should occur as soon as possible in the pre-remediation period, prior to the initiation of any remediation work, in order to completely characterize pre-remediation conditions. The study will focus on Reach 0 of Baker Creek, which occurs in Back Bay where the creek flows into Great Slave Lake, as well as a few other areas along the creek, especially where remediation works are planned or have been completed, such as Reach 1 (adjacent to A1 Pit), Reach 3 (adjacent to C1 Pit) and the realigned Reach 4 (between C1 and B1 pits). The vegetation surveys will assess plant distribution at the study sites and will target particular species for metal analyses. Target species would include cattails and other emergent macrophytes that are consumed by muskrat and other wildlife.

The second sampling campaign should be conducted once all remediation work on Baker Creek is completed and aquatic vegetation is re-established. When the SOE review determines that remediation work on Baker Creek is complete and aquatic vegetation has been re-established in remediated areas, it is recommended that follow-up sampling for emergent vegetation in Baker Creek be conducted in the subsequent 3-year SOE reporting period.

14.2.4 Terrestrial Environment Monitoring

14.2.4.1 Vegetation and Soil

It is anticipated that terrestrial vegetation will be affected in areas where remediation works are completed. During long-term monitoring, sampling of terrestrial vegetation will be completed in a single campaign that will be limited to previously impacted, remediated and revegetated areas occurring within the Giant Mine lease, as well as a suitable reference area. At the time of vegetation sampling, soil samples should also be collected from the same locations to assist in identifying contaminant correlations. The timing of the sampling campaign will be determined through the SOE reviews. When successful revegetation is reported in remediated areas, it is proposed that terrestrial vegetation sampling would be conducted in these areas within the subsequent 3-year SOE reporting period.

Sampling of terrestrial vegetation should focus on pertinent plant species such as medicinal plants with cultural significance (e.g., Labrador tea, berries) and forage species. Terminal leaves and twigs from several plant species in the area are collected for analysis. Plant species such as birch and willow are known to accumulate inorganic contaminants from contaminated soils in terminal leaves and twigs and may serve as an exposure pathway to browsing wildlife. Labrador tea has been shown to be particularly useful for assessing spatial distributions of contaminants on large mine sites because of the large surface area of the leaves and its ability to collect dust fall. When present, opportunistic sampling of edible berries should also be performed.

Soil samples are collected from the upper 2 cm of soil using a stainless steel trowel once leaf litter and extraneous materials are removed. A sub-surface sample is also collected from each station at a depth of approximately 15 cm.

Vegetation and soil samples will be analyzed for moisture content and metals listed previously in Table 14.2.3. All analyses should follow standard analytical protocols (e.g., U.S. EPA Method Number SW846 3050B Revision 2 for metals and U.S. EPA method 7470A for mercury). Methods include analytical blanks, spiked samples, and standard reference materials. The rationale and minimum required procedures for rigorous quality control are clearly defined in documentation supporting the methods. The QA/QC program is designed to ensure data of known quality which is defendable and is deemed suitable for the current project. All analytical data should be evaluated statistically to determine average concentrations and distributions for soil and individual vegetation species. Potential correlations between soil and plant species should also be ascertained. Appropriate environmental criteria have not been established for vegetation. Instead, areas of potential concern are to be identified through statistical comparisons and results obtained from background sites.

14.2.4.2 Wildlife

Wildlife surveys will be completed on three occasions during long-term monitoring and will be limited to remediated areas within the Giant Mine lease property. The first survey should occur as soon as possible in the pre-remediation period (Year 0), prior to the initiation of any remediation work at Giant Mine, in order to establish current baseline conditions. Two more campaigns will be conducted at years 5 and 15 of the remediation period. The wildlife surveys will focus on observations of presence/absence and area usage by small and large mammals and avian species as well as those listed as "at risk" or "may be at risk" in the NWT General Status Ranks. For birds, monitoring will include migratory bird surveys.

14.2.5 Air Quality Monitoring

Existing Monitoring Program

A routine air quality monitoring program at the Giant Mine site was initiated in 2004 and has been carried out annually in the summer months. The objective of the program was to establish a baseline for the fugitive particulate emissions pertaining to the tailings areas and other on-site sources such as disturbed areas and travelled routes prior to the completion of remediation works. Sampling has consisted of ambient air monitoring of total suspended particulate (TSP) matter at the nearest residential location in the former Giant Mine townsite, and both TSP and inhalable particulate matter (PM_{10}; fraction <10 µm) at four locations within the boundary of the Giant Mine site. Samples are collected over a 24-hour period on every 6th-day using a High-Volume sampler at the Giant Mine townsite and Mini-Volume samplers at the on-site locations. Total and inhalable particulate loading and metal content are determined on each sample.

Proposed Long-term Monitoring Program

Monitoring of site-wide air quality will continue during the remediation phase, however, it is proposed that several of the monitors be relocated to more secure locations, as shown in Figure 14.2.6. The high-volume sampler at the former Giant Mine townsite may need to be relocated to accommodate reclamation of the area and changes in the power lines. The mini-vol monitors will need to be relocated as sites where they are currently located are likely to be affected by remediation activities. The locations shown in Figure 14.2.6 were selected to monitor air quality at key locations near the lease boundary of the site. The site wide air quality monitoring will be continued until surface remediation activities are complete and for three years thereafter. At that time, the need for continued monitoring will be assessed and recommendations developed for revisions to the program as appropriate.

Figure 14.2.6 Proposed Long-term Air Quality Monitoring Stations

Remediation activities are expected to have two main effects on air quality that will need to be addressed. With respect to air quality, it is anticipated that some of the remediation works will produce dust. Fugitive dust will need to be monitored during tailings regrading and covering, excavation of contaminated soil, and demolition of buildings. A proposed sampling schedule and list of sampling parameters for fugitive dust are shown in Table 14.2.9. Monitoring locations and other details will be defined in dust control plans specific to each activity.

