CALPUFF AIR DISPERSION MODELLING FOR THE GIANT MINE REMEDIATION PROJECT

Prepared for:

Aboriginal Affairs and Northern Development Canada
Contaminants and Remediation Directorate

Prepared by:

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March 2012

EXECUTIVE SUMMARY

SENES Consultants Limited (SENES) was retained to complete dispersion modelling for Giant Mine Remediation Project (GMRP) activities with the CALMET/CALPUFF air dispersion modelling package. GMRP activities for this assessment are considered to include total suspended particulate (TSP), PM_{10}, $PM_{2.5}$, arsenic and combustion emissions (NO_x and SO_2) from GMRP activities in addition to projected worst case operations of the Jackfish Power Plant.

SENES previously completed a screening level air dispersion modelling assessment, which was summarized in the Developer's Assessment Report (DAR) for the GMRP Environmental Assessment. The objective of the study was to determine the potential for air quality impacts associated with proposed remediation plan activities. The screening level assessment determined that, based on a reasonable level of mitigation during remediation activities, wind blown dust would be the primary emission source of TSP and arsenic, which is similar to the current baseline scenario at the Giant Mine site. The assessment assumed that emissions from vehicle traffic on unpaved roads during non-freezing times of the year can be effectively controlled through watering and the application of calcium chloride to reduce evaporation rates. Emissions from bulldozing activities can also be controlled through watering.

The screening level ISCST3 model results predicted arsenic, TSP, PM_{10} and $PM_{2.5}$ concentrations during GMRP activities that are comparable to existing baseline monitoring results at the Giant Mine site, with exceedances of applicable criteria at on-site ambient monitoring locations. However, model results did not predict exceedances of any criteria at the nearest identified sensitive receptor locations for all particulate based contaminants assessed.

During the Information Request (IR) process for the GMRP Environmental Assessment, SENES was requested to re-run the screening level modelling assessment for the GMRP using the assumption that the Jackfish Power Plant would be operating at maximum capacity (27 MW) during the Remediation Project. Model results indicated that total NO_x emissions under this scenario could result in significant NO_2 ground level exceedances at identified sensitive receptor locations; therefore, SENES was requested to conduct a more comprehensive modelling exercise to further evaluate this scenario.

This CALPUFF modelling assessment included GMRP activities, 3 MW of incremental power from the Jackfish Power Plant (power requirement for GMRP freeze plant), and reasonable worst case indirect combustion emissions from the Jackfish Power Plant, including those emissions caused by local electricity demand, not just the Project. This was done so that the cumulative impact on local contaminant concentrations could be determined. It should be noted that the Jackfish Power Plant operates on an as required basis when other sources of electrical power are not available. The reasonable worst case emissions considered in this CALPUFF modelling assessment are based on the Jackfish Power Plant operating at 2/3rds capacity (18 MW) for an entire year, and is not based on historical typical plant operations.

CALPUFF model results for GMRP activities were consistent with the screening level air dispersion modelling assessment. CALPUFF model results predicted arsenic, TSP, PM_{10} and $PM_{2.5}$ concentrations during GMRP activities that are comparable to existing baseline monitoring results, with exceedances of applicable criteria at site ambient monitoring locations. Model results do not predict exceedances of any criteria at the nearest sensitive receptor locations from GMRP activities.

CALPUFF model results do predict exceedances of applicable 1-hour NO_2 and 24-hour $PM_{2.5}$ criteria at one receptor location close to the Jackfish Power Plant, which is based on the conservative assumption that the plant is operating continuously at 18 MW. The worst case maximum operations scenario for short term (i.e., 1-hour) Jackfish Power Plant operations, which assumes the plant is operating at 27 MW, predicts significant exceedances of 1-hour NO_2 criterion at the two identified receptor locations nearest to the plant.

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GLOSSARY OF TERMS

Albedo	A coefficient used to represent the reflecting power of a surface. Defined as the ratio of reflected radiation from the surface to incident radiation upon it.
AP-42 Emission Factors	AP-42 is the US EPA's primary compilation of emission factors and supporting information for more than 200 air pollution source categories. It is collectively known as "AP-42, Compilation of Air Pollutant Emission Factors".
Atmosphere	The gaseous mass or envelope of air surrounding the Earth. From ground-level up, the atmosphere is further subdivided into the troposphere, stratosphere, mesosphere, and the thermosphere; however, when discussing air quality, the layer of concern is the troposphere.
Bowen Ratio	The ratio of the sensible heat flux to the latent heat flux.
Canada-wide Standard	Standards developed under the Canada-wide Environmental Standards Sub-Agreement of the Canada-wide Accord on Environmental Harmonization. The Sub-Agreement is a framework for Ministers of provincial/territorial and federal governments to develop nation-wide standards that address environmental protection and health-risk reduction. Provincial/territorial governments have the option to adopt CWSs.
CALMET	A diagnostic, 3-dimensional meteorological model used in conjunction with CALPUFF.
CALPUFF	An advanced, integrated Gaussian plume air dispersion modelling system.
Concentration	The amount of a given substance that exists within another substance. With respect to air quality, it refers to the amount of a particular compound within a given volume of air. Typically in units of micrograms per cubic meter ($\mu g/m^3$).
Emission Factor	A relation between the quantities of a compound released to the atmosphere with an activity associated with the release of that contaminant. For example, for stationary sources, it is the relationship between the amount of a compound produced and the amount of raw material processed over a given amount of time.
Emission Rate	The weight of a compound emitted per unit of time (e.g., grams per second).
Mixing Height	The layer of the atmosphere where pollution gets mixed and dispersed. Factors controlling this phenomenon include solar radiation, wind speed, and local surface roughness.
Monitoring	The periodic or continuous sampling and analysis of air pollutants in ambient air or from individual emissions sources.
National Ambient Air Quality Objectives (NAAQOs)	Guidelines developed under the Canadian Environmental Protection Act that have been established to provide a measure of protection to people and the environment from adverse effects due to airborne pollutants.
Nitrogen Oxides (Oxides of Nitrogen, NOx)	A general term pertaining to compounds of nitric oxide (NO), nitrogen dioxide (NO_2) and other oxides of nitrogen. Nitrogen oxides are typically created during combustion processes, and are major contributors to smog formation and acid deposition.
Nitrogen Dioxide (NO_2)	A highly reactive gas having a characteristic reddish-brown colour and strong odour. The main anthropogenic source of NO_2 is fossil fuel combustion.

PM – Particulate Matter	Tiny subdivisions of solid matter suspended in a gas or liquid
PM_{10} – Particulate matter of 10 microns or less	Tiny subdivisions of solid matter suspended in a gas or liquid of 10 micrometres or less
$PM_{2.5}$ - Particulate matter of 2.5 microns or less	Tiny subdivisions of solid matter suspended in a gas or liquid of 2.5 micrometres or less
Sulphur Dioxide (SO_2)	A strong smelling, colorless gas that is formed by the combustion of fossil fuels. Power plants, which may use fuels high in sulphur, can be major sources of SO_2. SO_2 and other sulphur oxides also contribute to the problem of acid deposition.

1.0 INTRODUCTION

SENES Consultants Limited (SENES) was retained to complete dispersion modelling for Giant Mine Remediation Project (GMRP) activities with the CALMET/CALPUFF air dispersion modelling package. CALMET is a meteorological model that produces hourly three dimensional gridded wind fields from available meteorological, terrain and land use data. CALPUFF is a non steady-state puff dispersion model that utilizes CALMET wind fields and considers spatial changes in meteorology, variable surface conditions, and interactions with terrain. GMRP activities for this assessment are considered to include total suspended particulate (TSP), PM_{10}, $PM_{2.5}$, arsenic and combustion emissions (NO_x and SO_2) from GMRP activities in addition to projected worst case operations of the Jackfish Power Plant.

1.1 BACKGROUND

SENES completed a screening level air dispersion modelling assessment, which was summarized in the Developer's Assessment Report (DAR) for the GMRP Environmental Assessment. The objective of the study was to determine the potential for air quality impacts associated with proposed remediation plan activities. The primary contaminants of concern assessed for the study were TSP, PM_{10}, $PM_{2.5}$, arsenic, NO_x and SO_2.

The screening level assessment determined that, based on a reasonable level of mitigation during remediation activities, wind blown dust would be the primary emission source of TSP and arsenic, which is similar to the current baseline scenario at the Giant Mine site. The screening level ISCST3 model results predicted arsenic, TSP, PM_{10} and $PM_{2.5}$ concentrations during GMRP activities that are comparable to existing baseline monitoring results at the Giant Mine site, with exceedances of applicable criteria at on-site ambient monitoring locations. However, model results did not predict exceedances of any criteria at the nearest identified sensitive receptor locations for all particulate based contaminants assessed.

Model results also indicated that tailpipe emissions from construction equipment will result in exceedances of short term criteria (i.e., 1-hour criteria) in the areas immediately surrounding remediation activities, but not at the nearest identified sensitive receptor locations. In addition, based on the operation of the freeze plant with 3 MW of incremental power from the Jackfish Power Plant, NO_2 and SO_2 contaminant concentrations would not result in exceedances of applicable criteria at identified sensitive receptor locations.

During the Information Request (IR) process for the Environmental Assessment, SENES was requested to re-run the screening level modelling assessment for the GMRP using the assumption that the Jackfish Power Plant would be operating at maximum capacity (27 MW) during the

Remediation Project. Model results indicated that total NO_x emissions under this scenario could result in significant NO_2 ground level exceedances at identified sensitive receptor locations. Aboriginal Affairs and Northern Development Canada (AANDC) has, therefore, requested that SENES conduct a more comprehensive modelling exercise to further evaluate this scenario.

This CALPUFF modelling assessment includes GMRP activities, 3 MW of incremental power from the Jackfish Plant, and reasonable worst case indirect combustion emissions from the Jackfish Plant, including those emissions caused by local electricity demand, not just the Project. This was done so that the cumulative impact on local contaminant concentrations could be determined.

The following report details the methodology used to complete the current modelling assessment and provides a complete discussion of the CALPUFF modelling results. In addition to this introductory chapter, Chapter 2 provides information regarding existing air quality, and Chapter 3 discusses the various emission scenarios assessed. Chapter 4 provides an overview of the pollutant sources modelled and the methods used to quantify the air emissions. Chapter 5 describes the air dispersion modelling approach, and modelling results are presented and discussed in Chapter 6. Finally, key conclusions of the air dispersion modelling assessment are outlined in Chapter 7.

2.0 EXISTING AIR QUALITY

Existing air quality in the area surrounding the Giant Mine is a combination of emissions from sources in the general Yellowknife area (e.g., dust from traffic and wind erosion) plus a component that flows into the area from upwind sources (forest fires, etc.). When a modelling assessment is completed all of these other "background" sources must be included in order to get an accurate representation of the air quality during the GMRP activities. Historical measured background concentrations for all contaminants of concern were added to model predicted concentrations to capture the upwind portions of background.

Historical data from the air quality monitoring station located adjacent to the Sir John Franklin High School in central Yellowknife (National Air Pollution Surveillance [NAPS] Station 129003) as well as monitoring data from the GMRP site were used to estimate background pollutant levels. The Yellowknife monitoring station is influenced by activities in town, most notably by dust emissions from roads, which have relatively high silt concentrations from sanding during the winter. Monitoring data from the GMRP site will be influenced primarily by activities at the site, most notably by windblown dust emissions and traffic on mine roads.

Background concentrations of PM_{10}, $PM_{2.5}$, NO_2 and SO_2 were estimated as median 2005/2006 values from the NAPS monitoring station. 2006/2006 data was used as this is the most recent Annual Data Summary Report issued by Environment Canada (Environment Canada, 2008). In contrast, background TSP concentrations were estimated as the low end of average annual concentrations from the NAPS monitoring station based on the assumption that these results are influenced by road dust emissions. This assumption is supported by Giant Mine Town Site TSP monitoring results when site sources are not affecting results (i.e., when the wind is blowing from across Yellowknife Bay). Arsenic background concentrations were conservatively estimated from the high end of average annual concentrations form the NAPS monitoring station. In addition to modelled pollutants, background ozone concentrations were determined using hourly NAPS data for the year 2007. Background ozone is required for calculating NO_2 concentrations using the ozone limiting method (OLM) described in Section 5.2. Table 2.1 summarizes the selected background concentrations to be added to model predicted concentrations.

Table 2.1 Selected Background Pollutant Concentrations

Averaging Time	Background Pollutant Concentration (µg/m³)						
	Arsenic	TSP	PM_{10}	$PM_{2.5}$	NO_2	SO_2	O_3
1-hr	--	--	--	--	6	3	49
24-hr	0.004	18	9	2	6	3	49
Annual	--	18	--	--	6	3	49

3.0 ASSESSMENT SCENARIOS

For this assessment, emissions can be categorized into 1) direct emissions from GMRP site activities and 2) emissions from electric power generation at the Jackfish Power Plant. Although emissions from GMRP activities and operation of the freeze plant with 3 MW of incremental power from the Jackfish Power Plant will remain constant, local electricity demand from the Jackfish Power Plant naturally varies. In order to capture the variability of electricity demand, various scenarios were assessed. GMRP emission sources as well as the power plant emissions scenarios modelled are described in the sections below.

3.1 EMISSIONS FROM GMRP ACTIVITIES

Emission rates and source configurations from GMRP activities developed in the screening level assessment (INAC and GNWT, 2010) were used. There are a number of activities associated with the GMRP, each occurring at different time frames over the course of the remediation project. A worst case TSP, arsenic and combustion emissions scenario was developed based on the period when the greatest number of activities could be occurring simultaneously. The worst case scenario was assumed to be when the following activities were all occurring simultaneously:

- Baker Creek Rehabilitation;
- Contaminated Soils Excavation and Reclamation;
- Tailings and Sludge Pond Remediation;
- Freeze System Installation; and,
- Buildings and Infrastructure Demolition and Disposal.

The equipment required for the above activities was determined based on conversations with SRK Consulting for the screening level assessment (INAC and GNWT, 2010) and are outlined in Table 3.1

Table 3.1 Worst-Case GMRP Emissions Scenario

Activity	Location	Equipment
Freeze Plant operation and Active Freezing	Jackfish Power Plant	• 3 MW of Electrical Power from Diesel Generators
Baker Creek Rehabilitation	Baker Creek	• CAT 320 Excavator • CAT Sheep 815-6 Compactor
	Borrow Pit A2	• CAT 320 Excavator • Four (4) Tandem Trucks hauling backfill material

Activity	Location	Equipment
Contaminated Soils Excavation and Reclamation	Soils Surrounding Roaster Building	• CAT 320 Excavator • Four (4) Tandem Trucks hauling contaminated soils
	B1 Pit	• CAT D8 Bulldozer • CAT Sheep 815-6 Compactor
Tailings and Sludge Pond Remediation	South Tailings Pond	• CAT D8 Bulldozer • CAT D10 Bulldozer • CAT Sheep 815-6 Compactor
	Borrow Pit A1&C1	• CAT 320 Excavator • CAT D8 Bulldozer • Six (6) Rock Trucks hauling backfill material
Freeze System Installation	Underground Vaults	• Three (3) DR24 Drills
Buildings and Infrastructure Demolition and Disposal	Roaster Building	• Two (2) Concrete Saws • Truck Mounted Crane Note: Emissions from decontamination and demolition of the Roaster Building Complex are not considered significant. Potential emissions will be contained through (1) maintaining negative pressure and treatment of building air with HEPA filters, and (2) applying an adhesive to potential sources of contamination to encapsulate emissions during demolition activities.

