CONSULTING ENGINEERS & SCIENTISTS

REPORT

Air Quality Assessment for the Pine Point Pilot Project

Project Number: W08-1008

October 12, 2007

SUBMITTED TO: **Tamerlane Ventures Inc.**
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Blaine, WA 98230

SUBMITTED BY: **RWDI AIR Inc.**
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October 12, 2007

Tamerlane Ventures Inc.
441 Peace Portal Drive
Blaine, WA 98230

Attention: **David Swisher**

Subject: **Air Quality Assessment for the Tamerlane Pine Point Pilot Project**

As per your request, we have completed an air quality assessment of the proposed Tamerlane Pine Point Pilot Project (the Project) in the Northwest Territories (NWT). Worst-case emission estimates were developed for the construction and operation phases of the project using US EPA AP-42 emission factors and manufacturer's data. Construction emission rates, based on a worst case month of construction activities, were estimated to be less than those associated with the operations activities. The operation emissions for the Project are considerably lower compared to other existing NWT mines.

Emissions for the operation phase were modelled using CALPUFF in ISC mode. Predicted SO_2 concentrations are well below the applicable NWT standards. Maximum predicted 24-hour NO_2 concentration is below the applicable acceptable federal objective. The maximum predicted 1-hour and annual NO_2 concentrations are below the applicable acceptable federal objectives except for a small area centered on the haul road. The maximum 1-hour and 24-hour TSP, 24-hour PM_{10} and $PM_{2.5}$ concentrations are below the applicable NWT and Canada-Wide standards except for an area centered on the haul road. The maximum 1-hour and 8-hour CO concentrations were predicted to be above the desirable federal objectives but below the acceptable federal objectives.

Modelling has confirmed that haul road particulate and mobile emissions have a localized measurable effect on ambient levels of TSP, NO_2 and CO adjacent to the roads. Emission factors for haul road particulate and mobile emissions are considered conservative and ambient air quality impacts are within a short range of the Project facilities.

Monitoring of dust, PM_{10}, $PM_{2.5}$, NO_2, and CO is recommended as dispersion modelling predicted concentrations of particulate matter, NO_2, and CO to be above the most stringent ambient air quality criteria.

We trust that this report meets your current information requirements. If you have any questions or require further information, please contact the undersigned at (604) 730-5688 ext. 3222.

Sincerely,
RWDI AIR Inc.

Mark C. Milner, M.Eng, P. Eng.
Project Manager
Noise and Air Quality

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1.0 INTRODUCTION

The Pine Point Pilot Project (the Project) is located approximately 42 km east of Hay River, Northwest Territories (NWT). The Project will remove one million tonnes of lead/zinc ore over 12 to 15 months with to assess the feasibility of full-scale underground mining operations.

The operation of the Project will introduce new, local sources of air contaminants commonly associated with mine projects of the size and scope of the Project. The contaminants of interest include nitrogen dioxide (NO_2), sulphur dioxide (SO_2), and carbon monoxide (CO) from combustion sources (e.g., power generators, mine fleet exhausts) and; particulate matter (PM) from combustion and fugitive sources (e.g., haul roads, crushers, etc.). These emissions may result in potential impacts to vegetation or wildlife species, the ecosystem's structure or processes or human health. As such, this assessment describes existing air quality conditions in the project area as well as the potential air quality impacts from the Project. These potential impacts are evaluated in relation to ambient air quality criteria.

2.0 ASSESSMENT CRITERIA

Regulatory agencies have identified ambient air quality criteria or standards for the identified indicator contaminants, specifying maximum concentration levels in the atmosphere. These criteria are based on the lowest observed level of effect and incorporate a safety factor. For the purposes of this assessment, these criteria have been used to define thresholds for the indicator contaminants that, if exceeded, would be considered to be of potential concern.

Where air quality criteria for the NWT are not available, National Ambient Air Quality Objectives (NAAQOs) and criteria from other Canadian jurisdictions have been selected as the thresholds for the Project. The NAAQOs are divided into three categories, described as follows (Health Canada, 2005):

- **Maximum desirable level** is the long-term goal for air quality and provides a basis for an anti-degradation policy for the unpolluted parts of the country, and for continuing development of control technology.
- **Maximum acceptable level** is intended to provide adequate protection against effects on soil, water, vegetation, materials, visibility, personal comfort and well-being.

- **Maximum tolerable level** denotes time-based concentrations of air contaminants beyond which, due to a diminishing margin of safety, appropriate action is required without delay to protect the health of the general public.

Particulate matter is classified by aerodynamic diameter. The larger particles, referred to as dust or Total Suspended Particulates (TSP) are emitted from mining operations (e.g., crushing). Particulate matter with aerodynamic diameter less than 10 microns is known as PM_{10} or inhalable PM and PM with aerodynamic diameters less than 2.5 microns is known as $PM_{2.5}$ or respirable PM. $PM_{2.5}$ is primarily related to combustion processes.

The Canadian Council of Ministers of the Environment (CCME) has developed a Canada-Wide tandard (CWS) for $PM_{2.5}$. The CWS standard is more applicable in relating PM concentrations to human health pulmonary effects than the other measures of PM (e.g., TSP, PM_{10}). Achievement of the CWS for $PM_{2.5}$ is based on the average of the 98^{th} percentile concentrations for each year, averaged over three consecutive years from monitoring locations within an identified area. In determining CWS compliance, natural sources and long-range transport contributions can be discounted. In December 2002, the Northwest Territories adopted the 24-hr CWS as the NWT ambient air quality standard for $PM_{2.5}$.

Table 2-1 identifies and compares the NAAQOs, the NWT standards, Ontario criteria and the CWS. The criteria refer to different averaging periods to account for potential short-term acute exposures and long-term chronic exposures. On the basis of the precautionary principle, the most stringent criteria were selected as the standard for each contaminant.

Table 2-1: Air Quality Objectives and Standards

Air Quality Indicator	Averaging Time	National Air Quality Objectives			Ontario Criteria	NWT Standards	Most Stringent Standard
		Desirable	Acceptable	Tolerable			
TSP (µg/m^3)	24 hr	-	120	400	-	120	120
	Annual	60	70	-	-	60	60
PM_{10} (µg/m^3)	24 hr	-	-	-	50	-	50
$PM_{2.5}$ (µg/m^3)	24 hr	-	-	-	-	30	30

SO_2 (µg/m^3)	1 hr	450	900	-	690	450	450
	24 hr	150	300	800	275	150	150
	Annual	30	60	-	55	30	30
NO_2 (µg/m^3)	1 hr	-	400	1,000	400	-	400
	24 hr	-	200	300	200	-	200
	Annual	60	100	-	-	-	60
CO (µg/m^3)	1 hr	15,000	35,000	-	-	-	15,000
	8 hr	6,000	15,000	20,000	36,200	-	6,000

3.0 STUDY AREA

The proposed project is an underground mine comprising a shaft, run-of-mine (ROM) material storage building, crushing plant, Dense Media Separation plant and covered concentrate area. There is a haul road (approximately 600 m in length) from the concentrate area to the highway. The study area was selected to illustrate the spatial distribution of the concentration patterns associated with these project facilities and to represent areas where air quality impacts are likely to occur. More specifically, the study area was dimensioned such that air quality conditions at the study area border were anticipated to be similar with or without the project (i.e., air contaminant concentrations at the border of the study area are at ambient levels). As such, a 30 km by 30 km area centred on the facility was selected and is shown in Figure 3-1.

As concentrations tend to be the largest nearest to the emission sources and decrease with increasing distance from the emission source, a larger regional study area was not specifically included. The lack of surrounding infrastructure (i.e., the nearest source of emissions is Hay River, 42 km to the west) and the remoteness of the Project indicate that its effects will be more prominent on the local level.

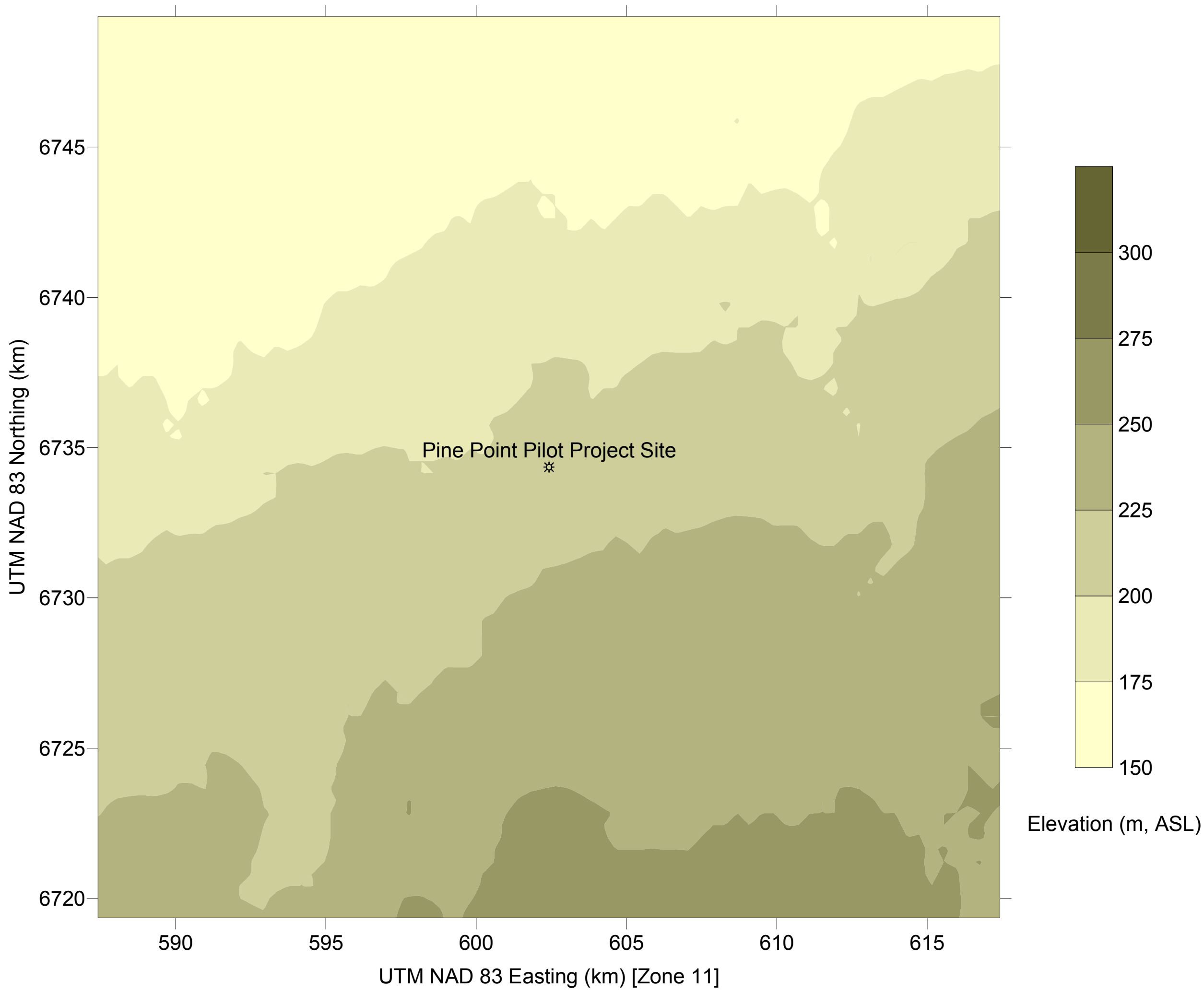


Figure 3-1: Contour Map of Study Area

4.0 BASELINE CONDITIONS

4.1 BASELINE EMISSIONS

The Project is located in a remote area where there are few anthropogenic emission sources. Hay River, located 42 km to the west, is the only such source of emissions in the vicinity of the Project. As indicated in the NWT Cumulative Impact Monitoring Program and Audit by the Department of Indian Affairs and Northern Development (2002), this emission source can be described as, "Community emission sources include power generation, residential and commercial heating, transportation and incineration of waste. Peak pollution concentrations occur in the springtime due to fugitive dust from roads and during temperature inversions on cold winter days that trap pollutants near the surface."

