# 2. Physical Impacts and Mitigation

In general, the physical impacts associated with the NWT Diamonds Project will be negligible when one considers the context in which the development will take place. While it is recognized that some local impacts will occur on a temporary basis within the claim block, the ecological integrity of the project area and the larger ecodistrict, ecoregion and ecozone will remain intact. Any potential physical impacts will result from disturbance of the terrain and hydrology. The significance of the residual effects of these impacts is summarized in Table 2-1. A comprehensive evaluation of impacts and mitigation is contained in Appendix IV-A1.

Terrain and permafrost impacts may include erosion, slope instability and subsidence. The severity is expected to be minimal due to the low topography and the implementation of good engineering design and construction practices for arctic regions. The wildlife habitat loss caused by quarrying eskers will be very small when one considers the amount of available habitat in the region. There will be a negligible residual effect on the permafrost layer from construction of the site infrastructure. Ground instability impacts will be negligible on a regional scale. Within the open pits, good engineering design and practice will minimize pit wall instability. Waste rock dumps will be located on stable substrates and benefit from new permafrost development. Waste dumps will also be contoured and revegetated to blend in with the surroundings. The residual effects from the open pits on ground instability will be negligible primarily because they will fill with water, submerging the pit walls, and the geographic extent of these lakes will be small compared to the number and size of lakes in the region.

Mine development will cause local impacts to the surface hydrology of the Koala watershed. Changes to present drainage patterns will result from the pit development, the Panda diversion channel and the release of water from Long Lake directly into Nema Lake. Short-term increases in stream flow will be experienced in watercourses downstream from lake dewatering operations. Stream flow will decrease in watercourses downstream of Moose Lake due to reductions in average runoff from Long Lake during mine operation. Changes in lake storage will result from the development of open pits where lakes now exist and the eventual formation of lakes in the mined-out pits. Overall, these effects are considered to be negligible to minor. There will be no detectable effect on the hydrology of Lac de Gras or the remainder of the Coppermine watershed.

Water quality will be affected by several project related activities such as sedimentation caused by construction of dams, roads and development of surface facilities and diversion channels near watercourses and lakes. The residual water quality and impacts from these activities is expected to be negligible or minor primarily due to the use of construction materials that contain a minimal clay

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Table 2-1
Summary of Physical and
Biological Residual Effects

| SIGNIFICANCE OF RESIDUAL EFFECTS | |
|---|---|
| Not applicable : | blank |
| Negligible : | ○ |
| Negligible/minor : | ● (yellow/orange) |
| Minor : | ● (green) |
| Minor/moderate : | ● (red) |
| Moderate : | ● (dark blue) |
| Moderate/major : | ● (black) |
| Major : | ● (red) |
| Unknown : | ? |
| Positive Impact : | ⊕ |

PROJECT PERIOD AND ACTIVITY

**EXPLORATION**

| VECs | Winter and Land/Barge Drilling | Noise | Bulk Sampling Facility | Tailings Disposal | Road Construction | Diesel Power Generation | Human Activity | Road Traffic | Quarrying | Presence of Roads | Sewage Disposal | Freshwater Supply |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Air Quality | | | Negligible | | | | | Negligible | | | | |
| Permafrost | | | | | Negligible | | | | | | | |
| Eskers | | | | | | | | | Minor | | | |
| Water Quality | Negligible | | Negligible | | Negligible | | | | | | | |
| Fish/Aquatic Habitat | Negligible | | | Negligible | Negligible/minor | | | | | | Negligible | Negligible |
| Vegetation | Negligible | | | | | Negligible | | | | | | |
| Wildlife/Wildlife Habitat | | | Negligible | | | | | | | Negligible | | |
| Caribou | | Negligible/minor | Negligible | Negligible | | | Negligible | | | Negligible/minor | | |
| Grizzly Bears | | Minor | Minor | | | | Negligible | | | Minor | | |
| Wilderness | | | | | | | Minor | | | | | |
| Biodiversity | | | | | | | Negligible | | | | | |
| Hydrology | | | | | Negligible/minor | | | | | | | |
| Climate | Negligible | | Negligible | | | Negligible | | | | | | |
| Groundwater | | | | | | | | | | | | |

**CONSTRUCTION**

| VECs | Blasting | Road Traffic | Roads, Dams, Infrastructure | Quarrying | Noise | Panda Diversion Channel | Lake Dewatering | Pre-stripping | Diesel Power Generation | Process Plant | Human Activity | Tailings Disposal | Flow and Stream Diversion |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Air Quality | Negligible | Negligible | | | | | | | | | | | |
| Permafrost | | | Negligible | | | | | | | | | | |
| Eskers | | | | Minor | | | | | | | | | |
| Water Quality | | | Negligible/minor | | | | | | | | | | |
| Fish/Aquatic Habitat | | | Minor | | | Negligible | Negligible/minor | | | | | | |
| Vegetation | | | Negligible | | | | | Negligible/minor | Negligible | | | | |
| Wildlife/Wildlife Habitat | | | Negligible/minor | | | | | | | Negligible/minor | | | |
| Caribou | | | Negligible/minor | | Negligible/minor | Negligible/minor | | | | Negligible/minor | Negligible/minor | Negligible/minor | |
| Grizzly Bears | | | Minor | | Minor | | | | | Negligible/minor | Negligible/minor | | |
| Wilderness | | | | | | | | | | | Minor | | |
| Biodiversity | | | | | | | | | | | Negligible | | |
| Hydrology | | | | | | Negligible | Negligible | | | | | | Minor |
| Climate | | | Negligible | | | | | | Negligible | | | | |
| Groundwater | | | | | | | Negligible | | | | | | |

**OPERATION**

| VECs | Process Plant Operation | Diesel Power Generation | Roads and Road Traffic | Tailings/Tailings Water Disposal | Freshwater Supply | Waste Rock Dumping | Excavation of Pits | Winter Roads | Human Activity | Panda Diversion Channel | Noise | Flow and Stream Diversion |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Air Quality | Negligible | Negligible | Negligible | | | | | | | | | |
| Permafrost | | | | Negligible | | | | | | | | |
| Eskers | | | | | | | | | | | | |
| Water Quality | | | | Negligible | | | | | | | | |
| Fish/Aquatic Habitat | | | Negligible/minor | | Negligible/minor | Negligible | | | | | | |
| Vegetation | | Negligible | | | | | Negligible/minor | Minor | | | | |
| Wildlife/Wildlife Habitat | Negligible | | Negligible | | | | | | | | | |
| Caribou | Negligible | | Negligible/minor | Negligible | | | | | Negligible/minor | Negligible/minor | Negligible/minor | |
| Grizzly Bears | Negligible/minor | | Minor | | | | | | Minor | | Minor | |
| Wilderness | | | | | | | | | Minor | | | |
| Biodiversity | | | | | | | | | Negligible | | | |
| Hydrology | | | | | | | | | | | | Minor |
| Climate | | Negligible | | | | ? | | | | | | |
| Groundwater | | | | | | | | | | | | Negligible |

**DECOMMISSIONING**

| VECs | Tailings/Surface Reclamation | Regrading Eskers | Dump Reclamation | Road Reclamation (culverts) | Diesel Power Generation | Human Activity | Flow and Stream Diversion | Recontouring, Revegetating | Presence of Waste Rock Dumps |
|---|---|---|---|---|---|---|---|---|---|
| Air Quality | | | | | Negligible | | | | |
| Permafrost | Positive Impact | | | | | | | | |
| Eskers | | | | | | | | | |
| Water Quality | | | | | | | | | |
| Fish/Aquatic Habitat | Negligible/minor | | Negligible/minor | Negligible/minor | | | | | |
| Vegetation | Positive Impact | | Positive Impact | Positive Impact | Negligible | | | | |
| Wildlife/Wildlife Habitat | | | | | | | | Positive Impact | |
| Caribou | | | | | | | | Positive Impact | |
| Grizzly Bears | | | | | | | | Positive Impact | |
| Wilderness | | | | | | Negligible | | | |
| Biodiversity | | | | | | | | | |
| Hydrology | | | | | | | Minor | | |
| Climate | | | | | Negligible | | | Negligible | ? |
| Groundwater | | | | | | | | | |

**POST-DECOMMISSIONING**

| VECs | Wind Erosion/Dust Generation | Drainage from Waste Rock Dumps | Landscape Alteration | Filling of Pits | Presence of Waste Rock Dumps |
|---|---|---|---|---|---|
| Air Quality | Negligible | | | | |
| Permafrost | | | | | |
| Eskers | | | | | |
| Water Quality | | Negligible | | | |
| Fish/Aquatic Habitat | | Negligible | | | |
| Vegetation | | | | | |
| Wildlife/Wildlife Habitat | | | | | |
| Caribou | | | | | |
| Grizzly Bears | | | | | |
| Wilderness | | | Negligible | | |
| Biodiversity | | | | | |
| Hydrology | | | | Positive Impact | |
| Climate | | | | | ? |
| Groundwater | | | | | |

fraction. There may be local water quality impacts due to an increase in total suspended solids (TSS). Lake dewatering will have negligible residual impact on water quality due to the use of settling ponds which, when necessary, will reduce TSS levels.

The water management plan encompasses discharge of water from the Long Lake tailings impoundment into either Leslie or Nema lakes and is designed so that federal receiving water criteria for the protection of wildlife are not exceeded. Water quality modelling for the two elements that are likely to exhibit elevated levels, aluminum and nickel, has demonstrated that the discharged tailings water will not surpass the receiving water criteria. Post closure release of Long Lake tailings water will cause negligible impacts to the surrounding water quality due to significant natural mitigation and contingency plans for zero discharge and/or use of a water treatment facility.

Drainage waters from the waste dumps will have a negligible impact on water quality. There are not expected to be large quantities of waste rock drainage due to the low amount of annual precipitation. Adjustment for pH is not anticipated, since there is sufficient aeration to cause natural pH attenuation. Nitrate is not expected to cause an impact due to responsible handling of ammonium nitrate based explosives and the slow oxidation of ammonium caused by low ambient air temperatures and low annual precipitation.

Exploration drilling may have a short-term and localized impact on water quality that is negligible due to drilling mitigation methods designed to recover solids and the use of flocculants to assist the natural settling processes.

Dust generated by the project activities may cause a slight increase in TSS concentrations in nearby lakes. However, the residual impacts will be negligible due to incorporation of fugitive dust control strategies. Fugitive dust should cause negligible impacts due to mitigation measures such as road watering and the use of road construction materials that contain a minimal fraction of silt sized material.

On a regional scale, ambient air quality will not be adversely affected by the project activities. Computer modelling has demonstrated that the Canadian Ambient Air Quality Objectives will be met at the mineral claim boundary. Due to the presence of thermal inversions there may be times, especially during winter, when the mobile equipment operating in the open pits may cause air quality degradation. In such cases, the operations may be transferred to a different elevation and/or other pits to minimize the potential exposure. Through application of these types of management strategies the residual impacts from degraded air quality in the open pits will be short term.

Climatological impacts, on a regional scale, will be negligible. Heat from power generation and fuel combustion may cause minor temperature differences between the plant site area and the surrounding tundra; however, the effect will be very local and the impact will not be significant. The development of site infrastructure and waste dumps will slightly affect the local wind regime. The altered wind pattern will have negligible impact upon the regional climate. The only structures remaining after decommissioning will be the waste dumps, and they are expected to have little effect on the wind patterns except in the immediate vicinity.

During the exploration, construction and operation phases, diesel power generation, boiler operation and mobile equipment will be sources of greenhouse gases, principally carbon dioxide ($CO_2$). The contribution of the NWT Diamonds Project to global warming is unknown because of the uncertainty in predicting climate change. The contribution of greenhouse gases from the project is slight when compared to those in the NWT and Canada. The $SO_2$ and $NO_x$ air emissions from project activities (power generation, diesel powered mobile equipment, etc.) will have negligible impact in the formation of acidic deposition. The quantities of $SO_2$ and $NO_x$ emissions released by the project are slight compared to the total for Canada.

The primary sources of noise are aircraft, mining equipment and blasting. Residual impacts from aircraft noise are expected to be negligible due to special building construction techniques and careful selection of a permanent camp site. Noise from operation of mine equipment and blasting is expected to have negligible impact on humans. Blasts will be audible within 30 km of the mine pits; however, they will be scheduled at approximately the same time each day, which will allow the employees to become accustomed to this regular disturbance. The potential impacts of noise on wildlife are discussed in the next chapter.

## 2.1 Terrain and Permafrost

Project activities resulting in primary modifications to terrain and permafrost in the development region will include the following:

- mining of open pits
- excavation of esker and rock for construction materials
- covering or removal of the tundra surface to provide infrastructure
- construction of tailings dams and waste rock dumps
- flooding and filling for control of water and waste materials.

The extent of primary impacts are controlled by the engineering plan. These are discussed in Volume I, Section 2.

The primary impacts will result in secondary terrain impacts that may include increased erosion, slope instability and subsidence. The potential severity of these impacts is related to the prevailing surficial soils, permafrost conditions and topography. Severity is expected to be minimal due to the low topographic relief; however, these impacts will be mitigated by ensuring that engineering design and construction follow sound engineering practice for arctic regions. Examples of large-scale mining operations engineered to mitigate environmental impacts on continuous permafrost terrain include Polaris mine, NWT, and Red Dog mine, Alaska (Giegerich 1992; Giegerich 1988). Smaller-scale mine operations on terrain similar to the NWT Diamonds Project include the Lupin mine, NWT (Dufour and Holubec 1988).

### 2.1.1 Terrain

Eskers have been identified as a valued ecosystem component since they are often used for carnivore denning, bird nesting and travel corridors by caribou and other wildlife. In addition, some eskers have been found to have archaeological significance. Potential impacts of project development to eskers are of public, professional and cultural concern.

During the construction and possibly the operation phases of the NWT Diamonds Project, portions of two eskers will be quarried and the granular material will be used for construction aggregate, dam cores, construction fill and road surfacing. Approximately 800,000 $m^3$ of borrow material are available from the Airstrip esker and more than 200,000 $m^3$ from the Misery esker. The total area disturbance of the eskers, which includes quarry sites and lake drainage, is estimated at 35 ha. A preliminary assessment of these potential borrow sources indicated no archaeological potential and limited use as wildlife habitat at the Airstrip esker, which has been the quarry source during the exploration phase. The Misery esker contains two archaeological sites; one is an isolated find and the other a small lithic scatter. Both sites were assessed as having low archaeological significance. Wildlife use at the Misery esker is also expected to be low.

#### 2.1.1.1 Mitigation

Esker impacts will be minimized by supplementing required road fill with mine waste rock from Misery and Panda pre-stripping operations. During the decommissioning and post-decommissioning periods, esker quarry sites will be re-contoured. Reclamation will commence after completion of the construction phase and will be ongoing. Roads will be reclaimed during the decommissioning period.

#### 2.1.1.2 Residual Effects

The main impact of quarrying eskers is considered negligible, as they will be affected for a short period of time only. Although the removal of the original eskers is irreversible, the loss of this habitat, which has limited wildlife usage, will be very small from a regional perspective.

### 2.1.2 Permafrost

Permafrost has been identified as a valued ecosystem component due to the possibility of ecological disturbance (to hydrology or soil stability) associated with its degradation within the active layer near the surface. There is some potential for permafrost to be affected during all phases of the project as a result of the following activities: road building, construction of the site facilities, dam construction, mining of open pits, tailings and waste rock deposition and surface restoration.

Permafrost soils are susceptible to thaw subsidence to varying degrees, depending on the nature and content of ground ice. Terrain units within the development area that are particularly sensitive to disturbance have been identified and are described in Volume II, Section 2.1. With few exceptions, the active layer soils within the development region are granular, well-drained and stable on the subdued topography that forms the regional landscape. There are no natural landslides, significant surface erosion areas or large-scale thermokarst depressions. The landform that is most susceptible to thaw subsidence if disturbed by construction activities is the peat-covered lacustrine lowlands found adjacent to some lakes. These soils have abundant ground ice that may thaw, resulting in water filled depressions if the surface vegetation and peat are disturbed or removed.

During the construction period, the risk of surface settlement due to permafrost thaw adjacent to the proposed road routes is confined to a 5 m wide corridor (on either side) over ice-rich terrain. During the operation and decommissioning periods, tailings deposition into Long Lake will result in the formation of new permafrost that will stabilize the surface, thereby resulting in a positive impact.

#### 2.1.2.1 Mitigation

Terrain impacts on thaw-sensitive soils have been mitigated by design measures aimed at preserving or enhancing the permafrost. All buildings have been founded on either bedrock or till. All heavily loaded buildings associated with the processing facilities will be founded on competent bedrock or on piles socketed into bedrock or frozen into fill. The design approach adopted for lightly loaded buildings on thaw-sensitive till is to install steel pipe piles through the till into underlying rock or permanently frozen (permafrost) till. Most buildings, except those at the permanent camp, will be built on a concrete slab on grade with gravel forming an insulated underlayer protecting the permafrost. Exposed glacial till along pit perimeters will be backsloped and covered with insulating riprap to prevent thawing and degradation of the permafrost.

Tailings dams, diversion ditches, waste rock dumps and other structures have been designed for the specific soil and permafrost conditions that they encounter. Temperature changes that may occur in the foundation soils have been predicted using geothermal analyses commonly used for design of facilities on permafrost soils. The analyses predict future ground temperatures and thaw depths, providing an engineering evaluation of the potential interaction between the structure and the underlying permafrost. These analyses provide a rational basis for design that will preserve or enhance permafrost conditions where adverse impacts are identified.

Roads and other embankments on permafrost have been designed as fill structures with sufficient padding over the surface to insulate the underlying permafrost. This method has proved successful for road construction during the exploration phase. Appropriate pad thickness has been developed for the variable nature of the landforms discussed in Volume II, Section 2.1, and has been used successfully during the exploration phase. Peat covered ice-rich soils will have sufficient cover to draw the permafrost table up into the fill. Soils that have little susceptibility to thaw settlement, such as well-drained till uplands, have a reduced pad thickness but are still sufficient to preserve the underlying permafrost at its undisturbed location. There is always a risk that some thaw subsidence may occur in the natural terrain at the toe of embankments, but this can be minimized by leaving original vegetative cover intact during construction.

Construction equipment movements between facilities will be limited to road fills or winter roads consistent with accepted practice for permafrost terrain. A permafrost temperature monitoring program, initiated for design of various facilities (EBA 1995), will be continued. This program will be enhanced during construction to verify that impacts on permafrost are consistent with predictions and to rectify any problems that may arise.

Monitoring of permafrost may include studying the composition and condition of neighbouring plant communities. Changes in vegetation as a result of varying permafrost and drainage conditions were identified by an elder during the Traditional Dene Environmental Knowledge pilot project conducted in Ft. Good Hope and Colville Lake, NWT (Johnson and Ruttan 1993).

#### 2.1.2.2 Residual Effects

Construction of site infrastructure will affect the ground thermal regime and cause permafrost to degrade or aggrade. These thermal changes do not constitute an environmental impact on their own; however, degradation of permafrost as a direct result of thermal changes can cause instability of the active layer. The greatest risk is the formation of shallow (<0.5 m) surface ponds, possibly in a band along the toe of fill sideslopes such as road embankments, airstrips and dams on permafrost foundations. These ponds would generally be very small and have no risk for contained suspended solids or turbidity that could be released into stream channels. The degree to which the area will be affected varies with terrain type and will be most prevalent in peat-covered lowlands. Interruption of the drainage may change the moisture balance of the active layer, causing long-term changes to plant species. The significance of residual effects on permafrost is considered negligible.

## 2.2 Ground Instability

The project area is geologically stable, of low seismic risk and with no natural landslides or significant surface erosion. Project activities resulting in primary impacts to ground stability in the development region will include open pit mining and the construction of waste rock dumps. Primary impacts will be controlled by the engineering plan discussed in Volume I, Section 2.4.

Secondary impacts may include slope instability and subsidence as discussed in Terrain and Permafrost (Section 2.1). The stability of the pit walls could be decreased by freeze-thaw effects of seeping groundwater and changing permafrost conditions. Waste rock deposited over slopes could affect slope stability due to foundation thawing.

### 2.2.1 Mitigation

Geotechnical studies based on drill core and data from exploration declines have been incorporated into pit design to ensure pit wall stability. Thus sound engineering design and construction practice will mitigate pit wall instability, and pit bench configurations will contain any small failures.

Waste rock dumps will be designed such that their edges will not intersect ice-rich soils that could thaw and subside. Rock will be dumped to promote new underlying permafrost development and stabilize the dump surface. Completed dumps will be contoured and revegetated.