Under the *NWT Environmental Protection Act*, the GNWT has adopted a number of concentration limits as ambient air quality standards (see Table 14.2.10). The GNWT standards are used in the assessment of air quality monitoring data as well as for determining the acceptability of emissions from proposed and existing developments. Where GNWT standards are not available for a particular pollutant, limits established in other jurisdictions are typically considered. This is the case for airborne arsenic, where the Ontario Ministry of the Environment's Ambient Air Quality Criterion of 0.3 $\mu g/m^3$ (24-hour average) has been used by the GNWT as a benchmark in its air quality reporting. The GNWT has not adopted a standard for PM_{10}, but several Canadian jurisdictions, including British Columbia and Ontario have adopted a PM_{10} concentration of 50 $\mu g/m^3$ that has been also been considered by the territorial government.

Table 14.2.9 Task Specific Air Quality Monitoring Schedule and Parameters

Reclamation Activity	Sampling Schedule	Parameters
Tailings regrading and construction of covers	Every 6 days	TSP, PM_{10}, and arsenic
Demolition of arsenic and asbestos contaminated facilities	Daily	TSP, PM_{10}, arsenic and asbestos
Excavation of contaminated soils	Daily	TSP, PM_{10}, and arsenic

Table 14.2.10 Ambient Air Quality Standards

Parameter and Standard	GNWT Ambient Air Quality Guidelines (μg/m^3)	Canadian National Ambient Air Quality Objectives	
		Maximum Desirable Concentration (μg/m^3)	Maximum Acceptable Concentration (μg/m^3)
Sulphur Dioxide (SO_2)			
1-hour average	450	450	900
24-hour average	150	150	300
Annual arithmetic mean	30	30	60
Nitrogen Dioxide (NO_2)			
1-hour average	-	-	400
24-hour average	-	-	200
Annual arithmetic mean	-	60	100
Total Suspended Particulate (TSP)			
24-hour average	120		120
Annual geometric mean	60	60	70
Fine Particulate Matter (PM_{10})			
24-hour average	50 (μg/m^3) (Ontario Ministry of the Environment Ambient Criterion)		
Fine Particulate Matter ($PM_{2.5}$)			
24-hour average	30	30	-
Airborne Arsenic			
24-hour average	0.3 (μg/m^3) (Ontario Ministry of the Environment Ambient Criterion)		

14.2.6 Physical Monitoring and Inspections

The Long-term Monitoring Plan for the site calls for a permanent staff presence to operate the water treatment systems. Site staff will also carry out daily or weekly monitoring of access roads, security fences, pit wall safety berms, power supplies, thermosyphons, tailings covers, ditches and spillways.

Spillways, ditches, and relocated sections of Baker Creek will be inspected annually by a geotechnical engineer. The tailings and sludge covers will be inspected annually for five years or until vegetation is fully established and erosion rates reach those consistent with the local environment. It is proposed that pit walls, crown pillars, and closed mine entries will be inspected annually for five years and every second year for ten years thereafter or as otherwise in conformance with the NWT *Mine Health and Safety Act.*

14.2.7 Construction Activity Monitoring

In addition to the monitoring components and activities that were outlined in the previous sections for the Long-term Environmental Monitoring Plan, sampling plans will also need to be developed to monitor for potential environmental effects resulting from specific construction/remediation activities or to confirm the effectiveness of particular remediation works (e.g., confirmatory soil sampling to ensure petroleum hydrocarbon removal). Such plans will be developed prior to initiating the particular construction/remediation activity requiring environmental monitoring. INAC, and PWGSC, through its procurement responsibilities, will retain oversight and monitoring responsibilities for the actions of all remediation contractors, including the design and implementation of activity-specific monitoring.

With respect to water quality, construction activities on Baker Creek are expected to cause erosion resulting in increased water turbidity. The effects of erosion will need to be monitored regularly in the creek during the implementation of construction activities such as upgrading the creek section that flows past the A2 Pit (Reach 1); upgrading the culvert or realigning the channel and building a bridge downstream of the A2 Pit at the highway crossing; and, abandoning the diversion around the C1 Pit (Reach 3) and building a new channel to the east of the pit along the current highway alignment.

During the implementation of remediation measures, it is expected that revisions to construction activities may be required from time-to-time to address environmental issues that were not foreseen. To ensure that environmental issues are identified in a timely manner, INAC will ensure that a qualified environmental professional will be on-site over the duration of the Remediation Project and have authority to direct the contractor(s) on corrective action to be taken to minimize environmental effects.

14.2.8 Cumulative Effects Monitoring

While the cumulative effects assessment for the Project set out in Chapter 11 does not identify any significant cumulative effects, it is recognized by the Project Team that this conclusion was reached without full consultation with Aboriginal communities and the public. To address concerns about potential cumulative effects involving the Remediation Project, a cumulative effects monitoring program will be developed for Project implementation. It is envisaged that the program will include monitoring of contaminant levels in fish, wildlife and plant species that form an important part of the diet of the people living in the Local Study Area. The cumulative effects monitoring program will be designed in collaboration with Aboriginal communities and other interested parties.

14.3 Addressing Terms of Reference for Monitoring, Evaluation and Management

The *Terms of Reference* for the EA require the development of a program to monitor the environment both on and off the Giant Mine site. This includes the identification of specific requirements for the monitoring program. The following discusses how the proposed EMEF and the Long-term Environmental Monitoring Program satisfies these requirements:

a) *A framework for effects monitoring, evaluation, and management for all stages of the development*. Section 14.1 sets out a management framework for effects monitoring including the establishment of an Environmental Management System and Environmental Management Plans designed to translate the commitments of the DAR, assessment outcomes and regulatory and licensing requirements into objectives and targets that will be subject to evaluation.