4.2 AMBIENT AIR QUALITY AND THE SELECTION OF BACKGROUND LEVELS

An important component of the Baseline assessment is the determination of representative air quality in the region. Given the remoteness of the area and the climate extremes, ambient air quality monitoring at the site was not undertaken. Background concentrations were determined by reviewing ambient air quality data collected at government controlled air quality monitoring stations in the NWT.

The closest air quality station to the Project for which air quality data exist is located in Yellowknife, approximately 500 km to the north-northeast across Great Slave Lake. Parameters collected at this station include TSP, $PM_{2.5}$, SO_2, NO_2, CO and ozone. Data for this station are shown in Table 4-1.

Table 4-1: Ambient TSP, $PM_{2.5}$, SO_2, NO_2 and CO Concentrations Measured by the NWT Environmental Protection Division in Yellowknife

Contaminant	Maximum 24 hr (µg/m^3)					Annual Average (µg/m^3)				
	2000	2001	2002	2003	2004	2000	2001	2002	2003	2004
TSP	**333**	**400**	**229**	**297**	**188**	47	34	27	31	31
$PM_{2.5}$	26	9	12	15	**125**	3	3	4	5	6
SO_2	39	24	29	13	12	4	5	7	2	2
NO_2	-	-	-	70	70	-	-	-	12	9
CO	-	-	-	-	2000	-	-	-	-	-

Notes: A dash (-) means not reported and bold values are values that exceed the most stringent standard.

Based on the Yellowknife ambient data, representative background concentrations were selected for the reasons described below. These are summarized in Table 4-2. For the particulate indicators, the given values are assumed to be representative in the absence of forest fire influences. The values indicated in the table are much less than the respective most stringent standard. Given the remoteness and expected spatial homogeneity, these values are deemed to be representative for the Project site.

Table 4-2: Background Concentrations Relative to the Most Stringent Standard

Air Quality Indicator	Averaging Time	Background Value	Most Stringent Standard
TSP (µg/m^3)	24 hr	34	120
	Annual	34	60
PM_{10} (µg/m^3)	24 hr	15	50
$PM_{2.5}$ (µg/m^3)	24 hr	4	30
SO_2 (µg/m^3)	1 hr	23	450
	24 hr	4	150
	Annual	4	30
NO_2 (µg/m^3)	1 hr	12	400
	24 hr	12	200
	Annual	12	60
CO (µg/m^3)	1 hr	200	15,000
	8 hr	200	6,000
O_3 (µg/m^3)	1 hr	50	-

TSP Background Concentrations

TSP measurements are influenced by local sources (e.g., traffic and dusty roads) and by distant events (e.g., forest fires). The limited human activity in the area and the infrequent, naturally occurring distant events will result in background TSP concentrations that will not vary significantly with time. For this reason, one-hour, 24-hour and annual average TSP concentrations are expected to be similar; and the annual average measurements are used to represent a background 24-hour value. The 5-year annual average concentration of 34 µg/m^3 is considered to represent 24-hour concentrations at the Project Site.

PM_{10} Background Concentrations

The NWT annual report (NWT 2006) states the daily maximum PM_{10} concentrations measured at the Sir John Franklin station ranged from approximately 10 to 60 µg/m^3 in 2006. The monthly averages ranged from about 5 to 15 µg/m^3 for the same period. For the Project, the maximum monthly average of 15 µg/m^3 was assumed to be representative of background concentrations.

$PM_{2.5}$ Background Concentrations

Values higher than the $PM_{2.5}$ CWS of 30 $\mu g/m^3$ were measured at this site in 2004. These events, however, have been attributed to forest fire activity, and 2004 was a year of strong forest fire influences. Annual average $PM_{2.5}$ concentrations have ranged from 3 to 6 $\mu g/m^3$. Given the remoteness of the Project and the lack of nearby sources, the 5-year annual average concentration of 4 $\mu g/m^3$ was assumed to be representative of background 24-hour concentrations at the Project Site.

SO_2 Background Concentrations

The 2000 to 2004 measurements indicate that maximum 24-hour SO_2 concentrations have ranged from 12 to 39 $\mu g/m^3$. The annual average SO_2 concentrations range from 2 to 4 $\mu g/m^3$. The SO_2 concentration of 23 $\mu g/m^3$ was selected to represent maximum background one-hour SO_2 concentrations at the Project Site. The five-year average SO_2 concentration of 4 $\mu g/m^3$ was selected to represent the 24-hour and annual average SO_2 concentrations at the Project Site.

NO_2 Background Concentrations

Maximum one-hour NO_2 concentration measured was 70 $\mu g/m^3$. The annual average concentrations ranged from 9 and 12 $\mu g/m^3$. These levels, however, are likely attributable to combustion sources near the monitoring stations (e.g., vehicles, residential heating etc.). As there are no existing combustion sources in the vicinity of the Project Site, the maximum annual average NO_2 concentration of 12 $\mu g/m^3$ was selected to represent maximum one-hour, 24-hour and annual average NO_2 concentrations at the Project Site.

CO Background Concentrations

The maximum measured one-hour CO concentration was 2,000 $\mu g/m^3$. Most of the hourly concentrations are less than 200 $\mu g/m^3$. Given the pristine nature of the Project Site, the CO concentration of 200 $\mu g/m^3$ was selected to represent one-hour and eight-hour CO concentrations.

O_3 Background Concentrations

Maximum hourly ozone values have typically been around 100 $\mu g/m^3$, with annual average values of about 40 $\mu g/m^3$. The NWT annual reports state that typical monthly O_3 concentrations at remote sites in Canada range from 40 to 80 $\mu g/m^3$ and that maximum values tend to occur in spring (i.e., around April). In Yellowknife, the monthly average O_3 values vary from a maximum of 62 μg/m^3 in April to a minimum of 27 μg/m^3 in July (NWT 2005). In comparison, the maximum and minimum monthly averages at Barrow, Alaska vary from 68 μg/m^3 in November to 34 μg/m^3 in April (Oltmans et al, 1989). For the Project a monthly average value of 50 μg/m^3 was assumed to be representative of background concentrations.

4.3 DISPERSION METEOROLOGY

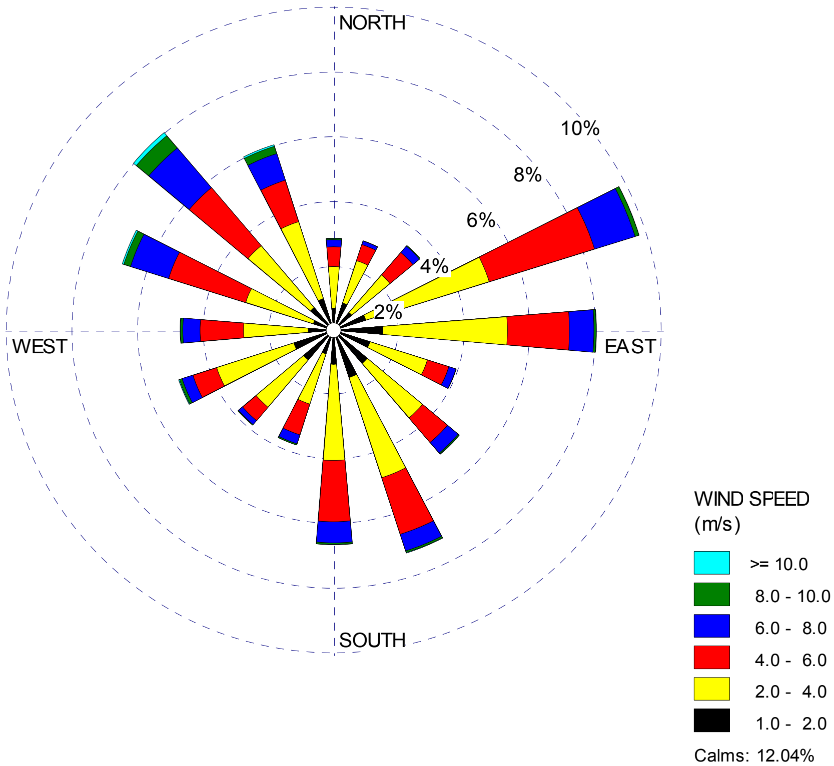
The meteorological data set used for this assessment contains the following parameters required for dispersion modelling:

- Wind direction - determines the downwind location of the plume and may be influenced by the passage of weather systems and local terrain;
- Wind speed - determines the plume rise, the extent of along-wind dilution and the production of mechanical turbulence. Wind speeds below 1 m/s are set to 1 m/s;
- Temperature – determines plume rise and is expressed in Kelvin;
- Pasquill-Gifford Atmospheric (PG) Stability Class - provides an indication of the level of atmospheric turbulence, which varies with time of day, season and wind speed; and
- Mixing height – determines whether the plume is trapped by an elevated inversion..

As the Project is located in the Great Slave Lake Region, the surface meteorological data from Hay River was deemed as being the most appropriate for this assessment. This data set consists of five years of data from 2002 to 2006 complemented with upper air data from Fort Smith. These data were processed with CPrammet, the meteorological pre-processor for CALPUFF, to create an ISC-type meteorological file.

Figure 4-1 show the joint frequency distributions of wind direction and wind speed in a polar histogram format (i.e., a wind rose) based on the pre-processed meteorological data from Hay River. The orientation of each bar indicates the direction from which the wind is blowing; with directions being shown for the 16 compass points. The length of each bar indicates the frequency of occurrence. The most frequent winds in this area are from the east-northeast, the east and the northwest. The annual average wind speed is 3.1 m/s.

Figure 4-1: Joint Frequency Distribution of Wind Direction and Wind Speed Observed at the Hay River Airport for the years 2002 to 2006.



4.4 BASELINE CONDITION SUMMARY

The Project site is located in a pristine environment with few existing air emission sources. Generally air quality in the NWT is considered to be pristine and near or at natural background levels. Near anthropogenic emission sources such as communities and industrial developments, air pollutant levels can be elevated above background levels (DIAND 2002). Note that smoke from forest fires can greatly affect air quality by causing high particulate matter (PM_{10} and $PM_{2.5}$) concentrations. Most exceedences of air quality standards in the NWT are linked to forest fires (DIAND 2002).

Background concentrations were determined by reviewing ambient air quality data collected in Yellowknife. These values are much less than the respective most stringent standard and, given the remoteness and expected spatial homogeneity, these values are deemed to be representative for the Project site

As site-specific meteorological data are not available, data from the Hay River Airport (2002 to 2006) were used. This data set was processed to create an ISC meteorological file for dispersion modelling.

5.0 IMPACT ASSESSMENT METHODS

5.1 GENERAL APPROACH

Project activities (generation of power, waste handling, ore processing, concentrate handling, haul road usage, etc.) will release products of combustion and entrain fugitive dust into the atmosphere. The two primary impact assessment tools for the air quality assessment are the preparation of an emission inventory and the application of a dispersion model. The following tasks were performed to assess the potential air quality impact of the Project:

- Identify and quantify atmospheric emission sources from the Project (emissions inventory);
- Use dispersion models to predict the associated concentrations;
- Add regional background values to the dispersion model predictions;
- Compare the resulting predictions to the ambient air quality standards.