### 2.2.2 Residual Effects

Exhausted pits will be filled with water and become deep, steep-sided lakes with limited littoral areas. Impacts are considered negligible as affected areas will be submerged.

The reclaimed waste rock dumps will be stable landforms which will have negligible impact.

## 2.3 Hydrology

The following sections describe the potential impacts of various project activities on surface and groundwater hydrology.

### 2.3.1 Surface Hydrology

Hydrology is considered a valued ecosystem component due to the importance of water flows locally, within the Koala and adjacent watersheds, and within the larger context of the Coppermine River basin. Hydrological changes are significant for local aquatic and terrestrial systems. Modifications in water flow or storage could have implications for water use downstream, due to the location of the NWT Diamonds Project at the headwaters of the Coppermine River.

The project will affect lake storage and streamflows within the area affected by mine activities during the 25-year life of the project, and thereafter. The Koala watershed will experience most of the impacts due to the concentration of exploration and mining activities in this watershed. The major impacts can be divided into three general categories: 1) changes to drainage patterns, 2) changes to lake storage and 3) changes to streamflow. The project activities that will cause these impacts are 1) lake dewatering, 2) road construction, 3) surface drainage control, 4) tailings disposal into the Long Lake impoundment and 5) mine closure. The following discussion will describe how these project activities will cause changes to the surface hydrological regime and quantify these effects where possible.

Impacts of the mining project on surface hydrology must be considered in the context of the secondary effects that these changes induce in other valued ecosystem components (e.g., fish, or other users of water downstream). It is the control of these secondary effects that dictates much of the water management plan and, therefore, governs the magnitude and timing of the primary residual effects to surface hydrology. Secondary effects are described in other sections of this volume.

Impacts described here will be almost entirely in the Koala drainage basin, where most project activities will be carried out. The Koala watershed constitutes a small portion of the Coppermine River catchment. Without exception, the effects of the project on surface hydrology will be confined to local drainages and will not be noticeable in Lac de Gras, or in other parts of the Coppermine watershed.

Hydrological impacts are dependent on implementation of the water management plan (Volume III, Section 3). Specific impacts will thus result from operating decisions. However, the general magnitude of the impacts are described in addition to potential trade-offs where they exist.

#### 2.3.1.1 Drainage Pattern Changes

Mine development will cause two principal changes to drainage patterns in the Koala watershed. First, the Panda diversion channel will be constructed to divert surface flow from northern Panda and Grizzly lakes, around the Panda and Koala open pits, directly into Kodiak Lake (Figure 2.3-1). This will essentially eliminate surface flow from Panda Lake to Koala Lake and from Koala Lake to Kodiak Lake, for the life of these pits. Surface drainage patterns from Kodiak Lake downstream to Lac de Gras will be unaffected by this development.

The diversion channel will remain in operation throughout the life of the project. At closure, the channel will be needed to direct natural streamflow into Kodiak

Lake and maintain a connected pathway for fish migration to upstream lakes. A preliminary assessment of post-closure water balances suggests that it will be necessary to maintain the diversion channel open for approximately 30 years following cessation of production until the Koala pit naturally fills with run-off water. For the purposes of this document, it has been assumed that no surface flow will be diverted from the Panda diversion channel to help fill Koala pit. An option exists to divert some surface inflow from the diversion channel into the lakes forming in the Panda and Koala open pits, in order to speed up the process of filling if environmentally advantageous.

The second principal change to drainage patterns in the Koala watershed will be associated with the diversion of Long Lake outflow. Presently, Long Lake drains through Leslie Lake into Moose Lake. Once the tailings disposal operation commences in Long Lake, water from the south end of the lake will be discharged via a spillway into Nema Lake, bypassing Leslie, Moose and Nero lakes (Figure 2.3-1). Surface drainage patterns downstream of Nema Lake will be unchanged.

Starting in Year 10, a pit will be developed at Leslie Lake which will operate until operations cease in Year 25. Following closure, it is assumed that water from Long Lake will continue to discharge to Nema Lake, via the spillway. This is discussed further in Section 2.3.1.2.

Several other minor changes will be made to surface drainage patterns throughout the project area. These include the following:

- Minor surface diversions will be undertaken within the Long Lake basin. These will be developed to route surface waters around active tailings cells.

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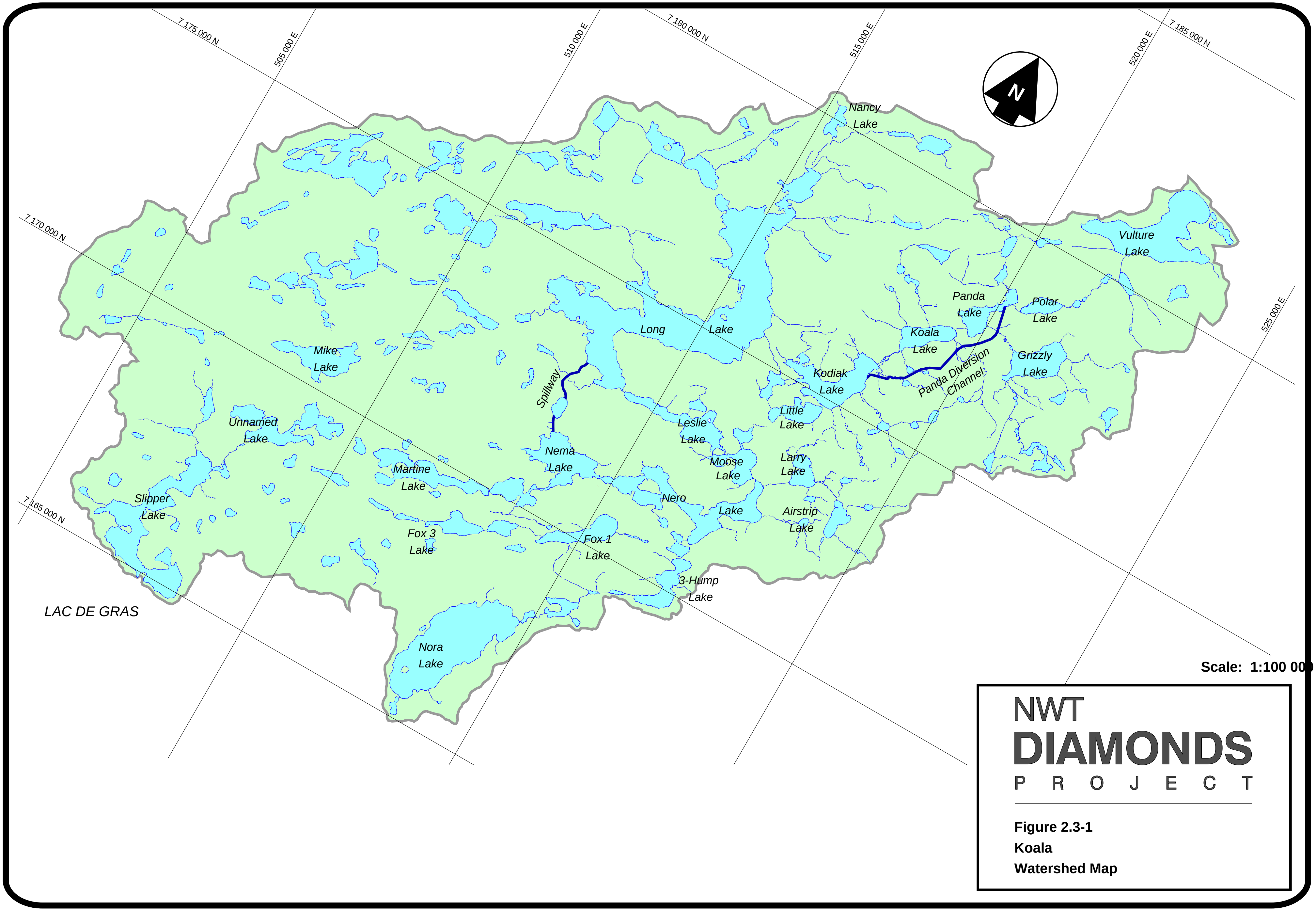



Figure 2.3-1
Koala
Watershed Map

Source: Rescan

- Runoff in the process plant site will be routed to sedimentation ponds before release.

- Diversions may be required to limit surface inflow to active pits. Water accumulating in the pits during mining will be pumped to sedimentation ponds prior to release to the environment.

- During the late stages of lake dewatering, water will be routed to sedimentation ponds instead of being released directly to the environment, if the concentration of suspended solids exceeds permitted discharge limits.

- Drainage control around the waste dumps may be required if drainage water quality is not acceptable.

These minor changes in surface drainage patterns will have little or no potential to affect the larger watercourses in the Koala watershed, which contain productive fish habitat.

***Mitigation***

Many of the induced changes to surface drainage patterns are developed to mitigate other environmental impacts (in the case of the Panda diversion channel, to provide compensation for lost stream habitat). Measures to mitigate the effects of these changes are neither necessary nor practical.

***Residual Effects***

Without mitigation measures directed to reducing the effects of these changes, the residual effects of the project on drainage patterns in the project area are as described above. These effects, overall, are rated as negligible to minor.

#### 2.3.1.2 Lake Storage Changes

Considerable volumes of water are stored in the lakes in the Koala watershed. The presence of this water in storage influences the surface hydrology of the basin, principally by attenuating extreme flow events. Changes in surface hydrology of the Koala watershed may be expected to occur during and after project development, as the total storage in the surface hydrologic system changes.

Total lake storage will be reduced during project development. Five lakes – Panda, Koala, Misery, Fox 1 and Leslie – will be dewatered prior to each pit's development. Long Lake will be partially dewatered before mine production begins, and then will be progressively filled with tailings during the first twenty years of the project's operational phase. Airstrip Lake will be dewatered during the construction phase in order to access construction material.

After mining is completed in each pit, they will be reclaimed as lakes. In all cases, the pits will be much larger than the natural lakes they replace. The end result will be an increase in lake storage in these water bodies. Long Lake, on the other hand, will be mostly filled in with tailings, which will represent a net loss in storage.

A list of all lakes to be dewatered during the operations of the NWT Diamonds Project is given in Table 2.3-1. In addition, area and volume estimates, volume of water to be removed, estimated recovery time and total volume after reclamation are presented.

**Table 2.3-1**
**Lake Storage Changes**

| Lake | Lake Area ($\times 10^3 m^2$) | Lake Volume ($\times 10^3 m^3$) | Dewatering Volume ($x10^3 m^3$) | Estimated Recovery Period (Years) | Area After Recovery ($x10^3 m^2$) | Total Volume After Recovery ($x10^3 m^3$) |
|---|---|---|---|---|---|---|
| Panda | 350 | 1,313 | 1,313 | 6 | 467 | 53,000 |
| Long | 6,144 | 45,287 | 12,000 | — | — | — |
| Airstrip | 193 | 453 | 453 | — | — | — |
| Misery | 137 | 1,024 | 1,024 | 147 | 306 | 30,000 |
| Koala | 380 | 2,254 | 2,254 | 34 | 355 | 30,500 |
| Leslie | 618 | 1,413 | 1,413 | 212 | 844 | 144,000 |
| Fox 1 | 437 | 3,030 | 3,030 | 153 | 579 | 91,000 |

Estimated annual precipitation, runoff and lake evaporation rates of 310 mm, 180 mm and 250 mm have been used (Volume II, Sections 2.3 and 2.6) in a simple water balance model to derive the recovery period for Panda, Misery, Koala, Leslie and Fox 1 lakes. The assumed evaporation rate of 250 mm is conservative (high), and therefore the lake recovery periods given in Table 2.3-1 are conservative estimates. Cone-shaped pits were assumed for calculating the total volumes of the pit lakes (Volume III, Section 3.4.3).

***Mitigation***

Following mine closure, it will be possible to reduce the time required to fill the pit lakes by directing water into the pits. For instance, the Leslie pit is forecast to fill over approximately 212 years after closure. This time could be reduced by routing some or all of the runoff from the Long Lake basin into the pit, rather than releasing this water via the spillway to Nema Lake. This would reduce the supply of water to lower portions of the Koala watershed. For the purposes of this EIS, it is assumed that this trade-off is resolved by allowing the pit to fill naturally, and letting the water from the Long Lake basin flow to Nema Lake indefinitely following closure.

***Residual Effects***

It is estimated that the total lake area lost due to dewatering and filling operations will be 891 ha, which accounts for about 0.06% of the area of the lakes in the Coppermine watershed. As mentioned above, the five lakes dewatered for pit development will, in the long term, be replaced by larger lakes which will form in the mined-out pits. Overall, the significance of these effects on lake storage with respect to surface hydrology is rated as negligible.

2.3.1.3 Streamflow Changes

Changes in streamflow will be induced directly and indirectly by several project activities. Two major effects on streamflow in the Koala catchment have been identified. First, short-term increases in streamflow will be observed in watercourses downstream from lake dewatering operations. Second, streamflow will be reduced in watercourses downstream from Long Lake, as the result of the operation of the tailings disposal facility. These changes to the local flow regime are discussed below.

In total, seven lakes will be dewatered. Five lakes (Panda, Misery, Koala, Fox 1 and Leslie) will be dewatered sequentially prior to open pit development. Airstrip Lake will be dewatered in order to access construction material. Long Lake will be partially dewatered by lowering its level by at least two metres before tailings deposition starts. During the dewatering operations, water will be pumped from the lakes directly into downstream watercourses until the suspended solids content of the water reaches the discharge limit, after which time the water will be routed to a sedimentation pond before release. The dewatering operations will generally commence in July at a designated pumping rate following spring freshet, and will continue for up to several months.

The dewatering operations will affect streamflow downstream from the lakes being dewatered. This may cause both positive and negative secondary effects to the fisheries resources of downstream watercourses. Generally, increased streamflow has a positive effect on fisheries resources because these resources tend to be flow-limited in the late summer period. However, this is only true up to a point. If too much water is pumped too quickly, negative secondary effects could result due to increased flow velocity, which would impede upstream fish passage.

In order to manage these effects, the Water Management Plan has established that the induced streamflow in a watercourse downstream from the dewatering operation should not exceed one-half of the mean annual flood in that watercourse. Streamflow effects are evaluated with this criterion in mind.

Table 2.3-2 summarizes the main features of the lake dewatering operations. The table lists the planned months during which each lake will be dewatered, the total volume of water to be pumped, the maximum pumping rate and the estimated pumping time in months.

**Table 2.3-2**
**Summary of Lake Dewatering Plan**

| Lake | Period of Dewatering | Total Volume Pumped ($\times 10^6$ $m^3$) | Dewatering Design Flow ($m^3/s$) | Pumping Time (Months) |
|---|---|---|---|---|
| Panda | Jul - Aug 1996 | 2.0 | 0.44 | 1.8 |
| Airstrip | Sep - Oct 1996 | — | — | — |
| Long | Jul - Nov 1997 | 16.8 | 1.35 | 4.8 |
| Misery | Jul - Aug 1998 | 1.7 | 0.44 | 1.5 |
| Koala | Jul - Sep 2000 | 3.0 | 0.44 | 2.6 |
| Fox 1 | Jul - Oct 2002 | 4.3 | 0.44 | 3.8 |
| Leslie | Jul - Aug 2006 | 2.1 | 0.44 | 1.8 |

In order to calculate the increased streamflow due to dewatering, the closest downstream watercourse containing productive fish habitat was identified for each lake to be dewatered. The maximum daily discharge (which approximates the mean annual flood) was then estimated for these watercourses according to the methods of Volume II, Section 2.3. The induced streamflow during dewatering was calculated as the estimated mean monthly discharge (based on a long-term estimated average annual runoff of 180 mm) plus the dewatering design flow from Table 2.3-2. The relevant information for the dewatered lakes and associated watercourses are listed in Table 2.3-3.

Table 2.3-4 summarizes the results of the streamflow analysis. The induced streamflows range from 12% to 45% of the mean annual flood; in all months the induced streamflow is within the guideline of 50%. Note that Misery Lake and Airstrip Lake have not been included in the analysis. Dewatering flows from Misery will be conveyed directly to Lac de Gras via an unproductive, ephemeral stream. Airstrip Lake will be dewatered in stages by excavating a stable channel in the esker separating Airstrip Lake and Larry Lake.

This analysis is conservative for at least two reasons. First, the maximum daily discharge (MDD) has been assumed to be the same as the mean annual flood, although the MDD will always be less than the mean annual flood, which is the annual peak instantaneous discharge. Second, early data from the 1995

**Table 2.3-3**
**Watercourses Affected by Lake Dewatering**

| Lake | Affected Stream | Catchment Area ($km^2$) | Maximum Daily Discharge ($m^3/s$) | Estimated Mean Monthly Discharge ($m^3/s$) July | Aug | Sept | Oct | Nov |
|---|---|---|---|---|---|---|---|---|
| Panda | Kodiak Lake outflow | 38.7 | 3.1 | 0.54 | 0.26 | | | |
| Airstrip | Larry Lake outflow | 4.3 | 0.8 | | | 0.02 | 0.02 | |
| Long | Moose Lake outflow | 87.1 | 5.8 | 1.28 | 0.62 | 0.39 | 0.34 | 0.31 |
| Koala | Kodiak Lake outflow | 38.7 | 3.1 | 0.54 | 0.26 | 0.16 | | |
| Fox | Martine Lake outflow | 133.0 | 7.8 | 1.95 | 0.95 | 0.59 | 0.52 | |
| Leslie | Moose Lake outflow | 87.1 | 5.8 | 1.28 | 0.62 | | | |

**Table 2.3-4**
**Summary of Streamflow Impacts for Lake Dewatering**

| Lake | Estimated MDD[a] ($m^3/s$) | Month | Estimated MMD[b] ($m^3/s$) | Dewatering Design Flow ($m^3/s$) | Total Estimated Flow ($m^3/s$) | Total Estimated Flow (%MDD) |
|---|---|---|---|---|---|---|
| Panda | 3.1 | July | 0.54 | 0.44 | 0.98 | 32 |
| | | August | 0.26 | 0.44 | 0.70 | 23 |
| Long | 5.8 | July | 1.28 | 1.35 | 2.63 | 45 |
| | | August | 0.62 | 1.35 | 1.97 | 34 |
| | | September | 0.39 | 1.35 | 1.74 | 30 |
| | | October | 0.34 | 1.35 | 1.69 | 29 |
| | | November | 0.31 | 1.35 | 1.66 | 29 |
| Koala | 3.1 | July | 0.54 | 0.44 | 0.98 | 32 |
| | | August | 0.26 | 0.44 | 0.70 | 23 |
| | | September | 0.16 | 0.44 | 0.60 | 19 |
| Fox | 7.8 | July | 1.95 | 0.44 | 2.39 | 31 |
| | | August | 0.95 | 0.44 | 1.39 | 18 |
| | | September | 0.59 | 0.44 | 1.03 | 13 |
| | | October | 0.52 | 0.44 | 0.96 | 12 |
| Leslie | 5.8 | July | 1.28 | 0.44 | 1.72 | 30 |
| | | August | 0.62 | 0.44 | 1.06 | 18 |

a: MDD = maximum daily discharge (approximates the mean annual flood).
b: MMD = mean monthly discharge estimated for an annual runoff of 180 mm.

monitoring program suggest that the method employed in Volume II, Section 2.3, may have underestimated the MDD. Therefore, the induced streamflows will constitute a smaller fraction of the mean annual flood than indicated in Table 2.3-4.

The second major impact to streamflow is the reduction in discharge which will occur in the Koala watershed downstream of Long Lake, due to the operation of the tailings impoundment in Long Lake. This reduction in discharge will arise because less water will be discharged from the impoundment each year than flows naturally from Long Lake in an average year. Also, the water will be routed directly to Nema Lake, bypassing Leslie Lake, Moose Lake and Nero Lake.

In an average year, approximately 8 million $m^3$ of water discharge from Long Lake into Leslie Lake (this assumes 180 mm of runoff over a catchment of 44.2 $km^2$). During operation of the tailings impoundment, the outlet to Leslie Lake will be closed off and a reduced amount of water, about 2.7 million $m^3$ annually, will be released via a spillway to Nema Lake.

This flow reduction will affect discharge between Leslie Lake and Slipper Creek, which drains into Lac de Gras. The magnitude of this impact in various watercourses was estimated as follows. The average annual discharge from several lakes downstream of Long Lake was estimated by applying an annual runoff depth of 180 mm to the entire catchment contributing to outflow from each lake. Reduced flow during mine operation was calculated the same way, assuming that the catchment was reduced in size by 44.2 $km^2$, which is the area of the Long Lake catchment. These reduced annual discharges were increased by 2.7 million $m^3$ in Nema, Martine and Slipper lakes, to account for the average amount of water which will be released from the south end of Long Lake each year during operation of the tailings facility.

