6.2.5 Meteorological Input Data

The CALMET model requires the input of surface and upper air meteorological fields. For this application, CALMET was initialized with surface station information from two surface weather stations one upper-air station over the five year period (2002-2006).

6.2.5.1 Surface Station Input

Hourly observed surface meteorological data were obtained from Environment Canada (EC) and used to initialize CALMET. As shown in Table 6-4, two EC weather stations (Schefferville Airport and Wabush Airport) were used to initialize CALMET. As the Schefferville Airport is relatively close (approximately 3 km) from the primary beneficiation area, and as the dataset over the period is relatively complete, CALMET was initialized by the surface meteorological information the majority of the time. During periods with missing (or calm) data, wind information from Wabush Airport (more than 200 km away) was considered as input. Figure 6-4 below shows the location of the Shefferville Airport relative to Project activities.

Table 6-4 Input Surface Meteorological Stations

Station Name	Type	Easting (km)	Northing (km)	Elevation (masl)	Surface Input Data Used
Schefferville Airport	EC	640.284	6074.848	521.8	Temperature, Wind Speed & Direction, Cloud Cover & Ceiling Height, Station Pressure, Relative Humidity
Wabush Airport	EC	643.38	5866.985	551.1	Temperature, Wind Speed & Direction, Cloud Cover & Ceiling Height, Station Pressure, Relative Humidity

For all input surface station data, quality analysis of the data was performed. For periods with calm winds or missing data, the following protocols were followed:

1) For periods with winds below the threshold of the anemometer, wind directions and speeds were marked as missing. Wind speeds and directions during such periods were thus calculated within CALMET using data from other nearby surface stations.
2) No data fills were required for periods with missing hourly data or missing fields for non-missing records. This is because CALMET requires only one non-missing value for each mandatory input surface meteorological field. In other words, the required surface input data was available from at least one station for each hour of period of interest.

Wind direction and wind speed play an important role in determining the overall transport of airborne pollutants. The hourly surface winds (from 2002 to 2006) from the two weather stations used as input in the CALMET modelling are summarized in the wind rose plots shown in Figure 6-5 below. Wind roses are an efficient and convenient means of presenting wind data. The length of the radial barbs gives the total percent frequency of winds from the indicated direction, while portions of the barbs of different widths indicate the frequency of associated wind speed categories. Note that periods with calm winds cannot be included in these diagrams as such periods often do not have valid measurement for wind direction.

As can be seen in Figure 6-5, wind patterns in the study region can vary considerably due to differences in factors such as synoptic meteorology (large-scale weather trends), terrain, and local surface characteristics. The Schefferville Airport meteorological station, which is the surface station nearest to Project activities, shows a higher proportion of winds from the west, north west, and south. For the other surface meteorological station considered (Wabush Airport), the dominant wind directions are from the west and from the south.

The „Radius of Influence' parameters in CALMET allow the user to specify weightings which control the influence of the input surface winds when the observations are merged with the „Step 1 Wind Field' (see Section 6.1). If the radii of influence are set to higher numbers, winds will be more spatially homogeneous near input stations and more directly reflect the observed surface stations values. If the radii of influence are set to lower numbers, more weighting is given to the „Step 1 Wind Field' which has been treated in CALMET to consider terrain effects, smoothing, and divergence minimization. For this study, the radius of influence parameters were set to allow for the observational winds to have a stronger influence than the „Step 1 Wind Field' within a 2 km radius of the input station locations, and have no influence beyond a distance of 20 km.

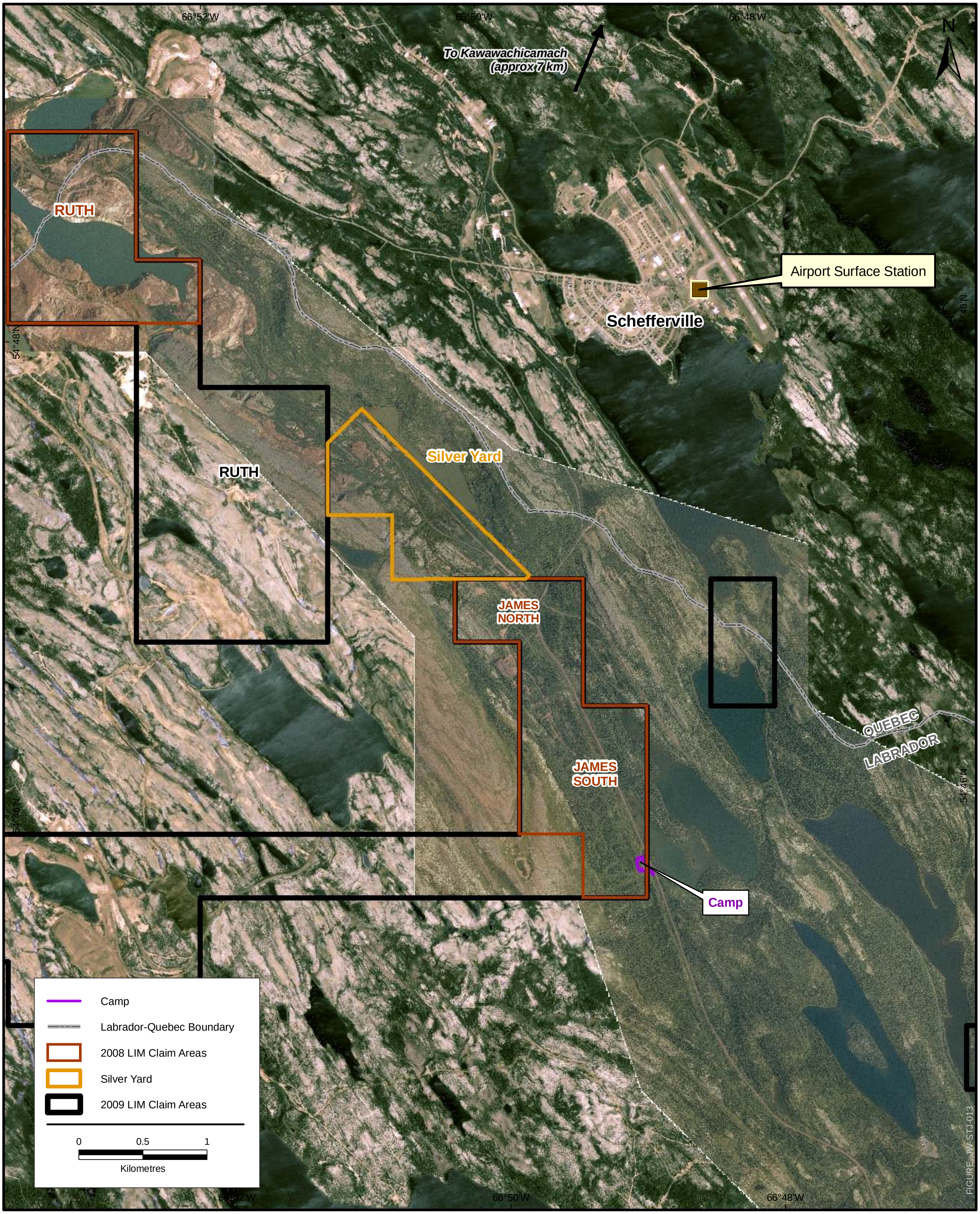
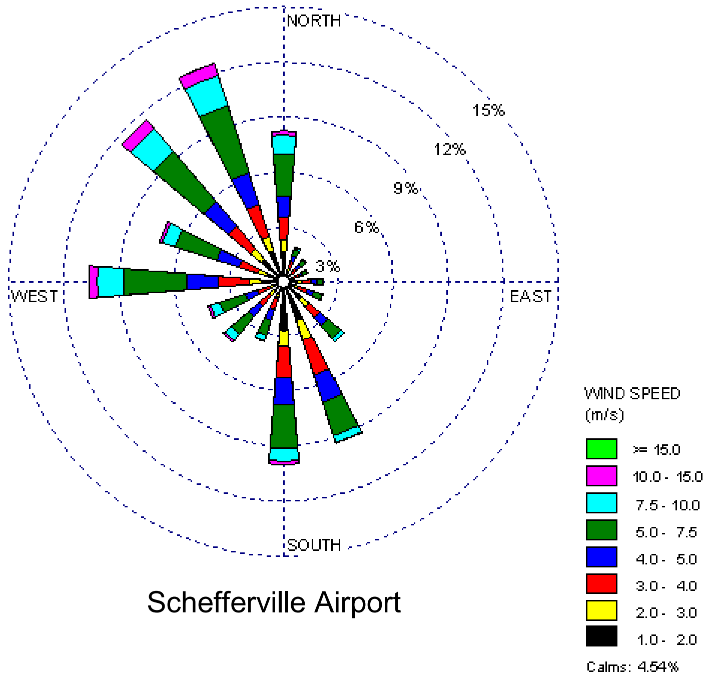
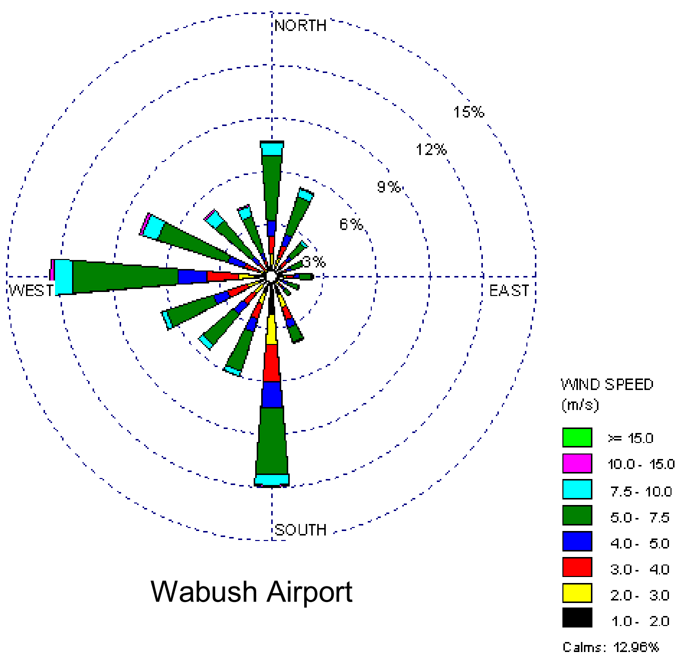