5.2 EMISSIONS ESTIMATE APPROACH

As the Project has not yet been constructed, there are no direct measures of Project emissions. A systematic approach was used to identify and quantify emissions that could occur due to the construction and operation of the Project. The key components of the source and emission inventory approach are as follows:

- Determine the activities and relevant activity levels associated with the Project;
- Determine temporal and spatial boundaries associated with these activities; and
- Apply industry-specific emission factors to the defined activities to calculate emission rates.

The first two components were derived from the December 2006, Development Assessment Report submitted to the Mackenzie Valley Environmental Impact Review Board and information provided by Tamerlane Ventures Inc. engineering staff. For the last component, the US EPA AP-42 document was used to provide emission factors for a wide range of industrial activities. An emission factor is a representative value that relates the quantity of a contaminant released into the atmosphere to an activity associated with the release of that contaminant. The following sections of the AP-42 document (www.epa.gov/ttn/chief) were employed:

- Section 11.9 (Western Surface Coal Mining) was used to estimate emissions from various mining activities.
- Section 11.19.2 (Crushed Stone Processing and Pulverized Mineral Processing) was used to estimate emissions from drilling activities.
- Section 11.24 (Metallic Mineral Processing) was used to estimate emissions from processing operations (i.e., crushing, concentrate handling, etc.).
- Section 13.2.2 (Unpaved Roads) was used to estimate emissions from the haul roads.
- Section 13.3 (Explosives Detonation) was used to estimate emissions for blasting activities.

In addition, US-EPA-approved manufacturer test data were used to estimate emissions associated with the power generators. Furthermore, the US EPA Tier II/III non-road emission standards and US EPA Heavy-Duty Highway Engines emission standards were used to estimate the exhaust emissions from the mine fleet and truck fleet activities at the site. Use of US EPA standards instead of vehicle-specific emission factors provides a conservative approach to assessing the mine and truck fleet emissions.

5.3 Dispersion Modelling Approach

A dispersion model provides a scientific link between emissions and ambient air quality downwind of the emission source. Dispersion models account for the transport and dispersion processes in relation to local terrain and meteorology. Given the importance of dispersion models for air quality impact assessments, regulatory agencies identify accepted models and provide guidance on their application (e.g., US EPA 2005, BC Ministry of Environment 2005, and Alberta Environment 2003)

The CALPUFF dispersion model, which is recommended by a number of regulatory agencies, was adopted to assess emissions from the Project. This model is the de facto standard for environment impact assessments in the Alberta Oil Sands region, and was used for the Miramar Doris North and High Lake Project assessments. In the context of the Project, the following assumptions with respect to the application of the CALPUFF model were made:

- From a meteorological perspective, the model was applied in the ISC mode, using the Hay River meteorological time series described in Section 4.3. This time series is comprised of hourly values of wind direction, wind speed, temperature, Pasquill-Gifford (PG) class and mixing height.

- Dispersion coefficients used were PG coefficients for RURAL areas computed using the ISCST multi-segment approximation.
- Nested receptor grids with a fine spacing (20 m) in the vicinity of the emission sources were adopted. The receptor grids were selected using the Alberta Model Guideline (Alberta Environment 2003), which resulted in 4,083 receptor grid points over a 30 km by 30 km area centered on the project area.
- Terrain elevations for each source and receptor were extracted from digital terrain elevation data that were obtained from 1:50,000 digital topographic maps (www.geobase.ca).
- Elevated terrain was accounted for using the plume path coefficient (PPC) method in CALPUFF. CALPUFF default stability-dependent PPC values of 0.5, 0.5, 0.5, 0.5, 0.35, and 0.35 were adopted for PG classes A to F, respectively.
- The Building Profile Input Program (BPIP-PRIME) was used to provide building parameters for the CALPUFF model to account for potential building downwash effects on stack emissions.
- Most NO_x emissions are in the form of NO and atmospheric reactions with ambient O_3 convert NO to NO_2. The ozone limiting method (OLM) was applied to the predicted NO_x concentrations to estimate NO_2 concentrations. An ozone concentration of 50 $\mu g/m^3$ (30 ppb) was adopted based on data obtained from the Northwest Territories Environment and Natural Resources Air Monitoring Network. While this value is less than that recommended by Alberta Environment (2003) it reflects the lower ozone concentrations in the Project region.

The model was used to predict maximum 1-hr, 24-hr, and annual average concentrations for the associated contaminants and the background concentrations defined in Section 4.2 were added to the model predictions.

6.0 IMPACT ASSESSMENT RESULTS

6.1 CONSTRUCTION EMISSIONS

The estimation of construction emissions is not a trivial exercise due to the dynamic, non-routine and non-repeating nature of construction activity. Such activities would entail the development of an emissions inventory detailed chronologically minute by minute (or at least on an hourly basis) whereas emission inventories for operations detail activities that are relatively steady state. This poses a challenge in that the required information is not typically available in advance and in sufficiently small time steps. This includes information such as:

- The exact nature of activities;
- The timing and staging of these activities;
- The nature of the equipment to be used; and
- The location of these pieces of equipment at specific times.

Despite these limitations, Project construction emissions can still be estimated by considering a worst-case day of construction activity. To do this, the amount of material moved over the approximately 15-month construction period (approximately 74,000 tonnes of material) was calculated on a monthly basis. From this, month eight was selected as the worst-case month as it involved the movement of the most material at 5,400 tonnes. (Note that ore moved during the construction phase was not counted in the construction inventory as it is ultimately placed in a covered storage area rather than used as road/foundation/construction material.) The emission inventory was then established conservatively assuming that all material moved was:

- Drilled;
- Blasted;
- Loaded into haul trucks;
- Dumped into a primary crusher;
- Screened and crushed in a secondary crusher;
- Loaded into a haul truck; and
- Dumped in its final location.

Also included in the emissions inventory were:

- Haul road activities (two dump trucks, 5 pick-up trucks and one Caterpillar 966 wheel loader;
- Diesel engine emissions from the above equipment and the underground equipment used in the construction process; and
- Generator emissions.

It was assumed that the 5,400 tonnes of material in month eight was moved 24 hours per day for 30 days (i.e., 180 tonnes per day). This is a reasonable assumption in that some days will see higher material movement rates while others will see lower material movement rates. It is also assumed that all crushing facilities are indoors with dust emission control technology in place.

Emission factors and methodologies used were the same as those used in the development of the emissions inventory for the operations scenario (Section 5.2). Resulting Project construction emissions are summarized in Table 6-1.

Table 6-1 Emission Sources and Estimated Emission Rates Associated with Construction Activities for the Project

Source Description	TSP (g/s)	PM_{10} (g/s)	$PM_{2.5}$ (g/s)	SO_2 (g/s)	NO_x (g/s)	CO (g/s)
Underground Activities						
Drilling	0.0002	0.0001	0.0000	0.0000	0.0000	0.0000
Blasting	0.0007	0.0004	0.0000	0.1389	1.1111	4.7222
Mobile engine emissions (underground)	0.0313	0.0125	0.0047	0.0000	0.0000	0.0000
Loading LHDs, primary crushing	0.0018	0.0007	0.0003	0.0000	0.0000	0.0000
Sub-total (g/s)	**0.034**	**0.014**	**0.005**	**0.139**	**1.111**	**4.722**
Haul Road Emissions						
Haul road	0.3646	0.1037	0.0104	0.0000	0.0000	0.0000
Sub-total (g/s)	**0.365**	**0.104**	**0.010**	**0.000**	**0.000**	**0.000**
Combustion Emissions						
Generators	0.0394	0.0394	0.0394	0.0059	5.5390	0.4495
Mobile fleet - production units only	0.0625	0.0625	0.0625	0.0031	1.3333	8.7500
Mobile fleet - underground	0.0389	0.0389	0.0389	0.0011	0.7800	0.6556
Sub-total (g/s)	**0.141**	**0.141**	**0.141**	**0.010**	**7.652**	**9.855**
Pine Point Pilot Operation Total (g/s)	**0.539**	**0.258**	**0.156**	**0.149**	**8.763**	**14.577**
(t/d)	**0.047**	**0.022**	**0.013**	**0.001**	**0.665**	**0.868**

These emission rates, based on a worst case month of construction activities, are less than those associated with the operations activities. Therefore air quality impacts from construction activities are expected to be less than those from operation activities.

6.2 OPERATION EMISSIONS

The primary emission sources and the emissions associated with the Project facilities are listed in Table 6-2. These emissions were modelled using CALPUFF to predict the potential air quality impacts of the Project. The following are noted relative to these emission estimates:

- The main sources of TSP emissions are the fugitive sources that include the haul road and underground activities. The haul road is the single largest source, even when a dust suppression efficiency of 80% has been incorporated in the estimations.
- The main contributors of PM_{10} and $PM_{2.5}$ are associated with underground activities. Loading and unloading of Load-Haul Dump (LHD) vehicles are the primary sources. The conveyors are covered and dust suppression is used. All the emissions are assumed to be vented through the underground vent stack.
- Blasting can be a significant source of short term SO_2, NO_x and CO emissions, with smaller amounts of TSP and $PM_{2.5}$ emissions. For this assessment, blasting was conservatively assumed to take place in the mine pits for one-hour each day between 1600 and 1700.
- Other sources of SO_2, NO_x and CO emissions are combustion related including the mobile fleet exhausts and the power generator stacks.
- Haul road TSP, PM_{10} and $PM_{2.5}$ emissions were assumed to occur continuously even though precipitation events can suppress these emissions.

Table 6-2: Emission Sources and Estimated Emission Rates

Source Description	TSP (g/s)	PM_{10} (g/s)	$PM_{2.5}$ (g/s)	SO_2 (g/s)	NO_x (g/s)	CO (g/s)
Underground Activities						
Drilling	0.003	0.001	0.0002	0.000	0.000	0.000
Blasting	0.034	0.018	0.001	2.222	17.778	75.556
Mobile engine emissions (underground)	0.039	0.039	0.039	0.001	0.780	0.656
Loading LHDs, primary crushing	0.332	0.133	0.050	0.000	0.000	0.000
Sub-total (g/s)	**0.408**	**0.191**	**0.090**	**2.223**	**18.558**	**76.211**
Ore Processing						
ROM storage transfers	0.007	0.003	0.001	0.000	0.000	0.000
Secondary/tertiary crushing, screening	0.040	0.015	0.006	0.000	0.000	0.000
Dense media separation	0.005	0.002	0.001	0.000	0.000	0.000
Concentrate bins	0.002	0.001	0.000	0.000	0.000	0.000
Sub-total (g/s)	**0.053**	**0.020**	**0.008**	**0.000**	**0.000**	**0.000**
Haul Road Emissions						
Haul road	0.635	0.181	0.018	0.000	0.000	0.000
Sub-total (g/s)	**0.635**	**0.181**	**0.028**	**0.000**	**0.000**	**0.000**
Combustion Emissions						
Genset	0.019	0.019	0.019	0.003	2.674	0.217
Mobile fleet - production units only	0.073	0.073	0.073	0.004	1.565	10.273
Waste oil combustion	2.51E-8	2.51E-8	2.51E-8	6.33E-7	4.20E-8	2.72E-7
Sub-total (g/s)	.092	.092	.092	.007	4.239	10.490
Pine Point Pilot Operation Total (g/s)	**1.189**	**0.484**	**0.208**	**2.230**	**22.797**	**86.701**
(t/d)	**0.100**	**0.040**	**0.018**	**0.009**	**0.498**	**1.235**

Note: The t/d total row is not a direct conversion from the g/s total row because blasting emissions only occur for one hour each day.