The results of the streamflow analysis are summarized on an annual basis in Table 2.3-5. Note that Leslie Lake has not been included in the analysis because the lake and its connecting streams are condemned by mine development.

**Table 2.3-5**
**Estimated Annual Reduction in Streamflow During the Operation of the Long Lake Tailings Impoundment**

| | Unaffected Basin | | Reduced Basin | | | | |
|---|---|---|---|---|---|---|---|
| | | | | Annual Discharge ($\times 10^6$ $m^3$) | | | |
| Catchment | Basin Area ($km^2$) | Annual Discharge ($\times 10^6$ $m^3$) | Basin Area ($km^2$) | Basin (A) | Long Lake (B) | Total (C=A+B) | Percent Reduction |
| Moose | 87.1 | 15.7 | 42.9 | 7.7 | 0.0 | 7.7 | 51 |
| Nero | 107.6 | 19.4 | 63.4 | 11.4 | 0.0 | 11.4 | 41 |
| Nema | 114.2 | 20.6 | 70.0 | 12.6 | 2.7 | 14.6 | 26 |
| Martine | 133.0 | 23.9 | 88.8 | 16.0 | 2.7 | 18.0 | 22 |
| Slipper | 185.7 | 33.4 | 141.5 | 25.5 | 2.7 | 27.5 | 16 |

Note: These figures do not account for timed releases from Long Lake (see Mitigation section, below).

Reductions in streamflow will be most noticeable in the streams at the outlet of Moose Lake and Nero Lake, for two reasons. First, these watercourses are hydrologically closest to Long Lake and hence the loss of catchment area is largest, as a fraction of the total catchment. Second, the water released from the south end of Long Lake bypasses these lakes.

Below Nema Lake, this impact will persist for the 25-year operating life of the mine. Once mine production ceases, the amount of water released from the Long Lake basin each year will return approximately to its former level of 8 million $m^3$/a. Because this water will continue to be released to Nema Lake, flow reductions will continue indefinitely in Moose and Nero lakes.

These effects will be localized to the Koala drainage. The reduced streamflow constitutes less than 0.2% of the total annual discharge in the Coppermine River at Point Lake. These flow reductions will not affect water availability in the Coppermine River.

Other minor changes to streamflow may be caused by the extraction of potable water from Grizzly Lake, the use of culverts in road construction, and changes to land surface characteristics brought about by the development of waste rock dumps, the reclaimed tailings impoundment in Long Lake and the plant site. These impacts to streamflow are, overall, smaller in magnitude than those described above.

***Mitigation***

The effects of dewatering flows on watercourses downstream are mitigated by limiting discharge so as not to exceed 50% of the mean annual flood in any downstream watercourse which contains fish habitat. With an upper limit established to the induced streamflow, the secondary impacts of lake dewatering on fisheries resources will be positive, and no further mitigation will be undertaken.

It will be possible to mitigate the streamflow reductions caused by operation of the Long Lake tailings impoundment. First, the lake dewatering operations will tend to offset the flow reductions in several years, including 2000 (for Koala Lake), 2002 (for Fox 1 Lake) and 2006 (for Leslie Lake). In remaining years, it will be possible to supplement the reduced streamflow in the watershed below Nema Lake by timing the annual release of water from Long Lake. Water can be held during freshet (when water is not in short supply) and then released during late July, August and September when flows are naturally limited. The tailings and water management plans have been designed to be flexible in this regard.

***Residual Effects***

The effects to streamflow described above will be localized to the Koala drainage basin. They will take place principally before and during mine operation, although some impacts to streamflow will persist indefinitely following mine closure. Overall, these effects are rated as minor.

### 2.3.2 Groundwater Flows

Groundwater has been identified as a valued ecosystem component because changes in flow could result in the potential drawdown of adjacent lakes and streams. Negligible groundwater flows are assumed in the Project area primarily because the pore space available for groundwater transport is defined, not only by the surficial geology and soil characteristics, but by the thickness of the active layer which is very limited in tundra environments. Moreover, the site lies in an area of continuous permafrost so subsurface flow in the active layer occurs only during the thaw period of active layer development, in the short sub-arctic summer.

The base of permafrost in the development area lies at about 240 m below surface. Currently, recharge to the regional groundwater flow system is provided by lakes underneath which permafrost is absent (Volume II, Section 2.1.2.5). Therefore, the main project activities that will affect groundwater movement are lake dewatering and mining of the kimberlite pipes underlying the lakes, which will take place during the construction and operation periods, respectively. Once mining has ceased, the pits will be abandoned and will be left to fill naturally as a result of precipitation and groundwater seepage. The taliks, or thawed zones, presently below the five proposed pits will become enlarged as the pits fill, further affecting groundwater flow conditions. The gradual refilling and concomitant shifting of the permafrost boundary under the pits will have an impact on the groundwater flow regime which will seek to achieve a steady-state.

The geographic extent of disturbance to groundwater flow comprises the immediate vicinity of each of the five proposed pits: Panda, Koala, Fox 1, Leslie and Misery. There is a high probability that dewatering of these lakes and subsequent mining will alter the groundwater flow regime by removing water from storage, affecting the water table in the area. However, groundwater flow modelling (discussed in Volume II, Section 2.3.2) predicts that lowering of the static water level around the perimeter of each pit is not expected to affect the nearest lakes to each pit measureably due to low surface gradients and hydraulic conductivities of the kimberlite and country rock. Furthermore, this effect will be reversible as steady-state conditions will prevail once the pits refill. As this occurs, the hydraulic head between neighbouring lakes and the pits will decrease linearly to zero.

The exception is Panda pit, which has the potential to experience some measureable seepage under the unfrozen northeastern pit wall, which separates the pit from the undrained portion of Panda Lake. Air photo lineaments and limited drilling have indicated faults that may provide a hydraulic connection between the pit wall and the remaining portion of the lake. Due to the hydraulic gradient along these fault zones, seepage may result in piping of the fault gouge material before Panda pit reaches its design depth.

#### 2.3.2.1 Mitigation

As Panda pit is mined, in-pit drilling will be conducted to delineate the width and extent of any faults and determine their respective hydraulic conductivities. Mitigative measures such as grouting or freezing will be implemented, if necessary.

2.3.2.2 Residual Effects

Near-surface groundwater flow in the vicinity of each proposed pit will be disturbed for the duration of dewatering activities but steady-state conditions will return soon after these activities cease; these changes in groundwater flow will hardly be measureable.

Regional groundwater movement below the maximum depth of permafrost will be affected during the dewatering and mining of each pit and for many years after while the pits are refilling naturally (Section 2.3.1). These changes are not expected to affect the water level in adjacent lakes measureably. The overall significance of the impact to groundwater flow in the Project area is considered negligible.

## 2.4 Water Quality

Water quality has been identified as a valued ecosystem component due to its importance to aquatic and terrestrial ecosystems and to the human populations that depend upon them. The preservation of water quality will ensure the integrity of ecological habitat and will enable human communities to continue to benefit from this essential resource and the fish and wildlife that it supports.

Various project activities could affect water quality within the immediate project area throughout all stages of mine development. Potential impacts associated with the operations phase, however, are the most important and are principally associated with contamination resulting from surficial disturbance and management of impounded tailings water. Generally, any impacts will be short-term and can be mitigated or prevented by suitable contingency planning, engineering design, construction practices and adherence to the water management plan.

The release of sediments or contaminants through tailings facility discharges or drainage from waste rock dumps may alter the water quality of receiving waters. This has been examined by mathematically modelling changes in water quality with respect to total aluminum and nickel concentrations.

### 2.4.1 Sedimentation and Suspended Solids

Water quality in the project vicinity may be affected by sediment arising from construction activities, including construction of dams, dikes and embankments; construction of roads; development of surface facilities; and development of surface diversion channels, including the Panda diversion ditch. Lake dewatering prior to pit development may also increase sedimentation.

2.4.1.1 Dams, Dikes and Embankments

Several dams, dikes and embankments will be constructed, principally in and around Long Lake for the tailings disposal system, and also at the inlets of Panda and Leslie or Fox lakes prior to the dewatering of these water bodies. Dike construction activities will result in sedimentation as fine granular material associated with the waste rock is introduced into waterways.

The likelihood and severity of impacts to water quality will depend on many factors, including the fines content of the material used to construct the dams, the proximity of the dams to watercourses or lakes and the season during which construction is carried out. Impacts will be minimal for the East, Outlet and Spillway dams around Long Lake, which will be built during the winter when surface waters are frozen. The Long Lake interior dikes A, B, C and D will be constructed during the open water season, and increased sediment loadings to Long Lake in the immediate vicinity of these structures will be associated with dike construction activities. However, Long Lake will have been converted to a tailings facility by this time, and any discharges to the environment will be controlled and monitored.

The Panda dam will be constructed in mid-1996. Construction activities will release some suspended solids to the watercourse feeding Panda Lake. Water quality will not be affected substantially in Panda Lake, which will be dewatered in advance of pit development after the dam is completed, or in downstream waters.

2.4.1.2 Road Construction

Road development around the permanent camp and pits may affect water quality principally through erosion and in-stream construction work. These impacts are expected to be of short duration and will be limited to watercourses in the immediate vicinity of roads. The grading and compacting of road surfaces will reduce erosion after construction is complete. In-stream construction activities, primarily the placement of culverts, will cause the release of sediment only while construction activities proceed.

2.4.1.3 Surface Facilities

The preparation of sites for surface facilities will involve the disturbance of vegetation and surficial materials and the placement of borrow material. These activities could result in sediment loadings to nearby streams and lakes. Sedimentation associated with surface facilities construction, however, have had no significant impact on water quality during bulk sample activities at the project site to date.

#### 2.4.1.4 Lake Dewatering

Panda, Misery, Koala, Fox and Leslie lakes will require dewatering prior to pit development. The aquatic impacts associated with the water removal are described in detail in Section 3.1. The following describes the potential water quality impacts that could arise during dewatering and focuses on possible increases in suspended solids as lake bottom material becomes exposed.

The seasonal timing of lake dewatering can have an important influence on the water quality impacts that arise in the absence of any mitigation strategies. If all dewatering is conducted during the summer periods, there is a strong likelihood that, following initial lake dewatering, suspended solid concentrations within the lake may increase above the discharge limits as lake sediments become exposed. Rainfall and wind mixing in newly created shallow sections of the lake could result in elevated TSS concentrations. This could pose a problem for continued discharge of lake water, which should be in compliance with Canadian Council of Ministers of the Environment (CCME) Guidelines.

#### 2.4.1.5 Mitigation

The potential for increased sedimentation due to construction activities will be mitigated through the use of coarse resistant waste rock and esker material for structures and roads. Construction activities will be carried out with consideration for seasonal activities of aquatic life.

With respect to lake dewatering, particular care will be taken toward the end of the dewatering process, near the lake bottom, where suspended solids are likely to approach the discharge limits. Where possible, the final dewatering will be scheduled for late fall so that freezing of the sediments and ice formation on the lake will prevent slumping and wind mixing. The primary mitigation strategy for handling potentially elevated suspended solids in this water, however, will be to pump it into a specially constructed sedimentation pond adjacent to the lake (pit) for settling. Excess water will be released from the pond only after suitable retention or treatment such that the water meets the discharge criteria.

#### 2.4.1.6 Residual Impact

Since dams, dikes, embankments, roads and other similar infrastructure will be constructed from coarse, resistant waste rock and esker material containing a minimal clay fraction, residual impacts from TSS are anticipated to be negligible. Water quality will be only locally and temporarily affected and manifest as elevated TSS. This material will settle out of the water column to be incorporated with the natural sediments in the immediate vicinity of the activity.

Discharge criteria will be achieved prior to any release during lake dewatering according to the described mitigation, thus residual impacts of lake dewatering on the receiving environment will be negligible.

### 2.4.2 Impact on Water Quality of Long Lake Tailings Pond

The friable nature of the kimberlite ore combined with the presence of an unidentified, amorphous or micro-crystalline component (K. Morin 1995 pers. comm.) makes it susceptible to generating very fine-grained solids. These solids may resist rapid settling, resulting in persistently elevated TSS values in tailings pond water. In addition, a portion of the amorphous fraction of kimberlite is readily soluble and capable of producing alkaline conditions.

Data from the winter drilling program and kimberlite solubility test-work (Table 2.4-1) indicate rapid changes in water chemistry upon contact with the kimberlite ore (Rescan 1995). Samples from all five kimberlite pipes produced similar water quality trends. However, the composition of the water in the Phase I tailings impoundment for the exploration program was variable depending on the specific kimberlite feed manifest as different TSS/total aluminum (Al) weight ratios (Table 2.4-2).

**Table 2.4-1**
**Effects of Kimberlites on Water Quality***

| Kimberlite Origin | Slurry pH | Dissolved Al (mg/L) |
|---|---|---|
| Panda | 9.1 | 0.011 |
| Koala | 9.1 | 0.024 |
| Fox | 10.1 | 0.304 |
| Leslie | 9.8 | 0.004 |
| Misery | 9.5 | 0.030 |

* Dechlorinated Vancouver Tap Water.
Source: Rescan 1995.

Despite the variability associated with tailings pond composition, three tailings pond parameters (total suspended solids, total nickel and total aluminum) have been identified as potentially limiting components for the regulation of water quality.

The current federal effluent limit for Al in wastewater treatment facilities in the NWT is 1.0 mg/L; the similar limit in British Columbia ranges between 0.5 mg/L and 1.0 mg/L. In the following section, it will be demonstrated that water quality in the receiving environment will not even exceed CCME receiving water criteria

**Table 2.4-2**
**Phase I and II Exploration Tailings Pond Water Composition**

| | pH | TSS (mg/L) | Total Al (mg/L) | Total Ni (mg/L) | Dissolved Ni (mg/L) | TSS/Al |
|---|---|---|---|---|---|---|
| Phase I Pond (16 Apr 94) | 8.25 | 21.0 | 1.42 | 0.093 | <0.020 | 14.8 |
| Phase I Pond (25 Jun 94) | 7.18 | 468.0 | 18.7 | 0.677 | <0.020 | 25.0 |
| Phase II Pond (26 Jun 94) | 7.80 | 498.0 | 7.94 | 0.348 | <0.020 | 62.7 |

of 25 mg/L, 0.025 mg/L and 0.10 mg/L, for TSS, total Ni and total Al, respectively. All other parameters in the tailings pond water are below CCME guidelines.

The water management plan describes a strategy for the handling of tailings water in Long Lake (outlined in Volume I, Figure 2.6-9). The central tenet of this plan with respect to water quality management is to discharge only clean surface runoff water that enters cell E in Long Lake. The quantity discharged will, on average, equal the volume of runoff minus that volume required for process water in the process plant. It has been suggested in the water management section that between 13 years and 18 years of storage capacity exists in Long Lake based on suspended solid limitations. The effect of tailings pond water discharge on water quality for parameters other than TSS is predicted according to the water management plan.

Presented below is a water quality model that predicts the evolution of the chemistry in the non-active tailings cell(s) and ultimately in Nema Lake during the life of the operation. By using several conservative assumptions to compensate for natural system uncertainties, the model presents a worst-case scenario for water quality in Nema Lake while still complying with CCME receiving water quality criteria. While several standards exist for other receptors (e.g., drinking water, wildlife, livestock, etc.), water quality standards for the protection of aquatic life are the most stringent. By complying with these objectives, operation of the NWT Diamonds Project will proceed without deleterious impacts to the aquatic or terrestrial environment.

#### 2.4.2.1 Model Description

A relatively simple box model has been developed to predict the evolution of water chemistry within the inactive cell(s) of the Long Lake tailings impoundment. Specifically, the model addresses the changes in water quality with respect to total Al and total Ni concentrations. Modelling efforts have focused on these parameters, as routine monitoring of the exploration tailings impoundments during 1994 indicated that only these metals might exist in sufficient concentrations to be of environmental concern in the tailings impoundment. Total suspended solids has not been modelled as all data thus far suggest that total Al concentrations in the Long Lake impoundment will be the controlling discharge parameter. Moreover, given the complex behaviour of suspended solids in shallow lacustrine systems, accurate modelling of TSS through the Long Lake facility is not possible.

The model considers those processes that will potentially affect water quality within the inactive cell(s) of Long Lake, specifically, internal dike seepage from active cell to inactive cell(s), natural runoff, water reclaimed to the plant and water discharged to the receiving environment. The foundation for the water quality model is the water balance for the tailings impoundment as described in Volume III, Section 3. However, some minor deviations have been incorporated to ensure the model is sufficiently conservative to compensate for inherent uncertainties in quantifying certain model parameters.

#### 2.4.2.2 Model Parameters

The following discussion describes the model for total Al only, as this is the controlling water quality parameter. Inputs and losses of Al to the system will be outlined and are summarized in Table 2.4-3. A similar model run for total Ni is presented in Table 2.4-4.

***Natural Runoff***

Runoff to the clean water cells within the tailings impoundment (the second column in Table 2.4-3) represents an important contribution of dilution water to these cells. However, this runoff also constitutes a small loading of Al to the inactive cells. Metal concentrations and, in particular, Al concentrations in natural runoff at the project site have been measured in snow as approximately 0.01 mg/L. The model has been designed to be more conservative by assuming that natural runoff contains 0.020 mg/L total Al, which is the background Al concentration in Long Lake. Runoff values have been based on each cell's catchment area and an estimated annual runoff of 180 mm as discussed in Volume III, Section 5. As portions of Long Lake are filled with tailings, dilution water catchment is diminished concurrently. This is reflected in the decreasing values of the Runoff column of Table 2.4-3.

The model does not consider the potential influence from waste rock drainage on Long Lake water quality. Aside from occupying a small footprint within the Long Lake catchment, the material in the dump is primarily composed of slow weathering granite that freezes, limiting drainage to the outer 150 m of the footprint. The contributions from this zone are assumed to be negligible.

**Table 2.4-3**
**Modelled Concentration of Total Aluminum in Effluent from Tailings Impoundment**

| Year | Runoff | | Seepage | | Process Plant | | Cell E Discharge | | Remaining In Inactive Cell | | Al Concentration in Discharge |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Water ($m^3$) | Al (kg) | Water ($m^3$) | Al (kg) | Water ($m^3$) | Al (kg) | Water ($m^3$) | Al (kg) | Water ($m^3$) | Al (kg) | (mg/L) |
| 0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 35,198,907 | 704 | 0.020 |
| 1 | 6,430,401 | 129 | 252,000 | 504 | 1,762,325 | 35 | 4,920,076 | 98 | 35,198,907 | 1,203 | 0.034 |
| 2 | 6,376,083 | 128 | 252,000 | 504 | 3,024,679 | 103 | 3,603,404 | 123 | 35,198,907 | 1,608 | 0.046 |
| 3 | 4,972,385 | 99 | 395,000 | 790 | 3,024,679 | 138 | 2,342,706 | 107 | 35,198,907 | 2,252 | 0.064 |
| 4 | 4,920,475 | 98 | 143,000 | 286 | 3,024,679 | 194 | 2,038,796 | 130 | 35,198,907 | 2,313 | 0.066 |
| 5 | 3,271,330 | 65 | 322,000 | 644 | 3,024,679 | 199 | 568,651 | 37 | 27,178,575 | 2,259 | 0.083 |
| 6 | 3,262,267 | 65 | 322,000 | 644 | 0 | 0 | 3,584,267 | 298 | 27,178,575 | 2,671 | 0.098 |
| 7 | 3,253,281 | 65 | 322,000 | 644 | 0 | 0 | 3,575,281 | 351 | 27,178,575 | 3,028 | 0.111 |
| 8 | 3,244,370 | 65 | 322,000 | 644 | 0 | 0 | 3,566,370 | 397 | 27,178,575 | 3,340 | 0.123 |
| 9 | 3,235,535 | 65 | 322,000 | 644 | 0 | 0 | 3,557,535 | 437 | 27,178,575 | 3,611 | 0.133 |
| 10 | 2,197,020 | 44 | 283,000 | 566 | 0 | 0 | 2,480,020 | 330 | 3,000,000 | 679 | 0.226 |
| 11 | 2,197,020 | 44 | 283,000 | 566 | 0 | 0 | 2,480,020 | 562 | 3,000,000 | 728 | 0.243 |
| 12 | 2,197,020 | 44 | 283,000 | 566 | 0 | 0 | 2,480,020 | 602 | 3,000,000 | 736 | 0.245 |
| 13 | 2,197,020 | 44 | 283,000 | 566 | 0 | 0 | 2,480,020 | 608 | 3,000,000 | 738 | 0.246 |
| 14 | 2,197,020 | 44 | 283,000 | 566 | 1,611,014 | 396 | 869,006 | 214 | 3,000,000 | 738 | 0.246 |
| 15 | 2,197,020 | 44 | 283,000 | 566 | 1,307,397 | 322 | 1,172,623 | 288 | 3,000,000 | 738 | 0.246 |
| 16 | 2,197,020 | 44 | 283,000 | 566 | 1,371,282 | 337 | 1,108,738 | 273 | 3,000,000 | 738 | 0.246 |
| 17 | 2,197,020 | 44 | 283,000 | 566 | 1,411,851 | 347 | 1,068,169 | 263 | 3,000,000 | 738 | 0.246 |
| 18 | 2,197,020 | 44 | 283,000 | 566 | 1,411,851 | 347 | 1,068,169 | 263 | 3,000,000 | 738 | 0.246 |

Runoff Al = Runoff Water Volume x 0.02 mg/L.
Seepage Al = Seepage Water Volume x Assumed Seepage Al Concentration (2 mg/L).
Process Plant Al = Process Plant Water x Previous Years Aluminum Concentration.
Discharged Water = Runoff Water + Seepage Water - Process Plant Water.
Al in Cell E Discharge = Discharged Water x Previous Years Aluminum Concentration in Cell E.
Remaining Al in Cell E = Previous Years Aluminum + Runoff + Seepage - Process Plant - Cell E Discharge (kg).
Aluminum Concentration in Cell E (Discharge) = Aluminum Remaining in Cell E / Volume of Cell E.