FIGURE NO:		
6-4	**Airport Location**	DRAFT DATE: 18/12/2008 REVISION DATE: 12/8/2009

Figure 6-5 Observed Winds at Input Surface Weather Stations (2002-2006)



Schefferville Airport



Wabush Airport

6.2.5.2 Upper Air Input

Twice-daily upper air sounding data from La Grande IV, located Western Labrador approximately 460 km west of the Project was used to initialize the upper air fields in CALMET. This station was selected based on guidance given in the NL DEC's Guidance for Plume Dispersion Modelling (NL DEC 2006). The model uses the upper level temperature and wind data to parameterize boundary layer parameters and determine upper level air flow. This data was downloaded from the NOAA ROAB Database and was prepared for use in CALMET with the model's READ62 pre-processor.

There were 78 missing soundings found in the period of interest (2002 to 2006) dataset and these were replaced by the sounding from the previous day for the same period (i.e., morning or evening). This was done as CALMET requires a complete upper air dataset to run. There were no extensive periods of missing data in the dataset with a maximum of three consecutive soundings found to be missing.

Sixteen missing surface-level data records in the sounding (i.e., FSL level „9') were replaced by data from the previous day for the same period.

The extrapolation of surface winds within CALMET allows for input surface station winds to also have influence in determining the flow patterns in the levels aloft. Along with choices concerning the method of computation for this extrapolation, the CALMET user is provided with an option to control, for each vertical level, the relative weighting of the extrapolated surface and upper-air values in the final interpolation. This model option is called the „BIAS' parameter.

For this application, the model-default method of extrapolation, using similarity theory and ignoring the influence of upper-air stations in the Level-1 wind field, was applied. A BIAS configuration was chosen to allow for surface wind input data to be more heavily weighted in the three lowest levels of the atmosphere (i.e., with no sounding station influence below 100 meters), but for upper air input wind data to be more heavily weighted in the levels further aloft (i.e., with no surface station influence above 500 meters). A CALMET input file with all parameterization options used for the modelling is proved in Attachment B.

6.2.6 Model Options

The most recent version of the CALMET model (Version 6.326, Level 080709) was used to predict the meteorological parameters required by the CALPUFF model. Model Options were selected based on the NL DEC's Guidance for Plume Dispersion Modelling (NL DEC 2006), consultation with the NL DEC, and guidance published by the U.S. Environmental Protection Agency (US EPA 1998). For model options with no NL DEC or U.S. EPA-recommended values, CALMET model default parameters were selected.

The CALMET input file, showing the values selected for this application, is provided in Attachment B.

6.2.7 CALMET Output

6.2.7.1 Wind Vector Diagrams

Surface wind vector plots provide an overview of how the wind fields predicted by CALMET vary across the modeling domain. The vector plots presented in this section were not selected to illustrate representative conditions, but rather to demonstrate how the CALMET-predicted winds can vary substantially across the domain for a given hour. In these diagrams, an arrow is shown to represent the direction and velocity of the wind for each meteorological grid cell. The direction of the arrow indicates the direction that the wind is blowing towards and the relative length of the arrow indicates the magnitude of the wind speed.

In Figure 6-6, surface winds for a calm night-time hour on January 6th 2004 at 12:00 Eastern Standard Time (EST) are presented. Atmospheric conditions were relatively stable during this time with a maximum wind speed of about 6 m/s predicted within the modelling domain. The action of CALMET's Diagnostic Wind Module and the influences of terrain, as well as the influence of the Schefferville Airport station data are both apparent during this period. For example, uniform calm winds (smaller in magnitude) from the Schefferville Airport surface station can be distinguished from model-predicted winds at other locations in the study domain (more influenced by the CALMET terrain algorithms).

In Figure 6-7, a wind vector diagram of the surface layer over the CALMET domain for July 16th at 00:00 EST is presented. Atmospheric conditions in the boundary layer were relatively stable during this period and the maximum wind speeds is approximately 5 m/s across the modeling domain. Wind directions are more uniform during this hour than in Figure 6-6.