6.3 GREENHOUSE GAS EMISSIONS

The impact of greenhouse gas (GHG) emissions on climate change is recognized as an important environmental issue internationally and by the federal, provincial, and territorial governments in Canada. This assessment of greenhouse gases follows the recommended procedures outlined by the Canadian Environmental Assessment Agency (CEAA) in their document *Incorporating Climate Change Considerations in Environmental Assessments: General Guidance for Practitioners*. CEAA developed this document to link project planning in environmental assessments to the broader management of climate change issues in Canada and due to concerns from the public and government agencies in how climate change should be addressed in project reviews.

Greenhouse gases other than CO_2 are generally quantified in terms of CO_2 equivalence. The equivalence factor has generally been agreed to be the relative global warming potential (GWP) of the gas as estimated by the Intergovernmental Panel on Climate Change (IPCC), the major international scientific body that is co-ordinating research on the climate change issue. The IPCC estimates GWPs for a number of GHGs for various time periods related to the effect of a quantity of the gas released now on future atmospheric temperature rise. These numbers vary widely from gas to gas, and they also vary from time period to time period for a given gas, depending on individual physical and chemical properties. The 100 year GWPs are used generally. The most recent estimates of 100 year GWPs used by Environment Canada are sanctioned by the IPCC and are shown in Table 6-3.

Table 6-3 Global Warming Potential

	CO_2	CH_4	N_2O
Global Warming Potential	1	21	310

These numbers mean, for example, that a kilogram of N_2O has 310 times the global warming effect of a kilogram of CO_2 over a period of 100 years from the year of release.

Emissions from this project were categorized in terms of on-site and transport emissions. The methodology used to calculate these emissions is based on the use of emission factors developed for these sources. The emission factors were obtained from Environment Canada and their recommended sources.

Emission factors are used to estimate the rate at which a pollutant is released into the atmosphere as a result of the process activity or unit of throughput. The emission factors used may be average emission factors or technology-specific emission factors. Additional information about emission factors is available in Annex 13 of Canada's latest National GHG Inventory Report.

Off-road emission factors were used for the on-site equipment and on-road emission factors were used for the transport vehicles. These emission factors are based on the amount of diesel fuel combusted and engine size.

The GHG emission estimates for the Project are reported in Table 6-4. The on-site sources, which include the diesel generators, are the largest category of GHG emissions. The total emissions from the project represent a 0.0008% increase compared to Canada's total reported emissions in 2005 and a 0.34% increase compared to NWT's total reported GHG emissions in 2005. Estimated GHG emissions from the Project are 5.8% of the emissions reported by Snap Lake underground Diamond Project (102,000 t/y of CO_2E). The lower amount of emissions from this Project as compared to Snap Lake is primarily due to diesel generator power requirements. The estimated diesel power requirement of this project is 1.4 MW whereas Snap Lake reported 13 MW.

Table 6-4

Greenhouse Gas Emission Estimates

	Emissions (tonnes per annum)			
Emission Source	CO_2	CH_4	N_2O	CO_2E
On-site	3,394	0.17	1.37	3,822
Transport	2,116	0.12	0.06	2137
Total	5,510	0.29	1.43	5,959

6.4 PREDICTED AMBIENT AIR CONTAMINANT CONCENTRATIONS

Dispersion modelling with CALPUFF was conducted to predict ambient air concentrations for the TSP, PM_{10}, $PM_{2.5}$, SO_2, NO_2, and CO within the study area. The following section describes the model results.

Table 6-5 summarizes the maximum ambient concentrations predicted by the CALPUFF model. In addition, maximum predicted concentrations are superimposed on a 30 km by 30 km base map centred on the Project site. The maximum predicted values are described in the following sub-sections on a contaminant basis.

6.4.1 TSP Concentrations

Most of the TSP emissions are associated with the haul roads (53%). Underground activities (34%) and mobile engine emissions (6%) are other significant sources. High TSP concentrations are predicted to occur in a small area near the Pine Point Pilot Project site. The maximum 24-hour concentrations are predicted to exceed the 24-hour standard of 120 $\mu g/m^3$ out to a distance of about 1 km as indicated by the brown region in Figure 6-1. Figure 6-2 shows that only a small area exceeds the annual standard of 60 $\mu g/m^3$. Of the 4,083 receptors modelled, 533 exceeded the annual standard. The majority of these receptors are located along the haul road.

6.4.2 PM_{10} Concentrations

Most of the PM_{10} emissions are associated with underground activities (40%) and haul road (38%). High PM_{10} concentrations are predicted to occur in the immediate vicinity of the Project site. Maximum 24-hour concentrations are predicted to exceed the 24-hour standard out to a maximum distance of about 600 m as shown in Figure 6-3. Beyond this distance, the maximum 24 hr average PM_{10} concentration is predicted to be less than the standard. Of the 4,083 receptors modelled, approximately 35% of the receptors exceeded the standard.

6.4.3 $PM_{2.5}$ Concentrations

Most of the $PM_{2.5}$ emissions are associated with underground activities (43%) and mobile engines (35%). High $PM_{2.5}$ concentrations are predicted to occur in the immediate vicinity of the Project site as shown in Figure 6-4. The maximum 98^{th} percentile concentrations are predicted to exceed the 24-hour CWS standard of 30 $\mu g/m^3$. Of the 4,083 receptors modelled, 236 exceeded the standard.

6.4.4 SO_2 Concentrations

Most of the SO_2 emissions are associated with blasting (99%) with combustion from power generation and mobile engines accounting for the remainder. The highest SO_2 concentrations are predicted to occur due south of the Project site as shown in Figure 6-5 to Figure 6-7. The maximum predicted one-hour, 24-hour and annual SO_2 concentrations are well below their respective standards.

6.4.5 NO_2 Concentrations

Most of the NO_x emissions are associated with power production (46%) and mobile equipment (27%). High NO_2 concentrations are predicted to occur due south of the Project site as indicated in Figure 6-8 to Figure 6-10. The maximum one-hour NO_2 concentrations are predicted to exceed their respective standards by less than 10%. Further analysis shows that of the 4,083 receptors modelled, only two receptors exceeded the one-hour NO_2 standard. The maximum 24-hour NO_2 concentration is just below the standard of 200 $\mu g/m^3$. The maximum annual NO_2 concentration averaged over a five year period is predicted to exceed its standard of 60 $\mu g/m^3$. Approximately 3% of the receptors exceeded this annual threshold.

6.4.6 CO Concentrations

Most of the CO emissions are associated with surface mobile engines (72%). Blasting is the next largest source (22%). As shown in Figure 6-11 and Figure 6-12, the highest CO concentrations are predicted to occur in the immediate vicinity of the Project site. The maximum predicted one-hour and eight-hour CO concentrations are above the maximum desirable federal objectives of 15,000 and 6,000 $\mu g/m^3$, respectively. However, the predicted concentrations are below the maximum acceptable federal objectives of 35,000 and 15,000 $\mu g/m^3$ for one-hour and eight-hour averages, respectively.

Table 6-5 Comparison of Maximum Predicted Concentrations to the Most Stringent Standard

Contaminant	Averaging Period	Maximum Predicted Concentration (μg/m³)[a]	Maximum Predicted Concentration + Background[b] (μg/m³)	Most Stringent Standard (μg/m³)	Number of Receptors Exceeded the Standard Based on Cummulative Effects
TSP	24 hr	**618**	652	120	1,600
	Annual	**187**	221	60	533
PM_{10}	24 hr	**222**	237	50	1,445
$PM_{2.5}$	24 hr[c]	**60**	64	30	236
SO_2	1 hr	144	167	450	0
	24 hr	6	10	150	0
	Annual	1	5	30	0
NO_2	1 hr	**413**	425	400	3
	24 hr	195	207	200	1
	Annual	**94**	106	60	121
CO	1 hr	**23,958**	24,158	15000	27
	8 hr	**14,791**	14,991	6000	965

a. Bold text = concentrations that have exceeded their Standard

b. See Table 4-2 for background values

c. The 98th percentile value averaged over three years

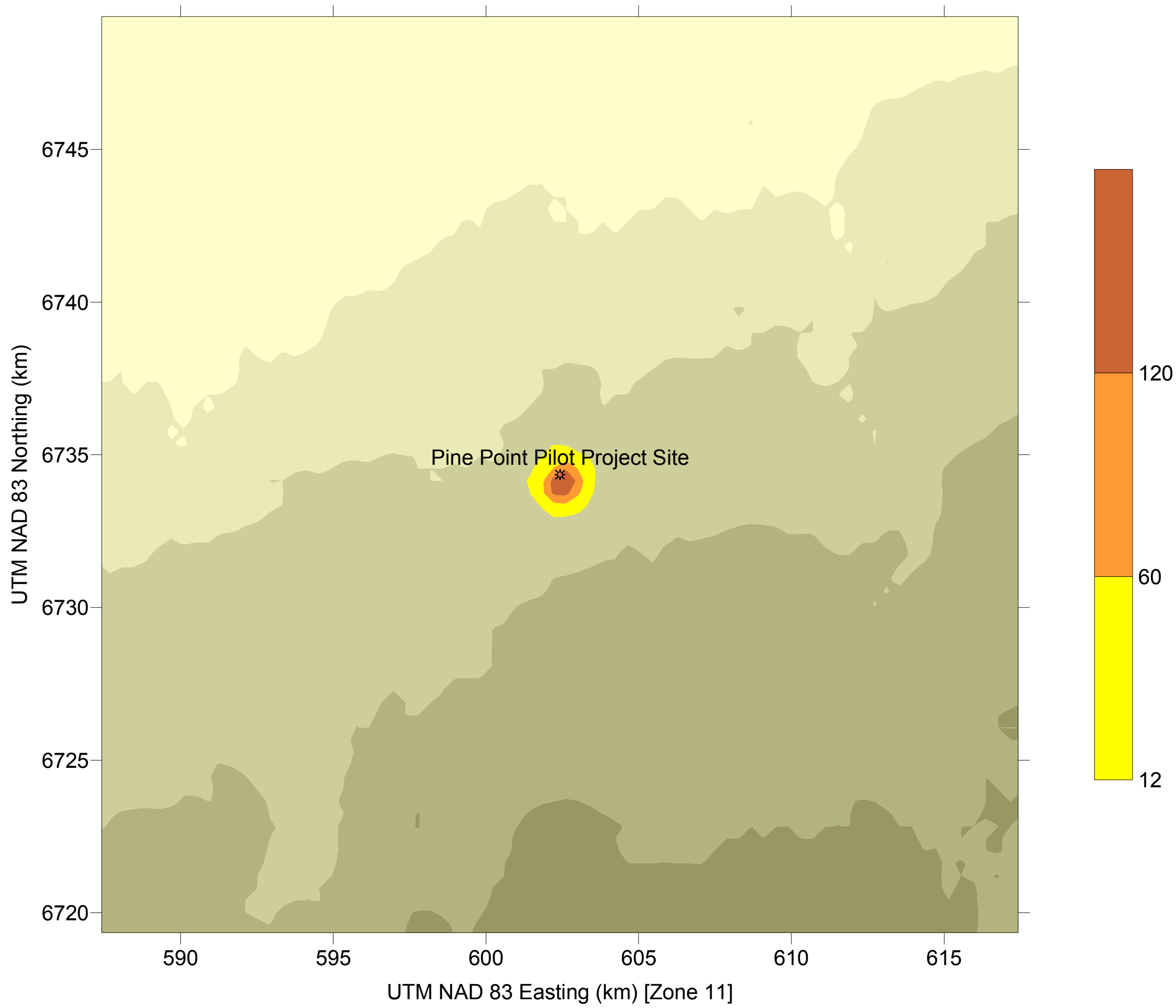


Figure 6-1: Maximum Predicted 24-Hour Average TSP Concentration Contours (µg/m^3) Based on CALPUFF Modelling