Note: This table was provided as Table 8.6.2 in the DAR for the GMRP Environmental Assessment (INAC and GNWT, 2010)

3.2 EMISSIONS FROM ELECTRICAL POWER GENERATION

The maximum GMRP freeze plant power requirement is 3 MW, which is assumed to be provided by the Jackfish Power Plant. In addition to this 3 MW of electrical power, there will be local power demands, which (based on 2007 data provided by the NWT Power Corporation) currently peaks at approximately 15 MW for short 1-hour periods of time and at approximately 9 MW for 24-hour periods of time, most often during the winter months. Therefore, a reasonable worst case scenario was considered to be the Jackfish Power Plant operating for an entire year at current peak rates. The following reasonable worst case Jackfish Power Plant operating scenarios were considered:

- the Jackfish Power Plant operating at 18 MW year round (approximately 15 MW plus 3 MW GMRP freeze plant requirements); and,
- the Jackfish Power Plant operating at 12 MW year round (approximately 9 MW plus 3 MW GMRP freeze plant requirements).

According to discussions with NWT Power Corporation, under worst case conditions it is possible that future hourly demand could approach the capacity of the plant (27 MW).

Therefore, a third worst case scenario was modelled, which assumed that the plant operates at 27 MW year round.

3.3 ASSESSMENT SCENARIO SUMMARY

The following three scenarios were modelled:

1. Direct GMRP activity emissions and the power plant operating at 18 MW year round plus GMRP activities;
2. Direct GMRP activity emissions and the power plant operating at 12 MW year round plus GMRP activities; and,
3. The power plant operating at 27 MW year round (this scenario does not include GMRP activities).

As a conservative measure, Scenario 1 has been used to present and discuss all pollutant concentrations in Chapter 6. Scenario 2 has been used to provide a less conservative and perhaps more realistic estimate of NO_2 and $PM_{2.5}$ concentrations, which are the primary pollutants of concern from combustion sources (i.e., the Jackfish Power Plant and mobile equipment for GMRP activities).

Finally, Scenario 3 has been used to provide a worst-case estimate of 1-hour NO_2 concentrations from the Jackfish Power Plant.

4.0 EMISSIONS CALCULATIONS

Emission rates and source configurations from GMRP activities developed in the screening level assessment (Section 8.6.2 Air Quality, DAR for the GMRP Environmental Assessment, INAC and GNWT, 2010) were used. All significant sources of particulate matter, arsenic and gaseous emissions were characterized and included in the emissions inventories for each of the GMRP activities outlined in Section 3.0. Site activities were conservatively assumed to occur for 10 hours per day, 7 days per week and 365 days per year. Winter site activities were assumed to be 50% of the peak summer rates based on reduced operations during the coldest months of the year. In contrast, the Jackfish Power Plant was conservatively assumed to operate continuously for 24 hours per day, 365 days per year. A summary of the individual sources included and the estimation method used in the dispersion modelling assessment is provided in Table 4.1.

The primary variable for estimating road dust, wind erosion and bulldozing emissions is the percentage of silt (i.e., 200 mesh or 75 µm) in the soil. Samples were collected from sections of Giant Mine site roads and analyzed for silt content by SRK Consulting. The results indicated silt contents ranging from 0.1% to 48.9%. Samples were averaged for each section of roadway which resulted in a range from 5.0% to 48.9%, with the high end of the range representing the roadway adjacent to the south tailings pond. Silt percentages for bulldozing and wind erosion emission calculations were based on the upper applicable limits for each calculation methodology.

Bulldozing emission calculations are based on U.S. EPA AP-42 methodologies, which have an upper limit of 15.1% silt. This upper limit was used for calculation purposes; however, it is also recommended that the tailings areas to be bulldozed be watered lightly if required to limit the generation of dust.

Wind eroded dust is typically an event-driven emission, since particles are not suspended unless a sufficient wind speed is reached, typically 5.14 m/s. For this assessment it was assumed that wind erosion from all Giant Mine site tailings pond areas would occur when wind speeds exceed 5.14 m/s.

Reduction of road dust emissions is commonly achieved by applying a control mechanism such as applying water or another dust suppressant to an unpaved road, which dramatically reduces dust emissions. Road dust emissions were assumed to be controlled by 80% during non-freezing periods of the year, which is based on the application of a chemical suppressant (i.e., calcium chloride) and light watering of haul roads every day. During the winter months it was assumed that mine site roads would be sanded with clean material (i.e., no arsenic content).

Arsenic emission rates were estimated as a percentage of TSP emission rates based on average concentrations from samples collected at each activity area of the site. Road dust samples collected by SRK were analyzed for arsenic concentrations. Contaminated soils and tailings pond arsenic concentrations were based on average values from reports by Golder titled "Geochemistry of Mine Wastes, Giant Mine Site, Yellowknife, NT (Golder, 2001)" and "Distribution of Arsenic in Surficial Materials: Giant Mine (Golder, 2005)."

Table 4.1 Summary of Emission Sources used in the Air Dispersion Modelling

Activity	Emission Factor Equation	Units	Reference	Comments
Rock & Tandem Truck Travel on Unpaved Roads	$E_{24hr} = 281.9 \times k \times (s/12)^a \times (W/3)^b$	g/VKT	AP-42 13.2.2, November 2006	- Unpaved Haul Roads - Road Silt Content and Arsenic Concentrations based on site specific measurements
Rock & Tandem Truck Travel on Paved Roads and Workers Driving to Site	$E_{24hr} = k \times (sL/2)^{0.65} \times (W/3)^{1.5}\text{-}C$	g/VKT	AP-42 13.2.1, November 2006	- Paved Highway
Grading and Dozing	SPM = E = 2.6 x (s)1.2 x (M)-1.3 PM_{10} = 0.75 x 0.45 x (s)1.5 x (M)-1.4 $PM_{2.5}$ = 0.105 x 2.6 x (s)1.2 x (M)-1.3	kg/hr	AP-42 11.9-2, October 1998	- Borrow Pit A1&C1: 1 Dozer - South Tailings Pond: 2 Dozers - Pit B1: 1 Dozer
Wind Erosion – Tailings Ponds	E = 1.9*s/1.5	kg/ha/day	AWMA - Air Pollution Engineering Manual, 1992	- Applied to Wind Speeds greater than 5.4 m/s for all tailings pond areas
Material Drops	$E = k \times (0.0016) \times (U/2.2)^{1.3} \times (M/2)^{-1.4}$	kg/tonne	AP-42 13.2.4, 1995	- Based on Maximum Anticipated Excavation Rates
Tailpipe Emissions (Rock & Tandem Trucks)	Mobile 6C Emission Factors	g/VKT	Mobile 6C 2007	- 6 Rock Trucks for Tailings Pond, - 4 Tandem Trucks for Baker Creek Rehabilitation, - 4 Tandem Trucks for - Contaminated Soils Remediation
Tailpipe Emissions (Excavators, Loaders, Bulldozers and Compactors)	U.S. EPA Non-Road Emission Factors	g/hp-hr	EPA420-P-04-009, April 2004, pp. 9 to 12.	- Borrow Pit A1&C1: 1 Excavator, 1 Dozer - South Tailings Pond: 2 Dozers, 1 Compactor - Baker Creek Rehab: 2 Excavator, 1 Compactor - Contaminated Soils Excavation: 1 Excavator - Pit B1: 1 Dozer, 1 Compactor - Demolition: 1 Crane, 1 Excavator - Freeze Pipe Installation: 3 Rock Drills
Jackfish Power Plant Emissions	U.S. EPA AP-42 Emission Factors	lb/hp-hr	AP-42 3.4 Table 3.4-1, October 1996	- Based on an electrical requirement of 12, 18 or 27 MW - emission source set-up based on information provided by NWT Power Corporation and a site visit conducted by SENES staff

Notes: AP-42 is a U.S. EPA compilation of air contaminant emissions due to various activities. See http://www.epa.gov/ttn/chief/ap42/index.html.
EPA Non-Road is a compilation of (industrial) emissions from non-road activities.

5.0 AIR DISPERSION MODELLING

5.1 CALMET/CALPUFF MODELLING PACKAGE

To evaluate the effects of the GMRP activities, air dispersion modelling was performed using the CALMET/CALPUFF modelling package, a current, state-of-the-art dispersion model. CALPUFF is a multi-layer, multi-species, non steady-state puff dispersion model that can simulate the effects of varying meteorological conditions in time and space on pollutant transport (Scire *et al.* 1999). CALMET is an advanced non steady-state diagnostic meteorological model that produces hourly three-dimensional gridded wind fields from available meteorological, terrain and land use data (Scire *et al.* 2000). CALPUFF runs in conjunction with CALMET to estimate the pollutant concentration or deposition value for each source-receptor combination for each hour of input meteorology. It can calculate short-term averages such as 1-hour and 24-hour or annual averages for air pollutants of interest. In this assessment, Version 6.326 of the CALMET model and Version 6.42 of the CALPUFF model were used, the most recent versions at the time when modelling was undertaken.

5.1.1 Air Dispersion Meteorology

The CALMET meteorological model was used to simulate meteorological conditions in the study area for a one year period (January 1 to December 31, 2007). The CALMET simulation was initialized using surface observations from the Yellowknife Airport meteorological station and upper wind field data from the Non-hydrostatic Mesoscale Model (NMM) analysis obtained from the National Centre for Environmental Prediction (NCEP). The NMM initialization fields were available for a grid having a spatial resolution of 32 km and temporal resolution of 6 hours. The use of mesoscale analysis facilitates the generation of three dimensional profiles for the proper simulation of the wind fields at upper levels in the atmosphere and allows for a better definition of the boundary layer heights (i.e., mixing heights) and thus an improved simulation of plume dispersion. The CALMET model was run for a modelling domain measuring 9 km in an east-west direction and 11 km in a north-south direction, with a grid spacing of 0.1 km.

To properly simulate the transport and dispersion of pollutants in CALPUFF, it is important to be able to accurately simulate the typical log-linear vertical profile of wind speed, temperature, turbulence intensity, and wind direction within the atmospheric boundary layer (i.e., within about 2,000 m above the Earth’s surface). In order to capture this vertical structure, a total of ten vertical layers were selected. Within CALMET, vertical layers are defined as the midpoint between two layer interfaces. (i.e., eleven interfaces = ten layers, with the lowest layer interface always being ground level or zero). The vertical interfaces used in this study are: 0, 20, 40, 80, 160, 300, and 600, 1000, 1500, 2200 and 3000 m.

CALMET requires geophysical data in order to prepare the wind fields and other meteorological parameters. The geophysical data include:

- terrain elevation data;
- land use data;
- surface roughness length;
- albedo;
- Bowen Ratio;
- soil heat flux parameter;
- vegetation leaf area index; and
- anthropogenic heat flux.

These parameters are discussed in more detail below.

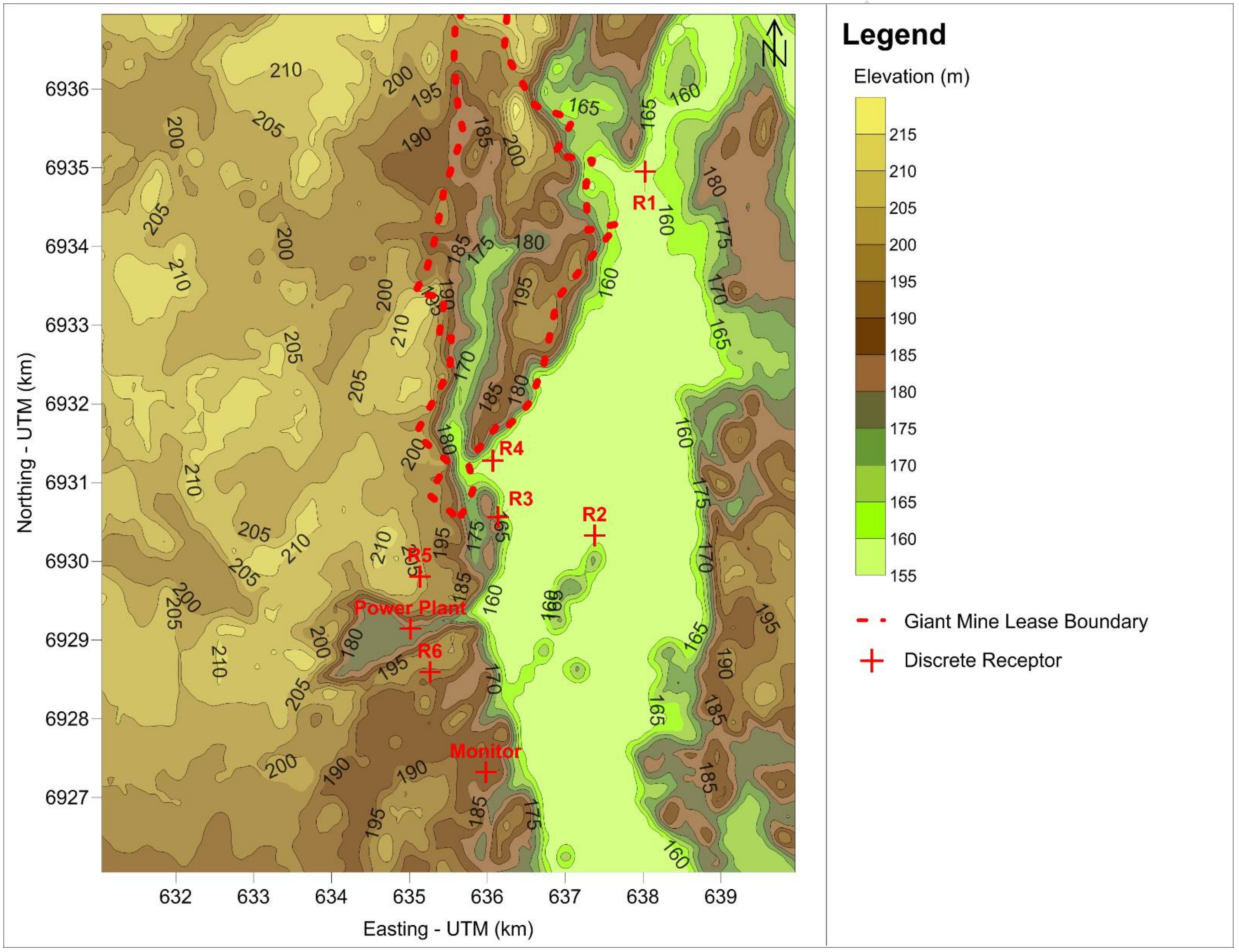
5.1.1.1 Terrain Elevation Data

Gridded terrain elevations for the modelling domain were derived from 30 arc-second Digital Elevation Models (DEM) produced by the United States Geological Survey (USGS). The spacing of the elevations is approximately 0.1 km. The raw terrain data was processed in each gridded cell (0.1 km x 0.1 km) within the CALMET modelling domain and the resulting terrain elevations are presented in Figure 5.1. This terrain field effectively resolves major land features within the modelled area.