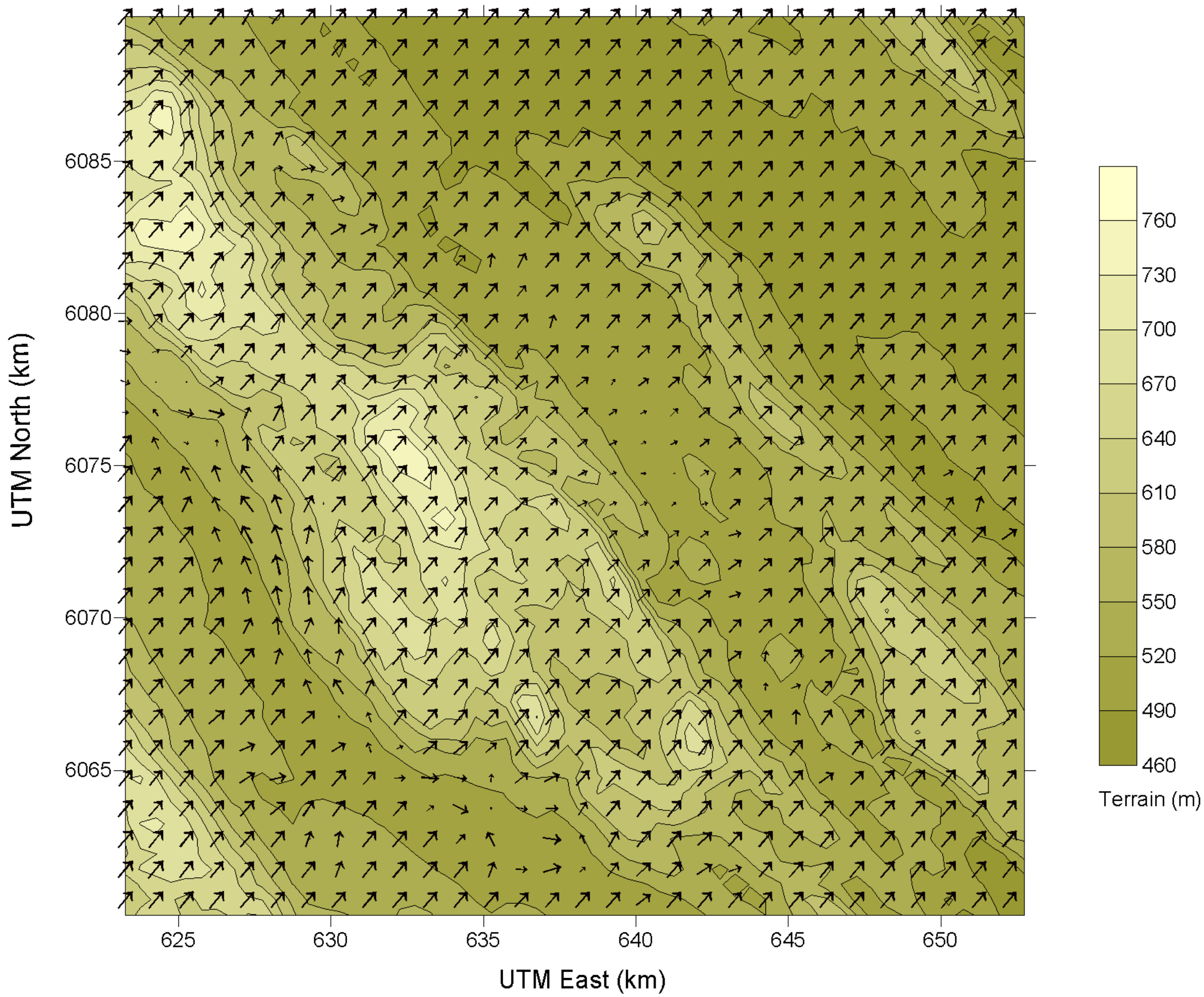


FIGURE 6-6

CALMET Level 1 (10 m) Winds: January 6th at 12:00 EST

Map Parameters
Projection: UTM
Datum: NAD 83
Zone: 19
Map Units: km
Date: 8/14/2009
Project: 1046156

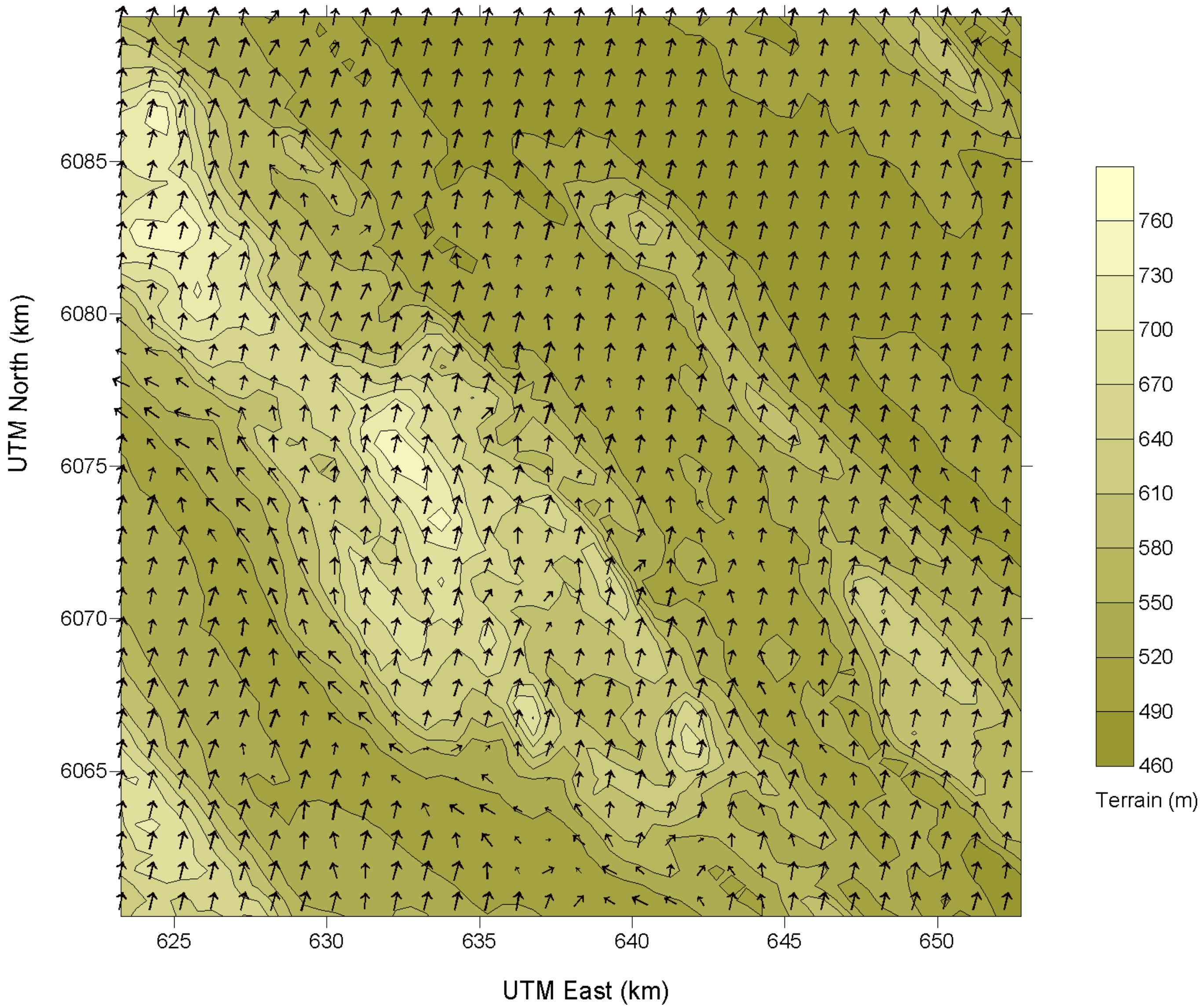


FIGURE 6-7

CALMET Level 1 (10 m) Winds: July 16th at 00:00 EST

Map Parameters
Projection: UTM
Datum: NAD 83
Zone: 19
Map Units: km
Date: 8/14/2009
Project: 1046156

6.2.7.2 Stability and Mixing Heights

Atmospheric turbulence near the earth's surface is often described in terms of atmospheric stability, which is governed by both thermal and mechanical factors. Atmospheric stability can be broadly classified as stable, neutral, or unstable.