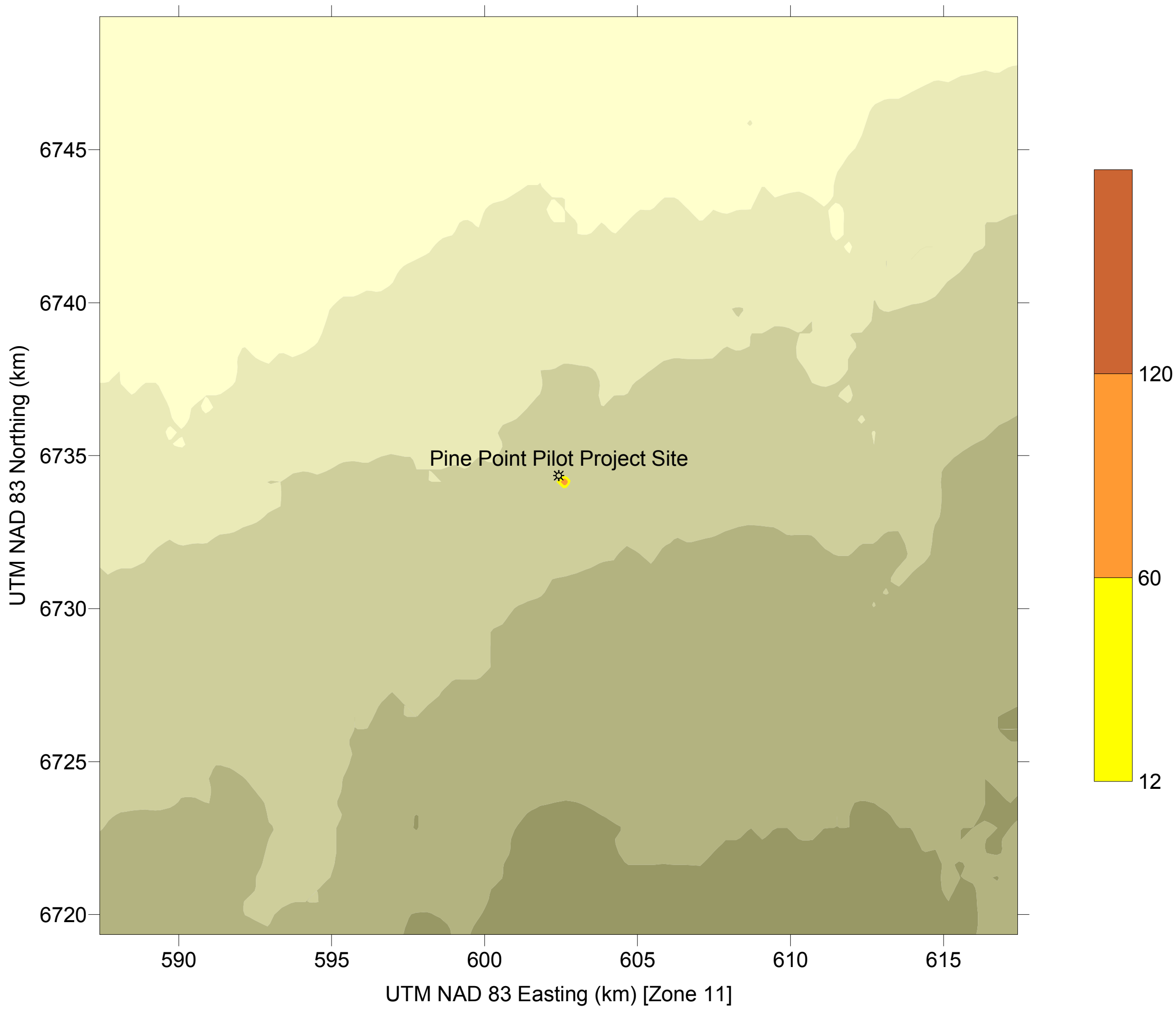


Figure 6-2: Maximum Predicted Annual TSP Concentration Contours (µg/m^3) Based on CALPUFF Modelling

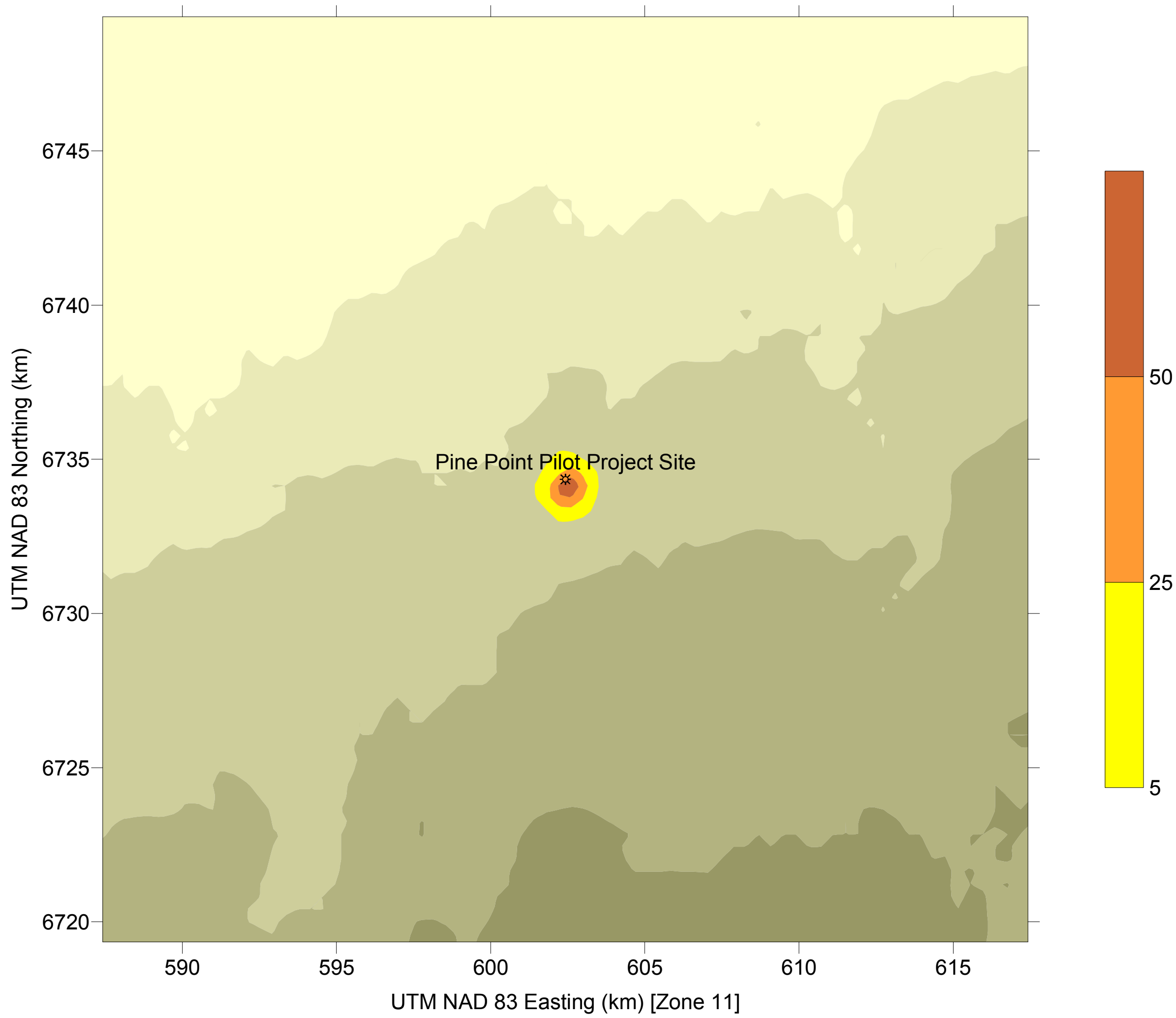


Figure 6-3: Maximum Predicted 24-Hour Average PM_{10} Concentration Contours (µg/m^3) Based on CALPUFF Modelling

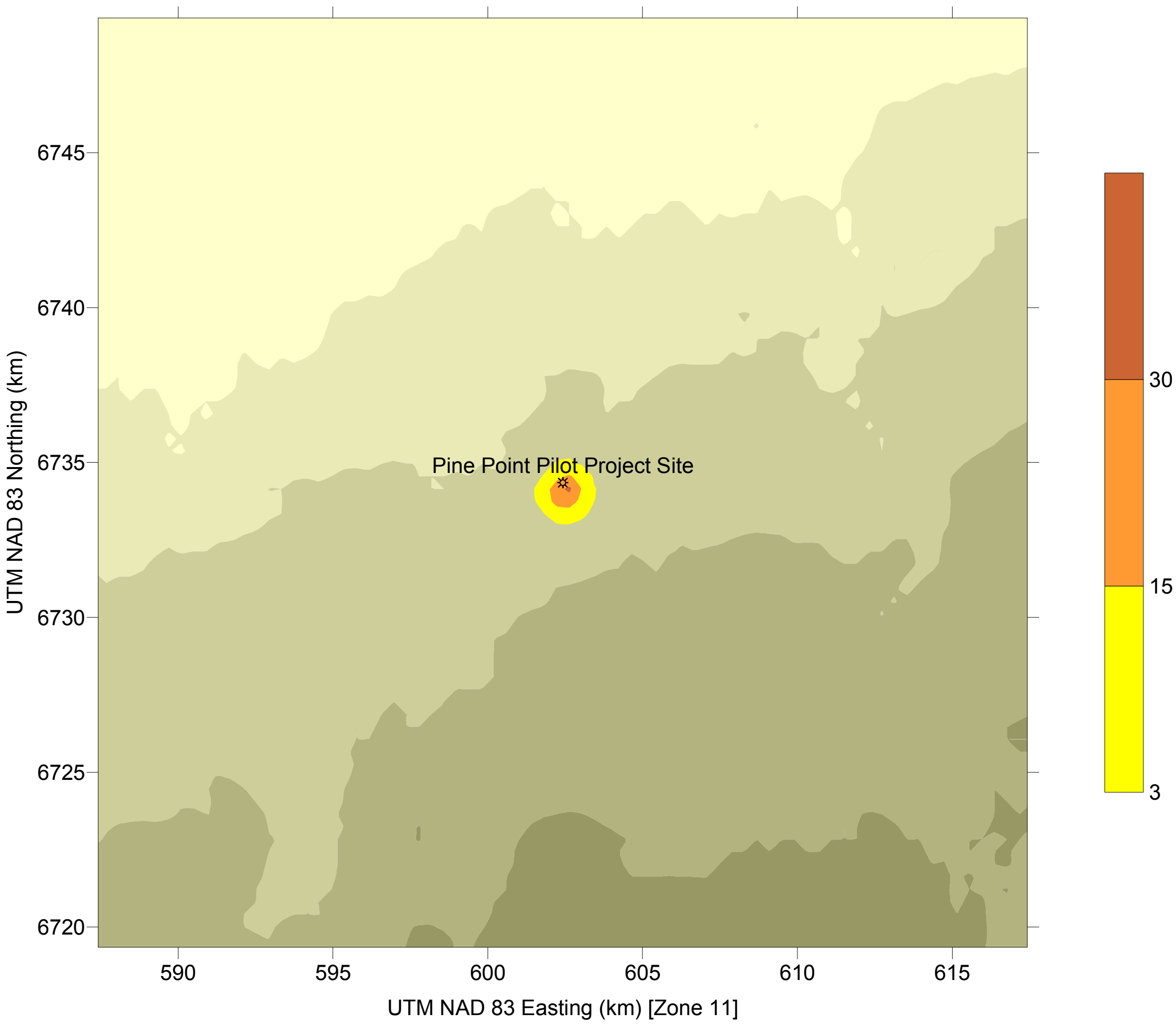


Figure 6-4: 98th Percentile Predicted 24-Hour Average $PM_{2.5}$ Concentration Contours ($\mu g/m^3$) Based on CALPUFF Modelling