**Table 2.4-4**
**Modelled Concentration of Total Nickel in Effluent from Tailings Impoundment**

| Year | Runoff | | Seepage | | Process Plant | | Cell E Discharge | | Remaining In Cell E | | Ni Concentration in Cell E (Discharge) (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Water ($m^3$) | Ni (kg) | Water ($m^3$) | Ni (kg) | Water ($m^3$) | Ni (kg) | Water ($m^3$) | Ni (kg) | Water ($m^3$) | Ni (kg) | |
| 0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 35,198,907 | 77 | 0.0022 |
| 1 | 6,430,401 | 14 | 252,000 | 126 | 1,762,325 | 4 | 4,920,076 | 11 | 35,198,907 | 203 | 0.0058 |
| 2 | 6,376,083 | 14 | 252,000 | 126 | 3,024,679 | 17 | 3,603,404 | 21 | 35,198,907 | 305 | 0.0087 |
| 3 | 4,972,385 | 11 | 395,000 | 198 | 3,024,679 | 26 | 2,342,706 | 20 | 35,198,907 | 467 | 0.0133 |
| 4 | 4,920,475 | 11 | 143,000 | 72 | 3,024,679 | 40 | 2,038,796 | 27 | 35,198,907 | 482 | 0.0137 |
| 5 | 3,271,330 | 7 | 322,000 | 161 | 3,024,679 | 41 | 568,651 | 8 | 27,178,575 | 491 | 0.0181 |
| 6 | 3,262,267 | 7 | 322,000 | 161 | 0 | 0 | 3,584,267 | 65 | 27,178,575 | 594 | 0.0219 |
| 7 | 3,253,281 | 7 | 322,000 | 161 | 0 | 0 | 3,5752,81 | 78 | 27,178,575 | 684 | 0.0252 |
| 8 | 3,244,370 | 7 | 322,000 | 161 | 0 | 0 | 3,566,370 | 90 | 27,178,575 | 763 | 0.0281 |
| 9 | 3,235,535 | 7 | 322,000 | 161 | 0 | 0 | 3,557,535 | 100 | 27,178,575 | 831 | 0.0306 |
| 10 | 2,197,020 | 5 | 283,000 | 142 | 0 | 0 | 2,480,020 | 76 | 3,000,000 | 163 | 0.0542 |
| 11 | 2,197,020 | 5 | 283,000 | 142 | 0 | 0 | 2,480,020 | 134 | 3,000,000 | 174 | 0.0582 |
| 12 | 2,197,020 | 5 | 283,000 | 142 | 0 | 0 | 2,480,020 | 144 | 3,000,000 | 177 | 0.0589 |
| 13 | 2,197,020 | 5 | 283,000 | 142 | 0 | 0 | 2,480,020 | 146 | 3,000,000 | 177 | 0.0590 |
| 14 | 2,197,020 | 5 | 283,000 | 142 | 1,611,014 | 95 | 869,006 | 51 | 3,000,000 | 177 | 0.0590 |
| 15 | 2,197,020 | 5 | 283000 | 142 | 1,307,397 | 77 | 1,172,623 | 69 | 3,000,000 | 177 | 0.0590 |
| 16 | 2,197,020 | 5 | 283,000 | 142 | 1,371,282 | 81 | 1,108,738 | 65 | 3,000,000 | 177 | 0.0590 |
| 17 | 2,197,020 | 5 | 283,000 | 142 | 1,411,851 | 83 | 1,068,169 | 63 | 3,000,000 | 177 | 0.0590 |
| 18 | 2,197,020 | 5 | 283,000 | 142 | 1,411,851 | 83 | 1,068,169 | 63 | 3,000,000 | 177 | 0.0590 |

Runoff Ni = Runoff Water Volume x 0.0022 mg/L.
Seepage Ni = Seepage Water Volume x Assumed Seepage Ni Concentration (0.5 mg/L).
Process Plant Ni = Process Plant Water x Previous Years Nickel Concentration.
Discharged Water = Runoff Water + Seepage Water - Process Plant Water.
Ni in Cell E Discharge = Discharged Water x Previous Years Aluminum Concentration in Cell E.
Remaining Ni in Cell E = Previous Years Nickel + Runoff + Seepage - Process Plant - Cell E Discharge (kg).

***Seepage***

While the tailings water balance assumes, for design purposes, that seepage will not occur through the filter dams (internal dikes), seepage has been considered as an important parameter contributing Al to the clean water cells. Apart from seepage, the active tailings cell is considered to operate at zero discharge until turbid water begins to approach design elevation. At that time, the water layer with minimum turbidity would be transferred to the next cell scheduled to receive tailings. Seepage rates through each of the internal dikes have been estimated based on engineering design and vary within each active cell. Table 2.4-5 summarizes the maximum projected seepage rates through each of the structures.

**Table 2.4-5**
**Estimated Seepage Rates Through**
**Internal Dikes in Long Lake**

| | **Seepage Rate $m^3/a$** |
|---|---|
| Dike A | 252,000 |
| Dike B | 143,000 |
| Dike C | 322,000 |
| Dike D | 283,000 |

The importance of the seepage estimate to the water quality model is not in the volume of seepage, but rather in quantifying the Al loading associated with seepage from an active cell to the clean water portion of the impoundment. For the purposes of this model, the concentration of total Al in the seepage has been assigned a concentration of 2.0 mg/L.

Monitoring of the water in the Phase I and Phase II ponds during 1994 indicated that total Al levels generally ranged from 0.6 to 1.42 mg/L (Table 2.4-6). On rare occasions, total Al values in these tailings ponds were seen to exceed 2 mg/L; however, they were accompanied by elevated TSS values. Consequently, they are suspected to represent premature collection of the tailings slurry before settling and are not considered representative of the quantity of fines which will pass through the dike. In the absence of information and/or data on this seepage quality, the model has conservatively assumed that it will be similar to that observed in the exploration tailings ponds. This assumption is argued to be conservative in that the ability of internal dikes to operate as filter dams has been ignored in this assessment.

To summarize, the model assumes that some seepage through a filter dam will take place when a tailings deposition cell is being actively filled. These seepage rates will vary depending on the cell being filled, but a constant concentration of

**Table 2.4-6**
**Exploration Tailings Pond Water Quality, 1994**

| Tailings Pond | Date of Sampling | Total Al (mg/L) |
|---|---|---|
| Phase I Pond | 9 Feb 94 | 0.62 |
| | 16 Apr 94 | 1.42 |
| Phase II Pond | 8 Aug 94 | 0.60 |

2.0 mg/L of total Al has been assumed to be contained in this seepage. It is further assumed that once a tailings cell is completely filled with solids, seepage no longer passes through the dike.

This is reflected in the third column of the model (Table 2.4-3), in which the volume and Al change as a result of the successive operation and closure of Long Lake cells. Initially only cell A contributes seepage until Year 3, when Cells A and B contribute simultaneously, temporarily increasing the loading. Cells A and B are closed by Years 3 and 5, respectively, resulting in seepage arising from Cell C from Year 5 onward. Finally, after cell C is full, seepage arises through internal dike D for the remainder of the duration of the model.

***Process Water Reclaim***

Water for process plant use (the fourth column of Table 2.4-3) will be supplied primarily from the clean water cells downstream of the cell of active deposition. Apart from considering the volume loss from the clean water cell(s), this reclaim will also remove a portion of the total Al inventory within the facility. This mass will be equal to the volume of water removed multiplied by the concentration of total Al in the clean water for that given year. From Years 6 to 13, the process plant values in Table 2.4-3 are zero, as process water will be collected from Cell C, the cell of active tailings deposition. Thus, there will be no consumption of clean water during that time interval; process water will be cycled internally.

***Cell E Discharge***

Similar to reclaim water, annual discharge of water from cell E (column five of Table 2.4-3) will also remove a mass of Al from the total inventory in the clean water portion of the impoundment. This loss has been determined as per the reclaim water and varies according to the concentration within cell E at the time of discharge. Here the model uses discharge volumes from the Water Management Plan (Volume III, Section 3). In this regard, it is merely predictive in its approach to assessing water quality.

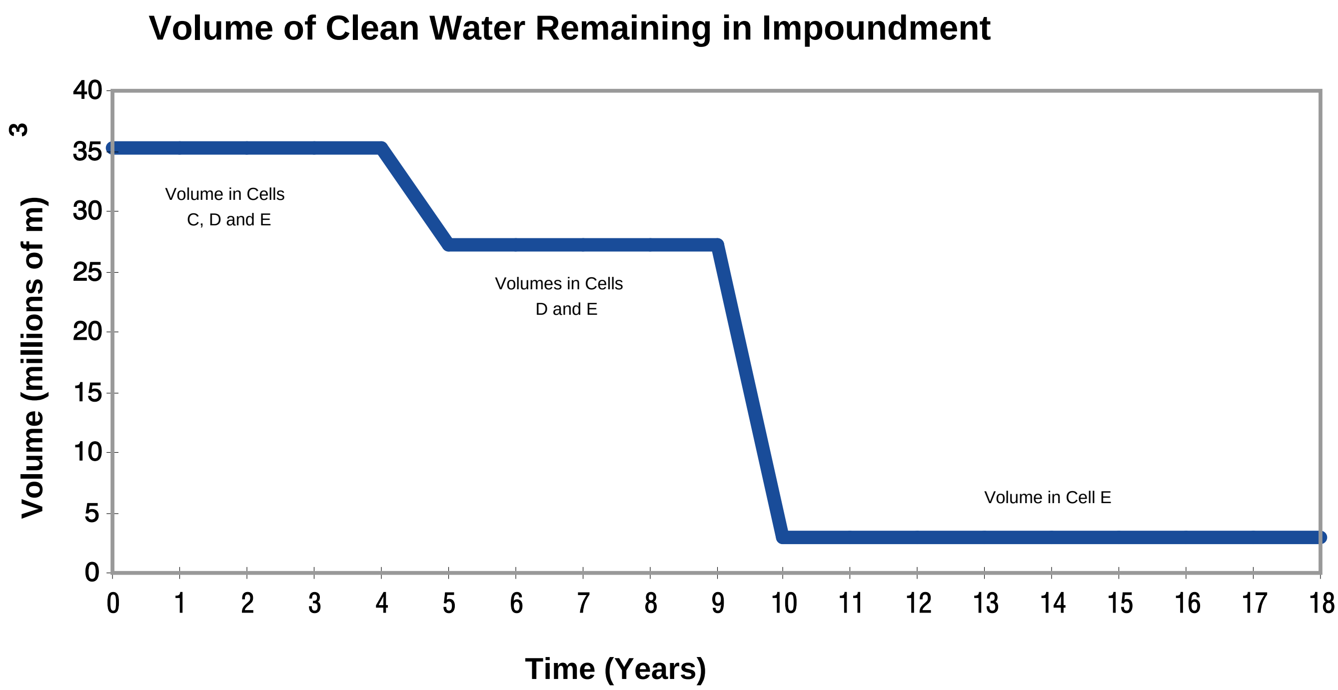
The last two columns (columns six and seven) of Table 2.4-3 are the Al and volume of water remaining in the inactive cell(s) and the concentration of Al in the discharge from the inactive cell(s). The remaining water and Al in the inactive cells simply describe the available volume (and associated Al inventory) of the portion of Long Lake below the cell of active deposition (Figure 2.4-1). The concentration of total Al in discharge (the seventh column of Table 2.4-3 and visually represented in Figure 2.4-1) is calculated as described above and is used as input data for predicting the final concentration in Nema Lake.

To further clarify Table 2.4-3, some sample calculations are discussed in detail below. The model commences at Year 0 immediately following dewatering of Long Lake to the 446 m elevation level. At this stage, no runoff occurs. The volume of water remaining in the clean cells, excluding cells A and B, is approximately 35.2 x $10^6$ $m^3$. Long Lake has a background concentration of Al of 0.020 mg/L, which is equivalent to a total mass of Al in the clean cells of 704 kg prior to operations (Table 2.4-3, column six). During Year 1, 6.4 x $10^6$ $m^3$ of runoff water is predicted to enter the clean cells of the impoundment (column one). Assuming that this runoff water has a total Al concentration of 0.02 mg/L results in an additional 129 kg of Al added to the clean cells of the impoundment. Seepage from filter dams is predicted to contribute 504 kg of Al, based on an assumed Al concentration in the dam seepage of 2.0 mg/L. However, the process plant will be removing clean water and a mass of Al equivalent to the previous year's concentration of Al in the clean cells multiplied by the volume removed to the process. Similarly, the discharge volume from cell E has been determined from the water balance in order to maintain the clean water level. This discharge will also remove a mass of Al equivalent to the discharge volume multiplied by the previous year's Al concentration. Therefore, for Year 1 the maximum Al concentration in cell E discharge, the final column of Table 2.4-3, is 0.034 mg/L, and this concentration will be used as the existing concentration in cell E for the next year's iteration.

Figure 2.4-1 graphically presents the model data for clean water volumes and predicted total Al concentration in cell E discharge for the base case scenario. This scenario realizes that turbid water reaches design elevation in cell D at or water volume to that of cell E alone (i.e., 3 x $10^6$ $m^3$) before Year 18 (Volume I, Figure 2.6-9). As exhibited in Figure 2.4-1, the volume of clean water in the impoundment is dictated by the tailings deposition scheme. By Year 5, cell C is being filled with tailings and the available volume of clean water for dilution is reduced from 35 x $10^6$ $m^3$ to approximately 27 x $10^6$ $m^3$. By Year 10, deposition has commenced in cell D, reducing the clean

#### 2.4.2.3 Model Assumptions

In order to model the evolution of total Al levels in the inactive cells within Long Lake, some recognized processes that would otherwise influence total Al concentrations (or total Ni or TSS) have been ignored. In so doing, the robustness of the model has not been compromised but rather additional levels of



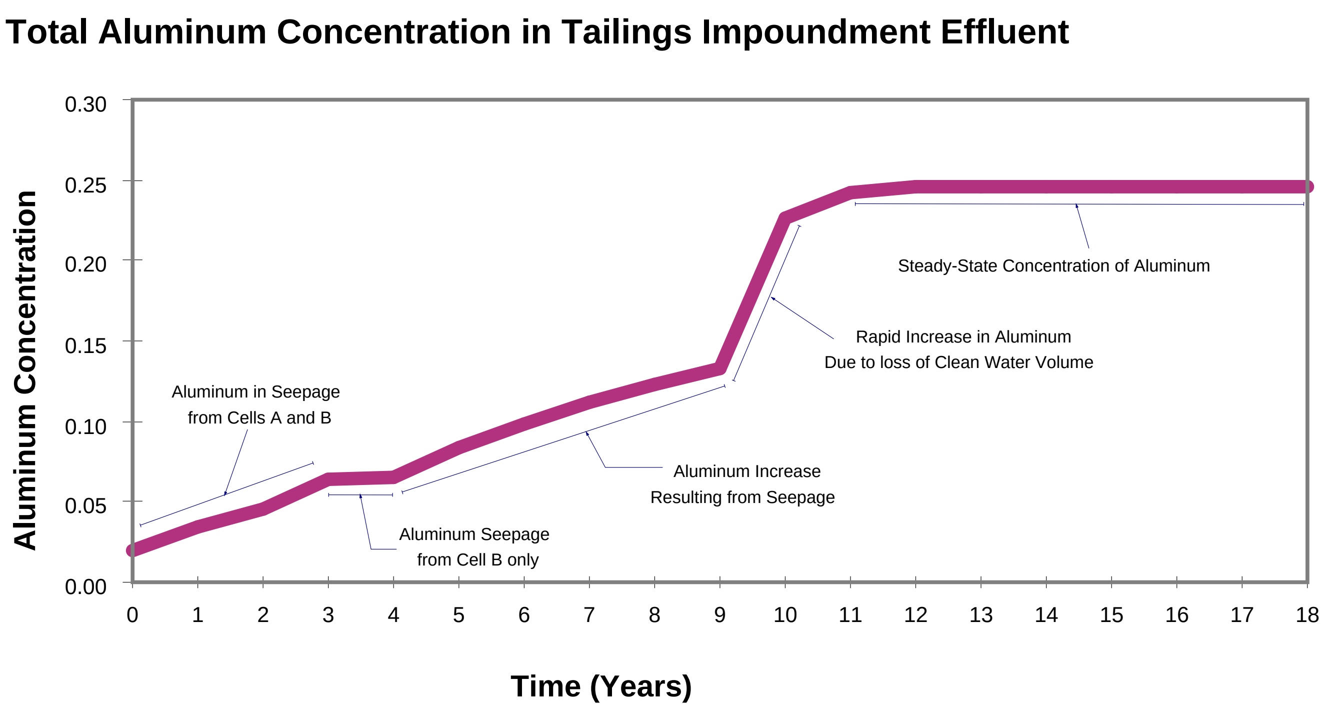




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**Figure 2.4-1**
**Changes in Long Lake During Operations Phase**

*Source: Rescan*

conservatism have been introduced. These aspects are discussed below in the context of Al which equally apply to the other parameters of concern.

***Instantaneous Mixing of Al Loadings***

As discussed, total Al loadings to the inactive cells have been assumed to result from natural runoff and seepage. These impacts have been conservatively assumed to mix instantaneously both laterally and vertically throughout the clean water portion of the impoundment. This assumption will result in an overestimation of Al concentrations at the lowermost cell E during the early years of the operation. The conservative aspect to this assumption is, however, considerably less as tailings are progressively deposited in cells C and D. Therefore, only Years 1 to 5 can be considered to have overestimated total Al concentrations.

While Long Lake was stratified in the summer, lake turnover before winter freeze-up ensures complete mixing of the water column, resulting in minimal chemical stratification. Chemical fractionation of the water column does not occur to the extent that if surface waters are preferentially removed from the facility because of thermal stratification, residual water composition should not deviate from that predicted by the model.

***Aluminum as a Conservative Parameter***

Aluminum has been assumed to behave as a conservative, dissolved parameter; in other words, no natural physical or chemical removal mechanisms (i.e., precipitation and settling) have been involved in the model. This assumption is false but has been included to keep the model conservative. Aluminum in the environment is most thermodynamically stable as a solid sesquioxide (a compound of oxygen and a metal in the proportion 3:2) and will be subject to natural mitigative pressures. In the soft, low-conductivity waters of the upper Coppermine River drainage basin, Al speciation is associated primarily with the hydroxide ion derived from the dissociation of water. At low pH, Al exists as a free, hydrated, tri-valent ion $Al^{3+}$ (Figure 2.4-2). As pH increases, Al is complexed by successive hydroxide groups as $Al(OH)^{2+}$, $Al(OH)_2^{+}$, $Al(OH)_3$ and $Al(OH)_4^{-}$. The species $Al(OH)_3$ is susceptible to precipitation as an amorphous solid, while both high and low pH environments enhance Al dissolution from solids. Consequently, Al exhibits a solubility minimum when $Al(OH)_3$ is the dominant species.