Stable atmospheric conditions occur when vertical motion in the atmosphere is suppressed. With respect to air quality, this means pollutants emitted near ground-level are not well-dispersed and are believed to have a larger incremental effect on local ambient levels. This type of situation frequently occurs at night, when the earth's surface emits thermal radiation and cools. Air in contact with the ground thus becomes cooler and denser than the air aloft. This phenomenon is referred to as a ground-based temperature inversion and is often associated with poor air quality conditions.

Unstable atmospheric conditions are also highly dependent on radiation at the earth's surface, and most frequently occur during day-time hours. During such times, as short-wave energy from the sun heats the ground, air in contact with the ground becomes warmer and less dense than the air aloft. Subsequently, vertical motion in the atmosphere is enhanced and the atmosphere is said to be unstable.

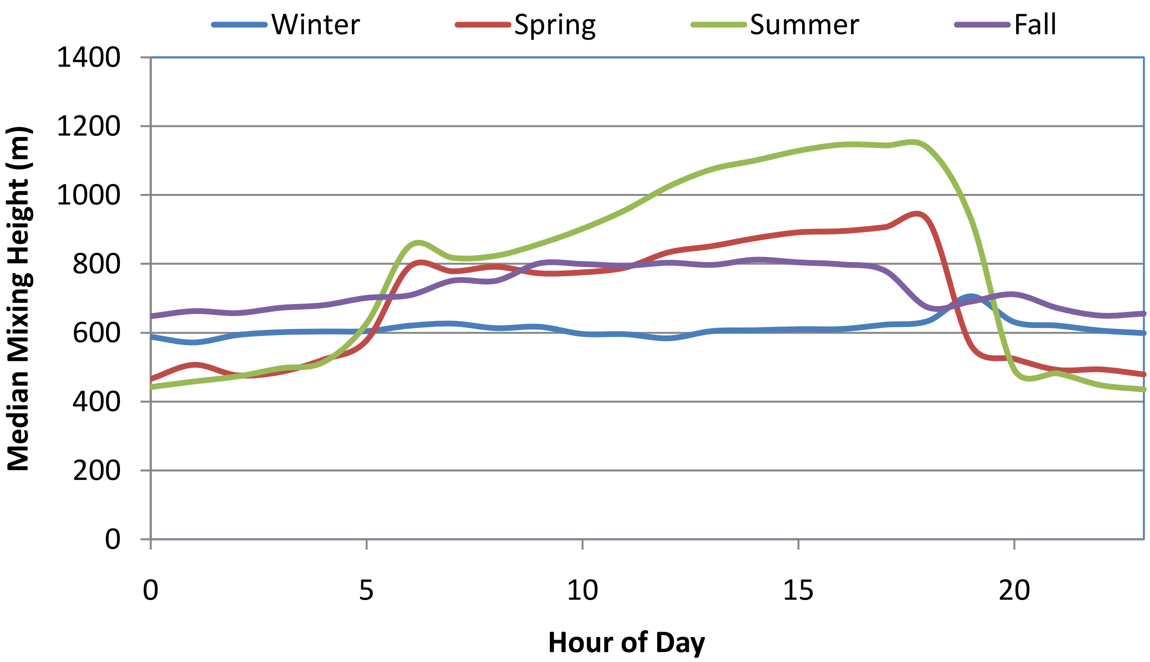
When a balance exists between incoming and outgoing radiation, there is no net heating or cooling of the air in contact with the ground, and vertical motions of the atmosphere are neither enhanced nor suppressed. Such an atmosphere is described as neutral and exists during overcast skies or during transition from unstable to stable conditions.

Mechanical mixing, which is mostly a function of lower level wind speeds (and surface roughness), can also influence atmospheric stability. Higher wind speeds (and a greater surface roughness) promote higher levels of turbulence in the region of discussion. This, in turn, leads to more mechanical mixing, which means that the atmosphere becomes more unstable. Mechanical mixing plays a more important role in determining stability when wind speeds are very high and at night, when convective vertical motion is suppressed.

The CALMET model calculates a maximum mixing height, as determined by either convective or mechanical forces. The convective mixing height is the height to which an air package will rise under the buoyant forces created by the heating of the earth's surface. The convective mixing height is dependent on solar radiation amount, wind speed, as well as the vertical temperature structure of the atmosphere. Mechanical mixing heights are, similarly, the height to which an air package will rise under the influence of mechanical-invoked turbulence. The mechanical mixing height is proportional to low-level wind speeds and surface roughness.

Diurnal variations of median mixing height, as estimated by the CALMET model at the grid cell nearest to the primary processing (beneficiation) area are shown for each season in Figure 6-8. Model mixing heights can vary from several meters to several thousand meters, depending on the intensity of solar radiation and wind speed. Daytime mixing heights are generally greater during the summer than during the winter due to different surface radiation budgets.

Figure 6-8 Median Diurnal Mixing Heights by Season near Beneficiation Area (2002-2006)



As shown in Figure 6-8, night time mixing heights are predicted to be slightly higher in winter under the influence of stronger winds associated with winter weather systems, which increase mechanical mixing heights in the model. In addition, due to the limited daylight and snow cover during the winter period, convective mixing is extremely limited and thus, mixing heights are primarily determined mechanically. On the other hand, during summer daytime hours when the effects of solar heating are greatest due to longer days, higher mixing heights are predicted due to convective motion. Conversely, the lowest mixing heights are predicted during summer nights due to losses of long-wave radiation.

6.3 CALPUFF Dispersion Modelling Methodology

As previously mentioned, the CALPUFF dispersion model was used to evaluate the potential changes in air quality due to the Project for all substantive emission sources.

The primary species considered in the dispersion modelling were NO_X (nitrogen oxides), SO_2 (sulphur dioxide), $PM_{2.5}$ (particulate matter less than 2.5 microns in diameter), PM_{10} (particulate matter less than 10 microns in diameter), TSP (total suspended particulate matter) and CO (carbon monoxide). For all modelled species, maximum ground-level concentrations (GLC) were calculated, then added to estimated ambient background concentrations to predict the cumulative changes in air quality due to Project-related emissions.

6.3.1 CALPUFF Model Description

The following description of the CALPUFF model's major model algorithms and options are all excerpts from the CALPUFF model's user manual (Scire et al. 2000b).

The CALPUFF model is a non-steady-state Gaussian puff dispersion model which incorporates simple chemical transformation mechanisms, wet and dry deposition, complex terrain algorithms and building downwash. The CALPUFF model is suitable for estimating ground level air quality concentrations on both local and regional scales, from tens of meters to hundreds of kilometres. It can accommodate arbitrarily varying point sources and gridded area source emissions. Most of the algorithms contain options to treat the physical processes at different levels of detail depending on the model application.

The major features and options of the CALPUFF model are summarized are briefly described below:

- Chemical Transformation: CALPUFF includes options for parameterizing chemical transformation effects using the five species scheme (SO_2, SO, NO_x, HNO_3, and NO) employed in the MESOPUFF II model, the six species RIVAD/ARM3 scheme, or a set of user-specified, diurnally-varying transformation rates.
- Subgrid Scale Complex Terrain: The complex terrain module in CALPUFF is based on the approach used in the Complex Terrain Dispersion Model (CTDMPLUS) (Perry et al. 1989). Plume impingement on subgrid scale hills is evaluated using a dividing streamline (H_d) to determine which pollutant material is deflected around the sides of a hill (below H_d) and which material is advected over the hill (above H_d). Individual puffs are split into up to three sections for these calculations.
- Puff Sampling Functions: A set of accurate and computationally efficient puff sampling routines are included in CALPUFF which solve many of the computational difficulties with applying a puff model to near-field releases. For near-field applications during rapidly varying meteorological conditions, an elongated puff (slug) sampling function can be used. An integrated puff approached is used during less demanding conditions. Both techniques reproduce continuous plume results exactly under the appropriate steady state conditions.
- Wind Shear Effects: CALPUFF contains an optional puff splitting algorithm that allows vertical wind shear effects across individual puffs to be simulated. Differential rates of dispersion and transport occur on the puffs generated from the original puff, which under some conditions can substantially increase the effective rate of horizontal growth of the plume.
- Building Downwash: The Huber-Snyder and Schulman-Scire downwash models are both incorporated into CALPUFF. An option is provided to use either model for all stacks, or make the choice on a stack-by-stack and wind sector-by-wind sector basis. Both algorithms have been implemented in such a way as to allow the use of wind direction specific building dimensions.
- Overwater and Coastal Interaction Effects: Because the CALMET meteorological model contains overwater and overland boundary layer algorithms, the effects of water bodies on plume transport, dispersion, and deposition can be simulated with CALPUFF. The puff formulation of CALPUFF is designed to handle spatial changes in meteorological and dispersion conditions, including the abrupt changes that occur at the coastline of a major body of water.
- Dispersion Coefficients: Several options are provided in CALPUFF for the computation of dispersion coefficients, including the use of turbulence measurements (σv and σw), the use of similarity theory to estimate σv and σw from modelled surface heat and momentum fluxes, or the use of Pasquill-Gifford (PG) or McElroy-Pooler (MP) dispersion coefficients, or dispersion equations based on the Complex Terrain Dispersion Model (CTDM). Options are provided to apply an averaging time correction or surface roughness length adjustment to the PG coefficients.

- Dry Deposition: A full resistance model is provided in CALPUFF for the computation of dry deposition rates of gases and particulate matter as a function of geophysical parameters, meteorological conditions, and pollutant species. Options are provided to allow user-specified, diurnally varying deposition velocities to be used for one or more pollutants instead of the resistance model (e.g., for sensitivity testing) or to by-pass the dry deposition model completely.
- Wet Deposition: An empirical scavenging coefficient approach is used in CALPUFF to compute the depletion and wet deposition fluxes due to precipitation scavenging. The scavenging coefficients are specified as a function of the pollutant and precipitation type (i.e., frozen vs. liquid precipitation).

6.3.2 Model Initialization

6.3.2.1 Computational Domain

The CALPUFF computational domain is the area in which the transport and dispersion of puffs are considered for the calculation of ground level concentrations. For this application, dispersion modelling was conducted using CALPUFF over a computational domain equal to the CALMET meteorological grid as defined in Section 6.2 of this report. A graphical representation of the modelling domain relative to the beneficiation and mine locations is shown in Figure 2-1.

6.3.2.2 Meteorological Data

Meteorological data such as mixing heights, stability and winds determine the transport and dispersion of pollutants within the CALPUFF model. To account for puff behaviour (plume dispersion) under a variety of meteorological conditions, five years of meteorological data (2002 to 2006) was considered in this application. Hourly three-dimensional meteorological data were prepared using the CALMET model (as described in Section 6.2) and used to drive the dispersion in CALPUFF.

6.3.2.3 Emission Rates and Stack Parameters

As previously mentioned, the CALPUFF model was used to predict maximum GLC due to all substantive Project-related emission sources. A summary of Project-related emissions, including the source characteristics and emission rates used as input to CALPUFF is provided in Section 5 of this report.

6.3.2.4 Building Downwash Effects

For stacks located in the wake region of buildings, enhanced plume dispersion due to turbulent wake and reduced plume rise caused by a combination of descending streamlines in the lee of the building and increased entrainment in the wake may occur. Building wake effects are generally expected to affect a stack if:

1) The stack is located a distance less than 5 times the greater of the building height or width from the building; and,
2) The height of the stack is less than 1.5 times the building height

The point sources in the beneficiation area range from about 5 m (diesel generators) to 33 boiler and dust collection system stacks on top of the primary crusher building). As the primary crusher building is approximately 32 m tall, and as the diesel generators are located within 10 m of the building, during certain meteorological conditions emissions from all of sources may be mixed rapidly down to ground level due to the influence of building downwash.

The U.S. EPA Building Profile Input Program (BPIP) Model (US EPA 1995) was used to estimate downwash effects based on the stack/building configuration presented in Section 5. CALPUFF uses the output from the BPIP model to account for the potential influence of building downwash in determining plume dispersion during certain meteorological conditions. The BPIP input and output files for this application are provided in Attachment C.

CALPUFF has two model options for downwash calculations (Scire et al. 2000b): the ISC downwash method, and the newer PRIME algorithm. The PRIME method was chosen because it is more up-to-date and recommended for most regulatory applications.

6.3.2.5 Receptor Grids

A series of nested Cartesian receptor grids surrounding the beneficiation area were selected following the NL DEC's Guidance for Plume Dispersion Modelling (NL DEC 2006). Terrain heights were calculated at each receptor point based on the previously-mentioned SRTM data (USGS 2007) to predict maximum concentrations at various points within the study domain. The primary purpose of these receptor grids are to predict maximum off-site GLC and depict the variance in predicted concentrations in the study area (isocontour plots). As shown in Figure 6-9, the density of the receptor grid decreases with distance from the Beneficiation Area as fewer receptor points are required to capture the local maxima.

In addition, maximum GLC were predicted at discrete sensitive receptors representing nearby cabins (including the worker's camp), residences, and recreational areas. Figure 6-10 shows the locations of the sensitive receptors relative to the area where Project activities will occur.

6.3.2.6 Terrain Effects

During the dispersion of a plume emitted from a given source, the impingement of the plume on nearby regions with elevated terrain can cause higher concentrations in dispersion models than would occur in regions of simple terrain.

In CALPUFF the effects of terrain between the source and receptor are accounted for in the dispersing plume (*i.e.*, the plume has a "memory" of the terrain that affected it between the source and receptor). To account for the possible distortion of the plume trajectory over elevated terrain, the CALPUFF model's Partial Plume Path Adjustment Method (PPPAM) was used to modify the height of the plume.

The PPPAM employs a plume path coefficient (PPC) to adjust the height of the plume above the ground. Default PPC values of 0.5, 0.5, 0.5, 0.5, 0.35, and 0.35 for Pasquill-Gifford (PG) stability classes A, B, C, D, E, and F, respectively are recommended by the CALPUFF authors and were used in this study.