5.1.1.2 Land Use Data

Land use and land cover (LULC) data were processed for each CALMET grid cell to produce a 300 m resolution field of fractional land use categories and weighted land use values of surface and vegetation properties. Surface properties, such as albedo, Bowen Ratio, roughness length, soil heat flux and leaf area index are computed proportionately to the fractional land use category within each grid cell. The CALMET default values for land use categories and the land use related parameters are listed in Table 5.1. These are based on the US Geological Survey and Land Use Classification System as shown in Table 5.2. The generated land use categories for each CALMET grid cell are shown in Figure 5.2.

Figure 5.1 Terrain Data Used in CALMET/CALPUFF Modelling Package



Note: Elevation contours are presented in 5 m elevation intervals; therefore, this figure does not accurately depict the shoreline of Yellowknife Bay.

Table 5.1 Default CALMET Land Use Categories and Associated Geophysical Parameters

Land Use Type	Description	Surface Roughness (m)	Albedo	Bowen Ratio	Soil Heat Flux Parameter	Anthropogenic Heat Flux (W/m ²)	Leaf Area Index
10	Urban or Built-up Land	1	0.18	1.5	0.25	0	0.2
20	Agricultural Land – Unirrigated	0.25	0.15	1	0.15	0	3
-20*	Agricultural Land – Irrigated	0.25	0.15	0.5	0.15	0	3
30	Rangeland	0.05	0.25	1	0.15	0	0.5
40	Forest Land	1	0.1	1	0.15	0	7
50	Water	0.001	0.1	0	1	0	0
54	Small Water Body	0.001	0.1	0	1	0	0
55	Large Water Body	0.001	0.1	0	1	0	0
60	Wetland	1	0.1	0.5	0.25	0	2
61	Forested Wetland	1	0.1	0.5	0.25	0	2
62	Nonforested Wetland	0.2	0.1	0.1	0.25	0	1
70	Barren Land	0.05	0.3	1	0.15	0	0.05
80	Tundra	0.2	0.3	0.5	0.15	0	0
90	Perennial Snow or Ice	0.05	0.7	0.5	0.15	0	0

Source: Scire *et al* 2000

Notes:

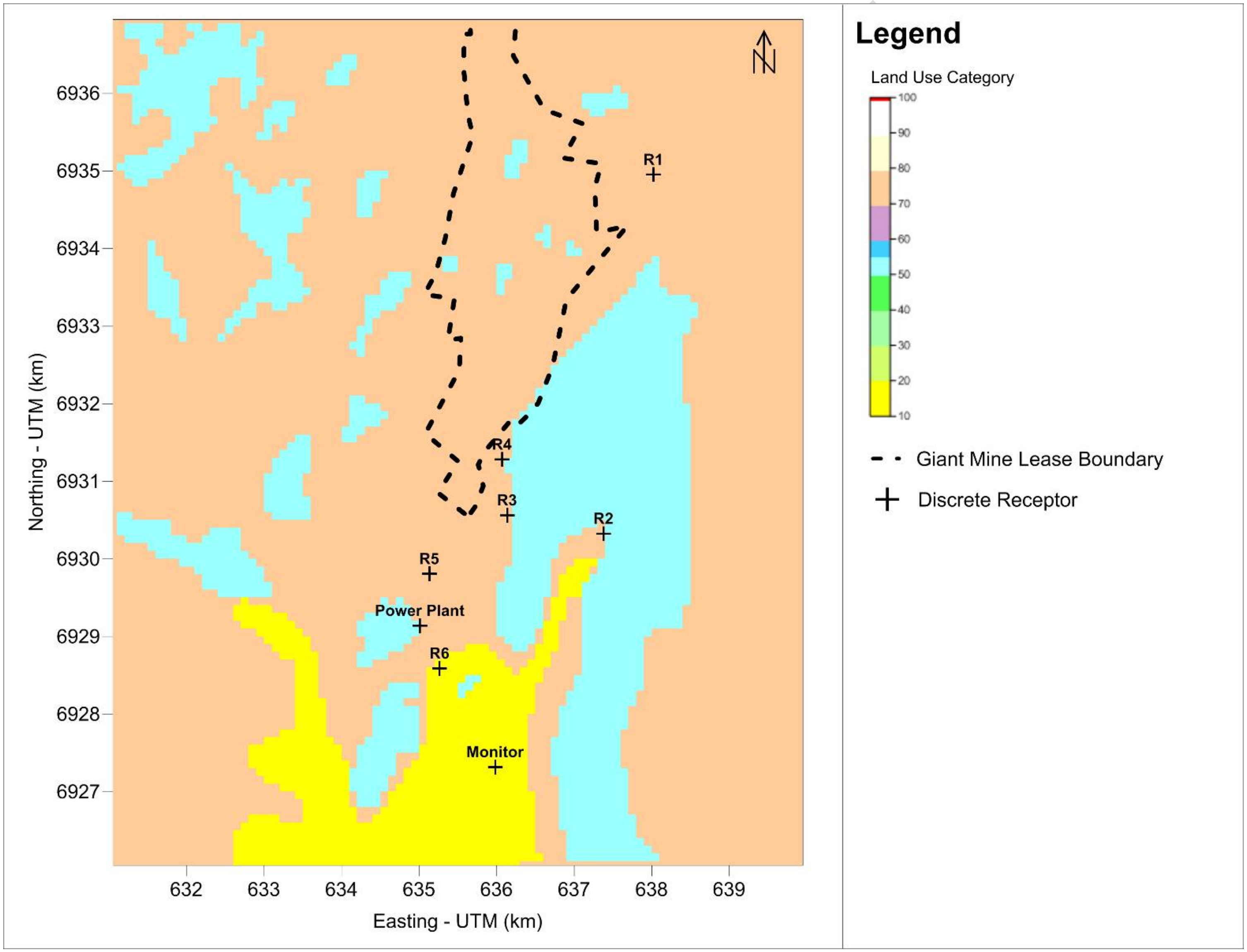
Land use categories and geophysical parameters are based on the 14-cateorgy system of the US Geological Survey Land Use Classification System (Table 5.2).

Table 5.2 US Geological Survey Land Use and Land Cover Classification System

Level I		Level II	
10	Urban or Built-up Land	11	Residential
		12	Commercial and Services
		13	Industrial
		14	Transportation, Communications and Utilities
		15	Industrial and Commercial Complexes
		16	Mixed Urban or Built-up Land
		17	Other Urban or Built-up Land
20	Agricultural Land	21	Cropland
		22	Orchards, Groves, Vineyards, Nurseries, and Ornamental Horticultural Areas
		23	Confined Feeding Operations
		24	Other Agricultural Land
30	Rangeland	31	Herbaceous Rangeland
		32	Shrub and Brush Rangeland
		33	Mixed Rangeland
40	Forest Land	41	Deciduous Forest Land
		42	Evergreen Forest Land
		43	Mixed Forest Land
50	Water	51	Streams and Canals
		52	Lakes
		53	Reservoirs
		54	Bays and Estuaries
		55	Oceans and Seas
60	Wetland	61	Forested Wetland
		62	Nonforested Wetland
70	Barren Land	71	Dry Salt Flats
		72	Beaches
		73	Sandy Areas Other than Beaches
		74	Bare Exposed Rock
		75	Strip Mines, Quarries, and Gravel Pits
		76	Transitional Areas
		77	Mixed Barren Land
80	Tundra	81	Shrub and Brush Tundra
		82	Herbaceous Tundra
		83	Bare Ground
		84	Wet Tundra
		85	Mixed Tundra
90	Perennial Snow/Ice	91	Perennial Snowfields
		92	Glaciers

Source: Scire *et al* 2000

Figure 5.2 Land Use Data used by CALMET



Note: Refer to Table 5.1 for Land Use categories.

5.1.1.3 Stability Classes and Mixing Heights

Meteorological mechanisms govern the dispersion, transformation and eventual removal of pollutants from the atmosphere. Dispersion comprises vertical and horizontal components of motion. The stability of the atmosphere and the depth of the surface-mixing layer define the vertical component and horizontal dispersion in the boundary layer as primarily a function of the wind field. The generation of mechanical turbulence is similarly a function of the wind speed, but in combination with the surface roughness. The variability in wind direction determines the general path pollutants will follow. To adequately characterize the dispersion meteorology, information is needed on the prevailing wind regime, mixing depth and atmospheric stability.

Atmospheric stability refers to the tendency of the atmosphere to resist or enhance vertical motion. The Pasquill-Gifford-Turner assignment scheme identifies six Stability Classes, "A" to "F", to categorize the degree of atmospheric stability (Pasquill 1962; Turner 1969). These classes indicate the characteristics of the prevailing meteorological conditions.

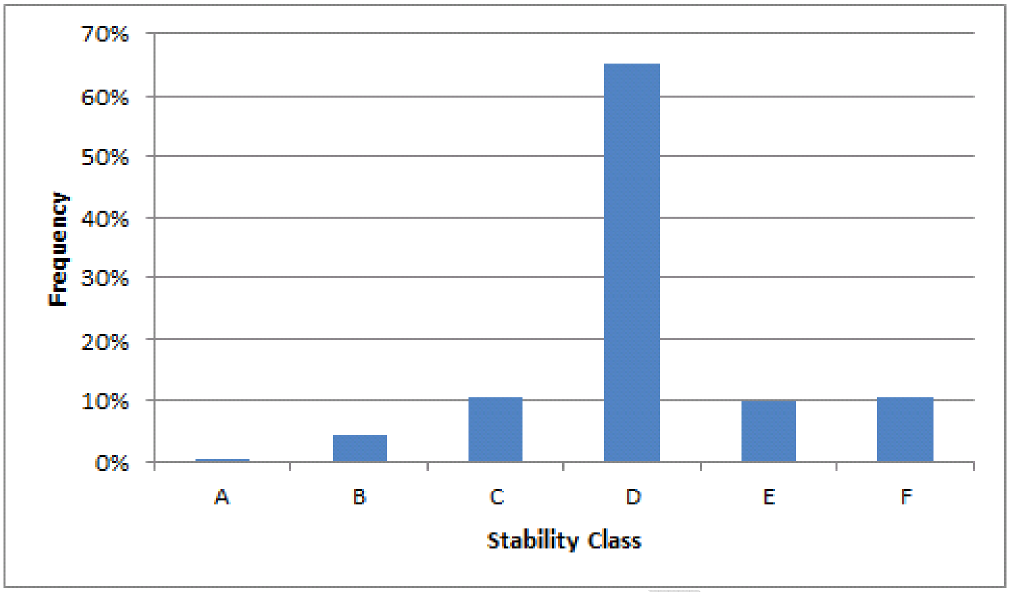
The stability classes are summarized in Table 5.3 below. Stability Class "A" represents highly unstable conditions that are typically found during summer, categorized by strong winds and convective conditions. Conversely, Stability Class "F" relates to highly stable conditions, typically associated with clear skies, light winds and the presence of a temperature inversion. Classes "B" through to "E" represent conditions intermediate to these extremes.

Table 5.3 Atmospheric Stability Class Category Description

Atmospheric Stability Class	Category	Description
A	Very unstable	Low wind, clear skies, hot daytime conditions
B	Unstable	Clear skies, daytime conditions
C	Moderately Unstable	Moderate wind, slightly overcast daytime conditions
D	Neutral	High winds or cloudy days and nights
E	Stable	Moderate wind, slightly overcast night-time conditions
F	Very Stable	Low winds, clear skies, cold night-time conditions

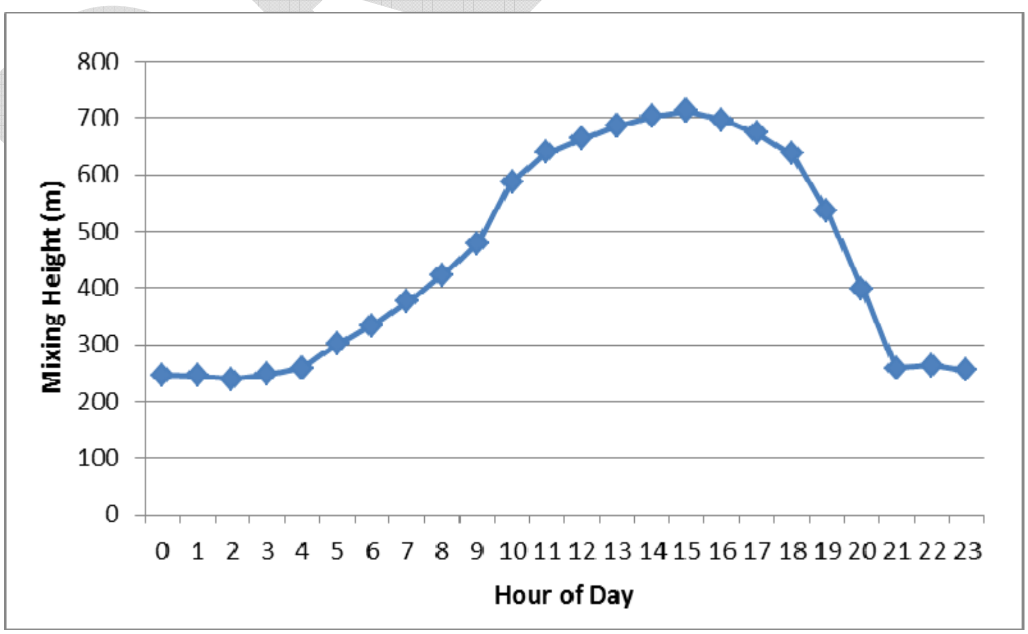
The frequency of occurrence for each stability class for the modelling period January 1 to December 31, 2007 as predicted by CALMET at the Project site is presented in Figure 5.3. The results indicate the most typical conditions are neutral stability class "D". The second highest frequency is stability class "F" which is indicative of highly stable conditions, which is conducive to moderate to low dispersion due to a lack of mechanical mixing.

Figure 5.3 Frequency Distribution of CALMET Stability Classes at the Project Site



Diurnal variations in average mixing depths predicted by CALMET at the Project site are illustrated Figure 5.4. It can be seen that an increase in the mixing depth begins during the morning hours due to the onset of vertical mixing following sunrise and that maximum mixing heights occur in the mid to late afternoon due to the dissipation of ground-based temperature inversions and the growth of convective mixing layer.