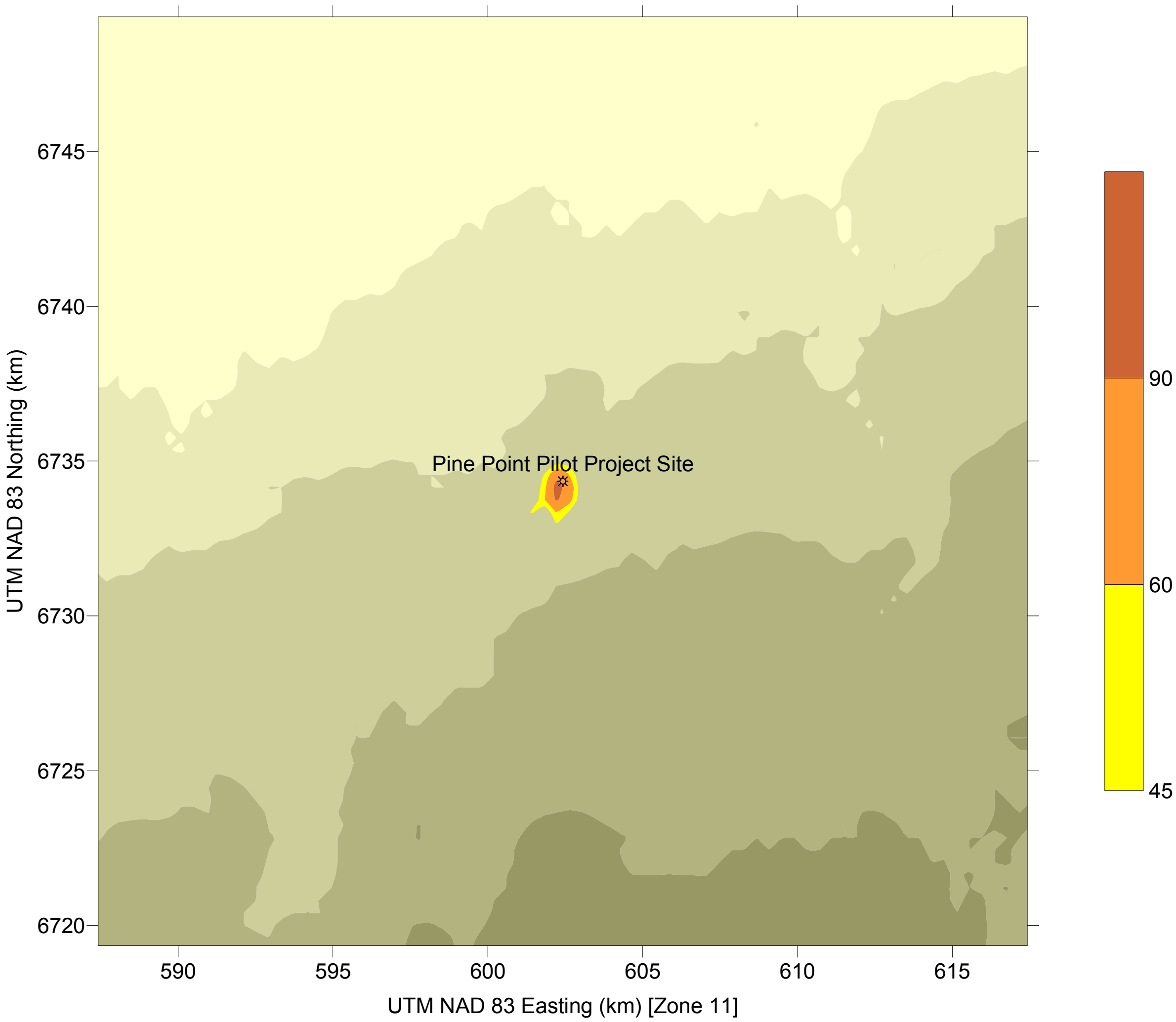


Figure 6-5: Maximum Predicted 1-Hour Average SO_2 Concentration Contours ($\mu g/m^3$) Based on CALPUFF Modelling

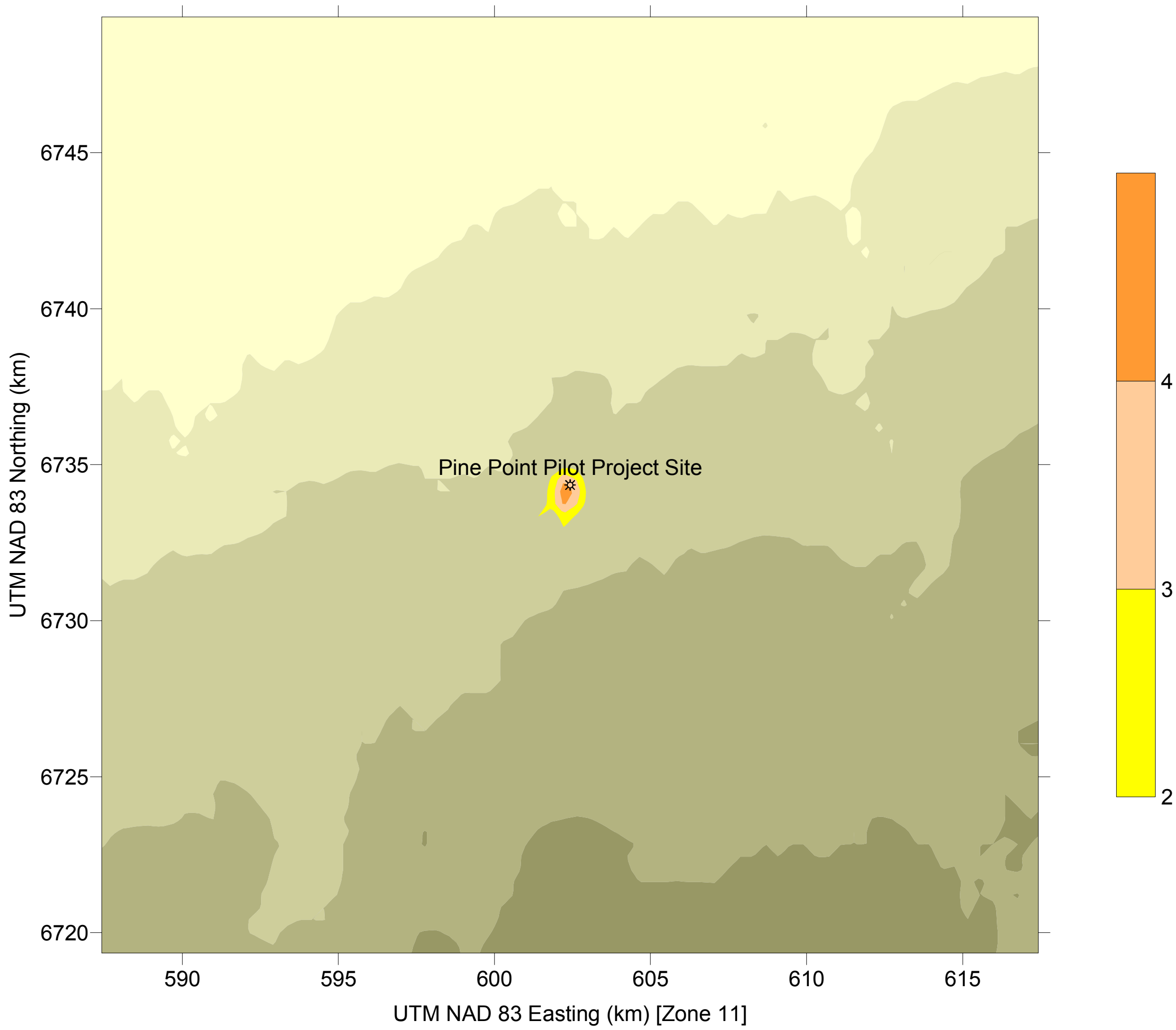


Figure 6-6: Maximum Predicted 24-Hour Average SO_2 Concentration Contours (µg/m^3) Based on CALPUFF Modelling

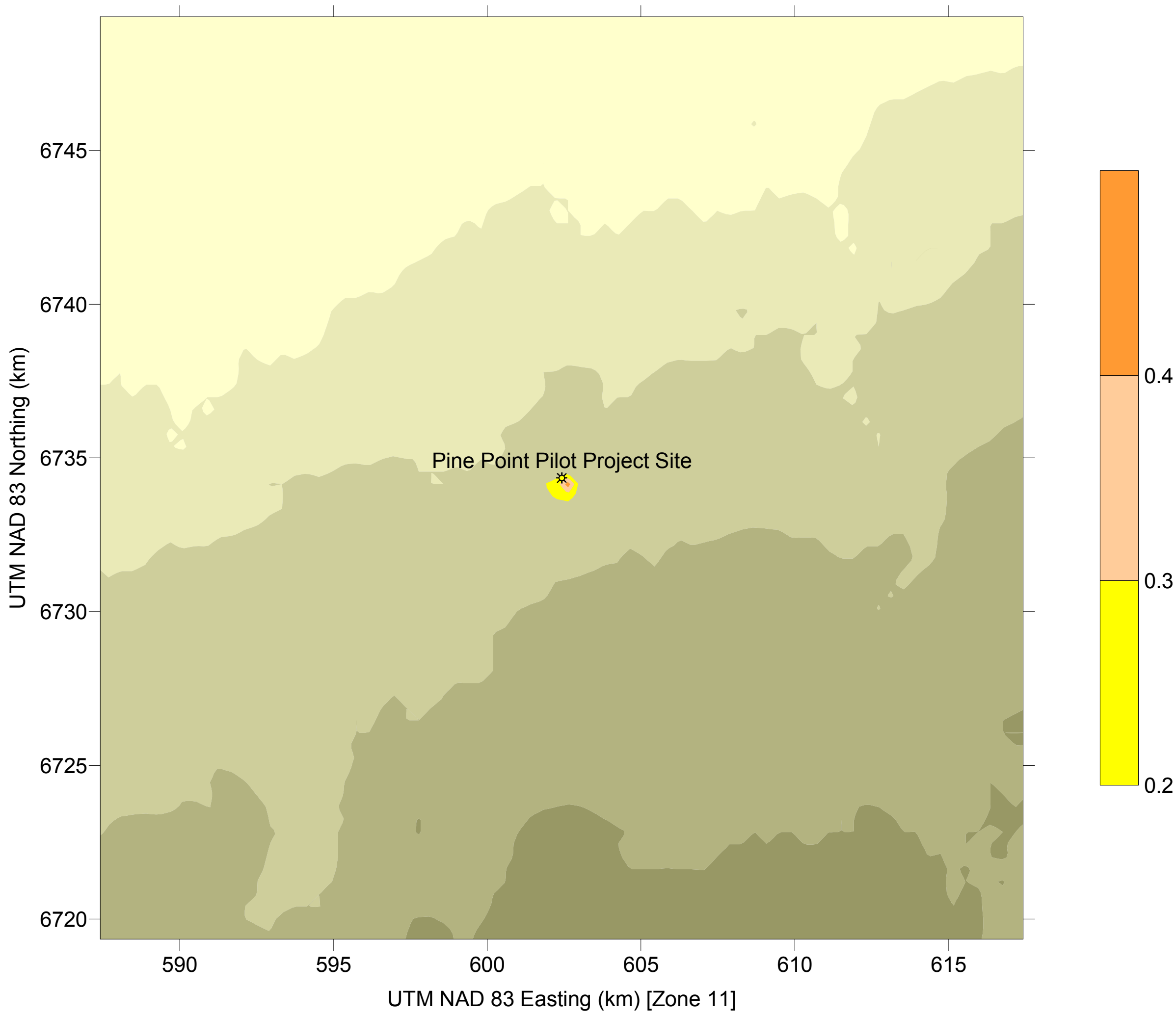


Figure 6-7: Maximum Predicted Annual SO_2 Concentration Contours ($\mu g/m^3$) Based on CALPUFF Modelling