   A Long-term Environmental Monitoring Program that spans the 25-year duration of the Project and monitors effects in relevant components of the environment that may be affected by the Remediation Project (frozen ground, surface and ground water, air, aquatic ecology, and terrestrial environment) is outlined in Section 14.2. The program includes monitoring of effects on aquatic and terrestrial biota as measures of the health of the ecosystems both on-site and off-site. Included in the program are plans for evaluating monitoring data and reporting requirements that allow for periodic assessments of the program and recommendations for program modifications. As part of adaptive management, where issues are identified, follow-up investigations will be designed to determine the cause(s) of adverse effects and corrective actions required.

b) *Monitoring standards, methodologies, and requirements for water quality, ground temperature, ecological effects and sediment contamination, and the effectiveness of mitigation and compensation measures*. Monitoring standards (e.g., QA/QC procedures) have been specifically addressed in Section 14.2 where applicable. In all cases, standard accepted methods and protocols for field sampling and laboratory analyses will be followed in sampling all environmental media. The monitoring programs outlined in prior sections are designed to measure the effectiveness of mitigation measures and effects of Remediation Project activities/components on the receiving environment (e.g. the performance of the minewater treatment system and the effects of the discharge on quality on receiving water and fish).

c) *Criteria for evaluating monitoring results, including triggers and thresholds for actions.* Applicable criteria include the discharge limits defined in the former water license and by MMER for treated effluent (see Section 14.2.2.3 - Table 14.2.7); CCME guidelines for the protection of freshwater aquatic life (see Section 14.2.2.4); and, sediment quality guidelines developed by CCME (see Section 14.2.3.2). For soils, the GNWT criteria for industrial land use would apply. Criteria have not been proposed for groundwater as the groundwater system at the Giant Mine site discharges to the underground mine workings and is subsequently pumped to surface for treatment. Criteria have not been proposed for aquatic and terrestrial vegetation as effects concentrations are species-specific and assessment of the health of biota is most effectively accomplished through field investigations.

d) *Internal management systems to ensure that results are properly assessed.* As set out in Section 14.1 a management structure consisting of an Oversight Committee made up of senior-level representatives from INAC and the GNWT is identified as having ultimate responsibility for ensuring the appropriateness and effectiveness of monitoring programs. To support their decision-making, auditing and reporting mechanisms have been identified as part of an Environmental Management System.

   Additionally, the role of the Oversight Committee will be supported by a GNWT-Government of Canada Giant Mine Remediation Intergovernmental Working Group, the role of which will be to ensure that the activities of federal and territorial departments contributing to the remediation of the Giant Mine site are integrated to the greatest extent possible and that information is shared to support overall due diligence in the remediation of the site.

   For the Long-term Environmental Monitoring Program, two levels of reporting are proposed involving periodic reviews (annual reports and SOE reviews every three years) of all operational and environmental data to assess the effectiveness of on-site operations, and the effectiveness of remediation works and the monitoring program. In the case of the ground freezing system where very large data collections are expected, a data management system will be developed to ensure proper collection, manipulation and interpretation of data.

e) *Plans for responding to unacceptable monitoring results through project management actions, and confidence in the adequacy of the management options available.* Unacceptable monitoring results will be identified either immediately (e.g., effluent discharge exceedances or toxicity test failures) or during the annual or SOE reviews. Procedures are in place to deal with some unacceptable monitoring results (e.g., with respect to effluent discharge). In other cases, supplementary monitoring may be recommended to identify the cause of the unacceptable observations and to develop a response strategy. Revision to the monitoring program is also expected to occur as a result of the annual or SOE reviews and audits.

f) *A description of any technology used in the implementation of the monitoring activities, and monitoring locations, frequency and duration*. Monitoring locations, frequency and duration are identified for all components monitored in the Long-term Environmental Monitoring Program and this information is summarized in Table 14.2.1. Technologies used in the implementation of monitoring activities are described where applicable and appropriate (e.g., multi port well system, ground freezing system).

g) *A schedule of anticipated activities to implement the monitoring program*. A number of monitoring activities currently occurring on the site, particularly in relation to monitoring surface water and minewater quality, will remain ongoing. New monitoring programs not already identified as part of the Long-term Environmental Monitoring Program will be identified and implemented as part of Environmental Management Plan development. Environmental Management Plans are anticipated to be prepared through 2010 and 2011.

h) *Plans to periodically review the efficacy of the proposed monitoring program and technologies used and a re-evaluation of the goals and benchmarks of the monitoring program.* This framework sets out auditing and two levels of reporting that will be used to evaluate monitoring results and to assess the monitoring program, technologies employed and goals and objectives of the various components of monitoring programs. The data from the Long-term Environmental Monitoring Program will be summarized in annual reports while an SOE report will be prepared every three years.

i) *Plans to engage with local communities in the development, implementation and review of monitoring activities.* Engagement and re-engagement of communities as the Remediation Project advances and in response to monitoring results is anticipated throughout the life of the Project. The public and Aboriginal communities will also have an ongoing role in shaping specific environmental monitoring activities as the Remediation Project moves from the EA to water licensing stage.

The GNWT and INAC recognize that Aboriginal communities will be important partners in ensuring that sound environmental management objectives for the Remediation Project are established and met and that the need to review and periodically amend or establish new systems and objectives in the interest of Aboriginal communities will be necessary. To establish Aboriginal involvement throughout the life of the Project INAC will work with local Aboriginal communities and organizations to create the mechanisms to support a direct and distinct Aboriginal role in the planning and implementation of monitoring and evaluation activities for the Remediation Project.

j) *The anticipated lifespan of active monitoring activities.* Most monitoring activities (e.g., water quality monitoring) are expected to continue throughout the duration of the Project while others (e.g., wildlife monitoring) may only occur on few occasions during the Project. This information is summarized in Table 14.2.1.

k) *Anticipated redundancies in the monitoring program.* Redundancies in the monitoring program will be identified through the annual and SOE reviews of the operational and environmental data. Some redundancies, for example with respect to aquatic and terrestrial vegetation and wildlife monitoring, have already been anticipated which is reflected in the number of sampling events for certain program components (see Table 14.2.1).