Figure 5.4 Diurnal Variation in CALMET Mixing Heights at the Project Site



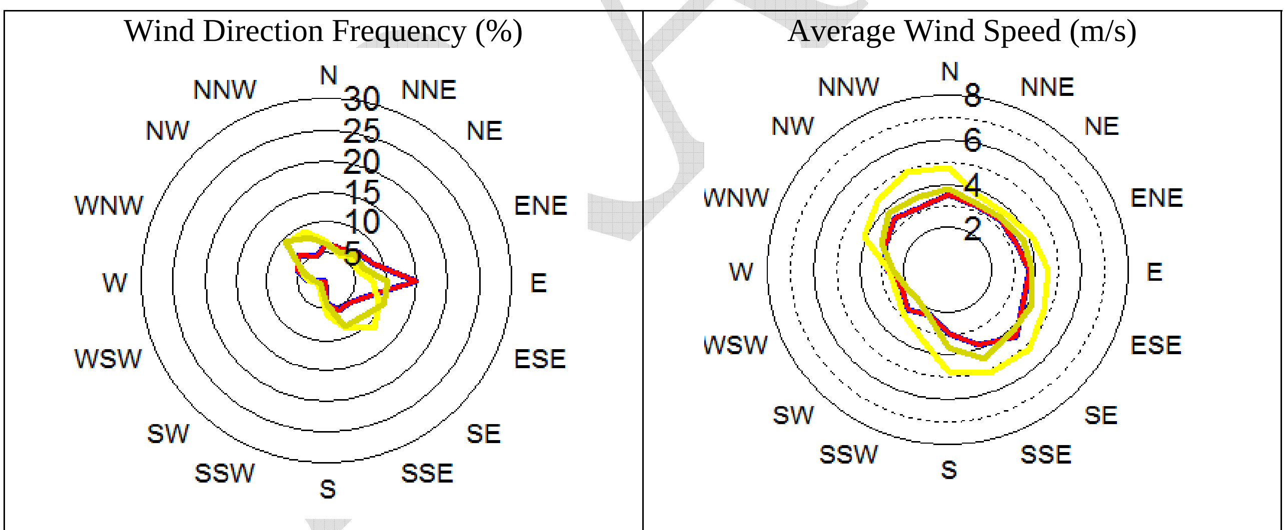
5.1.1.4 Wind

A summary of the average annual wind behaviour simulated by CALMET at grid points near the Yellowknife Airport, the Project site and Jackfish power plant for the period January 1 to December 31, 2007 is presented in Figure 5.5.

The meteorological observations at the Yellowknife Airport are also presented for comparison.

As can be seen in Figure 5.5, winds at the Project site derived from CALMET are predominately from the southeast (11.1% frequency) to east-southeast (9.5% frequency) at an average speed of 5.1 m/s and 4.7 m/s, respectively. The overall average annual wind speed is 4.4 m/s. Calm wind conditions (i.e., wind speeds less than 0.5 m/s) were predicted to occur 1.6% of the time. Winds at the Jackfish Power Plant are comparable to the site, but having slightly higher wind speeds. At the Yellowknife Airport station, winds blows predominately from the east (14.7% frequency) at an average speed of 3.6 m/s followed by the east-northeast (8.2 % frequency) at an average speed of 3.6 m/s. The average annual wind speed at the Yellowknife Airport station is 3.0 m/s. Calm conditions were predicted to occur 12.73% of the time at the Airport. CALMET winds and observed winds agree well because CALMET was initialized using the Airport surface observations.

Figure 5.5 Yellowknife Airport Wind Observations and CALMET Wind Roses



Wind Direction Frequency (%)	Average Wind Speed (m/s)
Yellowknife Airport Observations – 2007	Yellowknife Airport Observations – 2007
CALMET - Airport	CALMET – Airport (12.7%)
CALMET – Project Site	CALMET – Project Site (1.6%)
CALMET – Jackfish Power Plant	CALMET – Jackfish Power Plant (3.9%)
Notes: - Wind direction shown, is the direction winds blow **from** - CALMET Airport aligns with Yellowknife Airport Observations; therefore, the blue line is directly underneath the red line.	Note: % of calms shown in brackets

5.1.2 Modelling Domain and Receptor Grid

A variable spaced receptor grid was used to supply sufficient detail where needed close in to the Project site, while still maintaining reasonable computer run times.

Six (6) discrete receptors were also included in the model runs to predict concentrations at sensitive locations (Table 5.4). Five (5) of these locations were included in the previous ISCST3 screening level assessment. A sixth receptor (Niven Lake residential receptor) was added for the current assessment.

Table 5.4 Sensitive Receptor Locations

ID	Description	Easting - UTM (m)	Northing - UTM (m)
R1	Yellowknife River Park	638023	6934951
R2	N'Dilo Residential Receptor	637379	6930325
R3	Back Bay Residential Receptor	636136	6930562
R4	Boat Launch Recreational Receptor	636069	6931281
R5	Municipal Landfill Receptor	635132	6929807
R6	Niven Lake Residential Receptor	635264	6928589

5.2 CALPUFF MODEL CALIBRATION FOR NO_2 AND NO_x

To assess CALPUFF model results for NO_2 and NO_x emissions from the Jackfish Power Plant, a model run was completed that simulated the operation of the Jackfish Power Plant using actual electrical power generation data for the year 2007, meteorological data for the year 2007 and observations at the NAPS monitoring station for the year 2007. Hourly NO_x emissions were calculated using the hourly power output of the Jackfish Power Plant provided by NWT Power Corporation and US EPA AP-42 emission factors outlined in Table 4.1. To simplify this model scenario, calculated hourly NO_x emissions were distributed across the exhaust stacks proportionally based on each generators output power rating (i.e., it was assumed that all generators were operating when power was being produced by the plant). Typically, when the plant is producing a relatively small amount of power, it is likely that only one or two of the eight site generators would be operating. To determine the validity of distributing emissions to all stacks, a sensitivity analysis was completed where the CALPUFF model was run based on two scenarios: (1) a fixed amount of NO_x was emitted proportionally from all generators; and, (2) the same fixed amount of NO_x was emitted from only two generators. This sensitivity analysis indicated that model predicted ground level concentrations did not vary significantly; therefore, for ease of calculations it was assumed that NO_x emissions were distributed proportionally from all stacks.

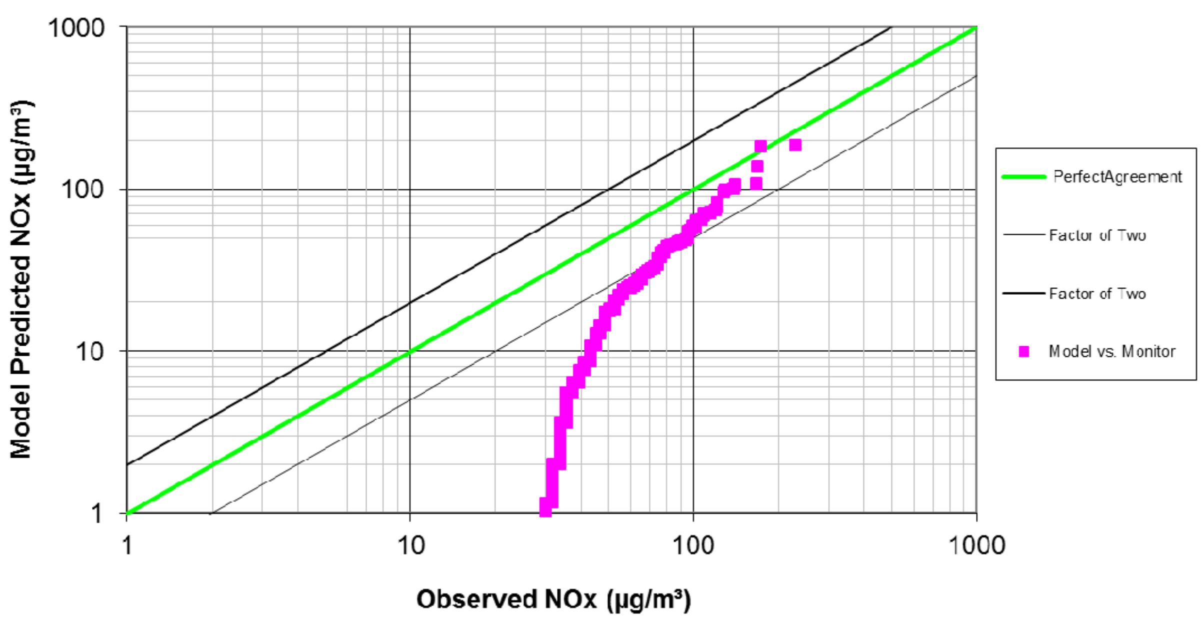
Modelled NO_x concentrations were then compared to monitored 2007 NO_x concentrations at the NAPS station to determine the relationship, if any, to power plant emissions. In addition, the ozone limiting method was used to calculated NO_2 concentrations, which were also compared to monitored data. The results of these comparisons are outlined below.

5.2.1 NO_x Validation

To compare modelled and monitored NO_x concentrations, a Q-Q plot was used. A Q-Q plot is a statistical tool commonly used in model validation, which graphically compares two probability distributions by plotting the quantile of one data set (model predicted NO_x) against the same quantile of the other data set (monitored NO_x). If the distributions compare well, the points will lie along the y = x line.

Figure 5.7 shows the comparison of modelled to monitored NO_x at NAPS Station 129003 in Yellowknife. As can be seen in the figure, modelled and monitored NO_x compare well at high concentrations (likely when winds are blowing from the Jackfish Power Plant to the monitoring station). At low concentrations, it can be seen that the model does not perform as well as it under predicts NO_x concentrations (likely when the Jackfish Power Plant was not operating). In general, this type of agreement suggests that the higher NO_x concentrations observed at the monitoring station are likely a result of the power plant emissions. Figure 5.7 is considered to demonstrate good agreement as modelling results are capturing the highest monitored NO_x concentrations.

Figure 5.6 Q-Q Plot of Modelled vs. Monitored NO_x at NAPS Station 129003



5.2.2 Ozone Limiting Method for Estimating NO_2

The ozone limiting method (OLM) has two main assumptions:

1. 10% of NO_x in a stack is emitted as NO_2; and,
2. the amount of remaining NO converted to NO_2 through a reaction with ambient ozone, is proportional to the ambient ozone concentration.

Based on these assumptions, NO_2 concentrations can be estimated using the following general equation:

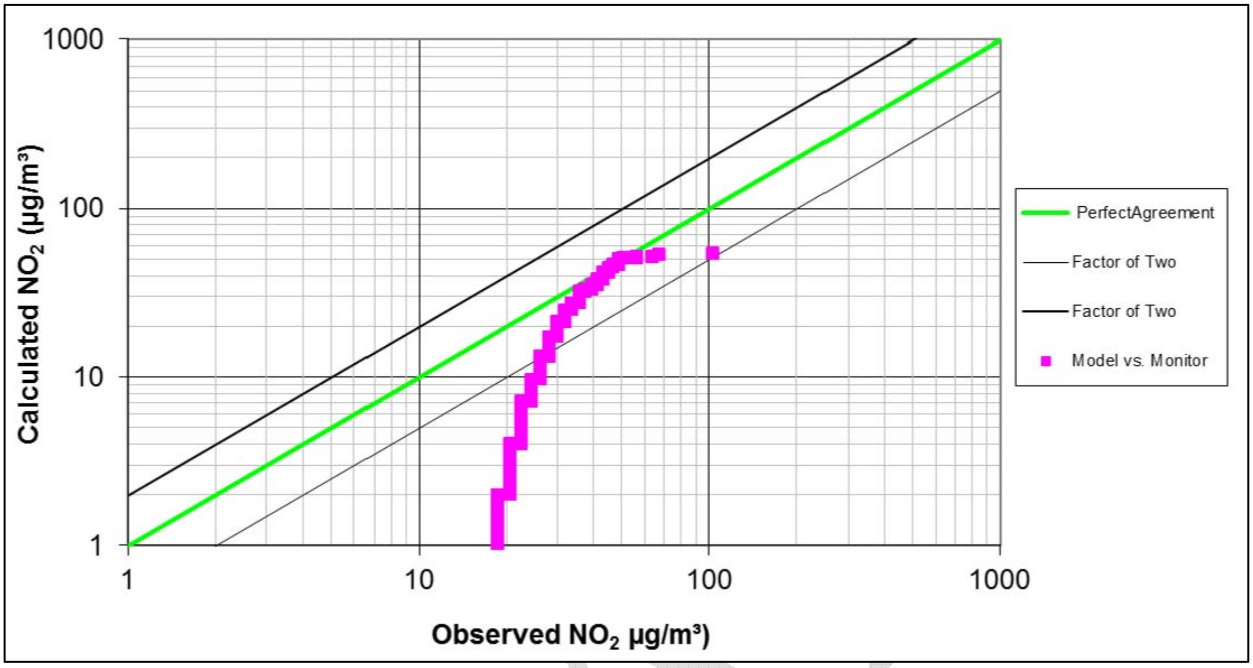
$$[NO_2]_{pred} = \{(0.1)*[NO_x]_{pred}\} + MIN\{(0.9)*[NO_x]_{pred} \text{ or } (46/48)*[O_3]_{bkgd}\}$$

where:

$[NO_2]_{pred}$ is the predicted NO_2 concentration (µg/m³)
$[NO_x]_{pred}$ is the predicted NO_x concentration (µg/m³)
MIN means the minimum of the two quantities within the brackets
$[O_3]_{bkgd}$ is the ambient O_3 concentration (µg/m³)
(46/48) is the molecular weight of NO_2 divided by the molecular weight of O_3

This formula was applied to model predicted hourly NO_x concentrations at the monitoring station location in order to predict NO_2 concentrations. Hourly measured ozone concentrations at the monitoring station were used in the calculation. The results were then compared to NO_2 monitoring data using a Q-Q plot (Figure 5.8). The Q-Q plot indicates that the OLM method does quite well at predicting the higher NO_2 concentrations observed at the monitoring station. At lower concentrations, however, the agreement is not as good, with the model under predicting NO_2 concentrations. These results are consistent with the NO_x Q-Q plot outlined in Figure 5.7 and based on the good agreement at higher NO_2 concentrations, the OLM is considered to be a representative method for predicting NO_2 concentrations at receptor locations.

Figure 5.7 Q-Q Plot of Modelled vs. Monitored NO_2 at NAPS Station 129003 using OLM



6.0 DISPERSION MODELLING RESULTS

The output from the CALPUFF dispersion model is the maximum predicted 1-hour average concentration at each of the modelled receptor points based on a full year of meteorological data (i.e., 8760 simulated hours). Hourly data is then post-processed to determine the maximum predicted 24-hour average or annual concentrations.

Maximum 1-hour, 24-hour and annual average contour plots for all pollutants have been generated for Scenario 1 (18 MW). The results for Scenario 1 have also been presented in tabular format for the specific sensitive receptor locations outlined above for comparison with applicable ambient air quality criteria. For comparison purposes, NO_2 and $PM_{2.5}$ concentrations (the primary contaminants of concern from diesel engines) for Scenario 2 (12 MW) have also been summarized in tabular format. Worst case 1-hour average concentrations based on maximum Jackfish Power Plant operations (27 MW – Scenario 3) are also presented.

6.1 18 MW SCENARIO

Table 6.1 presents the predicted impacts of GMRP activities and power plant emissions on local dust and gaseous pollutant concentrations for the scenario where the Jackfish Power Plant is operating at 18 MW. With the exception of $PM_{2.5}$ and NO_2, there were no exceedances of applicable criteria at any of the sensitive receptor locations.

As can be seen in the table, the 24-hour $PM_{2.5}$ criterion and the 1-hour NO_2 criterion were exceeded at the Niven Lake residential receptor (R6). To determine the nature of the exceedances, a frequency analysis was conducted. From the analysis it was determined that there were only 4 hours (0.05%) where the 1-hour NO_2 criterion was exceeded and 3 days (0.8%) where the 24-hour $PM_{2.5}$ criterion was exceeded at R6. It should be noted that these predicted exceedances are a result of the conservative assumption that the Jackfish Power Plant is operating at 18 MW for the entire year. In addition, as will be shown in the following contour plots, these exceedances are a result of the receptor's proximity to the Jackfish Power Plant.