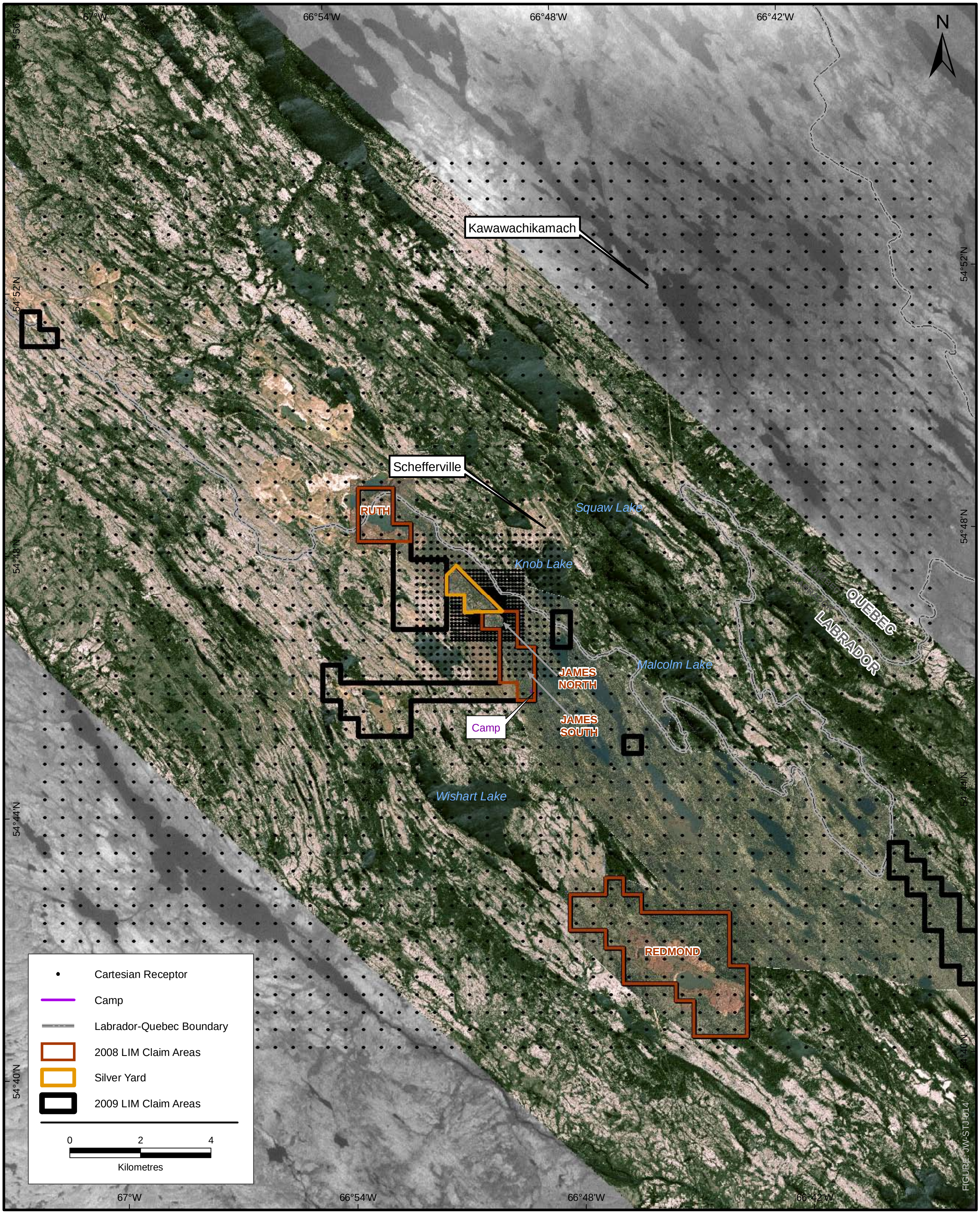


FIGURE NO:		DRAFT DATE: 18/12/2008
6-9	**Air Quality** **Nested Cartesian Receptor Grids**	REVISION DATE: 12/8/2009

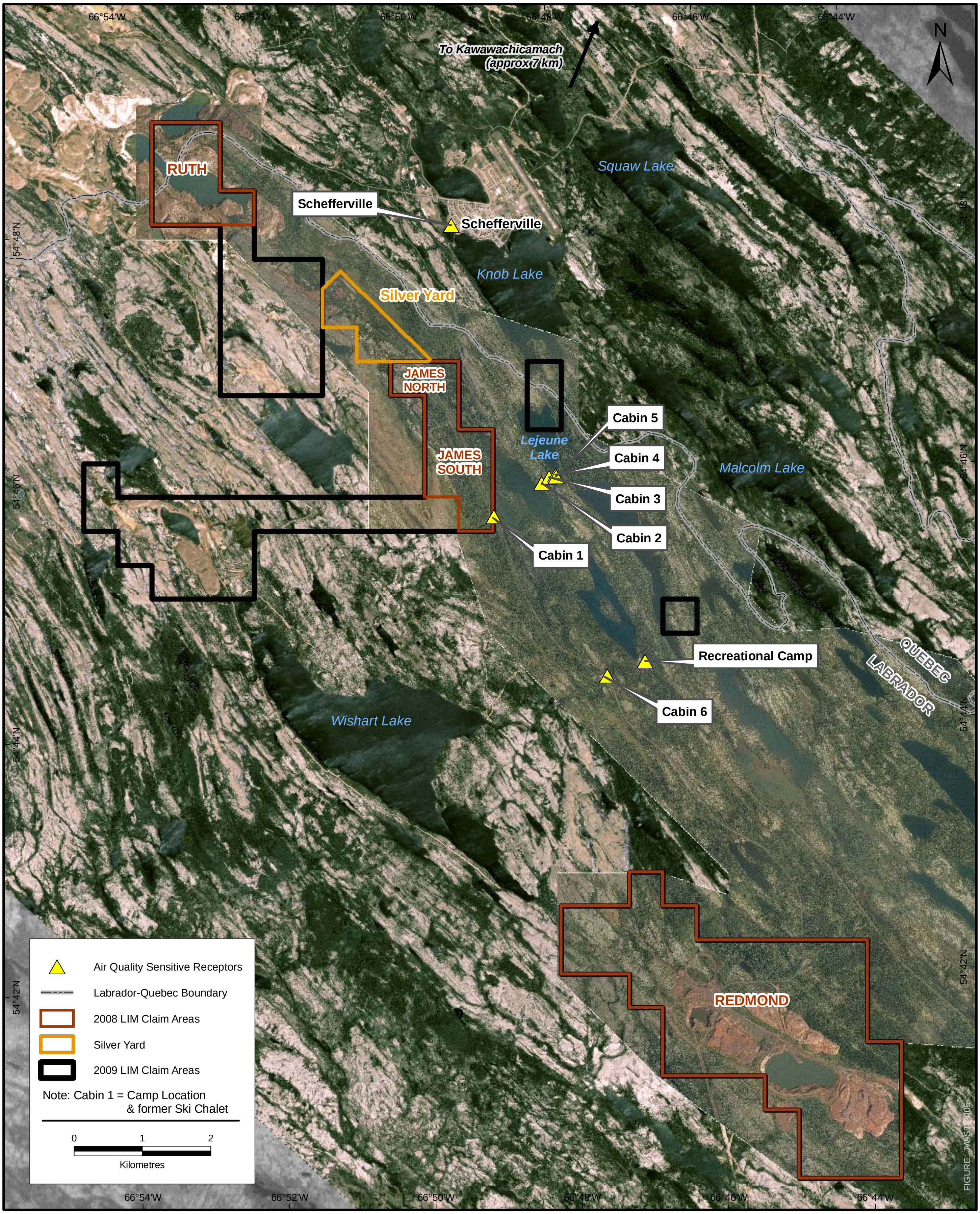


FIGURE NO:		DRAFT DATE:
6-10	**Sensitive Receptors**	18/12/2008
		REVISION DATE: 12/8/2009

6.3.2.7 Dispersion Coefficients

A fundamental parameter controlling plume dispersion in a Gaussian model such as CALPUFF are the dispersion coefficients. These values, which must be specified for both the horizontal as well as the vertical directions in the model, can be computed using several different methods in CALPUFF. The two U.S. EPA-approved methods are:

- From internally calculated turbulence values using micrometeorological variables (MDISP=2; MPDF=1)
- By using the PG dispersion coefficients for RURAL areas and the MP coefficients for urban areas (MDISP=1,MPDF=0)

The first method is similar to that used in the AERMOD regulatory dispersion model, while the second is similar to that used in the now-outdated ISC dispersion model. The first method was chosen for this assessment. This is consistent with the guidance provided in the NL DEC's Guidance for Plume Dispersion Modelling (NL DEC 2006).

6.3.2.8 Particulate Deposition Parameters

The consideration of deposition in dispersion models such as CALPUFF allows for contaminant mass to be depleted from the transporting plume. For emissions of particulate matter from low-lying fugitive sources (*i.e.* roads, loading/unloading), a substantive portion of the resultant plume will remain in lowest 1-2 meters above ground level and settle within a few hundred meters of the source (see for example, DRI 1999).