Solubility calculations for Al speciation were performed using the MINTEQA2 Geochemical Assessment Model for water of composition typical of Long Lake. The results demonstrate that Al speciation is pH controlled and that solubility is minimal within the pH range of 5.5 to 9.5 (Figure 2.4-2). Thus, as high pH tailings pond water mixes into the low pH environment of Long Lake (pH 6.3), dissolved Al (as $Al(OH)_4^{-}$) will convert to $Al(OH)_3$ and precipitate out of solution

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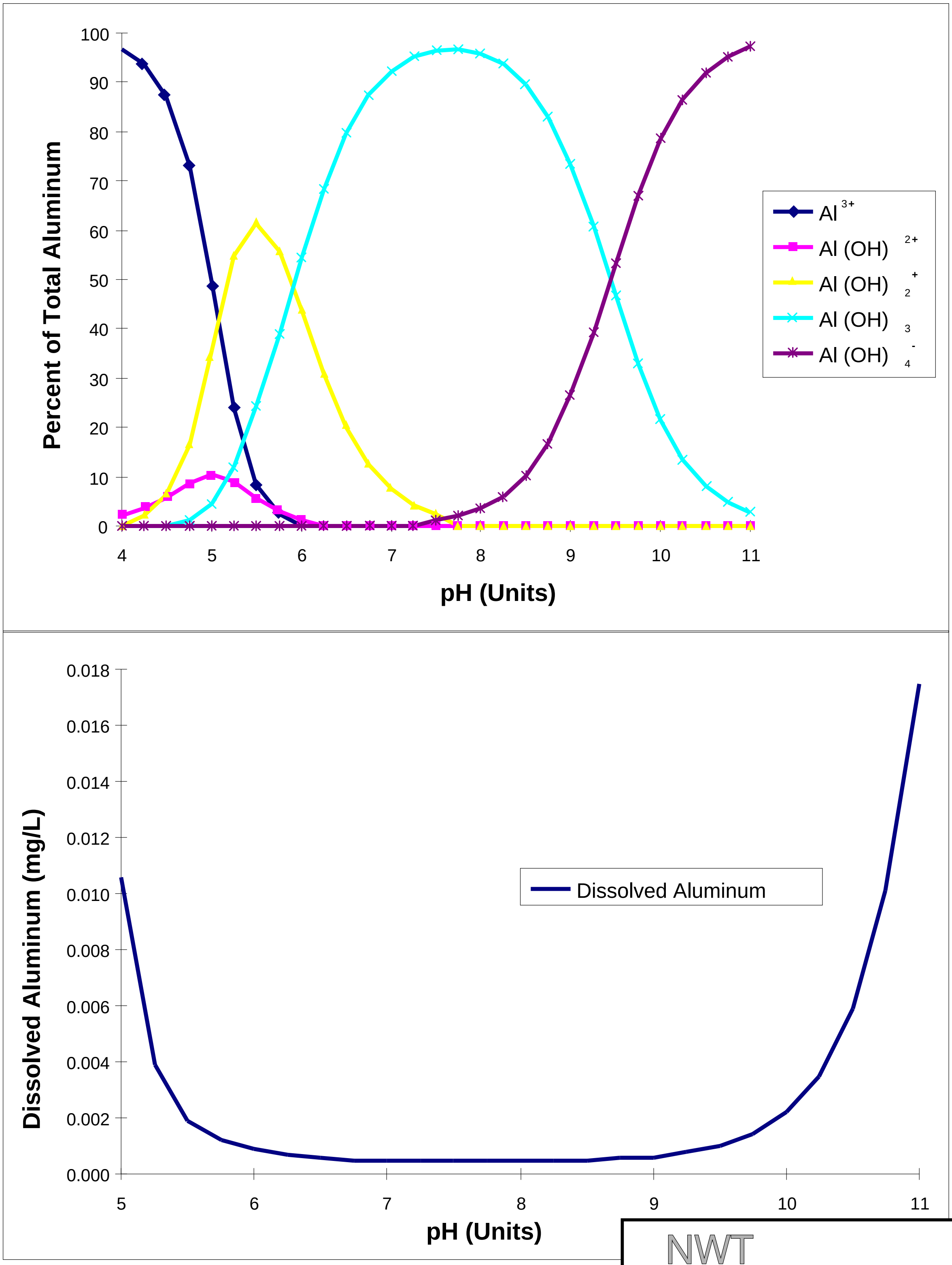


NWT DIAMONDS PROJECT

**Figure 2.4-2**
**Aluminum Speciation in Long Lake**

*Source: Rescan*

as an amorphous sesquioxide. As a solid, Al is then susceptible to sedimentation, particularly under ice cover when the lake waters are calm.

Recognizing that a large portion of the total Al within the inactive cells will be associated with the solid phase, it is conservative to assume that no settling of total Al will take place within the lake. This is considered to be especially conservative during the winter months, when ice cover will prevent wind mixing and promote the settling of solids. Indeed, settling of fines was observed in Koala Lake under ice-free conditions and is described in greater detail in Section 2.4.9.

Since settling rates are difficult to accurately quantify, the model has ignored this important Al removal mechanism, and therefore Al concentrations for all years are considered to be greatly overestimated. Particularly germane to this argument is the fact that the natural pH of Long Lake is approximately 6.5, and, therefore, seepage of dissolved Al into the clean water cells of the impoundment is predicted to rapidly produce precipitates of $Al(OH)_3$. Under calm conditions, they can aggregate and settle out of solution.

2.4.2.4 Model Results

The following section outlines the rationale as to why discharge from cell E throughout the first 18 years of operation is considered acceptable.

***Implications of Discharge to Receiving Environment***

End of pipe discharge criteria for Al do not currently exist specifically for the mining industry. However, federal effluent limits of 1.0 mg/L total Al do exist for wastewater treatment facilities in the NWT while similar effluent limits in B.C. range from 0.5 mg/L to 1.0 mg/L. In the absence of applicable mining effluent criteria for Al, the water management plan has been designed to ensure that the highly conservative federal receiving water criteria (CCME) for the protection of aquatic life are not exceeded in the receiving environment even though background Al is naturally elevated in these watercourses (Volume II, Section 2.4). The CCME guidelines are currently ten times more stringent than NWT effluent limits and five to ten times lower than B.C. limits; this is discussed in more detail in Volume II, Section 2.4. With respect to the tailings impoundment discharge, the receiving environment refers to Nema Lake. Nema Lake was not included in the baseline sampling, although Nero Lake, which feeds Nema Lake, was sampled intensively. For the purposes of the following discussion, water quality in Nema Lake is assumed to be similar to that observed in 1994 in Nero Lake. Table 2.4-7 provides a summary of the important water quality parameters under consideration.

**Table 2.4-7**
**Summary of Water Quality Background**
**for Nero/Nema Lake, 1994**

| CCME Guidelines | Parameters pH | Total Al | Total Ni |
|---|---|---|---|
| Concentration (mg/L) | 6.5 | 0.025 | 0.001 |
| CCME Guideline (mg/L) | - | 0.100 | 0.025 |

Based on background levels and the applicable CCME criteria, Nema Lake has a considerable assimilative capacity for the metals Al and Ni. Nema Lake is also a small and relatively rapid flushing lake with an annual inflow rate of approximately 12.6 x $10^6$ $m^3$ (excluding Long Lake) and a total volume of approximately 1.46 x $10^6$ $m^3$. Recognizing that flows through the lake are greatest during May, June and July of each year, the residence time of Nema Lake will be on the order of weeks and hence flushing and/or mixing will be relatively rapid. Therefore, determination of annual concentrations of Al and Ni in Nema Lake have correctly assumed mixing within the entire lake. Tables 2.4-8 and 2.4-9 present the predicted Al and Ni concentrations in Nema Lake during the discharge Years 1 to 18. Input parameters included background concentrations as per Table 2.4-7 for each parameter and cell E predicted discharge concentrations. For Al, a maximum incremental increase in Nema Lake of 0.017 mg/L is predicted, resulting in a peak concentration of approximately 0.061 mg/L, a value substantially lower than the CCME criterion for Al (Figure 2.4-3). For Ni, the maximum incremental increase is predicted to be 0.004 mg/L, resulting in a peak concentration of 0.011 mg/L, a value less than half of the CCME criterion for Ni.

Clearly, discharge from cell E during Years 1 to 18 can proceed without impact to the receiving environment. Moreover, conservative estimates of water quality within Cell E indicate that discharge of this water will not increase concentrations of Al or Ni (the only metals of environmental concern in the discharge) sufficiently to even approach applicable federal criteria for the protection of aquatic life for these parameters.

### 2.4.3 Waste Dumps

Waste rock dumps will be constructed adjacent to each open pit. The Koala/Panda dump is unique in that its proximity to the process plant and permanent camp site makes it the designated disposal site for inert site waste and coarse kimberlite tails. The other mine dumps will consist entirely of blasted waste rock from the respective pits which are predominantly granite. Although most infiltrating water from precipitation and snowmelt will freeze within the

**Table 2.4-8**
**Total Aluminum Concentration in Nema Lake (Receiving Environment) After Dilution**

| | Cell E Discharge | | Nema Inflow | | Nema Lake Total | | |
|---|---|---|---|---|---|---|---|
| Year | Water ($m^3$) | Al (kg) | Water ($m^3$) | Al (kg) | Water ($m^3$) | Al (kg) | Al Conc. (mg/L) |
| 1 | 4,920,076 | 98 | 12,600,000 | 315 | 17,520,076 | 413 | 0.024 |
| 2 | 3,603,404 | 123 | 12,600,000 | 315 | 16,203,404 | 438 | 0.027 |
| 3 | 2,342,706 | 107 | 12,600,000 | 315 | 14,942,706 | 422 | 0.028 |
| 4 | 2,038,796 | 130 | 12,600,000 | 315 | 14,638,796 | 445 | 0.030 |
| 5 | 568,651 | 37 | 12,600,000 | 315 | 13,168,651 | 352 | 0.027 |
| 6 | 3,584,267 | 298 | 12,600,000 | 315 | 16,184,267 | 613 | 0.038 |
| 7 | 3,575,281 | 351 | 12,600,000 | 315 | 16,175,281 | 666 | 0.041 |
| 8 | 3,566,370 | 397 | 12,600,000 | 315 | 16,166,370 | 712 | 0.044 |
| 9 | 3,557,535 | 437 | 12,600,000 | 315 | 16,157,535 | 752 | 0.047 |
| 10 | 2,480,020 | 330 | 12,600,000 | 315 | 15,080,020 | 645 | 0.043 |
| 11 | 2,480,020 | 562 | 12,600,000 | 315 | 15,080,020 | 877 | 0.058 |
| 12 | 2,480,020 | 602 | 12,600,000 | 315 | 15,080,020 | 917 | 0.061 |
| 13 | 2,480,020 | 608 | 12,600,000 | 315 | 15,080,020 | 923 | 0.061 |
| 14 | 869,006 | 214 | 12,600,000 | 315 | 13,469,006 | 529 | 0.039 |
| 15 | 1,172,623 | 288 | 12,600,000 | 315 | 13,772,623 | 603 | 0.044 |
| 16 | 1,108,738 | 273 | 12,600,000 | 315 | 13,708,738 | 588 | 0.043 |
| 17 | 1,068,169 | 263 | 12,600,000 | 315 | 13,668,169 | 578 | 0.042 |
| 18 | 1,068,169 | 263 | 12,600,000 | 315 | 13,668,169 | 578 | 0.042 |

dump as described in Volume III, Section 5.2, the perimeter of each dump for a width of approximately 150 m remains porous and would produce a drainage of some quality.

If a non-neutral drainage is produced, it is most likely to be alkaline. The pH of this drainage, if above 9.5 and exposed to some kimberlites, may dissolve metals that could be released into surface waters. As described above, the kimberlite is confined to the Koala/Panda dump. Other mine dumps are prone to leaching of nitrate residue from blasting with ammonium nitrate explosives.

#### 2.4.3.1 Mitigation

Mitigation for pH should not be required, as the exposed portions of the dump, which is composed predominantly of slow weathering granite, will be aerated, thus pH of any drainage is expected to remain fairly neutral. The location of the kimberlite coarse tails in the central frozen portion of the dump, coupled with the

**Table 2.4-9**
**Total Nickel Concentration in Nema Lake**
**(Receiving Environment) After Dilution**

| | Cell E Discharge | | Nema Inflow | | Nema Lake Total | | |
|---|---|---|---|---|---|---|---|
| Year | Water ($m^3$) | Ni (kg) | Water ($m^3$) | Ni (kg) | Water ($m^3$) | Ni (kg) | Ni Conc. (mg/L) |
| 1 | 4,920,076 | 11 | 12,600,000 | 25 | 17,520,076 | 36 | 0.0021 |
| 2 | 3,603,404 | 21 | 12,600,000 | 25 | 16,203,404 | 46 | 0.0028 |
| 3 | 2,342,706 | 20 | 12,600,000 | 25 | 14,942,706 | 45 | 0.0030 |
| 4 | 2,038,796 | 27 | 12,600,000 | 25 | 14,638,796 | 52 | 0.0036 |
| 5 | 568,651 | 8 | 12,600,000 | 25 | 13,168,651 | 33 | 0.0025 |
| 6 | 3,584,267 | 65 | 12,600,000 | 25 | 16,184,267 | 90 | 0.0056 |
| 7 | 3,575,281 | 78 | 12,600,000 | 25 | 16,175,281 | 103 | 0.0064 |
| 8 | 3,566,370 | 90 | 12,600,000 | 25 | 16,166,370 | 115 | 0.0071 |
| 9 | 3,557,535 | 100 | 12,600,000 | 25 | 16,157,535 | 125 | 0.0077 |
| 10 | 2,480,020 | 76 | 12,600,000 | 25 | 15,080,020 | 101 | 0.0067 |
| 11 | 2,480,020 | 134 | 12,600,000 | 25 | 15,080,020 | 160 | 0.0106 |
| 12 | 2,480,020 | 144 | 12,600,000 | 25 | 15,080,020 | 169 | 0.0112 |
| 13 | 2,480,020 | 146 | 12,600,000 | 25 | 15,080,020 | 171 | 0.0114 |
| 14 | 869,006 | 51 | 12,600,000 | 25 | 13,469,006 | 76 | 0.0057 |
| 15 | 1,172,623 | 69 | 12,600,000 | 25 | 13,772,623 | 94 | 0.0069 |
| 16 | 1,108,738 | 65 | 12,600,000 | 25 | 13,708,738 | 91 | 0.0066 |
| 17 | 1,068,169 | 63 | 12,600,000 | 25 | 13,668,169 | 88 | 0.0065 |
| 18 | 1,068,169 | 63 | 12,600,000 | 25 | 13,668,169 | 88 | 0.0065 |

fact that drainage from this portion of the Koala/Panda dump flows into the tailings disposal impoundment, eliminates the chance of a contaminated effluent reaching a surface water body.

Nitrate is not expected to cause measurable impacts from the waste dump for several reasons. First, responsible handling of ammonium nitrate-based explosives will minimize residual nitrogen in the waste rock. Second, the low precipitation and low temperatures for much of the year preclude rapid rates of ammonium oxidation within the dump as the conversion of ammonium to nitrate is bacterially mediated. Oxidation will progress very slowly and attenuate release to adjacent water bodies. Finally, the lakes of the Koala watershed are currently classified as oligotrophic and as a result have a high assimilative capacity for nutrients such as nitrate.

Upon mine closure, it is suspected that much of the flushing of water flow through the waste dump will have ceased, as both permafrost and the formation of ice within the rock pile will preclude water percolation. Consequently, any

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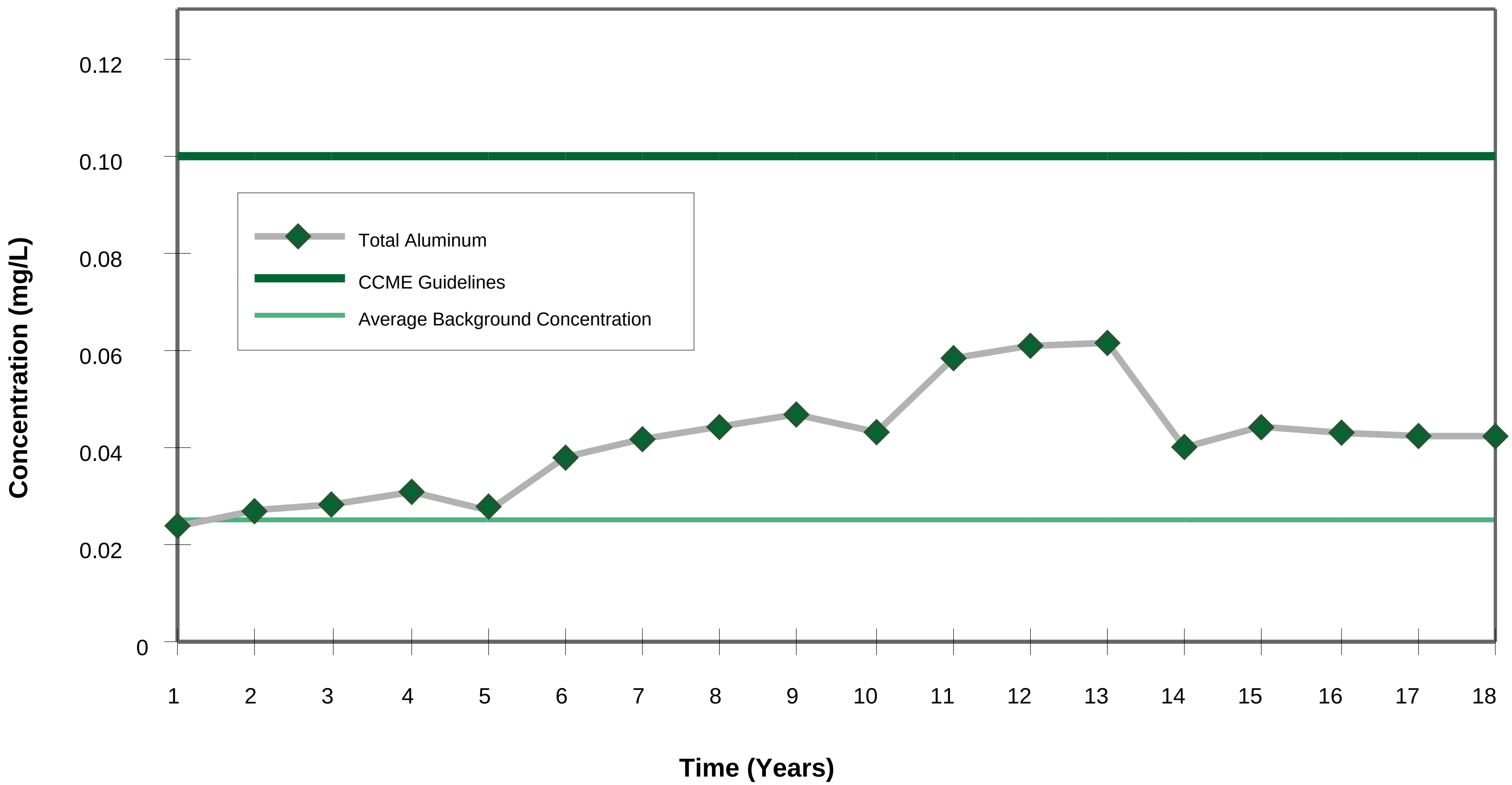


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**Figure 2.4-3**
**Predicted Concentration of Total Aluminium in Nema Lake**

*Source: Rescan*

introduction of particulate or dissolved material to the adjacent lakes will reduce with time.

2.4.3.2 Residual Impacts

The influence of natural attenuation of potential waste dump leachate combined with ongoing monitoring and treatment (if necessary) will result in negligible impact on water quality. Since waste dump glacial movement will infringe on lakes too slowly to affect water quality, the impact can be assumed to be negligible.

### 2.4.4 Dust

Dust can be generated from various activities in the pits, including pre-stripping, production, mining, vehicular traffic along mine roads and the dumping of waste rock. Impacts to water quality will be constrained to slight increases in total suspended solids (TSS) and total Al concentrations in nearby lakes. Evidence for these impacts is apparent from the baseline water quality monitoring program, where an increase in TSS, total Al and, to much lesser extent, dissolved Al in lakes near areas of high exploration activity and vehicular traffic was observed (Table 2.4-10).

**Table 2.4-10**
**Effects of Dust on Lake Water Quality (mg/L)**

| | Lakes Possibly Affected by Dust During Exploration in 1993 * | All Other Lakes in Koala Study Area |
|---|---|---|
| Total Aluminum | 0.079 | 0.024 |
| Total Nickel | 0.0017 | 0.0012 |
| Dissolved Aluminum | 0.020 | 0.012 |
| Dissolved Nickel | 0.0015 | 0.0011 |
| Suspended Solids | 3.7 | 1.6 |

* Affected lakes are defined as those proximal to dust generating activities.

Impacts will be limited to the ice-free period, due not only to reduced dust levels when conditions are frozen but also to more efficient settling of TSS when the lakes are ice-covered. Wind mixing can be a significant inhibitor of settling but is not a concern when the lakes are frozen. The settling of TSS will reduce the concentrations of total Al, as most of the Al in dust-affected lakes will be associated with the solid phase.