Table 6.1 Model Predicted Pollutant Concentrations at Sensitive Receptor Locations for the 18 MW Scenario

Receptor	Maximum Model Predicted Concentration (μg/m³)										
	TSP		PM_{10}	$PM_{2.5}$	As	NO_2			SO_2		
	24-hour	Annual	24-hour	24-hour	24-hour	1-hour	24-hour	Annual	1-hour	24-hour	Annual
R1	40.4	18.9	27.0	9.3	0.08	64.7	19.3	6.5	28.5	5.9	3.1
R2	64.3	21.1	45.9	16.4	0.15	80.5	55.0	7.7	25.1	5.5	3.3
R3	68.1	20.7	47.5	17.4	0.16	93.6	58.8	8.4	63.9	9.3	3.5
R4	70.1	21.6	47.3	17.1	0.16	79.7	38.1	8.2	86.5	10.9	3.6
R5	38.9	19.1	27.9	19.5	0.08	284.5	112.8	24.1	45.9	13.1	3.5
R6	37.4	18.7	25.0	**40.2**	0.07	**410.4**	174.4	53.9	64.1	24.6	4.6
Background (μg/m³)	**18**	**18**	**9**	**2**	**0.004**	**6**	**6**	**6**	**3**	**3**	**3**
AAQC (μg/m³)	**120**	**60**	**50**	**30**	**0.3**	**400**	**200**	**100**	**450**	**150**	**30**

In addition to the above tablature results, contour plots for each of the modelled pollutants are provided in Figures 6.1 through 6.11. It is important to note that the maximum concentrations shown at each location on all figures represent a hypothetical worst case scenario since the maxima at each receptor occur during different meteorological conditions. As a result, the figures are only representative of the maximum concentrations that can occur at each location, rather than a snapshot of any actual 1-hour or 24-hour period, since the maximum concentrations at each location most likely occur on different days.

Figures 6.1 through 6.4 show the effect of GMRP and 18 MW Jackfish Power Plant activities on particulate concentrations. These figures indicate the maximum 24-hour model predicted concentrations will exceed applicable criteria in the areas immediately surrounding GMRP activities. Annual TSP also exceeds the application criterion over a small area surrounding GMRP activities. Unlike TSP and $PM_{10,}$ $PM_{2.5}$ also exceeds the applicable 24-hour criterion in the vicinity of the Jackfish Power Plant, and as can be seen in Figure 6.4, emissions from the power plant lead to predicted $PM_{2.5}$ exceedances within the Niven Lake residential area.

Similar to particulate, arsenic concentrations also exceed the applicable criterion in the area surrounding the Project site (Figure 6.5). Since arsenic is calculated as a fraction of TSP, the contours expectedly follow a pattern similar to TSP. These results are consistent with the screening level air dispersion modelling assessment, which was summarized in the Developer's Assessment Report (DAR) for the GMRP Environmental Assessment (INAC and GNWT, 2010).

NO_2 contour plots are provided in Figure 6.6 (1-hour), Figure 6.7 (24-hour) and Figure 6.8 (annual). As can be seen in Figure 6.6, the 1-hour NO_2 criterion is exceeded in the area surrounding the power plant, extending about 600 m southeast to the Niven Lake residential area.

Similarly, the 24-hour criterion is exceeded in the area surrounding the plant, but not at any sensitive receptor location. There are no exceedances of the annual NO_2 criterion at any receptor location.

Additionally, all of the NO_2 contour plots indicate that the power plant is dominating the predicted NO_2 concentrations as there are no isopleths present in and around the Project site. This is due to the fact that there is not enough background ozone to convert NO to NO_2 near the Project site. Based on the background ozone specified in Table 2.1, there is enough ozone to convert 49 µg/m³ of NO to NO_2. Therefore, even if NO_x concentrations in the order of 400 µg/m³ was predicted near GMRP activities, the NO_2 concentration would only be approximately 87 µg/m³ using the OLM. In order to get exceedances of the 1-hour NO_2 criterion, for example, predicted concentrations of NO_x need to be greater than 3530 µg/m³[1]. This concentration of NO_x is only predicted immediately adjacent to the Jackfish Power Plant.

SO_2 contour plots (Figures 6.9 to 6.11) also illustrate the influence of both the Project and power plant emissions; however, unlike $PM_{2.5}$, there are no exceedances of the SO_2 criteria predicted at any receptor location.

[1] 400 µg/m³ NO_2 = 0.1*NO_x + 47 µg/m³
NO_x = 3530 µg/m³

Figure 6.1 Model Predicted 24-hour TSP Concentration – Scenario 1 - 18 MW

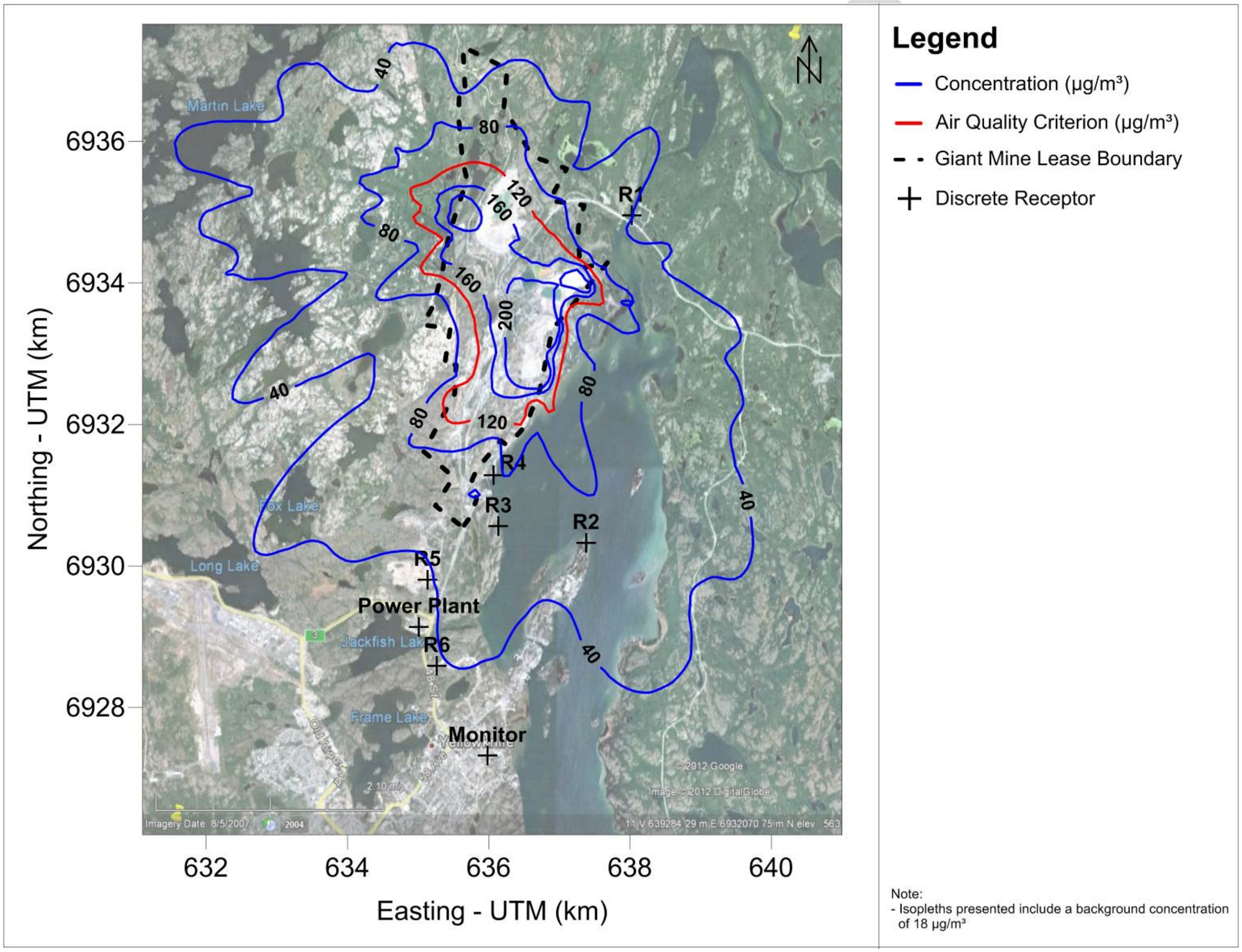


Figure 6.2 Model Predicted Annual TSP Concentrations – Scenario 1 - 18 MW

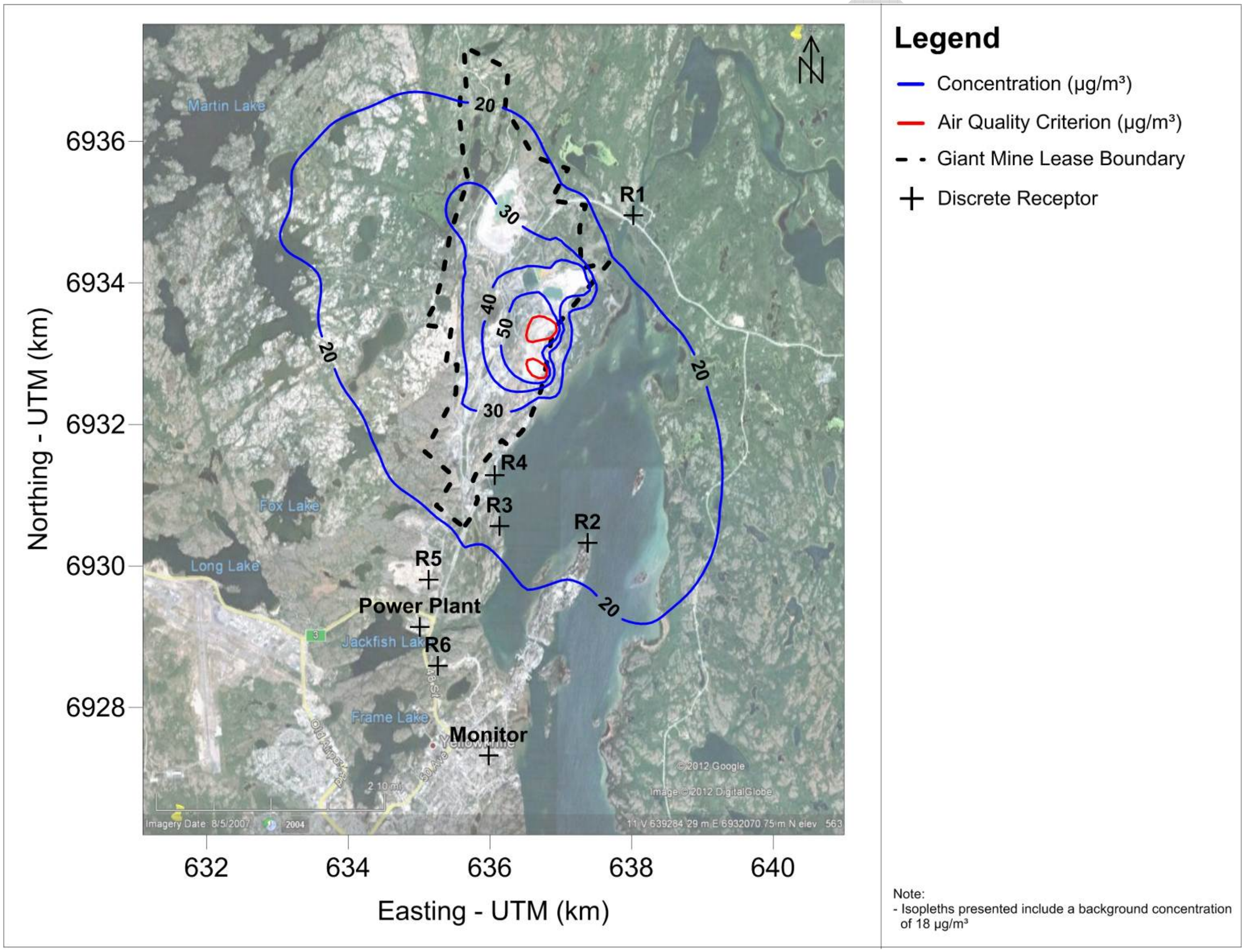


Figure 6.3 Model Predicted 24-hour PM_{10} Concentration – Scenario 1 - 18 MW

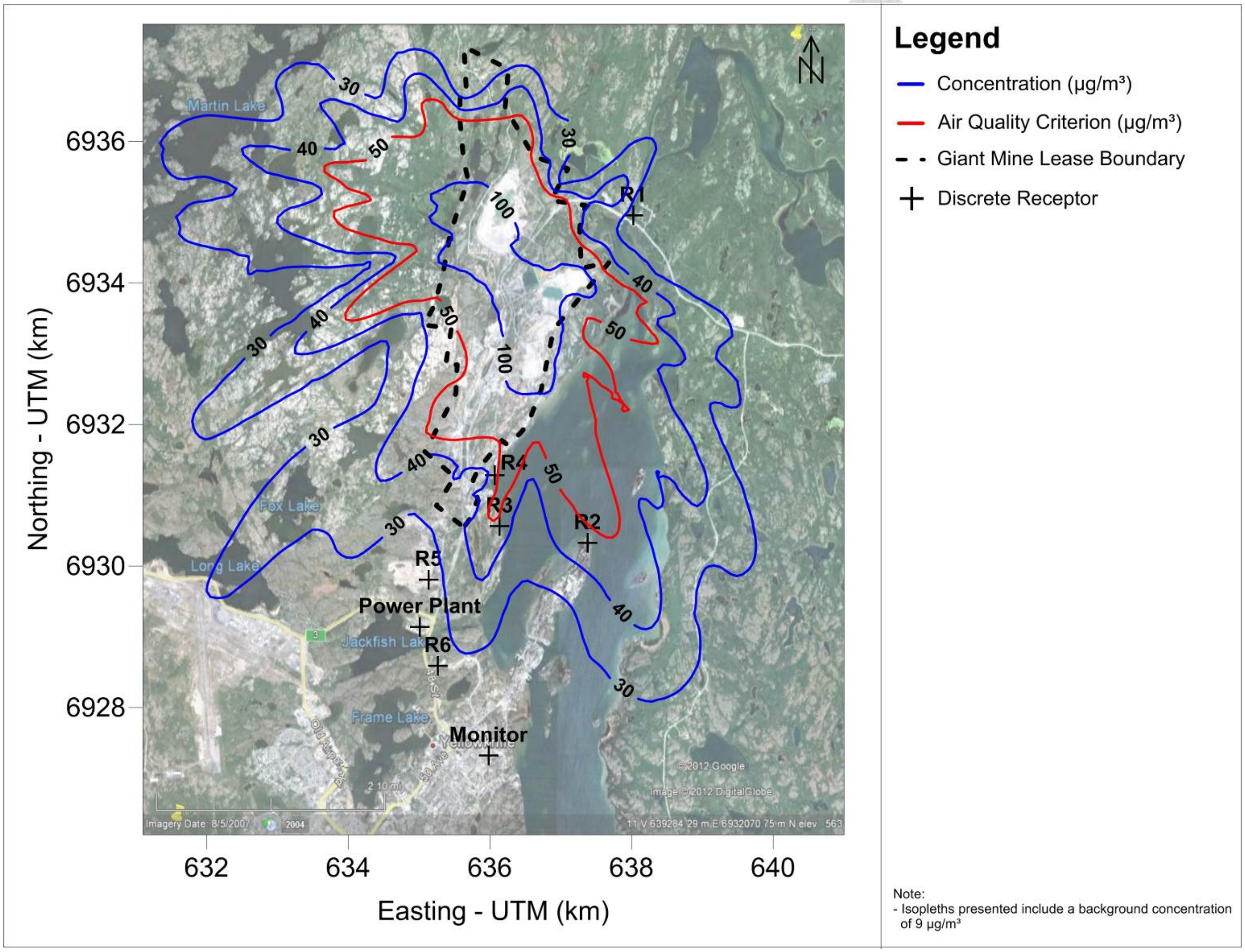


Figure 6.4 Model Predicted 24-hour $PM_{2.5}$ Concentrations – Scenario 1 - 18 MW