The terms of reference also require that the following assessments be provided:

l) *An assessment of the ability of the monitoring program to adequately detect and identify small arsenic trioxide leakage from the frozen block.* The minewater monitoring program which encompasses both sampling of water pumped from the mine as well as monitoring of minewater at several locations via the deep minewater monitoring wells will provide data on changes in arsenic levels over time. As the minewater monitoring network surrounds the arsenic trioxide chambers, the data collected from the well would be expected to provide an early warning of arsenic escape from the chambers (i.e., a sharp rise in the arsenic concentration in any of the samples would trigger follow-up investigations into the cause of the increase). Likewise, changes in the temperature of the multiple sensors installed in and around the freeze system on all chambers would trigger follow-up investigations. Additional information on the measures that will be in place to identify potential releases from the frozen block method is presented in Section 6.2.8.2 (Chain of Events Analysis).

m) *An assessment of the ability of the monitoring program to adequately protect human health and safety and the integrity of the local ecosystem, with consideration given to the potential impact of a catastrophic malfunction*. Risks associated with the Remediation Project, including those that could lead to a catastrophic malfunction, have been considered in detail. This includes consideration of contingencies for water storage should there be lengthy disruptions in power for mine pumping, bulkhead failures resulting in arsenic trioxide releases to the lower working of the mine, an analysis of a prolonged and cascading failure of the frozen block containment, the effects of seismic events, climate change and severe weather & flooding and the impact of accidents and malfunctions on the Remediation Project.

The comprehensive monitoring programs proposed in Section 14.2 have been designed to provide an early warning of changes in environmental quality, including those changes that may lead to a catastrophic malfunction, and thus provides the information necessary to take action to protect components of the environment, including human health. The monitoring programs include both on-site and off-site monitoring and are designed to measure environmental quality both during and following remediation activities such that a catastrophic malfunction without warning is highly unlikely.

15 Summary and Conclusions of the DAR

The *Giant Mine Remediation Project Developer's Assessment Report* was produced as a consequence of the referral to environmental assessment of INAC's water licence application to implement the Giant Mine Remediation Plan. The Giant Mine Remediation Plan represents the approach selected by INAC and the GNWT to minimize the risks posed by contaminants and physical hazards present at the Giant Mine site.

The DAR is based on the direction provided in the *Terms of Reference* that was issued by the Review Board in May, 2009. In addition to requiring a description of the development and its surrounding environment, the *Terms of Reference* have also directed the Project Team to provide a prediction of the impacts that might occur from the implementation of the Remediation Project and the potential significance of those predicted impacts. The DAR's conformity to the *Terms of Reference* is presented in Table 2.7.1. Where further clarification might be required, the Project Team will work with the Review Board and the Parties to the EA to ensure that the information necessary for them to assess any potential environmental effects is made available in a timely manner.

The DAR is anticipated to be a key reference for the Review Board as it decides whether the Remediation Project is, or is not likely to have a significant adverse effect on the environment, or be a cause of significant public concern. To facilitate the Review Board's review and decision-making, this chapter provides a summary of the conclusions of the DAR.

15.1 Conclusions of the Developers Assessment Report

The Project Team is of the opinion that the DAR has met the requirements of the *Terms of Reference* and that the DAR also reflects the principles and standard practices of environmental impact assessment, with the unique context of the Northwest Territories in mind.

In preparing the DAR, the Project Team has:

- Identified mitigation measures for addressing potential environmental effects, some of which will be incorporated into the Remediation Project design to pre-empt environmental consequences, and others that were identified through the EA process to further reduce the potentially adverse effects of the Remediation Project;
- Committed to the development of an Environmental Monitoring and Evaluation Framework and Environmental Management System to ensure that the environmental safeguards (mitigation) proposed in the DAR are implemented as operational procedures;
- Considered issues of malfunctions and accidents, as well as cumulative effects;

- Considered 10 years of consultation with interested parties in the Local Study Area who might be affected by the Project;
- Proposed a consultation and engagement strategy to respond to potential issues and concerns as the Project goes forward; and
- Compiled a list of commitments which is intended to assure the Review Board, Parties to the EA and the general public that the Remediation Project will be implemented in a manner that is protective of the environment and consistent with the findings of the DAR.

15.1.1 Effects of the Project on the Environment

The DAR includes an assessment of the potential effects of the Remediation Project on the environment. The environment, for the purpose of the DAR, was categorized into seven individual environmental components and 22 environmental sub-components.

Based on Project-environment interactions, a number of potentially adverse effects were identified. Generally, the adverse effects identified were temporary, localized, amenable to standard mitigation practices, or associated with areas that have limited ecological value (i.e. effects occurring on already contaminated habitat). Residual adverse effects (i.e., after mitigation) were identified for the following environmental components: Surface Water Environment, Geological & Hydrogeological Environment, Aquatic Environment, Terrestrial Environment and Additional Community Interests.

All the residual adverse effects were evaluated for significance and were determined to be minor and non-significant. Overall, it is anticipated that the Remediation Project will result in substantial long-term positive effects through the remediation of existing site hazards. The principal positive effect relates to the permanent reduction and isolation of contaminants within the SSA and the associated reduction in the risk and exposure of ecological and human receptors to those contaminants. To confirm this important positive outcome, the Project Team will, as described in Chapter14, implement a comprehensive monitoring program, the results of which will be reported to the regulatory authorities.

As a summary, the positive and potential adverse effects of implementing the Remediation Project are presented in Table 15.1.1.