2.4.4.1 Mitigation

It will be difficult to control fugitive dust resulting from the main mining activities such as blasting, pre-stripping, mining, ore stockpiling and waste dumping. Road surfaces will be sprayed with water during late spring and summer to minimize dust from road usage.

2.4.4.2 Residual Impacts

Settling of suspended solids from the water column during the period of ice cover will be effective in reducing total Al concentrations. Therefore, residual impacts from dust on water quality can be considered negligible.

### 2.4.5 Exploration Drilling Impacts

Potential impacts may result from exploration drilling programs undertaken during the winter. Baseline data for Koala Lake indicate that under-ice drilling results in elevated TSS, total Al and dissolved Al (Table 2.4-11) relative to average watershed levels. As shown by the drill monitoring program (Rescan 1995), drill chip effluent from the rotary drills displayed properties of high pH, suggesting that dissolution of unidentified components of the kimberlite was responsible for the observed increases in Al. Elevated pH and TSS result in higher values for total and dissolved Al. While the drilling is restricted to a few months during the winter, the fine-grained nature of the kimberlite drill chips causes elevated Al to persist through the summer (in excess of CCME guidelines), even though TSS is not in excess of 25 mg/L (Table 2.4-11). Therefore, unmitigated winter drilling is capable of producing a local, measurable impact.

**Table 2.4-11**
**Average Composition of Koala Lake Water**
**During and After Rotary Drilling**

| | Mar 94 | Jun 94 | Aug 94 | Average Koala Watershed |
|---|---|---|---|---|
| TSS (mg/L) | 15 | 10 | 6 | 4 |
| Total Al (mg/L) | - | 0.37 | 0.17 | 0.06 |
| Total Ni (mg/L) | - | 0.008 | 0.004 | 0.0025 |

2.4.5.1 Mitigation

For present and future exploration drilling, measures will be employed to control the discharge of fine solids into lake waters. Several methods were tested during the 1995 season, one of which involved flooded reverse circulation drilling with desilting cyclones, which substantially reduced impacts.

In previous exploration programs, the existing TSS and newly precipitated Al were allowed to settle out of the water column naturally. Evidence for natural settling comes from Koala Lake samples collected in March, June and August of 1994 (Table 2.4-12 and Figure 2.4-4), which indicate substantial decreases in both TSS and total Al (and total Ni) after the cessation of winter drilling. Furthermore, as Figure 2.4-5 illustrates, elevated TSS and Al decrease with distance. Either suspended solids fall out of solution rapidly enough so as not to affect successive lakes or the front of affected water has not fully influenced successive lakes.

#### 2.4.5.2 Residual Impacts

Natural mitigation is sufficient to minimize the impact within short spatial distances (one or two lake basins) by natural settling. Therefore, the residual impact is considered to be negligible as it is short-lived (perhaps six months to one year) and local (restricted to one or two adjacent lakes). It is worth noting that immediately after mitigative measures were taken for the 1995 program by the Proponent, bioassays consistently indicated 100% survival of all test organisms.

### 2.4.6 Post Closure Tailings Pond Discharges

Following cessation of mining, activities will be focused on returning as much of the project area as possible to its original use. A component of this program will be ensuring that any water to be discharged to the receiving environment will not cause adverse changes to water chemistry and result in waters exceeding receiving water criteria. The most important project feature to be considered are discharges from the tailings ponds (e.g., Long Lake and Panda or Koala pits).

Both Long Lake and Panda pit (once depleted of mineable ore) will receive tailings during mine operation. Control of water quality will be the key objective of the operational and closure environmental management plans.

#### 2.4.6.1 Long Lake

A best-estimate approach to assessing water quality within Cell E of the Long Lake tailings pond at the time of closure would be to assume that the chemistry within the tailings lake will be similar to that currently observed in the exploration tailings ponds (Table 2.4-12). These concentrations are considered to be conservative estimates, recognizing that tailings will not be discharged into Long Lake beyond Year 20 of the operation. Thus, any tailings pond water in Cell E requiring discharge between Year 20 and the cessation of mining (in Year 25) can be discharged to Panda or Koala pit and not directly to the environment. This contingency is important, as it allows the benefits of at least five ice-covered periods to be realized before closure. Ice cover of the lake will permit more efficient settling of the TSS.

**Table 2.4-12**
**Summary of Range of Concentrations of Key Water Quality Parameters Observed in Phase I Tailings Pond (1994 to 1995)**

| Parameter | Concentration Range (mg/L) |
|---|---|
| pH | 7.27 to 8.25 |
| TSS | 21 to 498 |
| Al total | 1.4 to 16.0 |
| Al dissolved | <0.2 to 0.77 |
| Cu total | 0.010 to 0.020 |
| Cu dissolved | 0.003 to 0.008 |
| Ni total | 0.092 to 0.413 |
| Ni dissolved | 0.016 to 0.041 |

Source: Water Surveillance Reports submitted to NWT Water Board (1994 to 1995) by BHP.

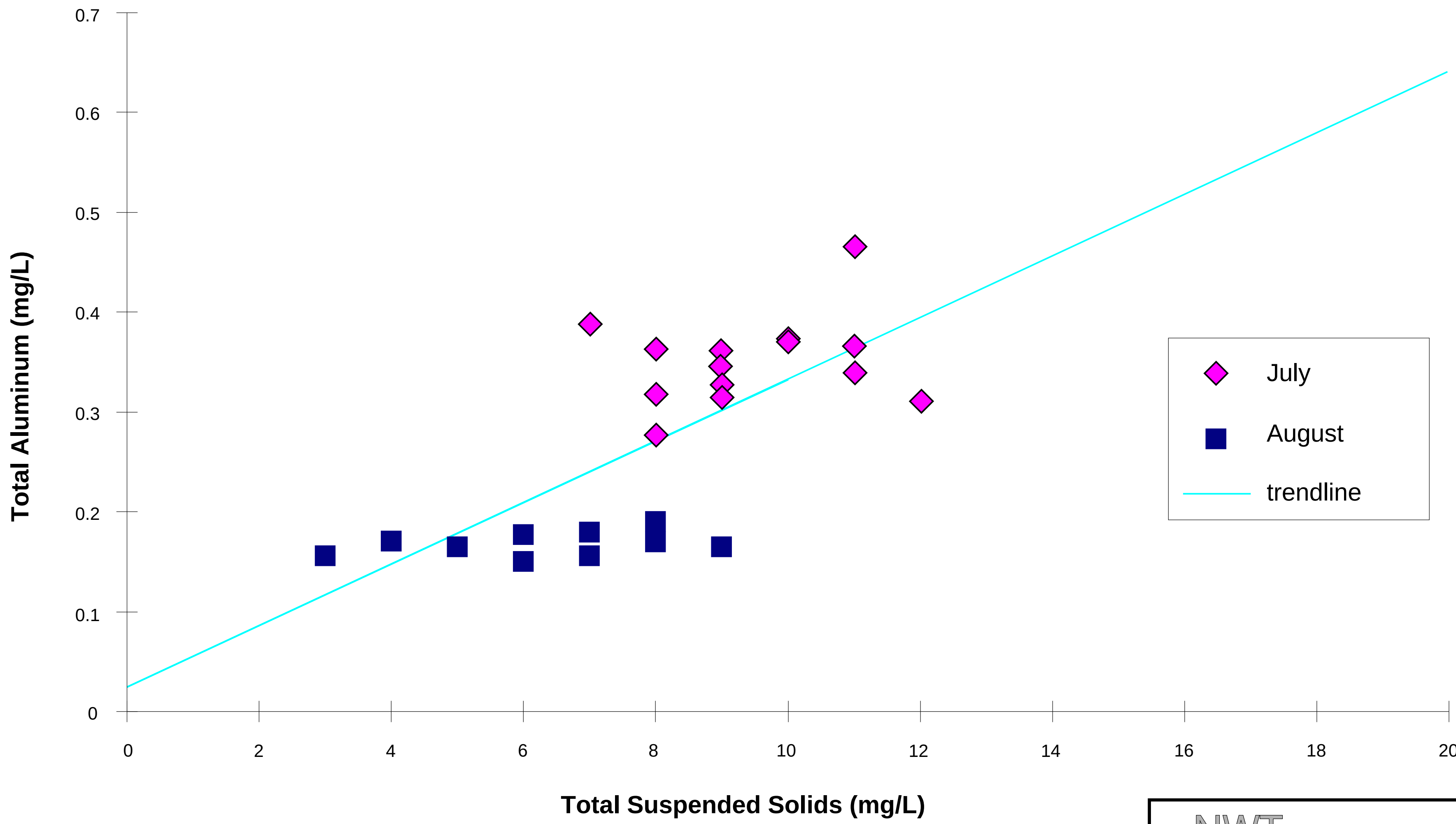
The pH of Cell E is expected to become more neutral over time once tailings pond water discharge is terminated. Additional solid formation of Al sesquioxide is predicted with subsequent settling and reduction of total Al in suspension. Therefore, after Year 25, direct discharge of overflow through a spillway is assumed possible without water quality impacts. Regular monitoring of tailings pond water will permit verification of water quality evolution over time with the contingency available for "zero discharge" through discharge into Panda or Koala pits.

Should discharge be necessary prior to attainment of discharge criteria, the Proponent has committed to the installation of a water treatment facility to produce a discharge of acceptable water quality.

2.4.6.2 Panda Pit

Panda pit will eventually be filled with tailings and a small amount of natural runoff. Approximately 20 m to 30 m of water cover is expected over consolidated tailings in the pit. Following termination of tailings discharge into Panda pit an estimated six years will be required to fill the pit with natural runoff.

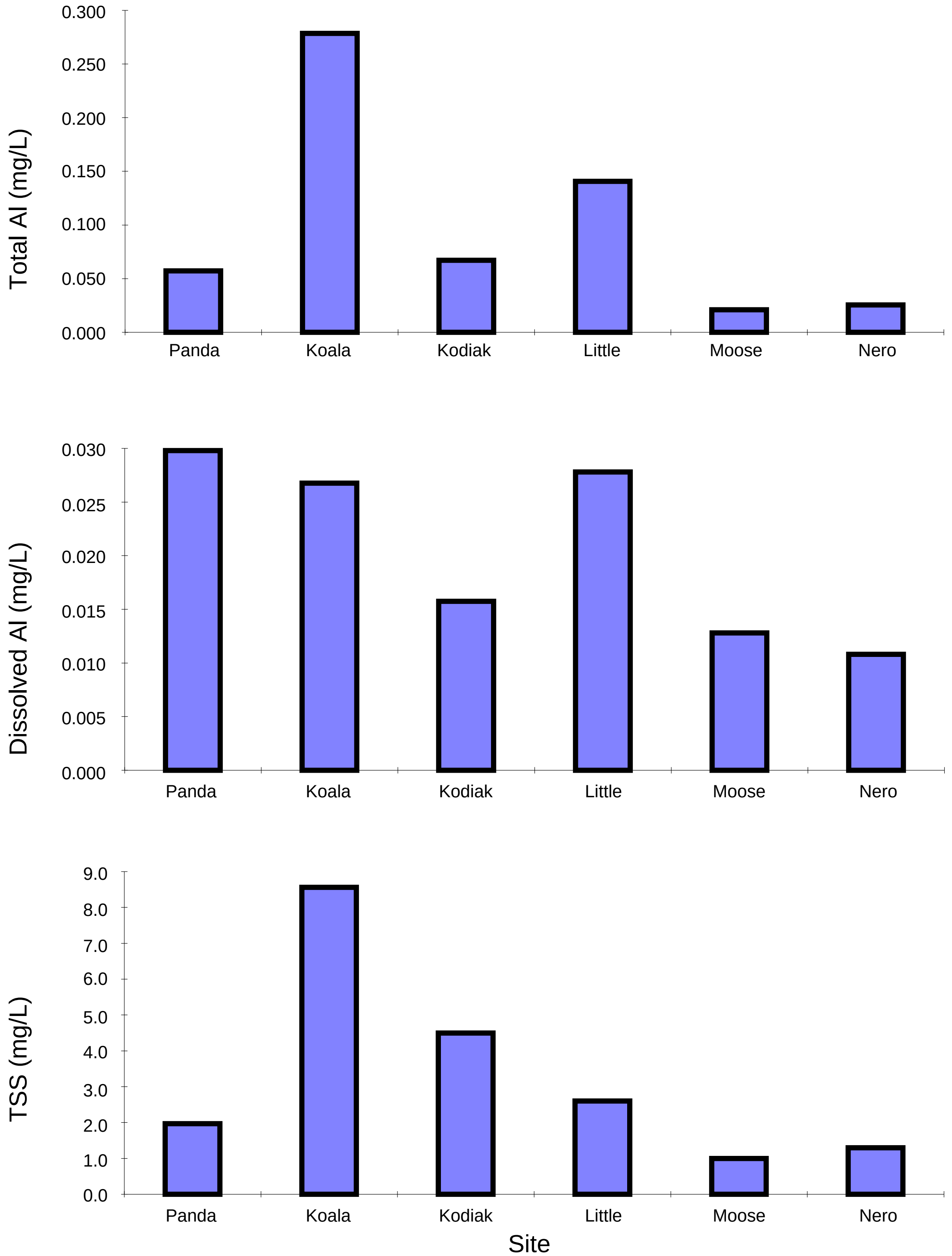
Two important factors should eliminate concerns regarding eventual overflow water quality. First, Panda pit will remain undisturbed for a substantial length of time before water flows downstream to Koala pit. As in the case of Long Lake, this contingency permits a zero discharge facility allowing for settling and precipitation of metals in Panda pit over time. Eventually, it is expected that water quality within Panda and Koala pits will evolve to acceptable discharge quality.




NWT DIAMONDS PROJECT

**Figure 2.4-4**
**Total Aluminum vs. TSS Concentrations in Koala Lake**

*Source: Rescan*




NWT DIAMONDS PROJECT

**Figure 2.4-5**
**Al and TSS in**
**Six Consecutive Lakes**

*Source: Rescan*

Secondly, in the unlikely event that water quality remains poor in Panda pit the contingency exists for utilizing water treatment. Therefore, there are no residual impacts to water quality forecast following closure of the Panda pit.

#### 2.4.6.3 Mitigation

Water quality of the eventual discharge from the Long Lake tailings pond, and from the Panda pit will be assured through the ability to discharge to mined out pits. If water quality is unacceptable, Long Lake discharge could be directed into Panda or Koala pits. Likewise, Panda pit discharge could be directed to Koala pit.

A water treatment facility will receive and treat water from Long Lake and Panda pit if further measures are necessary to improve water quality.

#### 2.4.6.4 Residual Effects

The potential for significant natural mitigation combined with contingencies for zero discharge and/or treated discharge indicates that the residual impacts from discharge of tailings pond water and discharge from Panda pit following closure are negligible.

## 2.5 Air Quality Impacts

Air quality is considered a valued ecosystem component because of its biological importance to vegetation, wildlife, employee health and safety. Air quality also has aesthetic value in terms of visibility and odour.

The main project activities affecting the air quality at the NWT Diamonds Project will take place during the operation phase. These activities will include diesel-fueled power generation, heat production by diesel-fired boilers (used in the winter for heating the permanent camp), ore handling in the primary crusher and ore reclaim areas, emissions from the main process plant and recovery plant, vehicle traffic, mining activities (blasting, ore handling) and solid waste destruction by the four solid waste incinerators. The primary concerns from an air quality perspective are associated with gaseous, particulate and fugitive dust emissions.

The property line of a facility is generally taken as the point at which a project is required to achieve the ambient air quality objectives. As such, for this assessment, the mineral claim block has been defined as the ambient air quality spatial boundary, as illustrated in Figure 2.5-1.

For the purposes of this assessment, the primary focus is air quality impacts that may be expected during the operation phase since this phase has the potential to have the largest impact. The process plant operates at 9,000 t/d during the first

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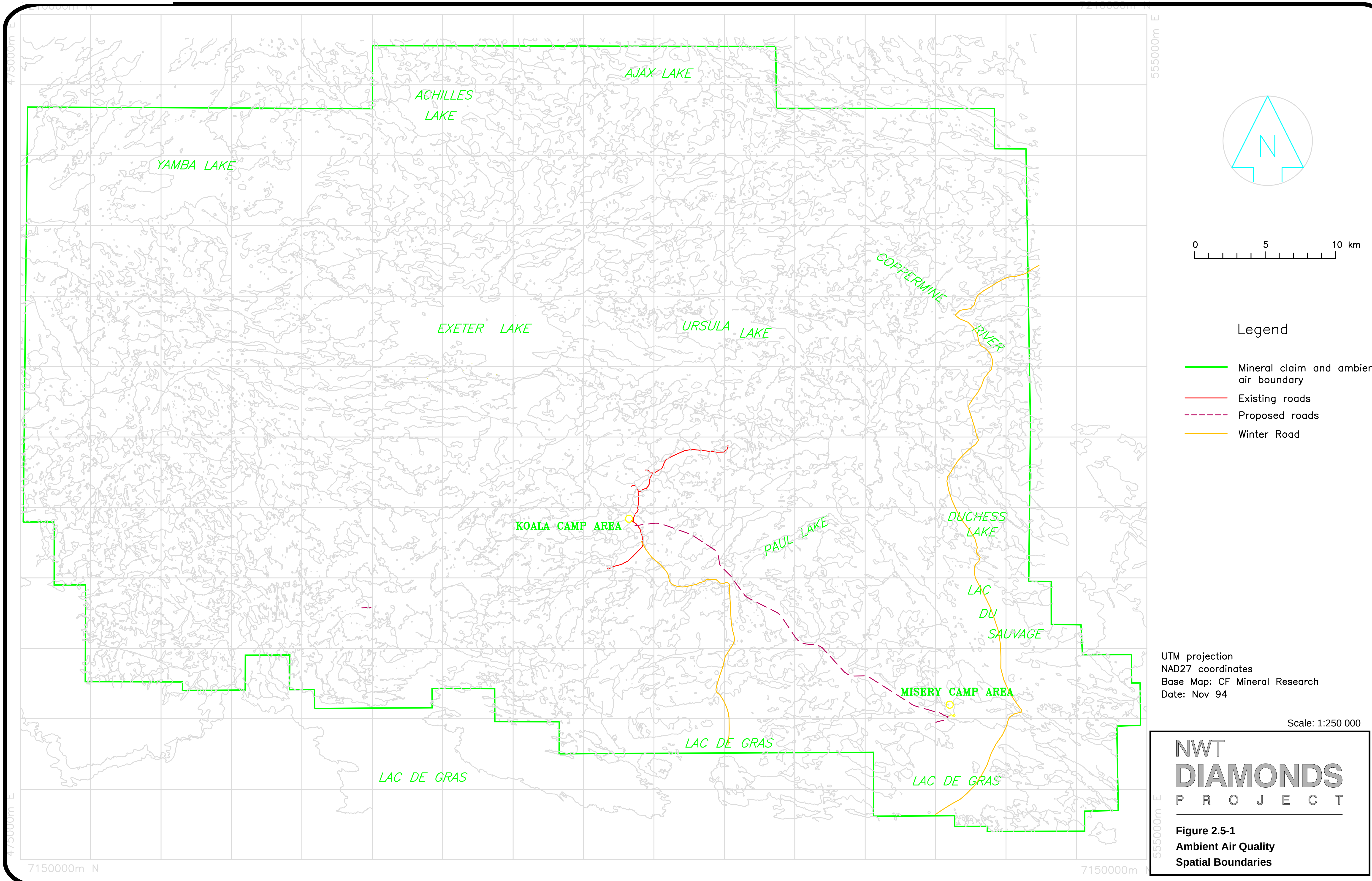


**Figure 2.5-1**
**Ambient Air Quality Spatial Boundaries**

Source: Rescan

nine years of production. The mining sequence for the five diamond pipes will involve sequential development activities beginning with Panda, Misery in Year 1, and Koala in Year 3. Development of the Fox pit will begin in Year 6. Leslie pit will be the last to be developed. Similar air quality impacts are expected for both the pre-production and production phases of the various open pits.

The air quality modelling assessment has been performed for 2 years during the operational phase, 2000 (Year 4) and 2006 (Year 10) when production has been increased to 18,000 t/d to assess the impact of the additional gensets.

To assess the long-term ambient air quality impact of the operation phase the emissions from the continuous processes were modelled using the Industrial Source Complex 2 (ISC2) air dispersion model, developed by the United States Environmental Protection Agency (U.S. EPA). The ISC2 ambient air dispersion model impact predictions have been compared with the Canadian Ambient Air Quality Objectives (CAAQO) for nitrogen oxides ($NO_x$), sulphur dioxide ($SO_2$), carbon monoxide (CO) and total suspended particulate (TSP) as these are the only parameters, other than ozone emissions, that are defined in CAAQO. The CAAQO are intended to provide protection against effects on soil, water, vegetation, animals, visibility, personal comfort and well being.