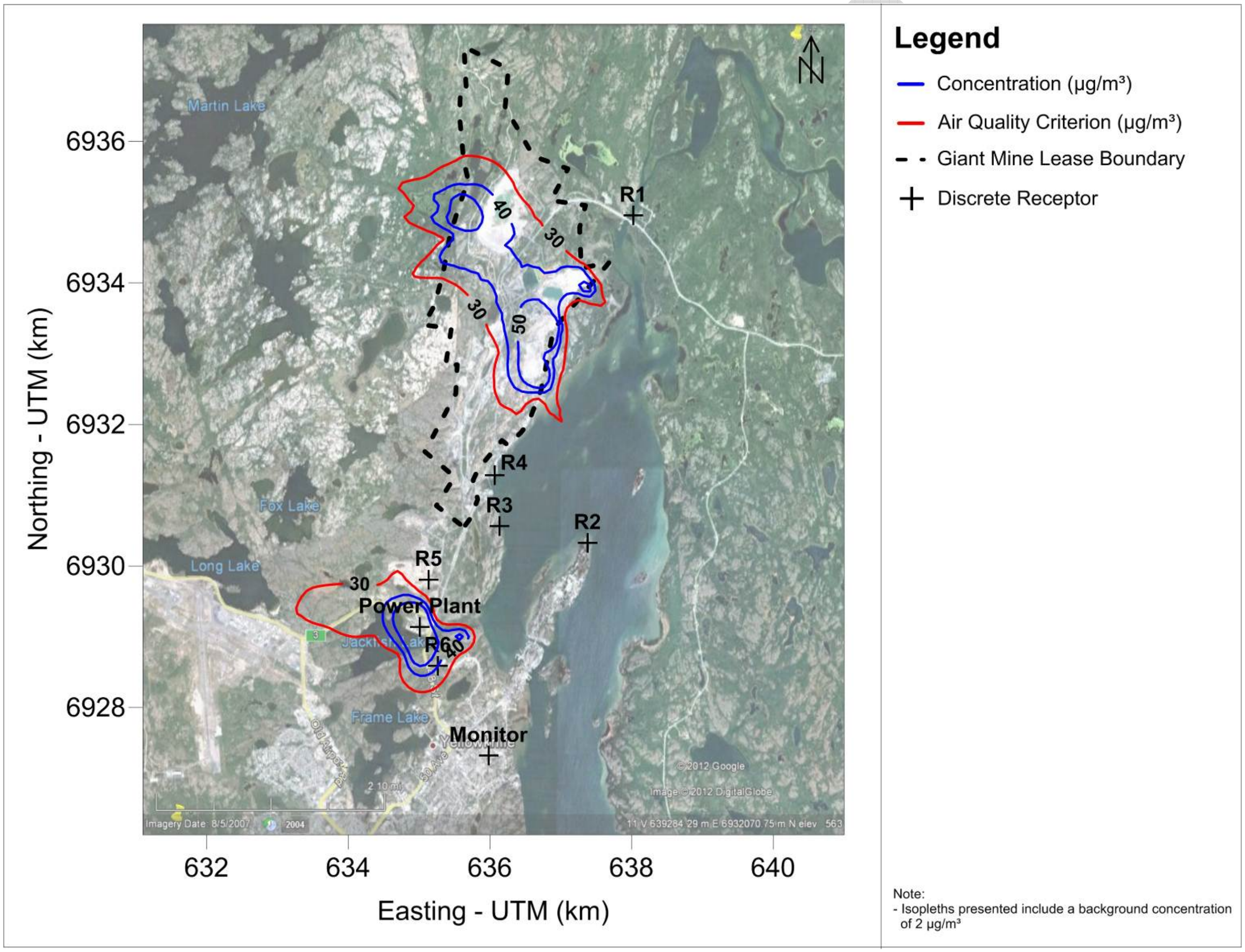


Figure 6.5 Model Predicted 24-hour Arsenic Concentrations – Scenario 1 - 18 MW

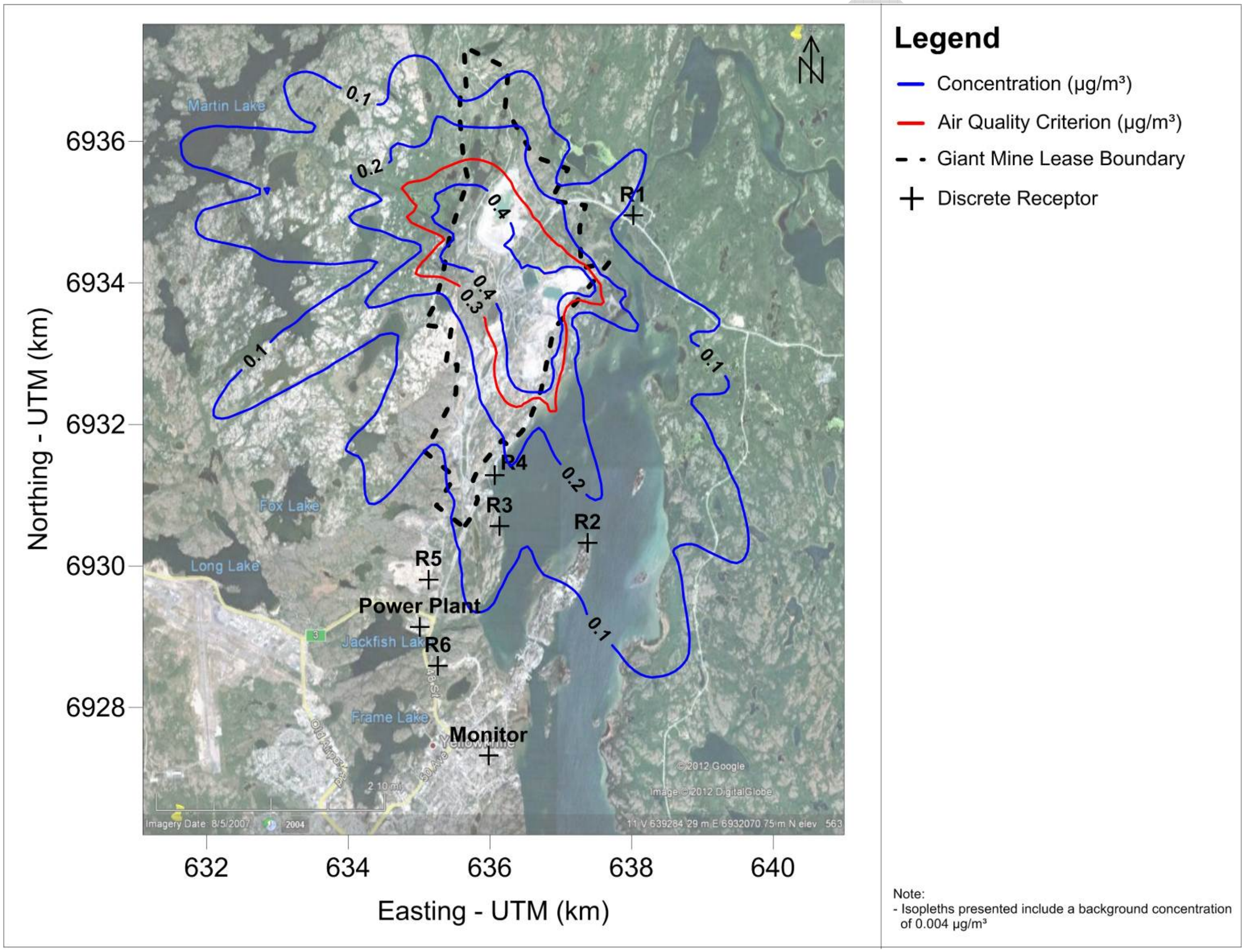


Figure 6.6 Model Predicted 1-hour NO_2 Concentration using OLM – Scenario 1 - 18 MW

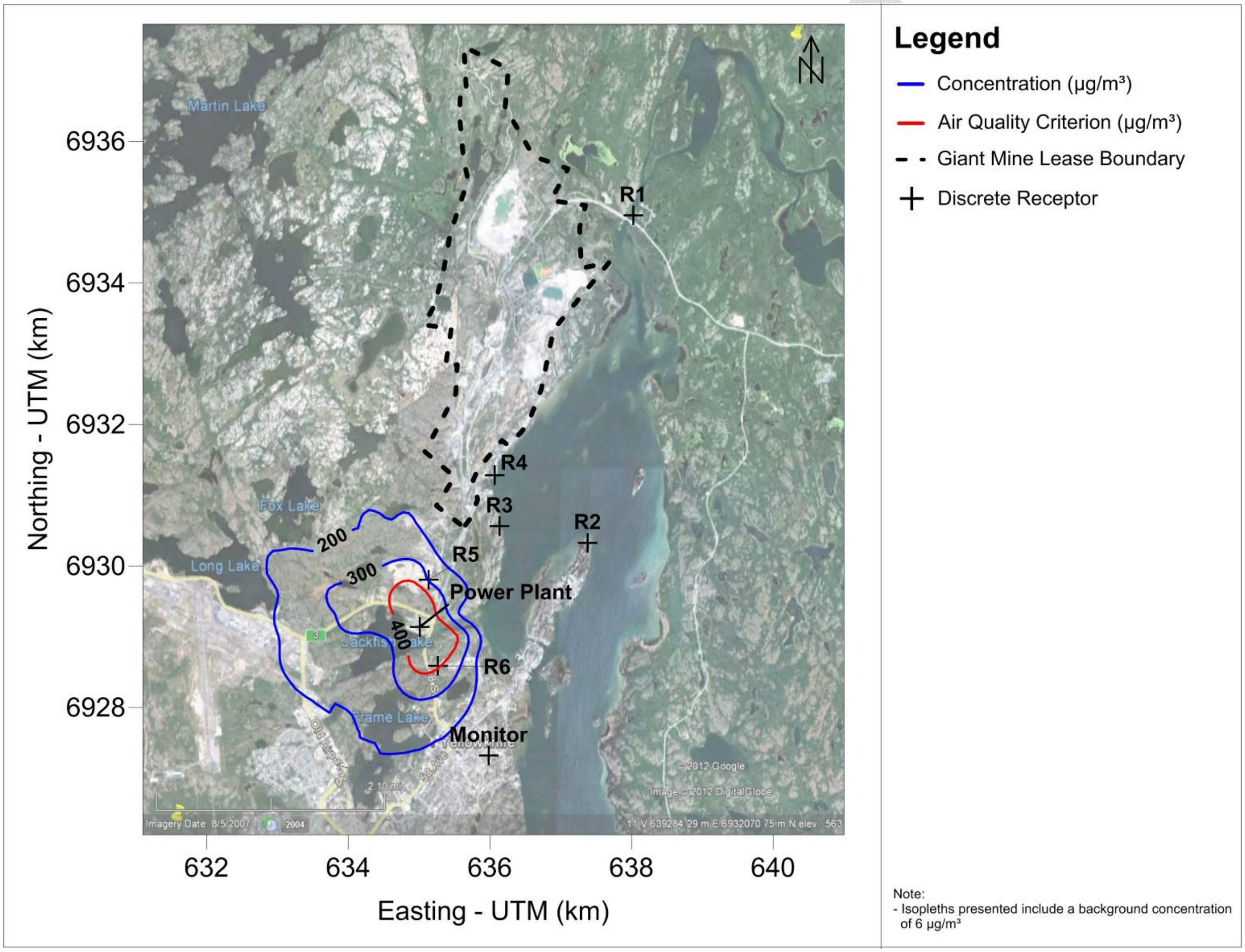


Figure 6.7 Model Predicted 24-hour NO_2 Concentration using OLM – Scenario 1 - 18 MW

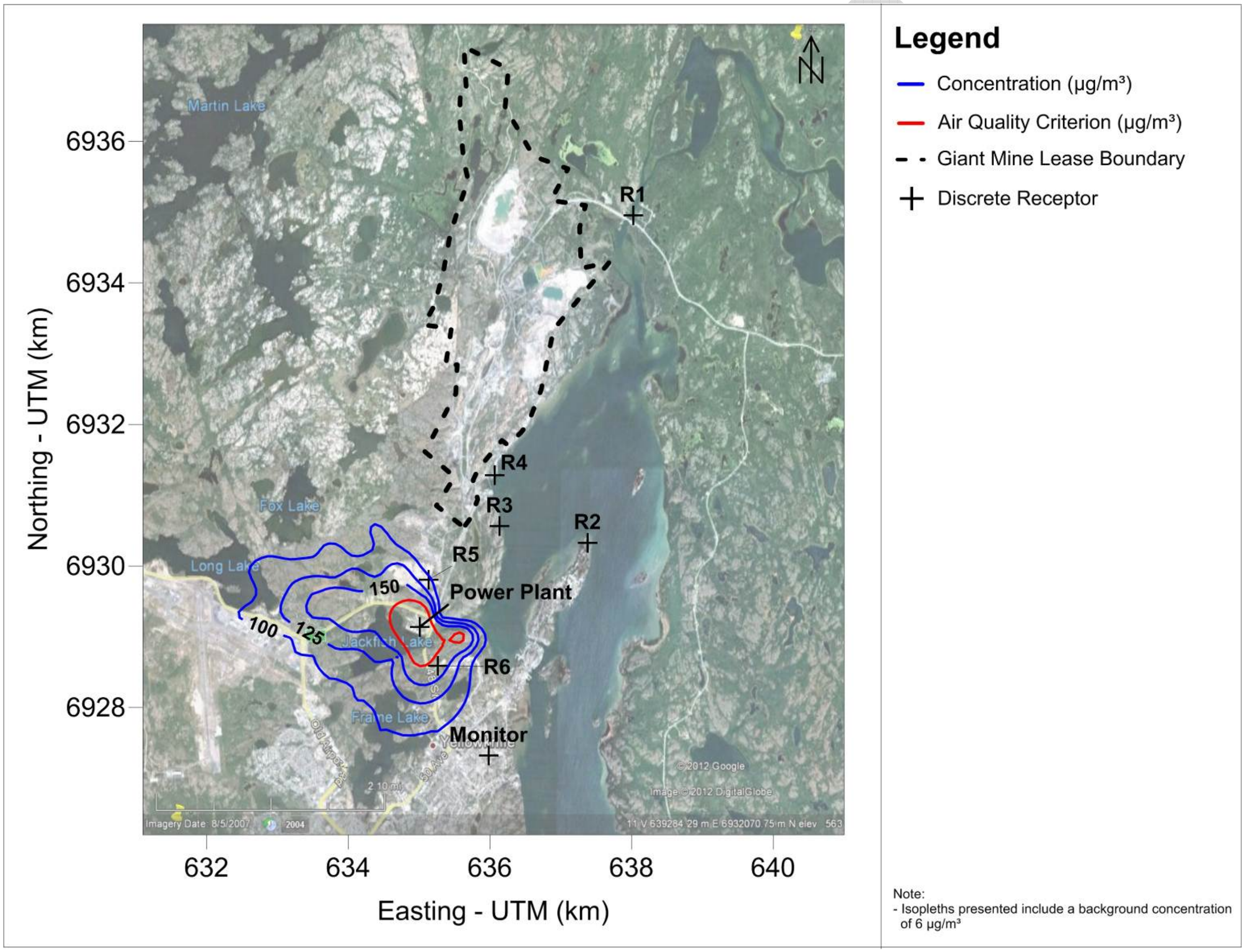


Figure 6.8 Model Predicted Annual NO_2 Concentration using OLM – Scenario 1 - 18 MW