Table 15.1.1 Summary of Remediation Project Positive and Adverse Effects

Environmental Sub-component	Positive Effects of Project Implementation	Potential Adverse Effects of Project Implementation
Hydrology	• A return to more natural hydraulic conditions in Baker Creek through elimination of seasonal minewater discharge • Physical rehabilitation of heavily-altered channel will reduce the risk of flooding the underground mine workings	• None
Surface Water Quality	• Long-term reduction in contaminant loading due to the remediation of surficial material • Removal or isolation of contaminated sediments in Baker Creek • Installation of a new minewater treatment system with discharge to Yellowknife Bay	• Potential for short-term increases in turbidity and contaminant mobilization, mainly through earthworks, de-contamination and infrastructure installation activities
Sediment Quality	• Sediment quality in Baker Creek improved by rehabilitation activities • Long-term reduction in contaminant loading from remediated surficial materials in the SSA	• Potential for further contamination of sediments in the short-term as a consequence of earthwork activities
Groundwater Flow	• Control over groundwater within the SSA to continue during the two phases of project implementation through control of the water level in the mine	• None
Groundwater Quality	• Remediation of underground workings, surficial material and capping of tailings impoundments will reduce contaminants loading to groundwater • Minewater quality expected to improve substantially with implementation of the frozen block method	• None
Permafrost	• None	• Possible localized loss of permafrost
Soil Quality	• Long-term reduced concentrations of contaminants in soils within the SSA	• Potential for small-scale contamination of soils through minor operational releases of hydrocarbons or arsenic-contaminated materials during remediation
Air Quality	• Long-term improvement in air quality through remediation of surficial materials and construction of vegetated covers on tailings impoundments and other disturbed areas	• Potential short-term impairment to air quality from elevated levels of dust, airborne arsenic, SO_x and NO_x during construction and transportation
Noise Environment	• None	• Short-term increase in noise during the remediation phase

Table 15.1.1 Project Advantages and Disadvantages (Cont'd)

Environmental Sub-component	Advantages	Disadvantages
Aquatic Biota and Habitat	• Reduction in exposure levels of aquatic species to contaminants (particularly arsenic) in Baker Creek in the post-remediation phase • Creation of new fish habitat in Baker Creek during re-alignment and remediation of the creek	• Temporary loss of aquatic habitat due to Baker Creek rehabilitation and the extension of the foreshore tailings cover • Effects to aquatic habitat in a small area in Yellowknife Bay due to installation and operation of the water treatment outfall/diffuser
Terrestrial Biota and Habitat	• Reduction in long-term exposure of terrestrial species to contaminants • Creation of new habitat that is not compromised by high concentrations of contaminants (e.g., rehabilitated reaches of Baker Creek)	• Disturbances to habitat due to earthwork activities • Loss of existing habitat in Baker Creek during remediation activities • Potential loss of raptor habitat with demolition of existing surface infrastructure • Elevated noise may discourage terrestrial species from using the site during remediation phase
Non-Human Biota and Human Health	• Reduction of long-term risk from contaminant exposure • Demolition of buildings and sealing of mine openings will eliminate long-term safety risks to wildlife and members of the public • Isolation of the arsenic trioxide dust within frozen blocks will effectively eliminate long-term risks • Backfilling open pits or constructing physical barriers around the open pits will reduce physical hazard	• Residual contamination on parts of the Giant Mine site will pose low level risk to human users who may harvest medicinal plants, berries or small wildlife • Residual contamination on the Giant Mine site will pose a low level risk to some non-human biota
Aboriginal Communities	• Reduction of long-term risk from contaminant exposure • Improved confidence in ecosystem health	• Short-term potential for perceived health risks
Traditional Land Use	• Remediated site to be more amenable to Aboriginal Traditional Land Use practices • Reduction in the long-term contaminant exposure to resources associated with traditional use	• Short-term potential for perceived risks to traditional resources
Aboriginal Heritage Resources	• None	• Potential for disturbance of archaeological / heritage resources
Land Use, Visual & Cultural Setting	• Opportunities for new land uses within the SSA after remediation • Improved visual condition • Potential for study, research and improved knowledge of local history	• Potential short-term disruption of community activities near SSA • Possible permanent loss of buildings and surface infrastructure with heritage value

Table 15.1.1 Project Advantages and Disadvantages (Cont'd)

Environmental Sub-component	Advantages	Disadvantages
Socio-economic Conditions	• Employment and business opportunities for construction-related activities, especially for Aboriginals and other northerners • Long-term employment and business opportunities for on-going water treatment plant and freeze plant operation, monitoring and maintenance activities, especially for Aboriginals and other northerners • Training opportunities for NWT residents	• Possible short-term shortage of certain trades and skill sets within local and regional labour markets
Transportation	• None	• Potential for temporary reduced level-of service on public roads within the SSA.
Local Resources	• None	• Potential to reduce overall supply of aggregate materials within the LSA

15.1.2 Effects of the Environment on the Project

The potential effects of severe weather conditions and other credible natural hazards on the implementation of the Remediation Project were assessed. A number of potential effects, such as damage due to flooding or seismic events were identified. However, it was determined that the combination of design features and external mitigation measures would be sufficient to address all potential adverse effects of the environment on the Remediation Project. No significant effects were predicted. A notable finding regarding this aspect of the EA is the conclusion that the proposed passive freeze system is suitably robust against a "worst case" climate change scenario. In the event that higher than anticipated rates of warming, or lower than anticipated thermosyphon efficiency occurred, the frozen block could be maintained by increasing the number of thermosyphons.

15.1.3 Cumulative Environmental Effects

The potential effects of the Remediation Project, in combination with the overlapping effects of other projects and activities (i.e., cumulative effects), was considered in the DAR. Cumulative effects can occur if there are spatial and temporal overlaps with a project under assessment. A set of other projects with the potential to overlap with the Remediation Project at the site, local and regional scales was identified. Those projects were evaluated to determine if their effects could combine with the residual adverse effects of the Remediation Project. Although several potential cumulative effects were identified, none were found to be significant. As a consequence, additional mitigation measures are not necessary to protect the environment.

15.1.4 Accidents and Malfunctions

The DAR considered upset events that might occur during either phase of Project implementation. Credible accidents and malfunctions were screened to determine if measurable adverse environmental effects could be expected. The evaluation of potential accidents and malfunctions during Project implementation concluded that adverse effects on the environment are unlikely. The detailed designs that are developed for the Remediation Project will incorporate strict safety standards to provide personnel, members of the public and the surrounding environment protection from the effects of abnormal events that might occur during the implementation of remedial measures and the long-term operation and maintenance phase.