To account for plume depletion due to settling/deposition of particulate matter (TSP, PM_{10}, $PM_{2.5}$), emitted particles were divided into three size classes, as defined in Table 6-5 below. The deposition parameters shown in Table 6-5 were chosen based on guidance from the NL DOE (Lawrence 2008).

Table 6-5 Particle Size Class Definitions and Deposition Parameters

Particle Size Class ID	Definition	Geometric Mass Mean Diameter (µ)	Geometric Standard Deviation (µ)	Number of Particle Intervals ((µ)
P1	P1 < 2.5(µ)	1.**25**	1.24	5
P2	2.5 < P2 < 10(µ)	5	1.24	5
P3	P3 > 10(µ)	20	1.24	5

Emission rates were calculated for each particle size class in Table 6-5 based on the estimates for TSP, PM_{10}, and $PM_{2.5}$ provided in Section 5. Each size class was then modelled with dry deposition/plume depletion to predict maximum GLC of P1, P2, and P3. The maximum predicted TSP/PM_{10}/$PM_{2.5}$ ground-level concentrations could then calculated from the intermediate species by summing the relevant size fractions as follows:

- $PM_{2.5}$ = P1;
- PM_{10} = P1 + P2; and,
- TSP = P1 + P2 + P3.

6.3.3 Model Options Selected

The CALPUFF dispersion model (Version 6.262 - Level 080725) was used for all dispersion modelling conducted in this study. Model Options were selected based on the NL DEC's Guidance for Plume Dispersion Modelling (NL DEC 2006), consultation with the NL DEC, and guidance published by the U.S. Environmental Protection Agency (US EPA 1998). For model options with no NL DEC or U.S. EPA-recommended values, CALPUFF model default parameters were selected.

A sample CALPUFF input file, showing the model options selected for this study, is provided in Attachment D. Note that the parameterization provided in this sample file represents a specific emissions scenario used to model specific air contaminants over a particular receptor grid (point source emissions; NO_X, SO_2, CO; nested Cartesian receptor grid). Therefore, case-specific model parameters (*i.e.*, the number of sources modelled, numbers of receptors, species considered, deposition options) would have different values for different model runs.

6.3.4 CALPUFF Post-processing

6.3.4.1 NOx to NO2 Conversion

When initially released from a combustion source into the atmosphere, NO_X is typically comprised of about 5 to 10% NO_2, with the remaining 90 to 95% in the form of NO. However, as a plume travels downwind, the majority of the released NO will convert to NO_2. Different methods are provided by regulatory authorities to account for the fraction of NO_X which will be present as NO_2 for the purposes of modelling assessments. The most conservative assumption to address the NO to NO_2 conversion is to assume that 100% of the NO emitted is immediately converted to NO_2. Another very widely used assumption to account for this conversion is the ozone limiting method (OLM).

Based on consultation with the NL DOE (Lawrence 2008), the OLM was selected to estimate ground-level concentrations of NO_2 from the maximum predicted NO_X in this study. The equations used to predict the maximum NO_2 GLC were the ones provided by the NL DEC for emissions from diesel generators (this is the most significant Project-related source of NO_X):

$$[NO2]_{hourly} = \{0.2 \times [NO_X]_{(predicted)}\} + \text{Minimum of } \{0.8 \times (NO_X]_{(predicted)}, [O_3]\}$$

$$[NO2]_{daily} = \{0.2 \times [NO_X]_{(predicted)}\} + \text{Minimum of } \{0.8 \times [NO_X]_{(predicted)}, [O_3]\}$$

$$[NO2]_{annual} = \{0.2 \times [NO_X]_{(predicted)}\} + \text{Minimum of } \{0.8 \times [NO_X]_{(predicted)}, [O_3]\}$$

where:

$[NO_X]_{(predicted)}$ is the model predicted concentration value in $\mu g/m^3$ for the given time frame

$[NO_2]_{(hourly)}$ is the predicted NO_2 concentration on an hourly basis in $\mu g/m^3$

$[NO_2]_{(daily)}$ is the predicted NO_2 concentration on an daily basis in $\mu g/m^3$

$[NO_2]_{(annual)}$ is the predicted NO_2 concentration on an annual basis in $\mu g/m^3$

and $[O_3]$ is the estimated background O_3 concentration in $\mu g/m^3$ as follows:

Hourly = 65 $\mu g/m^3$, Daily = 60 $\mu g/m^3$, Annual = 35 $\mu g/m^3$

The ozone concentrations used in the equations above are based on ambient monitored values at Goose Bay and were recommended by the NL DEC (Lawrence 2008).

7.0 DISPERSION MODELLING RESULTS

The CALPUFF dispersion model was used to predict maximum ground-level concentrations due to substantive Project-related emission sources during operation. As previously mentioned, emissions occurring during the construction phase are expected to be substantially less than those occurring during operation and were not modelled.

A summary of the dispersion modelling results is presented in Table 7.1. Modelling was conducted over all pertinent averaging periods for CO, SO_2, NO_2, $PM_{2.5}$, PM_{10}, and TSP. Estimated background concentrations, provided by the NL DEC (Lawrence, 2008), were added to the model-predicted values and compared to the NL regulatory standards. Refer to Section 4 for more information concerning the estimated background concentrations used in this assessment.

Overall, ground-level concentrations (GLC) were predicted to be below the regulatory standards most of the time for most averaging periods. However, 1-hour NO_2 and the 24-hour PM, PM_{10}, $PM_{2.5}$ concentrations are predicted to exceed the regulatory standard at locations near the beneficiation area property line during certain meteorological conditions. In general, the highest concentrations were predicted to occur along the northeast property boundary. A detailed description of the dispersion modelling predictions is provided for each contaminant in the following sub-sections.

Table 7-1 Summary of Maximum Predicted Ground-Level Concentrations

Air Contaminant	Averaging Period	Regulatory Standard (μg/m3)	Estimated Background Concentration (μg/m3)	Maximum Predicted Concentration (μg/m3)	Maximum Predicted Concentration with Background (μg/m3)	Percent of Standard (%)
NO_2	1 hr	400	3.8	**405**	**409**	**102%**
	24 hr	200	3.8	185	189	95%
	Annual	100	3.8	38	42	42%
SO_2	1 hr	900	5	436	441	49%
	3 hr	600	5	338	343	57%
	24 hr	300	5	161	166	55%
	Annual	60	5	10	15	25%
TSP	1 hr	-	15	705	720	n/a
	24 hr	120	15	**204**	**219**	**182%**
	Annual	60	15	15	30	49%
PM_{10}	1 hr	-	10	348	358	n/a
	24 hr	50	10	**93**	**103**	**207%**
$PM_{2.5}$	1 hr	-	5	112	117	n/a
	24 hr	25	5	**32**	**37**	**149%**
CO	1 hr	35,000	114	745	859	2%
	8 hr	15,000	114	392	506	3%

Bold Indicates an exceedance of a regulatory standard

7.1 Sulphur Dioxide (SO_2)

A summary of the maximum predicted ground-level SO_2 concentrations, including background, is presented for the 1-hour, 3-hour, 24-hour and annual averaging periods in Table 7.1. There are no predicted exceedances of the NL regulatory standard for any of the averaging periods considered.

Plots of the maximum predicted ground-level SO_2 concentrations, including background, are presented for the 1-hour, 3-hour, 24-hour and annual averaging periods in Figures D-1 to D-4 (Attachment E). The highest predicted SO_2 concentrations generally occur in the immediate vicinity of the beneficiation area, along the northeast property boundary.