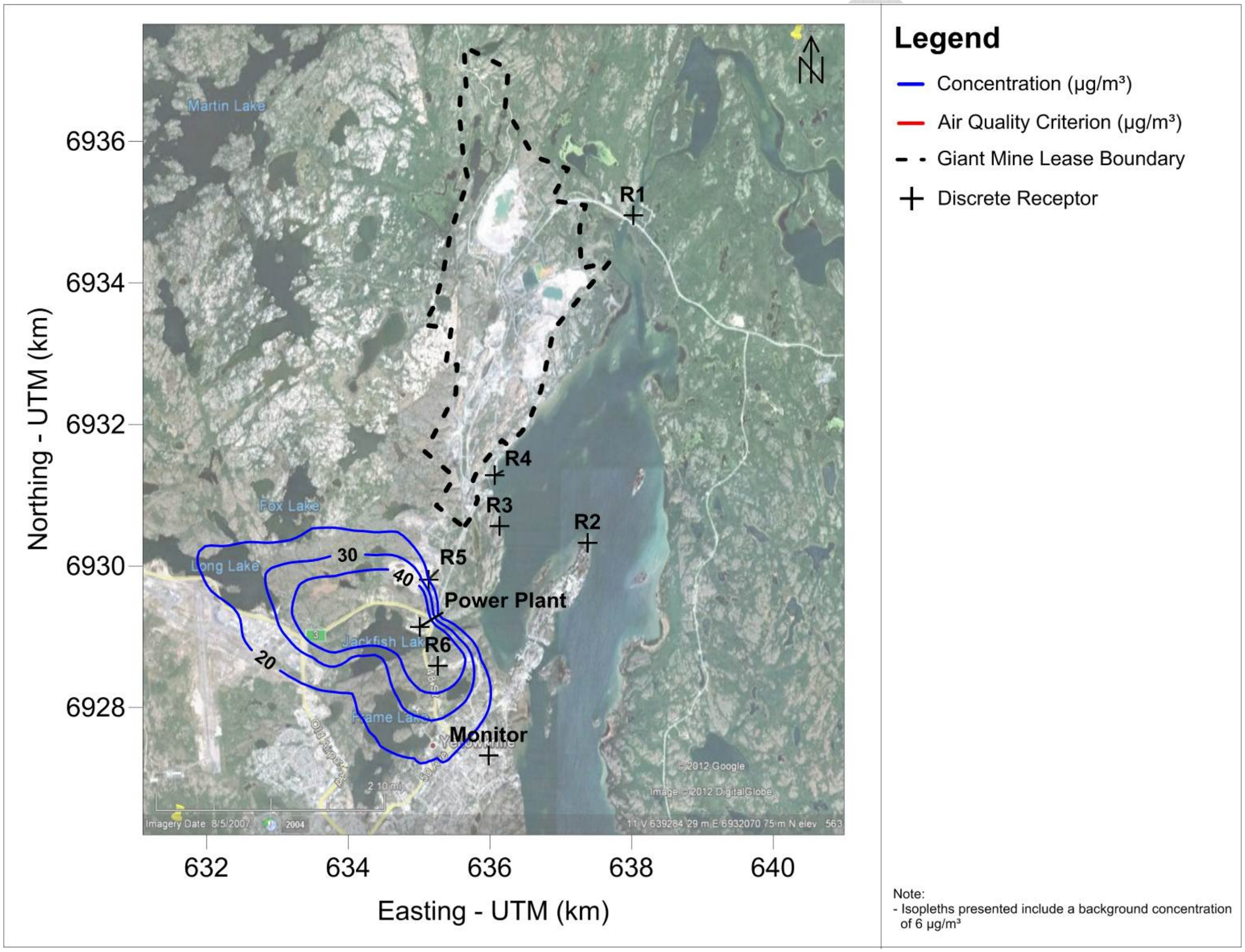


Figure 6.9 Model Predicted 1-hour SO_2 Concentration – Scenario 1 - 18 MW

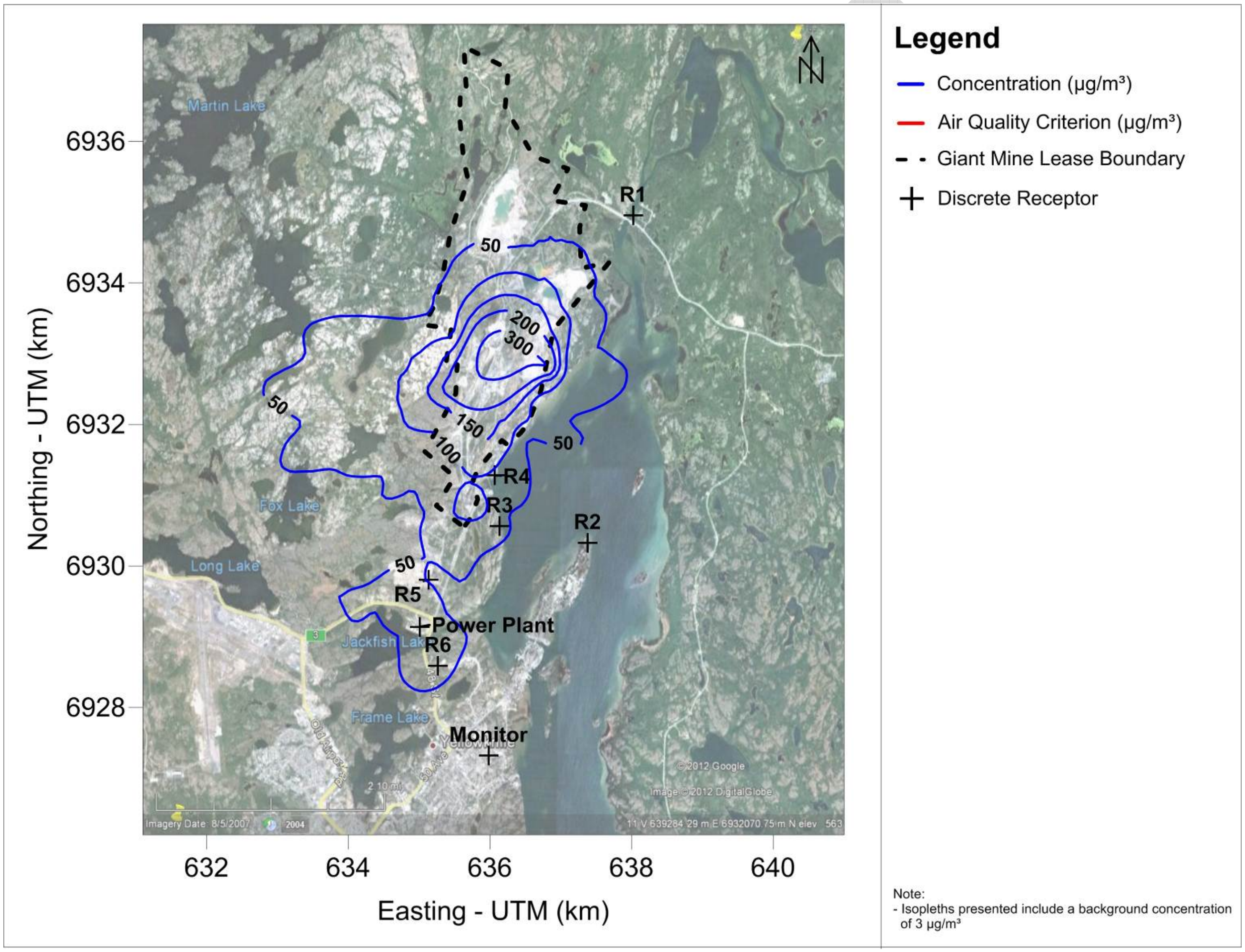


Figure 6.10 Model Predicted 24-hour SO_2 Concentration – Scenario 1 - 18 MW

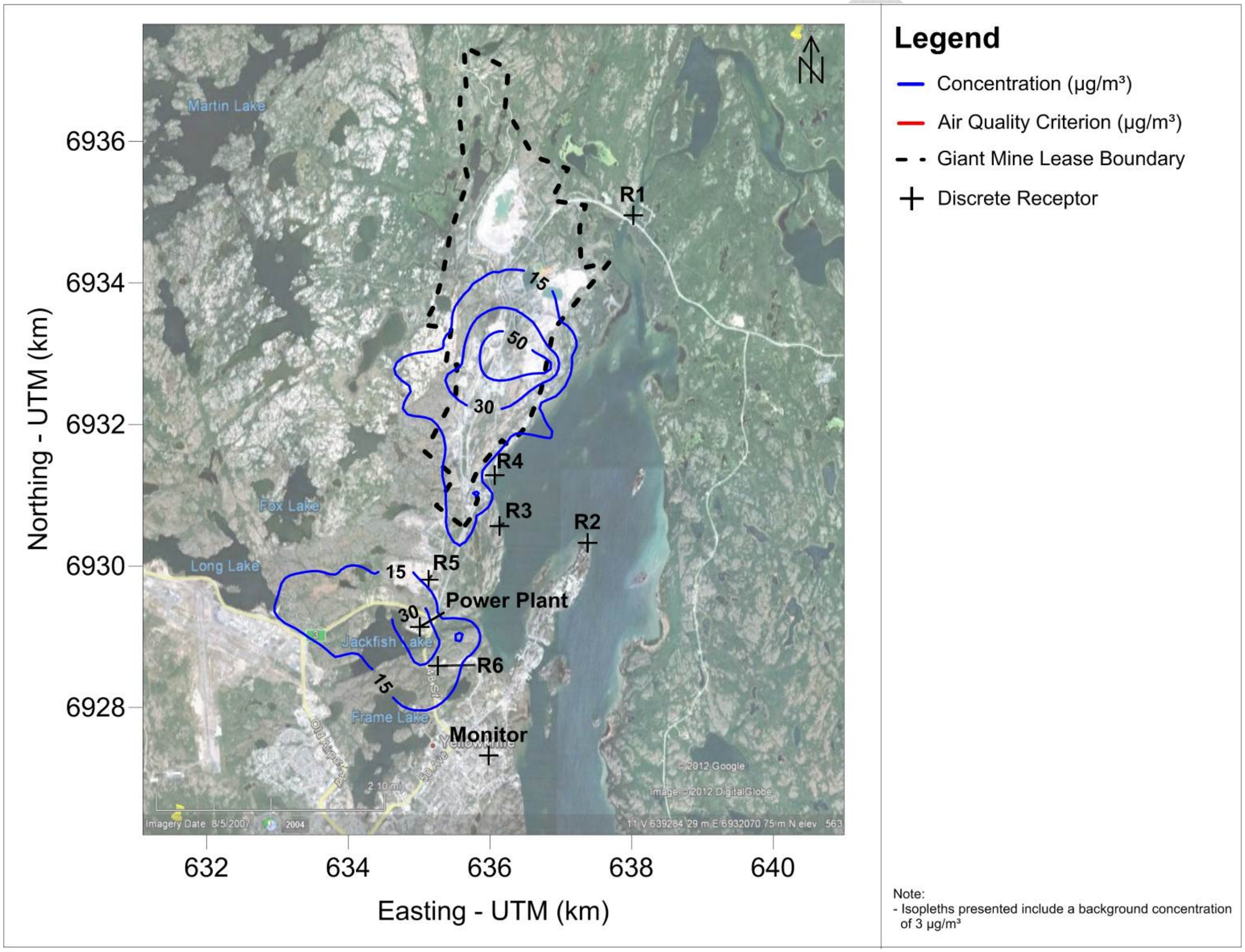
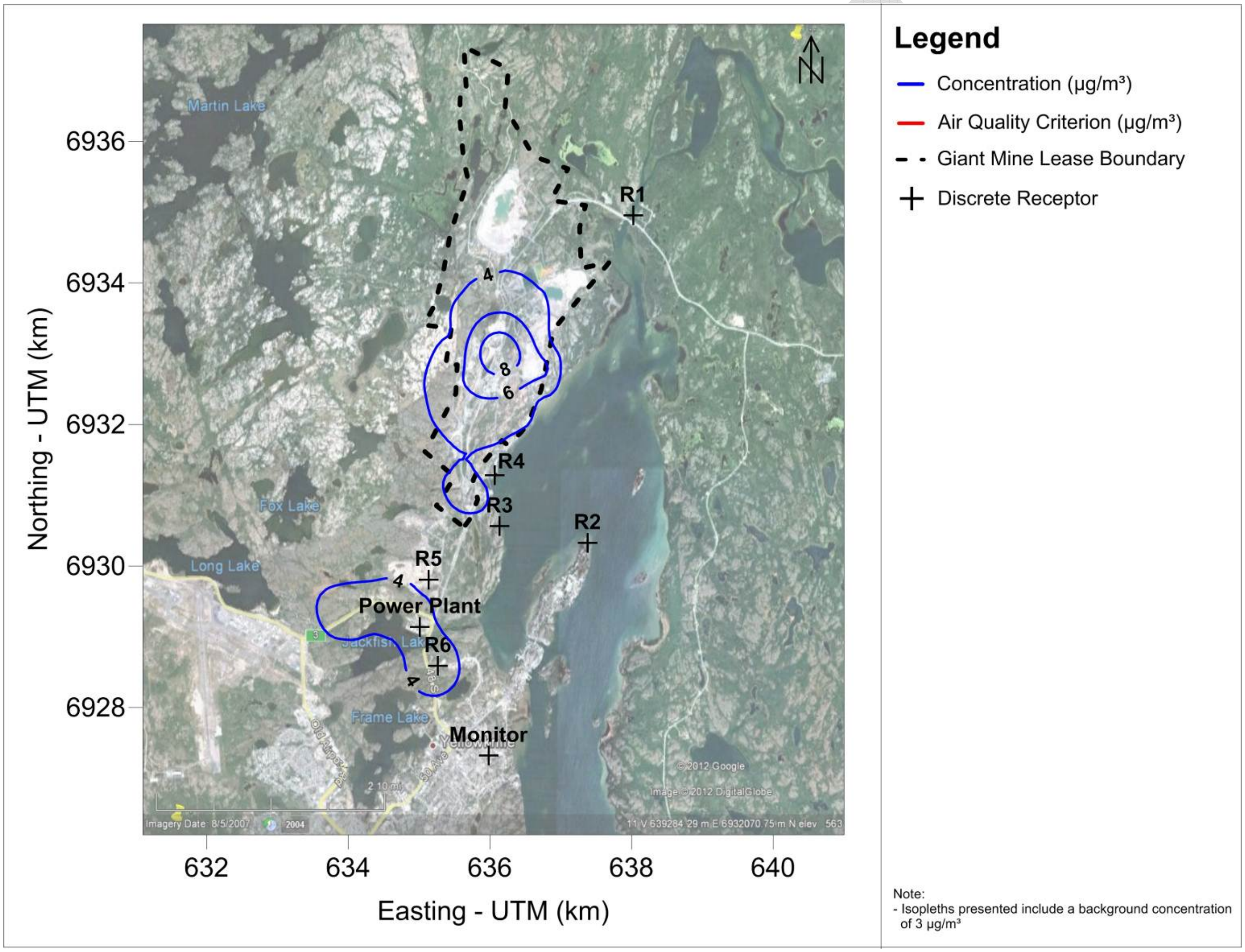


Figure 6.11 Model Predicted Annual SO_2 Concentration – Scenario 1 - 18 MW



6.2 12 MW SCENARIO

As previously discussed, the 2007 peak 24-hour local electricity demand was approximately 9 MW. With the additional 3 MW requirement for the freeze plant, a more realistic scenario is therefore the case where the Jackfish Power Plant is operating at 12 MW rather than 18 MW. To examine the differences between the two operating scenarios, a CALPUFF model run was completed for NO_x and $PM_{2.5}$ based on 12 MW of power generated by the Jackfish Power Plant. Only NO_x and $PM_{2.5}$ were considered in this assessment since these are the primary pollutants of concern emitted from combustion sources and which also exceeded their applicable criteria under Scenario 1 with 18 MW of power generated by the Jackfish Power Plant.