15.2 Next Steps

The submission of the DAR represents a major milestone in the EA process. As outlined in the Review Board's EA workplan, the analytical phase of the EA will continue with the requirement that the Project Team respond to Information Requests directed to it, participate in technical meetings and prepare technical reports. The Project Team will ensure that it has sufficient resources available to it to address those procedural requirements in an efficient and expedient manner. In addition to its responsibilities as a participant in the Review Board's process, the Project Team will concurrently be working on the following tasks in order to realize the Giant Mine Remediation Plan:

- Continue the Freeze Optimization Study, including the potential re-calibration of freeze-block design assumptions based on the data generated;
- Carry out additional consultation to verify the analysis and findings of the EA;
- Carry out additional consultation to acquire input on the Project Team's strategy for specific remediation components, particularly Baker Creek and the tailings covers; and
- Develop detailed designs for the various remediation components.

15.3 List of Commitments

Based on the prior experience of other developments undergoing environmental assessment by the Review Board, it has been found useful for Proponents to compile and submit a list of commitments. Clear identification of commitments in the environmental assessment process can sometimes lead to early agreement on specific issues, such that they are "taken off the table", which in turn allows participants to focus on the key remaining issues of concern. As noted previously, a commitment list is also intended to assure the Review Board, Parties to the EA and the general public that the Remediation Project will be implemented in a manner that is protective of the environment and consistent with the findings of the DAR. The anticipated additional project planning, reports and studies and the mitigation and monitoring elements of the project set out in tables 15.3.1 and 15.3.2 serve to summarize the commitments of the proponent made elsewhere in the DAR.

The commitments presented in Table 15.3.1 relate to the ongoing design of the Remediation Project. The table should not be considered an exhaustive listing of detailed design, but rather indicative of the ongoing commitment to the planning required to implement the Project in an environmentally responsible manner.

Likewise, while the commitments presented in Table 15.3.2 are drawn from the mitigation measures set out in the DAR, they should be considered preliminary. While these commitments represent the best assessment of the Project Team to minimize the environmental effects of the Project, it is understood that as the environmental assessment process goes forward, both in design and in Aboriginal and public consultation, new commitments may be agreed to and added. The commitments have been grouped into five categories, each with a different table, and include:

1. Anticipated Plans, Reports and Studies;
2. In-design Mitigation Features;
3. Mitigation and Monitoring During the Remediation Phase;
4. Post-Remediation Monitoring and Mitigation; and
5. Other Commitments.

Table 15.3.1 DAR Commitments - Anticipated Plans, Reports and Studies

Anticipated Plans, Reports and Studies	
Commitment	**Location in DAR**
INAC will prepare a comprehensive procurement strategy that optimizes employment, business and training opportunities for Aboriginal, local and northern residents.	Chapter 1, Section 1.4.4, Chapter 8, Table 8.11.3, Table 8.11.5
A detailed design for the remediation of Baker Creek will be prepared with active involvement from Aboriginal communities, Yellowknife residents, and government departments. The detailed design for the rehabilitation of Baker Creek will be based upon, among other things, flood carrying capacity, habitat creation, erosion resistance and the restoration of a natural hydrograph.	Chapter 8, Table 8.4.2, Table 8.7.2
Results of the freeze optimization study will be used as input to the detailed engineering and design process.	Chapter 6, Section 6.2.9.1
A detailed revegetation plan, which includes studies to select species and define seeding, planting and fertilization requirements will be produced.	Chapter 6, Section 6.6.6 Chapter 8, Table 8.8.2

Table 15.3.1 DAR Commitments - Anticipated Plans, Reports and Studies (Cont'd)

Commitment	Location in DAR
Design of a new water treatment plant that will be based upon Best Available Technology for the separation of arsenic precipitates from the treated water.	Chapter 6, Section 6.8.5
An engineering study of alternative on-land and offshore outfall and diffuser installation methods will be completed. The detailed designs for the outfall and diffuser will be based on the findings of this study.	Chapter 6, Section 6.8.6 Chapter 8, Table 8.4.5
Plans will be developed for the demolition of buildings and handling of waste, based on current industry best practises that meet local requirements for protecting the safety of site workers and the public, and protection of the environment.	Chapter 6, Section 6.11.1
Environment, Health and Safety Plans for implementation of the Project will be developed, which will include details regarding: • Emergency/spill response; • Erosion and sedimentation controls; • Dust management; • Building demolition; • Fuel management; • Protocols for vegetation surveys; and • Measures to respond to potential transportation incidents.	Chapter 8, multiple sections
Plans will be developed for the collection and management of contaminated water generated during remedial works (e.g., excavation water contaminated with arsenic or hydrocarbons).	Chapter 8.4.5
A Wildlife Management Plan will be developed.	Chapter 8, Table 8.8.2
Habitat surveys will be conducted in any areas that are to be disturbed to confirm that rare or endangered species are not present.	Chapter 8, Section 8.8.2.4
Pre-demolition audits will be conducted to determine if structures to be demolished are being used as wildlife habitat.	Chapter 8, Table 8.8.2
A protocol for the management and reporting of archaeological artefacts and sites will be developed.	Chapter 8, Table 8.10.3
Memoranda of Understanding (or similar types of arrangements) will be developed with key emergency response services providers.	Chapter 8.11.3
A Traffic Management Plan will be developed.	Chapter 8, Table 8.11.4