7.2 Nitrogen Dioxide (NO_2)

A summary of the maximum predicted ground-level NO_2 concentrations, including background, is presented for the 1-hour, 24-hour and annual averaging periods in Table 7.1. The maximum NO_2 ground-level concentrations are predicted to be below the regulatory standards, with the exception of 1-hour NO_2 which has a maximum predicted value of 409 occurring on the northeast side of property line. However, as shown in Figure D-5 (Attachment E), the maximum predicted concentrations of NO_2 decrease to 380 $\mu g/m^3$ within 130 meters of the property line and there are no sensitive receptors within 2.5 km of the beneficiation area.

A summary of the maximum predicted ground-level NO_2 concentrations at sensitive receptor locations is provided in Attachment F. The results show the maximum predicted GLC are well below the regulatory standards at these locations.

7.3 Carbon Monoxide (CO)

A summary of the maximum predicted ground-level CO concentrations, including background, is presented for the 1-hour, and 8-hour averaging periods in Table 7.1. There are no predicted exceedances of the NL regulatory standard for any of the averaging periods considered.

Plots of the maximum predicted ground-level CO concentrations, including background, are presented for the 1-hour, and 8-hour averaging periods in Figures D-8 to D-9 (Attachment E). The highest predicted CO concentrations generally occur in the immediate vicinity of the beneficiation area, along the northeast property boundary.

7.4 Total Suspended Particulate (TSP)

A summary of the maximum predicted ground-level TSP concentrations, including background, is presented for the 1-hour, and 24-hour, and annual averaging periods in Table 7.1. The maximum TSP ground-level concentrations are predicted to be below the regulatory standards, with the exception of 24-hour TSP which has a maximum predicted value of 219 $\mu g/m^3$ occurring on the northeast side of property line. However, as shown in Figure D-11 (Attachment E), the maximum predicted concentrations of TSP decrease to 110 $\mu g/m^3$ within 135 meters of the property line and there are no sensitive receptors within 2.5 km of the beneficiation area.

A summary of the maximum predicted ground-level TSP concentrations at sensitive receptor locations is provided in Attachment F. The results show the maximum predicted GLC are well below the regulatory standards at these locations.

7.5 Particulate Matter Less than 10 Microns in Diameter (PM_{10})

A summary of the maximum predicted ground-level PM_{10} concentrations, including background, is presented for the 1-hour, and 24-hour, and annual averaging periods in Table 7.1. The maximum PM_{10} ground-level concentrations are predicted to be below the regulatory standards, with the exception of 24-hour PM_{10} which has a maximum predicted value of 103 $\mu g/m^3$ occurring on the northeast side of property line. However, as shown in Figure D-12 (Attachment E), the maximum predicted concentrations of PM_{10} decrease to 50 $\mu g/m^3$ within 153 meters of the property line and there are no sensitive receptors within 2.5 km of the beneficiation area.

A summary of the maximum predicted ground-level PM_{10} concentrations at sensitive receptor locations is provided in Attachment F. The results show the maximum predicted GLC are well below the regulatory standards at these locations.

7.6 Particulate Matter Less than 2.5 microns in Diameter ($PM_{2.5}$)

A summary of the maximum predicted ground-level $PM_{2.5}$ concentrations, including background, is presented for the 1-hour, and 24-hour, and annual averaging periods in Table 7.1. The maximum $PM_{2.5}$ ground-level concentrations are predicted to be below the regulatory standards, with the exception of 24-hour $PM_{2.5}$ which has a maximum predicted value of 37 $\mu g/m^3$ occurring on the northeast side of property line. However, as shown in Figure D-13 (Attachment E), the maximum predicted concentrations of PM_{10} decrease to 24 $\mu g/m^3$ within 58 meters of the property line and there are no sensitive receptors within 2.5 km of the beneficiation area.

A summary of the maximum predicted ground-level $PM_{2.5}$ concentrations at sensitive receptor locations is provided in Attachment F. The results show the maximum predicted GLC are well below the regulatory standards at these locations.

8.0 CONCLUSIONS

To assess the potential for a change in air quality due to Project-related emissions, a detailed Air Quality Technical Study was conducted. The study was conducted following generally accepted methodologies to establish existing (baseline) conditions, estimate emissions from potential Project activities, and predict the maximum downwind concentrations of the pertinent air contaminants. The results of this study provide the necessary data to assess potential environmental effects due to air contaminant emissions from the Project in the EIS this study supports.

The most substantive Project-related emissions during operation are due to fuel combustion and fugitive dust emissions. The emission sources can be categorized into three groups:

- Emissions from the beneficiation area;
- Emissions due to trucks hauling ore from the mines to the beneficiation area; and,
- Emissions due to blasting and on-site traffic at the mine site locations.

The results of the dispersion modelling (which consider all substantive emissions from the beneficiation area) show that although there may be potential exceedances of regulatory standards at locations near the property line during adverse meteorological conditions, these higher values are limited to within about 150 m of the property line. As this region is far from any of the sensitive receptor locations, it is unlikely that prolonged human exposure to air contaminant concentrations at these levels will occur. Therefore, as the predicted exceedances represent worst-case meteorological conditions, are limited in spatial extent, seasonal, and are short-term in duration, no substantive changes in air quality are expected on the local or regional scales due to emissions from the primary processing facility.

Although fugitive dust emissions will occur due to vehicle traffic along the road during operations, the majority of the fugitive dust will remain in lowest 1-2 meters above ground level and settle within a few hundred meters of the road (DRI 1999). The haul route is an existing dirt road, and although traffic along the route is expected to increase with Project activities, no more than five trucks are expected to pass in a given hour. As such, while some dusting of vegetation may occur due to vehicle traffic during certain meteorological conditions, no substantive changes in air quality are expected due to such emissions as they will be localized in extent and short-term in duration.

Emissions due to blasting and on-site traffic at the mine site locations are not expected to cause substantive changes in air quality as they will be emitted inside a pit and the transport distances to the nearest sensitive receptors are relatively far (greater than 1.5 km). Emissions from the diesel locomotive used for transporting ore from the beneficiation area are not expected to increase from the current levels and should not cause substantive changes in air quality as such emissions will be intermittent (one trip per day) and short-term in duration. Emissions from the standby diesel generators installed at the worker's camp will be intermittent, short-term in duration, and negligible relative to other emissions during operation.

As emissions occurring during construction are expected to be fractionally small compared to those occurring during operation, the maximum model-predicted concentrations during operation provide a conservative envelope for potential air changes in air quality due to emissions during this phase.

Therefore, on an overall basis, the modelling results show the local and regional changes in air quality due to Project-related emissions, including background, are not expected to be substantive.

9.0 CLOSURE

This report has been prepared by Jacques Whitford with the input and assistance of Labrador Iron Mines Ltd. for the sole benefit of Labrador Iron Mines Ltd. The report may not be relied upon by any other person, entity, other than for its intended purposes, without the express written consent of Jacques Whitford and Labrador Iron Mines Ltd.

This report was undertaken exclusively for the purpose outlined herein and is limited to the scope and purpose specifically expressed in this report. This report cannot be used or applied under any circumstances to another location or situation or for any other purpose without further evaluation of the data and related limitations. Any use of this report by a third party, or any reliance on decisions made based upon it, are the responsibility of such third parties. Jacques Whitford accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions taken based on this report.

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This report presents the best professional judgement of Jacques Whitford personnel available at the time of its preparation. Jacques Whitford reserves the right to modify the contents of this report, in whole or in part, to reflect any new information that becomes available. If any conditions become apparent that differ significantly from our understanding of conditions as presented in this report, we request that we be notified immediately to reassess the conclusions provided herein.

This report has been prepared by a team of Jacques Whitford professionals on behalf of Labrador Iron Mines Ltd.

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