The modelling predicts that the overall, long-term ambient air quality impact on areas at or beyond the mineral claims boundaries will be negligible. The ISC2 computer dispersion modelling estimates the worst case conditions and has predicted that the long-term combined process emissions impact for the modelled parameters are all less than the CAAQO at and outside the air quality project boundaries (mineral claim boundary).

Air quality impacts during exploration will be caused by road traffic, the bulk sampling plant operation, airstrip activities and diesel power generation. Road traffic, to and from the various underground workings and the exploration camp, will create fugitive dust. The roads in the vicinity of the exploration camp and the winter road will be negligible sources of fugitive dust during September to April, since they will be frozen and/or snow covered. Dust created by road traffic during the summer months will quickly settle within approximately 300 m to 500 m of the road, small particles will have a longer deposition time and, depending on the wind speed, may be carried further than 500 m. Emissions from the exploration camp diesel power generator will include $NO_x$, $SO_2$, CO and TSP. The diesel power plant will run 24 h/d on a year-round basis.

During construction of the permanent camp there is a high probability that air quality will be affected by fugitive dust from road traffic. Again, the primary concern is during the summer months when the activities are intensified and the roads are not snow covered. A secondary source of fugitive dust will be blasting and aggregate crushing for preparation for the permanent camp and processing plant. Blasting is only expected to take place once or twice per day. Although the dust cloud created by a blast is quite impressive, the ambient dust concentrations quickly diminish and the long-term impact on air quality is negligible.

During operation, air quality will be affected by a number of activities including operation of the process plant, blasting in the open pits, diesel power generation at the permanent camp and Misery, heating boiler operation, haul road traffic, wind erosion of waste dumps and solid waste incinerator emissions.

Particulate emissions are expected from the primary crusher, reclaim area, process and recovery plants. However, each of these processes will be equipped with either high efficiency wet scrubbers and/or high ratio pulse jet fabric filters to minimize emissions.

Fugitive dust resulting from blasting for development of the open pits may cause a short term increase in TSP concentrations. Blasting will be done only once or twice per day and the prevailing winds will decrease the ambient concentrations and deposit the dust. The planned method of controlled blasting techniques will decrease fugitive dust emissions, particularly as a result of less fly rock and stemming ejection. Pre-stripping and production blasting will take place at different times for each pit.

Diesel power generation at the Koala and Misery camps will cause the emission of $NO_x$, $SO_2$, CO and TSP, as will the winter operation of heating boilers. Haul road traffic and wind erosion of the waste dumps may also cause a slight increase in the ambient air TSP concentrations, essentially within a 1 km radius of these activities. There are four solid waste incinerators (Koala camp, process plant, shop complex and Misery camp) that will run on an as-needed, intermittent basis, not expected to exceed 15 h/d. The contributions of gaseous and particulate air contaminants from the incinerators will be very small compared to contributions from the other stationary sources (diesel gensets, boiler) and the mobile equipment.

The main concerns with respect to air quality during decommissioning will be fugitive dust emissions from heavy equipment travelling along unpaved roads during mine reclamation and exhaust emissions.

The only concern for air quality during post-decommissioning will be wind erosion of the reclaimed waste dumps. The extent of the concern will depend upon many environmental factors such as soil moisture and wind speed.

### 2.5.1 Air Emissions

To assess the overall impact of air emissions, each of the processes were identified and their estimated emissions were modelled for two separate years during the operational phase. Air emissions from stationary sources such as the diesel power generating plant will include $NO_x$, $SO_2$, CO and TSP. The power plant will consist of six Caterpillar 3616 driven generators, or equivalent, each rated at 4,400 kW. For the 9,000 t/d process plant, four generators will operate while the remaining two will be on standby. Under daily average operations the four engines will operate at 70% of full load. The daily peak for operation consists of four engines operating at 82.5% of full load for less than 2 h/d. The diesel generators may operate at 100% full load for a duration of one to several minutes, several times a day. The minimum operational mode will have three engines operating at 70% of full load.

The fuel used for the diesel power plant engines will typically contain 0.05 wt.% sulphur with a maximum density of 850 $kg/m^3$ @ 15°C. Use of this lower sulphur fuel will help to minimize air emissions impacts. The heating boiler emissions and operating parameters for the diesel-fueled power generating plant are summarized in Table 2.5-1.

The Misery site power plant will consist of three Caterpillar 3512B driven generators, or equivalent, each rated at 1,100 kW. Two generators will be running at 75% full load, 24 h/d, with one generator on standby. The system will be diesel fueled typically containing 0.05 wt.% sulphur.

Two 600 hp diesel-fired heating boilers will be used in the winter months (September to April). The boilers (each rated at 16.9 MJ/h) will be located in the camp services building For a conservative (i.e., worst case) estimate of boiler emissions it was assumed that the boilers operate on No. 2 diesel fuel containing 0.05 wt.% sulphur.

Air emissions from the diesel-fired heating boilers will vary on a monthly basis according to demand for heating the permanent camp and process plant buildings. Preliminary heat balances indicate that both boilers will operate most of the time during the four coldest months of the year, December to March. One boiler will operate most of the time during the months of September, October, November and April. No boilers will operate during most of late spring and the summer months, May to August. During the operating periods it is estimated that each boiler will run at an average of 75% of full load.

Particulate air emissions are expected from a number of stationary sources including the diesel power plant, diesel-fired heating boilers, dust collectors at the primary crusher and stockpile reclaim areas, and wet gas scrubbers at the process and recovery plants. The locations of each of these emission sources is shown on Figure 2.5-2.

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**Table 2.5-1**
**Equipment/Source Air Emissions**

| | Emission Parameters (concentration) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Particulate g/s | CO g/s | $SO_2$ g/s | $NO_x$ g/s | Exit Vel. (m/s) | Stack Temp. (°C) | Stack Dia. (m) | Stack Flow ($m^3$/min) | Stack Discharge Height Above Grade (m) | Operation (h/d) | Emission Control Equipment | Notes |
| Koala Diesel Power Plant | 0.185 | 0.679 | 0.834 | 20.64 | 20.2 | 439 | 0.9 | 796 | 22.9 | 24 | Standard | |
| Misery - Power Plant | 0.08 | 0.61 | 0.23 | 3.86 | 23.9 | 406 | 0.5 | 281.6 | 10 | 24 | Standard | |
| Power Heating Boilers | 0.03 | 0.065 | 0.41 | 0.029 | n/a | 160 | 0.61 | n/a | 11.5 | 24 | Standard | Winter operation |
| Primary Crusher (2001)[1] | <0.208 | -- | -- | -- | 11.0 | 5 | 0.7 | 250 | 8.8 | 24 | Fabric filter or wet gas scrubber | |
| Reclaim Area (2001)[1] | <0.181 | -- | -- | -- | 10.0 | 5 | 0.7 | 216.7 | 11.9 | 10 | Fabric filter or wet gas scrubber | |
| Process Plant (2001)[1] | <0.694 | -- | -- | -- | 9.0 | 5 | 1.4 | 833.3 | 32.0 | 24 | Wet gas scrubber | |
| Recovery Plant (2001)[1] | <0.117 | -- | -- | -- | 4.6 | 5 | 0.8 | 140 | 35.0 | 12 | Wet gas scrubber | |
| Koala Camp Incinerator | 100 mg/$m^3$ | <100 mg/$m^3$ | -- | -- | n/a | n/a | 0.5 | n/a | 6 | 15 | Standard | Operates intermittently |
| Plant Incinerator | 100 mg/$m^3$ | <100 mg/$m^3$ | -- | -- | 7.7 | n/a | 0.38 | n/a | 6.23 | 10 | Standard | Operates intermittently |
| Shop Incinerator | 100 mg/$m^3$ | <100 mg/$m^3$ | -- | -- | n/a | n/a | n/a | n/a | n/a | n/a | Standard | Operates intermittently |
| Misery Incinerator | 100 mg/$m^3$ | <100 mg/$m^3$ | -- | -- | n/a | n/a | n/a | n/a | n/a | n/a | Standard | Operates intermittently |

1: Emission rates for 2007 are twice that for 2001.

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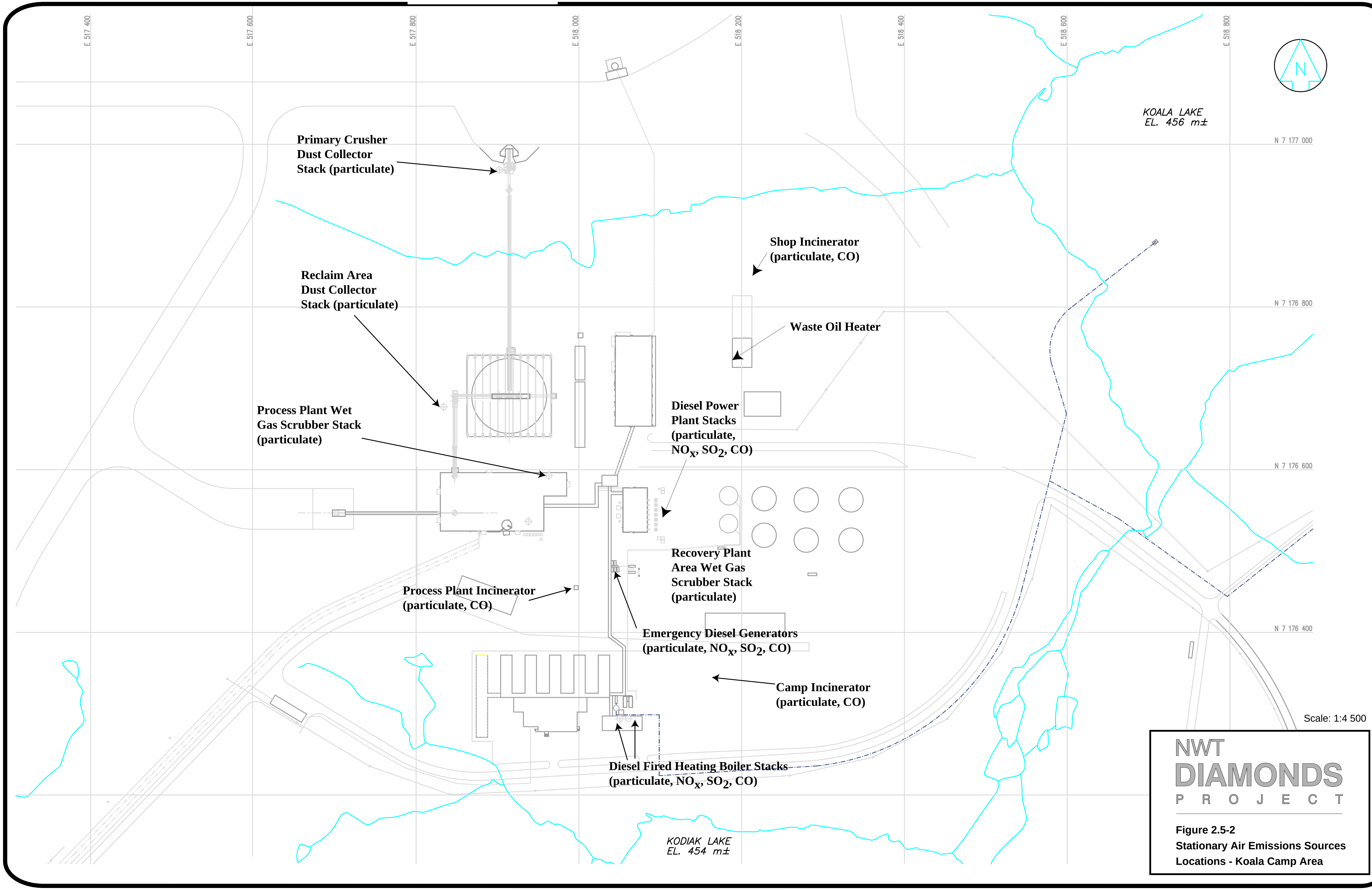


Figure 2.5-2
Stationary Air Emissions Sources Locations - Koala Camp Area

Source: Rescan

Particulate emissions levels from the primary crusher and stockpile reclaim area fabric filters and the process and recovery plant wet dust scrubbers will not exceed 50 mg/$Nm^3$ (Northwest Territories regulations). Each of the above noted stationary particulate emissions sources have been included in the computer dispersion modelling to predict air emissions impact of the project.

The Koala camp, process plant, shop and Misery Camp solid waste incinerators as well as open burning of clean wood and paper products will operate on an intermittent basis and as such have not been included in the ISC2 modelling. The estimated emission rates are summarized in Table 2.5-1.

In addition to the above-noted stationary emission sources, there will be a variety of mobile sources operating in and about the site. The emissions from the mobile sources will be dispersed not only by the above mentioned natural effects, but also because of their own motion and will be dispersed randomly across the site.

Mobile source emissions for each parameter vary according to the year of operation. Table 2.5-2 provides a summary of each of the diesel fueled equipment and their operating hours during Year 4 and Year 10. The operating hours, along with the manufacturer's emission data, provide the basis to estimate the $NO_X$, $SO_2$, CO and TSP emissions (in units of grams per second per square metre, g/s/$m^2$) from each open pit for the two separate modelling scenarios (Table 2.5-3). The mobile equipment units operating in the open pits were treated as area sources for dispersion modelling.

An additional source of particulate emissions will likely be wind erosion of waste dumps and the run-of-mine (ROM) ore stockpile. For the first model scenario, 2000, three different area sources were added to the ISC2 model to account for wind erosion (ROM stockpile, Panda/Koala and Misery East and South waste dumps). The emission rate for wind erosion of waste dumps is based upon the silt content (particles <75 µm diameter) of the waste material, number of days per year with precipitation of ≤0.254 mm (107 for the 1994), and the percentage of time the wind velocity is ≤5.4 m/s (36.9% for 1994 for Koala camp weather station). Assuming the waste material contains 6.5% silt (EBA Engineering Consultants Ltd. 1995) the emission rate was calculated to be $2.57 \times 10^{-5}$ g/s/$m^2$ (Cowherd, Englehart *et al.* 1990). The emission rate and the areas of each waste dump and the ROM stockpile for both model scenarios are summarized in Table 2.5-3.

There are two common methods of estimating air emissions from stationary and mobile sources. The first method is to use empirical emission factors supplied by the U.S. EPA in the Compilation of Air Pollutant Emission Factors document. The second method is to use emission factors supplied by the equipment manufacturer. Generally, the emission factors supplied by the manufacturers are

**Table 2.5-2**
**Equipment Operating Hours in Each Pit**

| | | Year 4 | | Year 10 | | | |
|---|---|---|---|---|---|---|---|
| | **Engine Type** | **Panda** | **Koala** | **Koala** | **Fox** | **Leslie** | **Misery** |
| Diesel Rotary Drill | 3512 | 2812 | 2608 | 148 | 3493 | 1779 | 0 |
| Hydraulic Shovel | 3516EUI | 3430 | 1881 | 0 | | 5311 | 0 |
| Haul Trucks | 3516EUI | 51604 | 11468 | 2628 | 39420 | 21024 | 0 |
| Wheel Loader | 3516EUI | 4126 | 477 | 605 | 1840 | 2158 | 0 |
| Hydraulic Shovel | 3516EUI | 0 | 0 | 0 | 5164 | 5324 | 0 |
| Excavator | 3306TA | 1723 | 1598 | 114 | 2693 | 2078 | 0 |
| Track Dozer | 3412 | 8077 | 7490 | 535 | 12625 | 9740 | 134 |
| Rubber Tired Dozer | 3408 | 4846 | 4494 | 321 | 7575 | 5844 | 20 |
| Motor Graders | 3406 | 4846 | 4494 | 321 | 7575 | 5844 | 95 |
| Water Trucks | 3408 | 2154 | 1997 | 143 | 3367 | 2597 | 57 |
| Aux. Haul Trucks | 3508EUI | 0 | 0 | 0 | 11680 | 23360 | 57 |
| Air-Trac Drill | 3204 | 692 | 642 | 46 | 1082 | 835 | 25 |
| Blasthole Stem Machine | 3054 | 1108 | 1027 | 73 | 1731 | 1336 | 17520 |
| Portable Lights | n/a | 9231 | 8560 | 612 | 14428 | 11132 | 8 |
| Diesel Rotary Drill | 3512 | 0 | 0 | 0 | 0 | 5269 | 13 |

more conservative (i.e. higher) than the U.S. EPA factors. Where ever possible the emission factors from the manufacturers were used for air dispersion modelling assessment to provide a conservative prediction of the ambient air quality.

Ambient dispersion modelling was used to estimate the combined impact of the various stationary process and mobile source emissions, on the ambient air quality of the Koala Lake and Misery Area. Gaussian models are the most widely used techniques for estimating the impact of nonreactive pollutants. The ISC2 model is a steady-state Gaussian plume model that can be used to assess pollutant concentrations from a wide variety of sources. The model can account for settling and dry deposition of particulates; downwash; area, line and volume sources; plume rise as a function of downwind distance; separation of point sources; and limited terrain adjustment. It can be operated in both long and short-term modes. ISC2 is commonly used for predicting air quality impacts from mining projects.

Two input files are necessary to run the ISC2 model. The first contains the selected modelling options, source location, receptor location, meteorological data file specification and output options. The second contains meteorological data.

**Table 2.5-3**
**Area Emission Sources**

| | Emission Parameters ($g/s/m^2$) | | | | |
|---|---|---|---|---|---|
| | **Particulate** | **CO** | **$SO_2$** | **$NO_x$** | **Area (ha)** |
| **2000** | | | | | |
| Panda Pit | $1.42 \times 10^{-6}$ | $9.03 \times 10^{-6}$ | $4.68 \times 10^{-6}$ | $5.79 \times 10^{-5}$ | 36 |
| Koala Pit | $1.65 \times 10^{-6}$ | $8.92 \times 10^{-6}$ | $4.56 \times 10^{-6}$ | $5.75 \times 10^{-5}$ | 12.25 |
| Misery Pit | $1.04 \times 10^{-6}$ | $6.75 \times 10^{-6}$ | $3.5 \times 10^{-6}$ | $4.22 \times 10^{-5}$ | 27.56 |
| Run of Mine (ROM) Stockpile | $2.57 \times 10^{-5}$ | — | — | — | 9 |
| Panda/Koala Waste Dump | $2.57 \times 10^{-5}$ | — | — | — | 400 |
| Misery Waste Dump (East and South) | $2.57 \times 10^{-6}$ | — | — | — | 64 |
| **2006** | | | | | |
| Koala Pit | $1.09 \times 10^{-7}$ | $6.87 \times 10^{-7}$ | $3.56 \times 10^{-7}$ | $4.39 \times 10^{-6}$ | 27.56 |
| Fox Pit | $1.62 \times 10^{-6}$ | $9.30 \times 10^{-6}$ | $5.18 \times 10^{-6}$ | $5.70 \times 10^{-5}$ | 33.1 |
| Leslie Pit | $8.32 \times 10^{-7}$ | $4.62 \times 10^{-6}$ | $2.82 \times 10^{-6}$ | $2.82 \times 10^{-5}$ | 64 |
| Misery Pit | $2.56 \times 10^{-7}$ | $9.78 \times 10^{-7}$ | $1.21 \times 10^{-6}$ | $2.14 \times 10^{-6}$ | 27.56 |
| Panda Waste Dump | $2.57 \times 10^{-5}$ | — | — | — | 400 |
| Fox Waste Dump | $2.57 \times 10^{-5}$ | — | — | — | 361 |
| Run of Mine (ROM) Stockpile | $2.57 \times 10^{-5}$ | — | — | — | 9 |
| Leslie Waste Dump (South) | $2.57 \times 10^{-5}$ | — | — | — | 56.25 |
| Misery Waste Dump (North) | $2.57 \times 10^{-5}$ | — | — | — | 100 |

Under ideal conditions the model should be used with five years of on-site meteorological data. This is not possible for the NWT Diamonds Project, since the Koala camp weather station, 600 m southeast of the exploration camp (Figure 2.5-3), began operation in late 1993. Approximately 86% of the 1994 hourly meteorological data were suitable for use by the ISC2 model. In this case the length of data record may be too short to assure that the conditions producing worst-case estimates have been adequately sampled. Since the year of on-site data is not continuous, the U.S. EPA recommends the highest concentration estimates from ISC2 should be used for comparison with ambient air quality objectives (U.S. EPA 1986). The assumptions made for the ISC2 model evaluation are outlined in the following discussion.