Table 15.3.2 DAR Commitments - Mitigation, Monitoring and Other Commitments

A) In-design Mitigation Features	
Commitment	**Location in DAR**
The freeze system (active and passive) will be designed to remain effective under "worst case" climate change scenarios.	Chapter 9, Section 9.2.3
Mine openings to surface will be sealed with structures requiring minimal maintenance to remain stable and effective in the long-term.	Chapter 6, Section 6.3.4
Physical barriers will be established around the perimeter of the A1, A2, B2, B3 and C1 pits; the B1 and Brock pits will be backfilled.	Chapter 6, Section 6.4.3, Table 6.4.1
Only demolition material from buildings that can be decontaminated of hazardous materials will be disposed in a non-hazardous waste facility.	Chapter 6, Section 6.12.1
Process residues 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 freeze zones.	Chapter 6, Section 6.12.2
The footprint of areas requiring disturbance of vegetation is to be minimized.	Chapter 8, Table 8.4.2 & Table 8.6.7 & Table 8.11.2
To the extent feasible, disturbance of areas known to possess permafrost will be avoided.	Chapter 8,Table 8.5.4
New borrow sources will only be used in situations where insufficient material is available from previously disturbed areas.	Chapter 8, Section 8.8.2.4
Free standing structures will be designed and built to meet applicable earthquake standards in the National Building Code.	Chapter 9, Section 9.2.3
Surface drainage (including spillways and conveyance structures) in remediated tailings areas will be designed to convey the selected PMP event. Designs will also accommodate increased surface flows associated with climate change (if any).	Chapter 9, Section 9.2.3
B) Mitigation and Monitoring - During the Remediation Phase	
Commitment	**Location in DAR**
Any spills of arsenic dust encountered during underground preparation will be cleaned up and deposited in the nearest accessible arsenic chamber or stope.	Chapter 6, Section 6.2.5.2
Temperatures in the frozen wall around each chamber or stope will be monitored throughout the initial freezing to ensure that the design criteria are met before dust saturation.	Chapter 6, Section 6.2.6

Table 15.3.2 DAR Commitments - Mitigation, Monitoring and Other Commitments (Cont'd)

Commitment	Location in DAR
During dust saturation, water addition rates and levels will be monitored within each chamber and stope, and any seepage into the surrounding drifts will be monitored.	Chapter 6, Section 6.2.8.1
Where concentrated sources of arsenic contaminated materials are encountered in stable underground workings, such as the main tunnels, they will be removed to a secure underground disposal site.	Chapter 6, Section 6.3.2
Hazardous material in the underground mine workings will be brought to surface for disposal in accordance with procedures appropriate to the material type.	Chapter 6, Section 6.3.3
Earthworks activities will be conducted using standard operational practices to control erosion and sedimentation. The sediment control works will be maintained and operated until the areas have been stabilized (e.g., through revegetation) and erosion is reduced to levels typical of natural areas.	Chapter 6, Section 6.6.9
Soils that are co-contaminated with petroleum hydrocarbons and arsenic will be deposited in a frozen zone. .	Chapter 6, Section 6.10
PCB-contaminated soil will be excavated, handled and disposed of in accordance with the *Guideline for the General Management of Hazardous Waste in the NWT*.	Chapter 6, Section 6.10
Hazardous materials, from building demolition, or other activities will be handled and disposed of according to industry best practices and the *Guideline for the General Management of Hazardous Waste in the NWT*.	Chapter 6, Section 6.11.3 Chapter 6, Section 6.12.2
Waste asbestos materials that are not contaminated with arsenic will be bagged and buried in the Northwest Pond in a designated hazardous material (HAZMAT) area.	Chapter 6, Section 6.11.3
Hazardous materials other than asbestos waste and arsenic trioxide contaminated waste will be disposed in an approved facility.	Chapter 6, Section 6.12.2
Bulk quantities of fuel will be stored in double-walled containers. The fuel dispensing area will be lined and a sump will be dug to collect any spills that may occur.	Chapter 8, Table 8.4.5 Table 8.5.2, Table 8.5.3
Spill kits will be available at fuel storage and dispensing facilities.	Chapter 8 Table 8.4.5, Table 8.5.2, Table 8.5.3
Spill response training will be provided to personnel.	Chapter 8, Table 8.4.5, Table 8.5.2, Table 8.5.3

Table 15.3.2 DAR Commitments - Mitigation, Monitoring and Other Commitments (Cont'd)

Commitment	Location in DAR
Daily inspection of vehicles and fuel storage facilities will be carried out.	Chapter 8 Table 8.4.5, Table 8.5.2, Table 8.5.3
Silt curtains will be employed during construction of the outfall to minimize the area affected by dispersion of sediment solids disturbed during placement of the outfall pipe and diffuser.	Chapter 8, Table 8.4.5
The in-stream rehabilitation of portions of Baker Creek will be carried out while the reach is dewatered whenever possible. In creek reaches where realignment is planned, remediation work can be carried out under dry conditions after creek flows have been diverted or during periods approved by DFO.	Chapter 8, Table 8.4.6
If permafrost areas cannot be avoided, excavations will be regraded/sloped, armoured and vegetated to promote permafrost development.	Chapter 8, Table 8.5.4
Clean-up kits will be kept at drilling sites in the event of a release of arsenic trioxide dust.	Chapter 8, Table 8.6.7
During the unfrozen period, haul roads and earthworks work areas will receive an application of a chemical suppressant or light watering to control dust.	Chapter 8, Table 8.6.7
All motorized remediation vehicles will be maintained in good condition in accordance with applicable regulations.	Chapter 8, Table 8.6.7
All heavy equipment will be equipped with standard industrial noise suppression devices.	Chapter 8, Table 8.6.8, Table 8.8.2
Consideration will be given to implementing remedial works during periods that avoid key life stages of resident and migrating species. Regulatory authorities are to be informed of specific activities that are anticipated to cause a disturbance.	Chapter 8, Table 8.8.2
The Project Team commits to working with the Yellowknives Dene First Nation to identify and preserve any graves and additional Aboriginal Heritage Resources that may be present within the SSA.	Chapter 7, Section 7.6.6.1
All areas that have the potential of being subjected to new surface disturbances will be evaluated by the Prince of Wales Northern Heritage Centre prior to the initiation of remediation to determine archaeological heritage potential.	Chapter 8, Table 8.10.3
Borrow sources will be regraded, contoured and, where possible, re-vegetated to encourage conformity with the surrounding landscape.	Chapter 8, Table 8.11.2
During extreme rainfall events, work stoppages will be	Chapter 9, Section 9.2.2.3