Table 6.2 compares the predicted impacts of GMRP activities and power plant emissions on 1-hour NO_2 and 24-hour $PM_{2.5}$ concentrations for each operating scenario. As can be seen in the table, the 1-hour NO_2 exceedance observed at the Niven Lake residential receptor (R6) under the 18 MW scenario is no longer present when the Jackfish Power Plant only operates at 12 MW. Table 6.2 also shows that at receptors in the vicinity of the plant (R5 and R6), $PM_{2.5}$ concentrations are also lower; however, for receptors further from the Jackfish Power Plant but closer to the Project site, concentrations remain unchanged. This indicates that predicted $PM_{2.5}$ concentrations at sensitive receptor locations are dominated by different sources of particulate emissions; with receptors R1 to R4 dominated by GMRP activities and receptors R5 and R6 dominated by operations of the Jackfish Power Plant.

In general, predicted 1-hour NO_2 and 24-hour $PM_{2.5}$ concentrations for the 12 MW scenario are about 30% lower for receptors in the vicinity of the power plant (R5 and R6) compared to the more conservative 18 MW scenario.

Table 6.2 Model Predicted 1-hr NO_2 (using OLM) and 24-hr $PM_{2.5}$ Concentration for the 12 MW and 18 MW Scenarios

Receptor	Model Predicted Pollutant Concentration (μg/m³)			
	1-hour NO_2		24-hour $PM_{2.5}$	
	12 MW	18 MW	12 MW	18 MW
R1	60.8	64.7	9.3	9.3
R2	71.3	80.5	16.4	16.4
R3	80.1	93.6	17.4	17.4
R4	70.8	79.7	17.1	17.1
R5	207.4	284.5	13.7	19.5
R6	295.2	**410.4**	27.8	**40.2**
Background (μg/m³)	**6**		**2**	
AAQC (μg/m³)	**400**		**30**	

6.3 27 MW SCENARIO

Based on discussions with NWT Power Corporation it is possible that in the future the Jackfish Power Plant could operate at maximum capacity (27 MW) for short periods of time (i.e., approximately 1-hour). Therefore, a CALPUFF model run was completed for NO_x based on 27 MW of power generated by the Jackfish Power Plant. Only NO_x was considered in this assessment since this is the primary pollutant of concern from combustion sources with a 1-hour criterion. It should be noted that the Jackfish Power Plant rarely operates at maximum capacity, and did not operate at maximum capacity for the representative year 2007 considered in Section 5.2.

CALPUFF model results predicted a maximum ground level 1-hour NO_x concentration immediately adjacent to the Jackfish Power Plant of 8145 µg/m³. Using the OLM, the calculated maximum 1-hour NO_2 concentration is 868 µg/m³, which is greater than 200% of the 400 µg/m³criterion. Based on the OLM, at this maximum NO_x concentration receptor location the 1-hour NO_2/NO_x ratio is 10.7%. The average 1-hour NO_2/NO_x ratio for the maximum operations scenario for the entire receptor grid is 21%, with receptor locations closer to the plant demonstrating a lower ratio and locations further from the plant demonstrating a higher ratio (i.e., the further away the receptor the more time for NO emissions to be converted to NO_2). Therefore, when the Jackfish Power Plant is operating at maximum capacity (approximate total NO_x emission rate of 112 g/s) there is insufficient atmospheric ozone to convert the majority of NO to NO_2 over short periods of time.

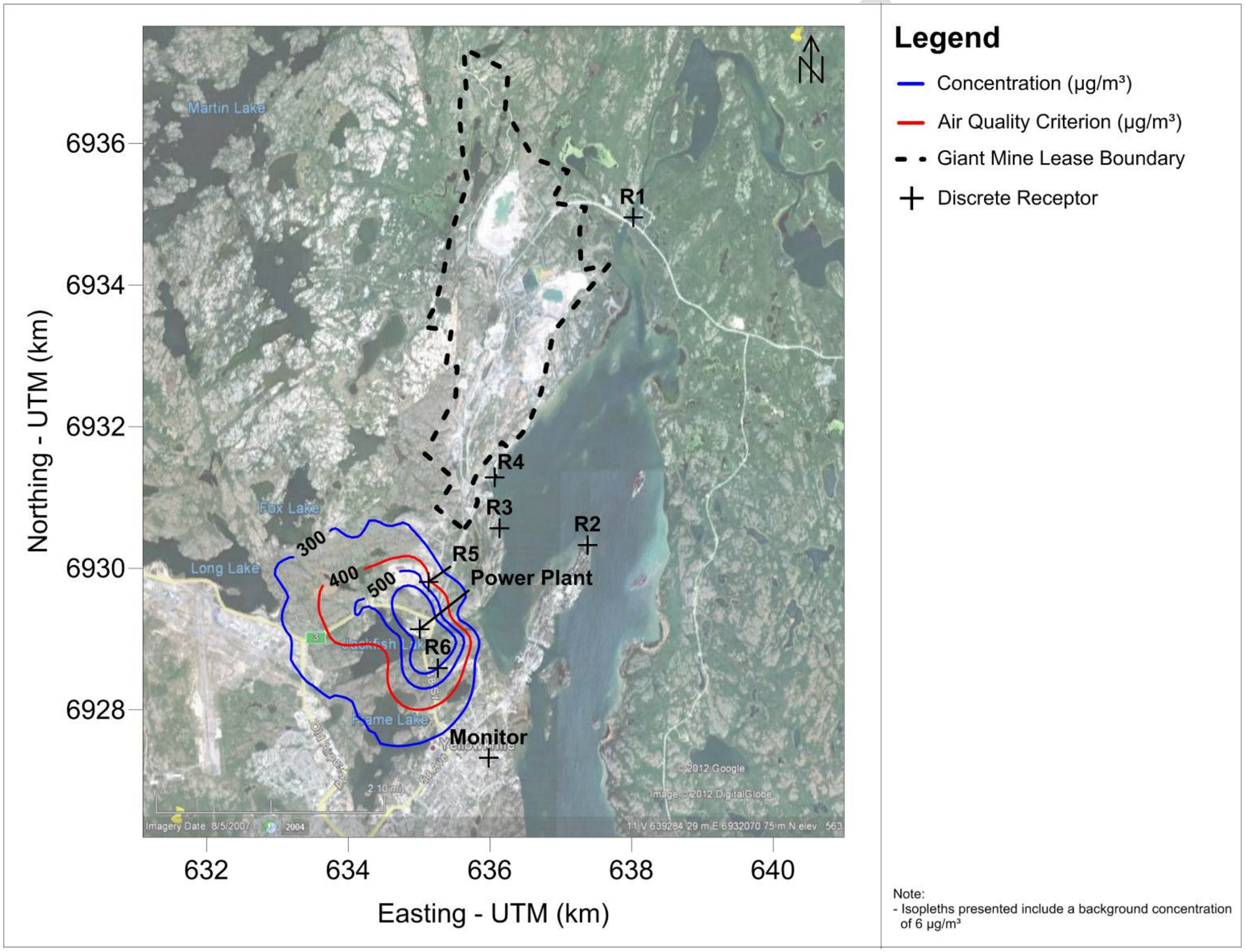
It should be noted that the average 24-hour NO_2/NO_x ratio for the maximum operations scenario for the entire receptor grid is 67%. However, operation of the Jackfish Power Plant at maximum capacity for a 24-hour period was not considered to be a reasonable scenario.

Table 6.3 compares CALPUFF model predicted 1-hour NO_2 concentrations for the 27 MW, 18 MW and 12 MW scenarios. Figure 6.12 illustrates maximum 1-hour NO_2 concentrations using OLM for the 27 MW scenario. As can be seen in Table 6.3 and Figure 6.12, significant exceedances of the 1-hour NO_2 criterion are predicted at receptor locations close to the Jackfish Power Plant, with predicted concentrations 1.5 times the criterion at the Niven Lake receptor (R6). Again, it should be noted that these predicted exceedances are a result of the very conservative assumption that the Jackfish Power Plant is operating at 27 MW for the entire year.

Table 6.3 Model Predicted 1-hr NO_2 Concentrations using OLM

Receptor	**Model Predicted Pollutant Concentration (µg/m³)**		
	1-hour NO_2		
	27 MW	**18 MW**	**12 MW**
R1	70.6	64.7	60.8
R2	94.1	80.5	71.3
R3	114.6	93.6	80.1
R4	64.0	79.7	70.8
R5	**424.9**	284.5	207.4
R6	**598.0**	**410.4**	295.2
Background (µg/m³)	**6**		
AAQC (µg/m³)	**400**		

Figure 6.12 Model Predicted 1-hour NO_2 Concentration using OLM – Scenario 3 - 27 MW



7.0 CONCLUSIONS

CALPUFF model results for GMRP activities were consistent with the screening level air dispersion modelling assessment, which was summarized in the Developer's Assessment Report (DAR) for the GMRP. The screening level assessment determined that, based on a reasonable level of mitigation during remediation activities, wind blown dust would be the primary emission source of TSP and arsenic, which is similar to the current baseline scenario at the Giant Mine site. The screening level ISCST3 model results predicted arsenic, TSP, PM_{10} and $PM_{2.5}$ concentrations during GMRP activities that are comparable to existing baseline monitoring results at the Giant Mine site, with exceedances of applicable criteria at on-site ambient monitoring locations. However, model results did not predict exceedances of any criteria at the nearest identified sensitive receptor locations, as a results of GMRP activities, for all particulate based contaminants assessed.

CALPUFF model results do predict exceedances of applicable 1-hour NO_2 and 24-hour $PM_{2.5}$ criteria at one receptor location, which is based on the conservative assumption that the Jackfish Power Plant is operating continuously at 18 MW. The worst case maximum operations scenario for short term (i.e., 1-hour) Jackfish Power Plant operations, which assumes the plant is operating at 27 MW, predicts significant exceedances of 1-hour NO_2 criterion at the two identified receptor locations nearest to the plant.

For GMRP activities, the air quality modelling analysis assumed a reasonable level of mitigation, including efficient dust control (e.g., watering) of mine site haul roads during non-freezing periods of the year. In addition, good dust management practices will ensure that any effect associated with material handling and transportation of materials is minimized. As required during non-freezing periods, on-site haul roads and areas to be bulldozed should be lightly watered every day to reduce the generation of dust. When visible dust is generated behind haul trucks during non-freezing periods, additional watering will be required. Application of chemical suppressants on unpaved roads will reduce the required watering frequency.

8.0 REFERENCES

AWMA (Air & Waste Management Association). 1992. Pollution Engineering Manual: Chapter 4–Fugitive Emissions. Van Nostrand Reinhold. USA.

Canadian Environmental Protection Act (CEPA) 1989. Ambient Air Quality Objectives (AAQO).

Environment Canada, National Air Pollution Surveillance (NAPS) Network: Annual Data Summary for2005 and 2006, October 2008
http://www.ec.gc.ca/rnspa-naps/default.asp?lang=En&n=77FECF05-1#reports

Government of Canada. 1999. Canadian Environmental Protection Act (CEPA) National Ambient Air Quality Objectives. Environment Canada. Ottawa, ON.

Indian and Northern Affairs Canada (INAC) and Government of the Northwest Territories (GNWT), Giant Mine Remediation Project Developer's Assessment Report, October 2010

Pasquill, F. 1962. Atmospheric Diffusion. D. Van Nostrand Company Inc.

Scire, J., S., Strimaitis, D.G and R.J. Yamartino. 1999. A Users Guide for the CALMET Meteorological Model (Version 5). Earth Tech Inc. Concord, MA.

Scire, J., F. Robe, M. Fernau, E. Insley and R. Yamartino. 2000a. A Users Guide for the CALMET Meteorological Model (Version 5). Earth Tech Inc., Concord, MA.

Scire, J., D. Strimaitis and R. Yamartino. 2000b. A Users Guide for the CALPUFF Dispersion Model (Version 5). Earth Tech Inc., Concord, MA.

US EPA (United States Environmental Protection Agency). 1995. AP 42, Fifth Edition. Compilation of Air Pollutant Emission Factors. Chapter 13.2.3 Heavy Construction Operations. January 1995.

US EPA (United States Environmental Protection Agency). 1998. AP 42, Fifth Edition. Compilation of Air Pollutant Emission Factors. Chapter 11.9 Western Surface Coal Mining. October 1998.

United States Environmental Protection Agency (U.S. EPA) 1998. AP 42, Fifth Edition. Compilation of Air Pollutant Emission Factors. Volume 1: Stationary Point and Area Sources.

United States Environmental Protection Agency (U.S. EPA) 2000. AP-42: Compilation of Air Pollutant Emission Factors, Volume 2: Mobile Sources.

United States Environmental Protection Agency (U.S. EPA) 2004. Exhaust and Crankcase Emission Factors for Nonroad Engine Modelling – Compression-Ignition. April.

US EPA (United States Environmental Protection Agency). 2006a. AP 42, Fifth Edition. Compilation of Air Pollutant Emission Factors. Chapter 13.2.4 Aggregate Handling and Storage Piles. November 2006.

US EPA (United States Environmental Protection Agency). 2006b. AP 42, Fifth Edition. Compilation of Air Pollutant Emission Factors. Chapter 13.2.2 Unpaved Roads. November 2006.

US EPA (United States Environmental Protection Agency). 2010. Exhaust and Crankcase Emission Factors for Nonroad Engine Modelling – Compression-Ignition. Assessment and Standards Division Office of Transportation and Air Quality. EPA-420-R-10-018 NR-009d. July 2010.