In the absence of any on-site data, the mixing height was assumed to be 500 m for every hour of meteorological data. The nearest sites where Environment Canada Atmospheric Environment Service (AES) collects upper air data are Coppermine (370 km northwest), Baker Lake (720 km east), Fort Smith (525 km south), and Norman Wells (730 km west). Unfortunately upper air data for 1994 or any previous year are not currently available for any of these stations due to a change in mainframe computer systems by the AES. When the upper air data becomes

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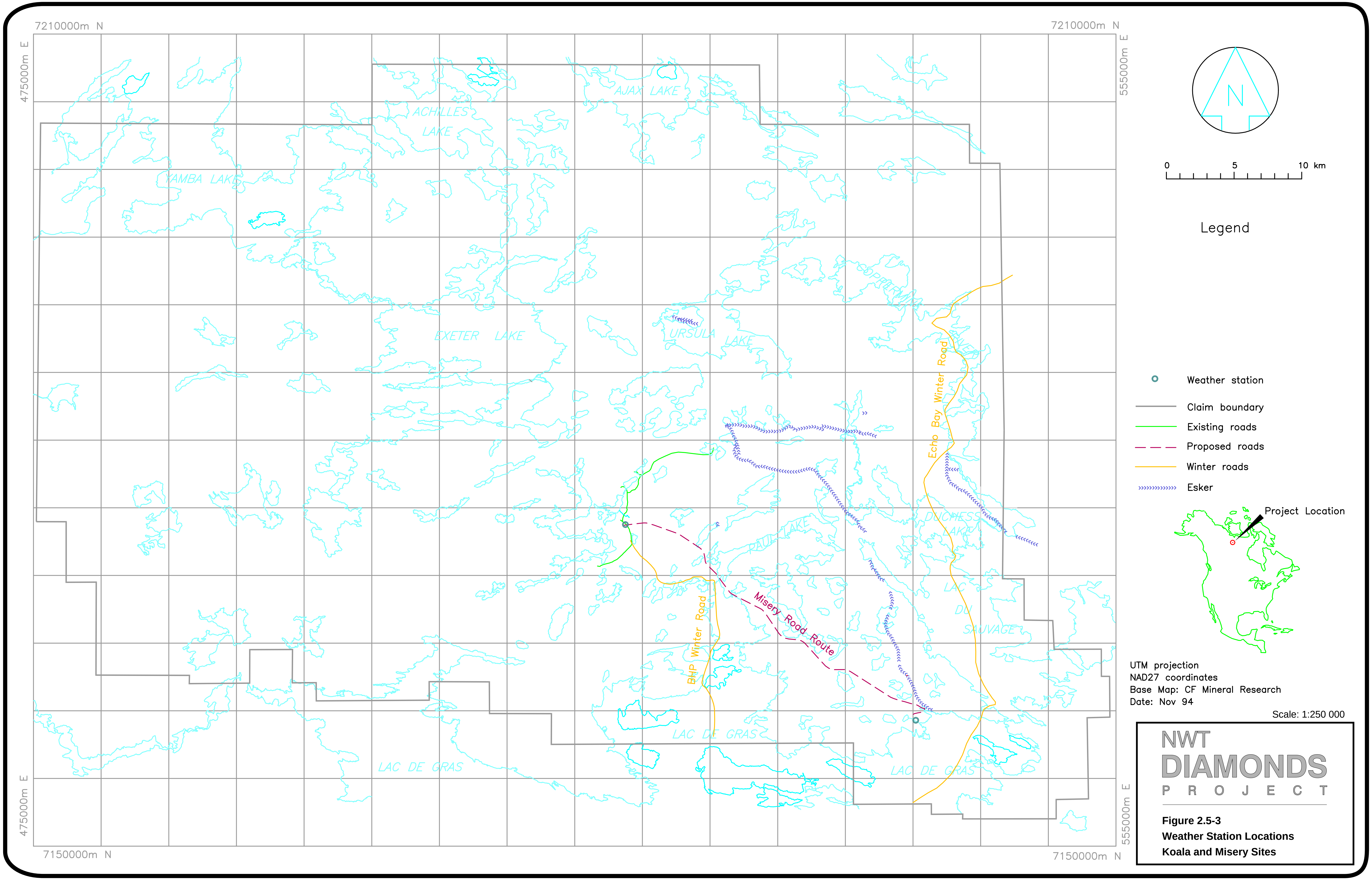


*Source: Rescan*

available it will be compared with the assumed mixing height to determine the validity of this assumption. Historical mixing height data have been prepared by Portelli (1977) for Coppermine, Baker Lake, Fort Smith and Norman Wells for a four-year period July 1965 to June 1969. Mixing heights for the NWT Diamonds Project would be similar to Baker Lake, since it is at a similar latitude and is not under the influence of the Mackenzie Mountains. The highest mean maximum afternoon mixing heights for Baker Lake occur during July and are in the range of 1,000 m. The lowest mixing heights occur during January and December and are in the order of 100 m. The AES mixing heights are summarized in Table 2.5-4.

**Table 2.5-4**
**Mean Maximum Afternoon Mixing Heights (m)**

| Month | Baker Lake | Norman Wells | Ft. Smith | Coppermine |
|---|---|---|---|---|
| Jan | 107 | 155 | 208 | 149 |
| Feb | 150 | 247 | 324 | 170 |
| Mar | 220 | 474 | 547 | 207 |
| Apr | 278 | 812 | 1,025 | 282 |
| May | 384 | 1,327 | 1,499 | 515 |
| Jun | 637 | 1,555 | 1,779 | 533 |
| Jul | 1,016 | 1,448 | 1,610 | 695 |
| Aug | 982 | 1,117 | 1,537 | 647 |
| Sep | 664 | 758 | 1,009 | 608 |
| Oct | 347 | 355 | 578 | 311 |
| Nov | 172 | 180 | 283 | 225 |
| Dec | 136 | 135 | 231 | 172 |
| **Annual** | **485** | **753** | **930** | **406** |

Source: Portelli (1977).

The presence of low mixing height, i.e., 200 m or 300 m, may cause fumigation. Fumigation occurs when a plume is emitted into a stable layer of air and in effect the plume is contained by the temperature inversion layer, causing higher than normal ground level concentrations. The arctic thermal inversion is a major factor for pollution events because of the formation of a stable layer of air near the ground, which prevents mixing and dilution of air contaminants. Over the Arctic Ocean, surface-based inversions tend to persist for approximately eight separate 12-hour intervals in winter and spring on the average, and two separate 12-hour intervals in the summer. Inversion conditions have been closely associated with well-documented winter pollution problems at Fairbanks, Alaska (Maxwell 1982) and are expected to occur at the NWT Diamonds site. Arctic inversions are further discussed in the next section.

Stagnation conditions are characterized by calm or very low wind speeds and variable wind directions. When stagnation occurs, the dispersion of air contaminants, especially those from low level emission sources, tends to be minimized, potentially leading to high ground level concentrations. Data collected at the on-site weather station show that stagnation or calm conditions, i.e., hourly average wind speeds <1.0 m/s, occur approximately 6% of the time (based on data collected from August 14, 1993, to January 3, 1995). The longest duration of calm winds during 1994 was 14 h on March 5, from 0900 to 2200 hours. However, due to the extremely low temperatures there were several consecutive hours of zero wind speeds when the anemometer was apparently frozen; thus wind speed records are not considered reliable for these instances.

The ISC2 model will only allow a minimum ambient temperature of 250.0 K (-23.0°C) in the meteorological data file. For the meteorological data set, approximately 29% of the total of 7,416 h of data showed temperatures below 250.0 K. In order for the ISC2 model to run, all of the ambient temperatures below 250.0 K were set to 250.0 K. Plume rise is the parameter affected by ambient temperature. The larger the difference between the stack gas and the ambient temperature, the higher the plume rises, and thus more dispersion takes place, decreasing the impact. If the temperature is actually colder than the 250.0 K set into the model, the true rise will be higher than predicted by the model. Therefore the ground level concentrations will actually be lower than the model predicted.

Gaussian models predict unrealistically high concentrations when wind speeds of less than 1 m/s are input into the model. For on-site meteorological data used for ISC2 modelling, any hourly wind speed below the response threshold of the anemometer was input as 1 m/s and the wind direction from the previous hour was used. This is consistent with the recommendations for treatment of calms found in the Guideline on Air Quality Models (U.S. EPA 1986).

The terrain in the vicinity of the NWT Diamonds process plant is relatively flat. However, there is topography with an elevation of approximately 500 m, which is above stack height, found in a northwesterly direction at a radius of approximately 850 m from the emission sources. The highest stacks for the project are the diesel power plant stacks, which will reach an elevation of 489 m, while the diesel-fired boiler stack tops will be at an elevation of 470 m. The ISC2 predictions are considered adequate for the purposes of this evaluation, because all of the parameters modelled on a long-term (annual) basis were within the acceptable Canadian Ambient Air Quality Objectives. In addition, since the predominant wind direction is from the northwest (18% of the time) the contaminants will be transported southeast of the plant.

As the name implies, the Pasquill-Gifford stability classes define the degree of stability or insolation. One of a total of six Pasquill-Gifford stability classes was assigned to each hour of meteorological data (Table 2.5-5) based upon wind speed, degree of cloudiness and insolation. Insolation is the rate of radiation from the sun received per unit of the Earth's surface. Strong insolation corresponds to a sunny mid-day in mid-summer. Slight insolation corresponds to similar conditions in mid-winter. Regardless of the wind speed, the neutral category, D, was used for any sky conditions during the hour preceding or following night (Gifford 1961). Sunrise/sunset tables were obtained from Environment Canada specifically for the latitude and longitude of the project site and used to determine which hour corresponded to sunrise and sunset. Hourly cloud cover data were not available. Therefore, during night time it was assumed conditions were thinly overcast and during the day, strong insolation (sunny with little cloud cover) conditions were present.

**Table 2.5-5**
**Pasquill-Gifford Stability Categories (after Turner 1969)**

| | Daytime Insolation[1] | | | Night-time Conditions | |
|---|---|---|---|---|---|
| **Surface Wind Speed (m/s)** | **Strong (Solar Heating)** | **Moderate (Solar Heating)** | **Slight (Solar Heating)** | **Thin Overcast or ³ 4/8 Cloudiness[2] (Weak Radiation Loss)** | **£3/8 Cloudiness (Strong Radiation Loss)** |
| <2 | A | A-B | B | | |
| 2-3 | A-B | B | C | E | F |
| 3-5 | B | B-C | C | D | E |
| 5-6 | C | C-D | D | D | D |
| >6 | C | D | D | D | D |

A: Extremely Unstable Conditions
B: Moderately Unstable Conditions
C: Slightly Unstable Conditions
D: Neutral Conditions[3]
E: Slightly Stable Conditions
F: Moderately Stable Conditions

1: Insolation is defined as solar heating of the earth's surface:
- strong solar heating – little or no cloud cover;
- moderate solar heating – moderate cloud cover;
- slight solar heating – large amount of cloud cover.

2: The degree of cloudiness is defined as that fraction of the sky above the local apparent horizon that is covered by clouds.

3: Applicable to heavy overcast, day or night.

Source: Gifford (1961).

The ISC2 dispersion model was used to predict long-term (annual) as well as 1-hour and 24-hour ambient air ground concentration averages for TSP, $SO_2$, $NO_X$ and CO concentrations at a total of 498 receptors. Since the preliminary modelling showed that $NO_X$ as $NO_2$ had the highest predicted concentrations, additional receptors were added to determine the full plume dispersion. The distribution of the receptors in a Cartesian network is shown in Figure 2.5-4.

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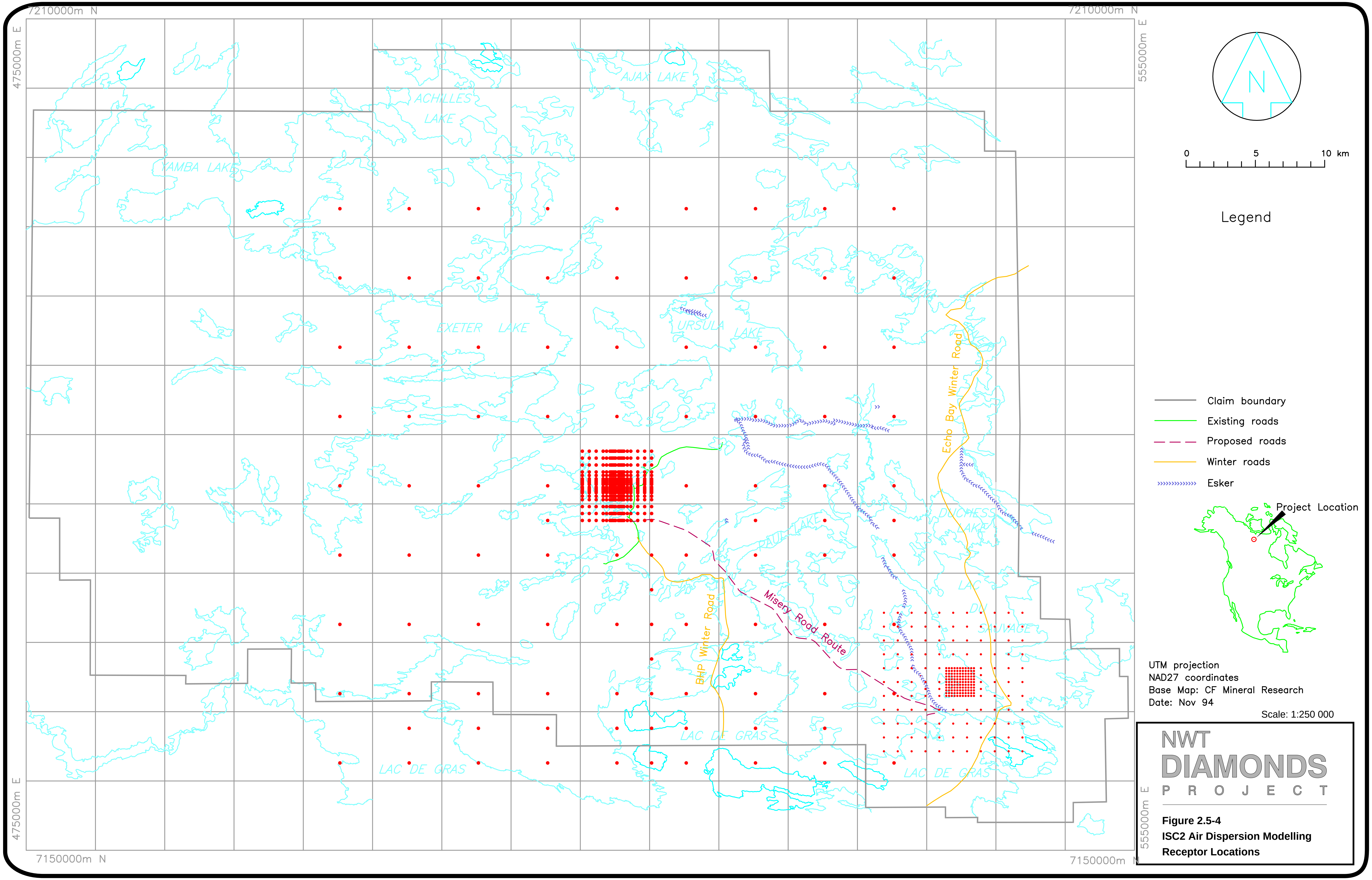


**Figure 2.5-4**
**ISC2 Air Dispersion Modelling Receptor Locations**

*Source: Rescan*

For the TSP dispersion modelling the following stationary emission sources were used: diesel power plant, diesel fired heating boilers, dust collectors at the primary crusher and reclaim area, and wet gas scrubbers at the main process plant and recovery plant. In addition, fugitive TSP emissions from mobile sources were included in this model. This included emissions from road and mining activities within the open pits (Koala, Panda). Fugitive dust emissions from the ore and waste haulage roads for Panda, Koala and Misery were predicted using the U.S. EPA Fugitive Dust Model (see below). Modelling for the gaseous contaminants ($SO_2$, $NO_x$ as $NO_2$ and CO) included contributions from the following stationary sources: the diesel power plant, and the diesel fired boilers. The locations of all stationary sources of air contaminants are shown in Figure 2.5-2. A summary of the stack parameters for each stationary source used in the ISC2 dispersion modelling is provided in Table 2.5-1.

The Canadian Ambient Air Quality Acceptable Objectives (CAAQO) are intended protection against effects on soil, water, vegetation, materials, animals, personal comfort and well being. The tolerable level objectives denote time based concentrations of air contaminants above which, due to a diminishing margin of safety, appropriate action is required to protect the health of the general population. For the purposes of this evaluation the acceptable level objectives were considered to be the basis for comparison.

Tables 2.5-6 and 2.5-7 summarize the ambient air dispersion modelling results with averaging periods of annual (long-term), 24 hours and one hour for each emission source. The worst case, long-term (annual) averages are all below the CAAQO at or beyond the mineral claim boundary. Figures 2.5-5 to 2.5-10 illustrate the ambient air dispersion modelling contours for each of the parameters.

Figures 2.5-5 and 2.5-6 illustrate the annual ambient air concentrations for TSP and the area of impact for both the Koala Lake area and the Misery Camp area. The worst case annual concentration from the Koala area at or beyond the mineral claim boundary is <0.04 $\mu g/m^3$ for Year 4 and 0.05 $\mu g/m^3$ for Year 10, which are both below the CAAQO of 70 $\mu g/m^3$. The highest concentrations were observed, as expected, downwind of each source. Particles with large aerodynamic diameter will deposit near the source while the finer fractions will be carried farther downwind and deposited. Since the ISC2 model predicted TSP concentrations to be well below the CAAQO, the deposition rate of particulate is small and therefore not expected to be a concern. The estimated particle size distribution for the exhaust gas from the particulate scrubbers suggests that 70% of the particles are >100 µm in diameter (Fluor Daniel 1994a), and consequently, most of the particulate will settle near the base of the stacks.

Figures 2.5-7 and 2.5-8 illustrate the area of impact and predicted mineral claim boundary concentrations for sulphur dioxide emission on an annual basis from

**Table 2.5-6**
**Ambient Air Dispersion Modelling Results**
**Maximum Boundary Concentrations 2000 (Year 4)**

| Parameter | Averaging Period | Concentration at Boundary (A.A.) South of Source (µg/Nm³) | | | Canadian Ambient Air Quality Objectives (mg/Nm³) | |
|---|---|---|---|---|---|---|
| | | Koala Area | Open Pits Panda, Koala | Misery Site | Acceptable | Tolerable |
| Sulphur Dioxide | **Annual** | **0.07** | **0.05** | **<0.32** | **<60** | -- |
| | 24 hours | 7.3 | 5.3 | <23 | <300 | 300-800 |
| | 1 hour | 8.8 | 8.1 | <44 | <900 | -- |
| Suspended Particulate | **Annual** | **0.04** | **0.016** | **<5.3** | **<70** | -- |
| | 24 hours | 3.6 | **1.7** | <342 | <120 | 120-400 |
| | 1 hour | -- | -- | | -- | -- |
| Carbon Monoxide | 8 hours | -- | -- | -- | <15,000 | 15,000-20,000 |
| | 1 hour | 8.4 | 15.7 | 90 | <35,000 | -- |
| Nitrogen Oxide (as $NO_2$) | **Annual** | **1.7** | **0.63** | **<0.97** | **<100** | -- |
| | 24 hour | 156 | 65.6 | <62 | <200 | 200-300 |
| | 1 hour | 189 | 101 | <131 | <400 | 400-1,000 |

A.A.: Ambient Air.

sources at both the Koala Lake area and the Misery Camp site. The annual ambient air sulphur dioxide concentration from the Koala area is 0.07 µg/m³ for Year 4 and 0.13 µg/m³ for Year 10, at or beyond the mineral claim boundary, well below the annual CAAQO of 60 µg/m³.

The carbon monoxide ambient air concentration from the Koala area on a one hour basis is 8.43 µg/m³ for Year 4 and 16.45 µg/m³ for Year 10 at or beyond the mineral claim boundaries, well below the CAAQO of 35,000 µg/m³. Since the annual concentrations were more than two orders of magnitude below the CAAQO it was not deemed necessary to plot the results.

Figures 2.5-9 and 2.5-10 illustrate the area of impact and predicted concentrations for nitrogen oxides emissions at both sites. The nitrogen oxide ambient air concentrations from the Koala area at or beyond the mineral claim boundary is 1.72 µg/m³ for Year 4 and 3.41 µg/m³ for Year 10, well below the CAAQO of 100 µg/m³ as highlighted in Tables 2.5-5 and 2.5-6. The input files used for ISC2 modelling are included in Appendix IV-B2.