Table 15.3.2 DAR Commitments - Mitigation, Monitoring and Other Commitments (Cont'd)

Commitment	Location in DAR
implemented when remediation activities that could threaten water quality or the aquatic environment are being carried out.	
The Project Oversight Committee will be supported by a GNWT – Government of Canada Giant Mine Remediation Intergovernmental Working Group as described in Chapter 14. The role of the Working Group will be to ensure that the activities of federal and territorial departments contributing to the remediation of the Giant Mine site are integrated to the greatest extent possible, and that information is shared to support overall due diligence in the remediation of the site.	Chapter 13, Section 13.11
Both INAC and the GNWT are committed to developing an Environmental Management System (EMS) that will be central to the ongoing monitoring and performance improvement of the Giant Mine remediation Project.	Chapter 14, Section 14.1.1
An audit protocol, including third-party auditing, and review process will be an integrated part of the EMS.	Chapter 14, Section 14.1.1
The assessment of environmental performance, and compliance with the objectives and targets of the EMP's will be carried out through a regular program of monitoring and evaluation set out in the EMS.	Chapter 14, Section 14.1.3
Where activities on site are governed by specific authorities, for example protection of fish habitat under the *Fisheries Act* as enforced by DFO, the Project Team will work with such authorities to achieve compliance.	Chapter 14, Section 14.1.5
As the project advances, and in response to monitoring results, Aboriginal communities and the public will be engaged in the review of monitoring results and the identification of adaptive management approaches needed to address any environmental issues identified through the monitoring program.	Chapter 14, Section 14.1.6
To establish Aboriginal involvement throughout the life of the project, INAC will work with local Aboriginal communities and organizations to create the mechanisms to support a direct and distinct Aboriginal role in the planning and implementation of monitoring and evaluation activities for the Project, including the formation and funding for a joint Aboriginal and government body in cooperation with Aboriginal communities.	Chapter 14, Section 14.1.6.1
INAC and the GNWT will continue to support the Community Alliance in its role of sharing information about the remediation project with the Yellowknife community and relaying public concerns and issues about the remediation of Giant Mine back to INAC.	Chapter 14, Section 14.1.7
To ensure the effectiveness of efforts to manage risks, and to ensure that of themselves remediation actions do not	Chapter 14, Section 14.2

Table 15.3.2 DAR Commitments - Mitigation, Monitoring and Other Commitments (Cont'd)

Commitment	Location in DAR
contribute significant environmental effects, a long-term monitoring program will be developed and implemented.	
Annual Report(s) will be prepared annually to summarize and review all operational and environmental data collected in the 1-year reporting period.	Chapter 14, Section 14.2
Status of the Environment (SOE) Reports will be prepared every three years during the initial 15-year remediation period and every five years thereafter, to summarize, review and interpret the operational and environmental data collected in the reporting period and to provide recommendations for modification to the monitoring program or site operations that may be affecting environmental quality.	Chapter 14, Section 14.2
To address concerns about the effects on the Project and other projects on the receiving environment, a cumulative effects monitoring program will be developed as part of project implementation.	Chapter 14, Section 14.2.8
C) Additional Mitigation and Monitoring – Post Remediation[34]	
Commitment	**Location in DAR**
Water draining from the tailings containment areas will be directed to the minewater collection system for treatment until such time that water quality meets the arsenic concentration discharge criterion. Direct discharge (e.g., to Baker Creek) of surface drainage that does meet the arsenic discharge criterion will be permitted.	Chapter 6, Section 6.6
Monitoring wells will be installed within the sludge and tailings containment areas to permit long-term water level measurements and collection of pore water samples for analysis.	Chapter 6, Section 6.6.7
Water levels in the mine will be maintained significantly below the local static water level until such time that monitoring indicates it is suitable for release to the environment without treatment.	Chapter 7, Section 7.2.3
The occurrence of an earthquake with a magnitude of 5.0 or greater will prompt a geotechnical inspection of the tailings covers, dams, conveyance channels and other potentially vulnerable structures.	Chapter 9, Section 9.2.2.1

[34] The Environmental Monitoring and Evaluation Framework and the Environmental Management System established as part of it, as well as the Long-term Environmental Monitoring Program will continue into the post-remediation stage and in some form indefinitely.

Table 15.3.2 DAR Commitments - Mitigation, Monitoring and Other Commitments (Cont'd)

Commitment	Location in DAR
D) Other Commitments	
Commitment	**Location in DAR**
The Project Team remains open to improvements in the frozen block method, and will re-evaluate alternatives if technologies advance or if monitoring data indicate unforeseen emerging risks to the environment and/or humans.	Chapter 6, Section 6.2.2
INAC's Giant Mine Project Office will provide direct oversight of the project implementation, and continue to act as the lead for regulatory affairs, communications, and consultation.	Chapter 6, Section 6.13.1
The Project Team will secure the input of government wildlife regulators and traditional knowledge holders during work schedule planning in order that remediation activities consider the presence and key life stage of sensitive species in a work area.	Chapter 8, Section 8.8.2.4
The Project Team will maintain effective lines of communication with community organizations using land adjacent to the Giant Mine to encourage awareness of all parties of land uses that might be disturbed during the Remediation Phase.	Chapter 8, Table 8.11.2
The Project Team will continue to have dialogue with parties interested in preserving the Giant Mine's heritage buildings.	Chapter 8, Table 8.11.2
Remediation activities will be carried out within a regulated work environment under the authority of the Workers' Safety and Compensation Commission.	Chapter 8, Table 8.11.4

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Appendix A

Giant Mine Remediation Plan

Appendix B

Supporting Documents to the Giant Mine Remediation Plan

Appendix C

Additional Supporting Documents