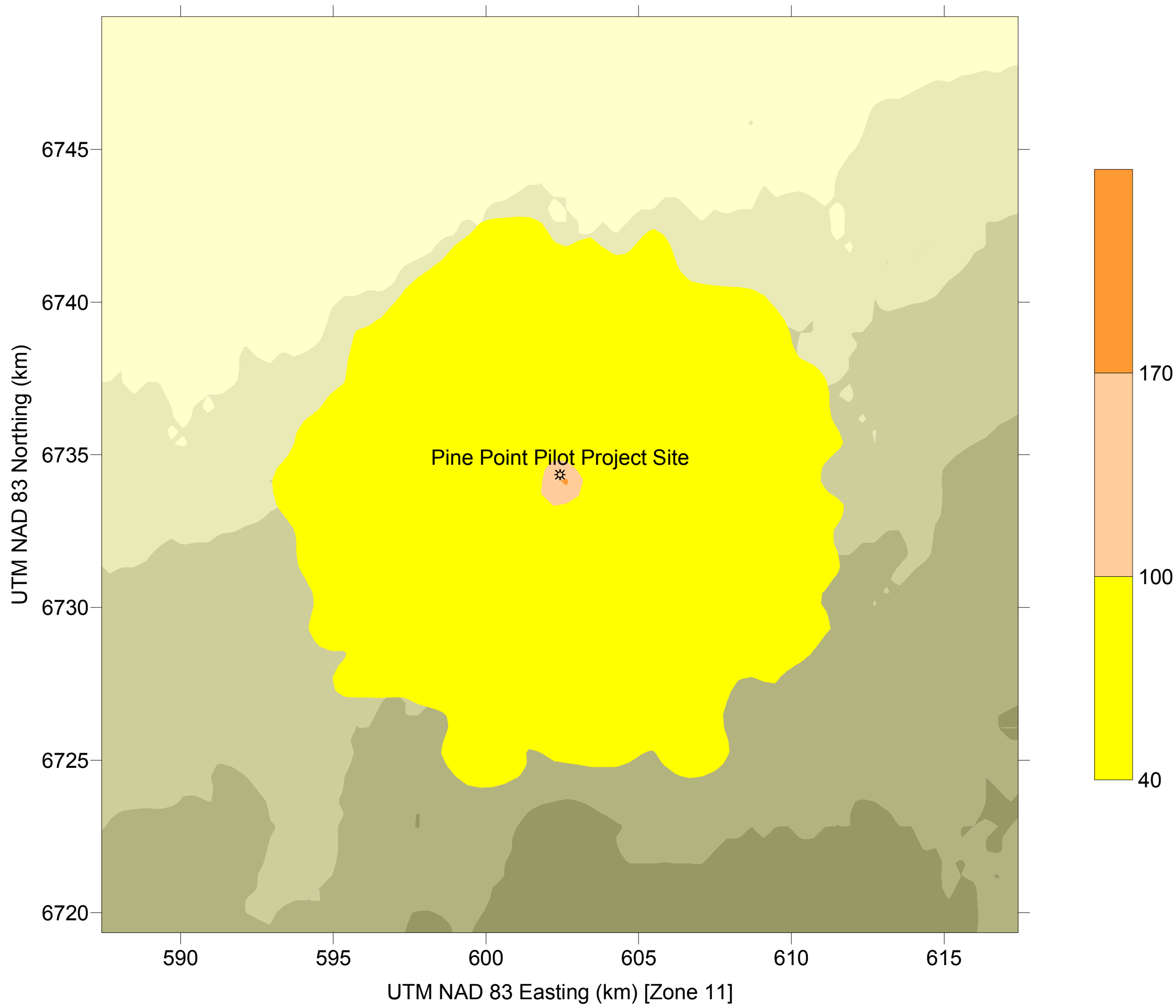


Figure 6-8: Maximum Predicted 1-Hour Average NO_2 Concentration Contours ($\mu g/m^3$) Based on CALPUFF Modelling

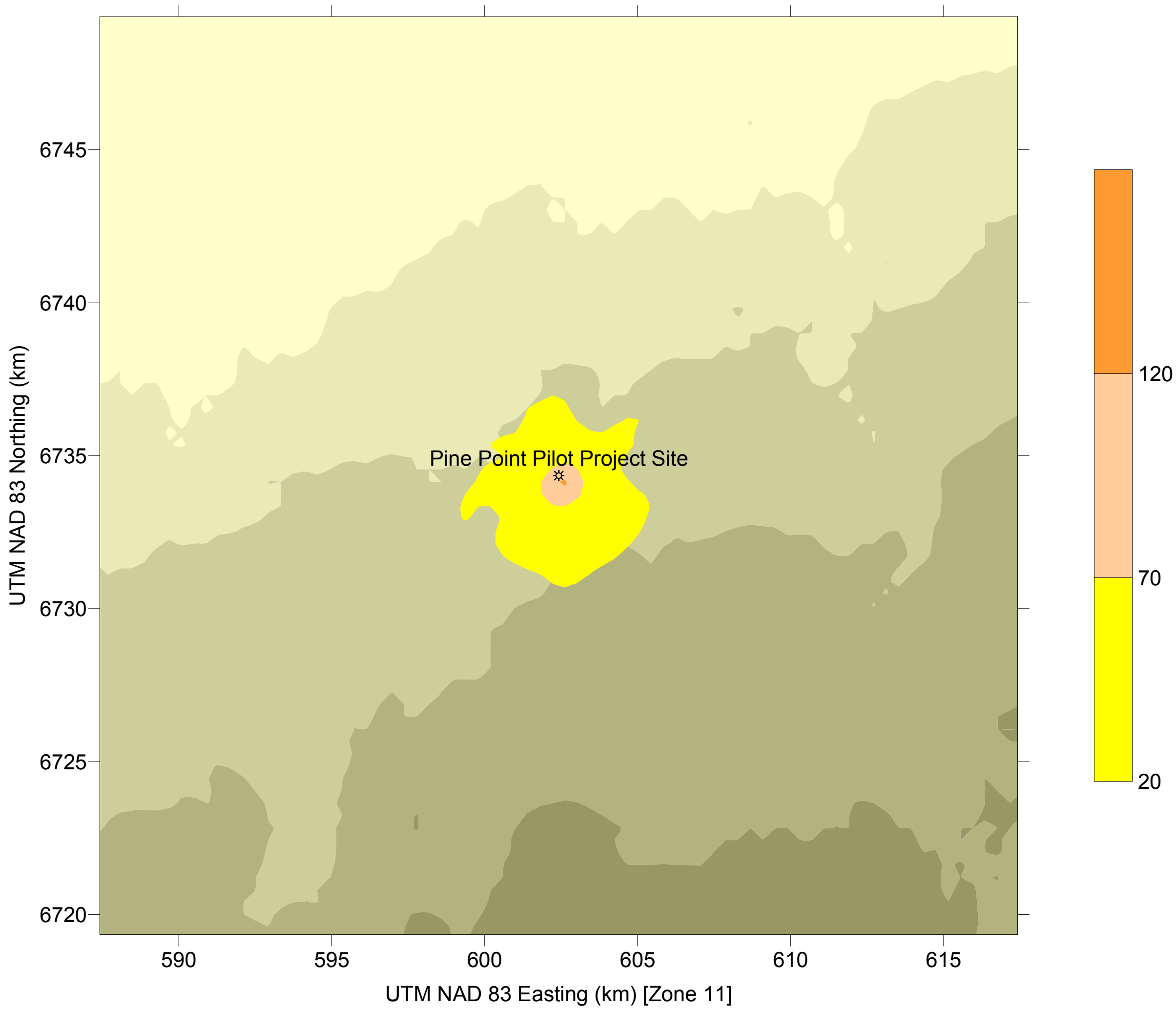


Figure 6-9: Maximum Predicted 24-Hour Average NO_2 Concentration Contours ($\mu g/m^3$) Based on CALPUFF Modelling

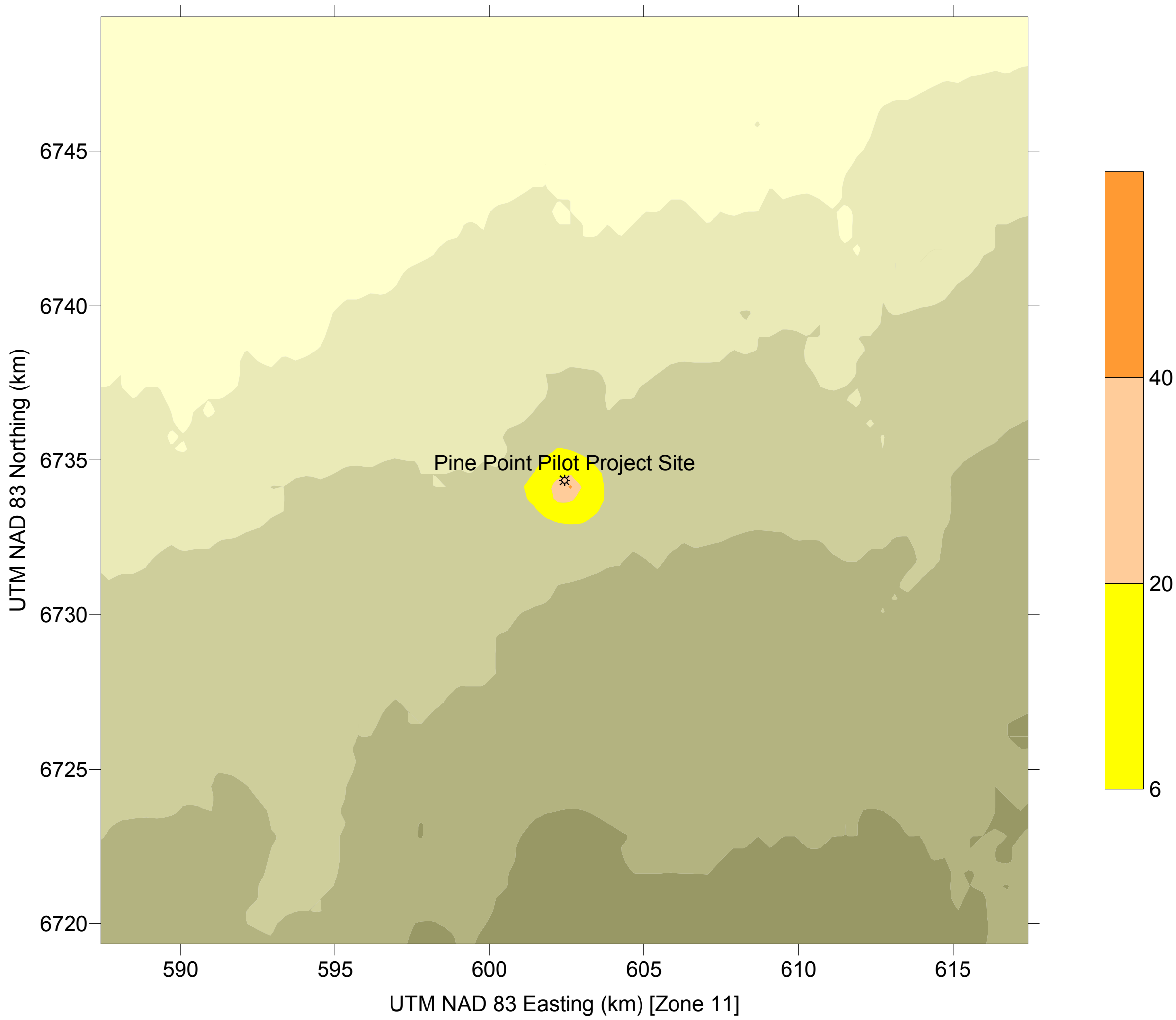


Figure 6-10: Maximum Predicted Annual NO_2 Concentration Contours ($\mu g/m^3$) Based on CALPUFF Modelling

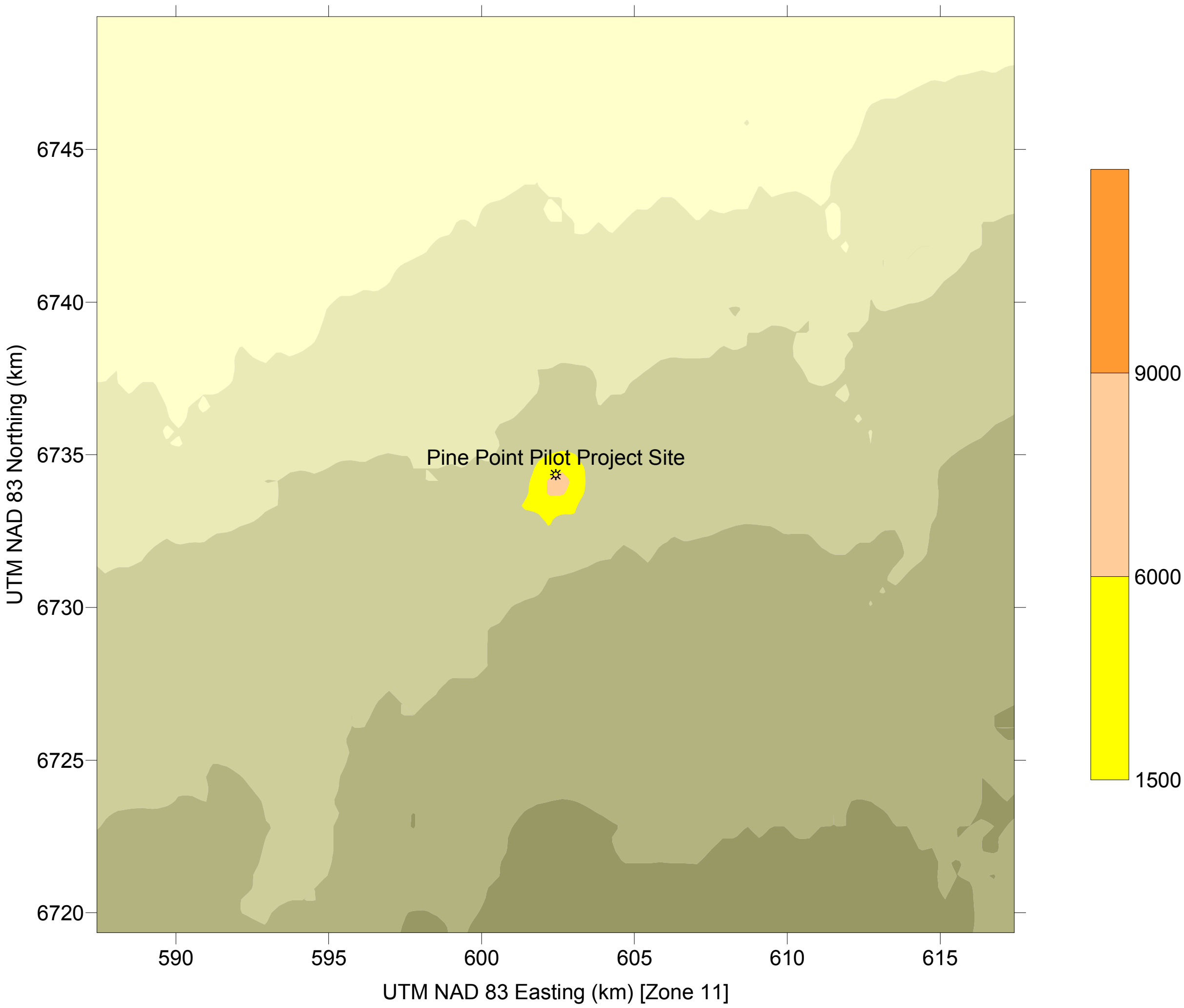


Figure 6-11: Maximum Predicted 1-Hour Average CO Concentration Contours (μg/m^3) Based on CALPUFF Modelling

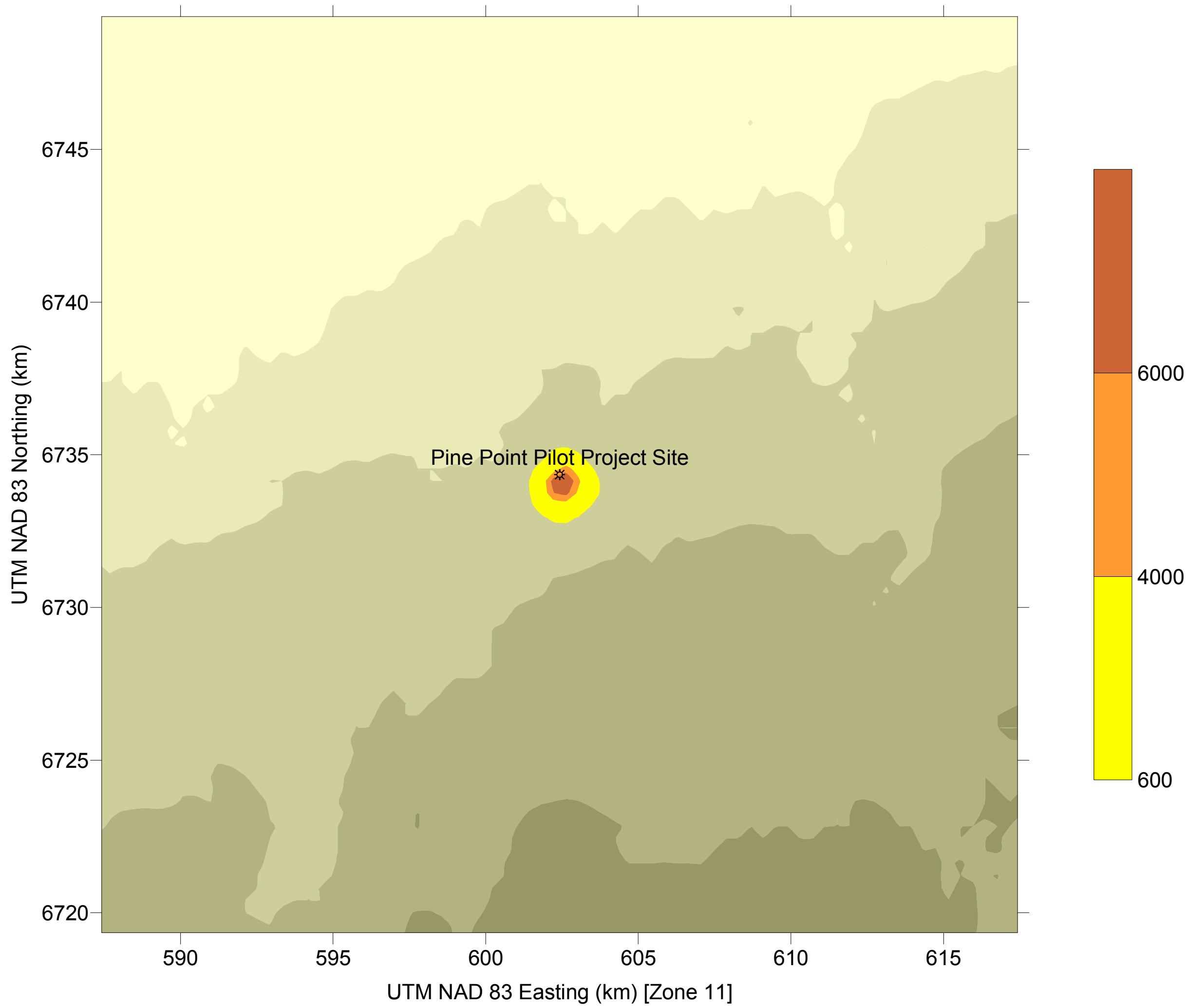


Figure 6-12: Maximum Predicted 8-Hour Average CO Concentration Contours (µg/m^3) Based on CALPUFF Modelling

7.0 PROJECT EMISSIONS COMPARISON AND RESULTS SUMMARY

As indicated in Table 7-1, the estimated daily emissions for the Project are considerably lower than the daily emissions estimated for the other existing mines. In addition, the Project will only be in operation for 12 to 15 months following construction, compared to 20 years or more for each of the other mines considered. Thus, total life-of-mine emissions will be considerably less for the Project than for other mines in the NWT.

Table 7-1 Comparison of Various Existing NWT Mine and the Project Emissions Estimates

Emissions Parameter	EKATI Diamond Mine[1]	Diavik Diamond Mine[2]	Snap Lake Diamond Mine[3]	Pine Point Pilot Project
SO_2 emissions (t/d)	0.469	0.200	0.179	0.009
NO_x emissions (t/d)	5.923	16.500	5.684	0.498
TSP emissions (t/d)	21.388	8.900	0.555	0.100
PM_{10} emissions (t/d)	–[4]	2.800	0.209	0.040
$PM_{2.5}$ emissions (t/d)	–[4]	0.600	0.113	0.018
CO emissions (t/d)	–[5]	–[5]	–[5]	1.235

(1) Data obtained from the BHP EKATI ™ Project EIA (BHP 1995)
(2) Data obtained from the Diavik Diamond Mine EIA (Diavik 1998)
(3) Data obtained from the Snap Lake Diamond Mine EIA (De Beers 2002)
(4) Neither PM_{10} nor $PM_{2.5}$ emissions data available for the BHP EKATI ™ Project EIA
(5) CO emissions data were not available for the BHP EKATI ™ Project, Diavik Diamond Mine, or Snap Lake Diamond Mine EIAs

The relative magnitude of estimated emissions from the Project gives some indication of potential effects on air quality, but the effects that these emissions will have on ground-level concentrations are considered to be the more direct indicator.

CALPUFF dispersion modelling conducted for the Project indicates the following:

- *The maximum predicted 1-hour, 24-hour and annual ground-level SO_2 concentrations are well below the applicable NWT standards.*
- *The maximum predicted 24-hour NO_2 concentration is below the acceptable NAAQO. The maximum predicted 1-hour and annual NO_2 concentrations are below the acceptable NAAQO except for a 200-m diameter polygon centered approximately 400 m from the mine site on the haul road.*
- *The maximum 1-hour and 24-hour TSP, 24-hour PM_{10} and 24-hour $PM_{2.5}$ concentrations are below the applicable NWT and Canada-Wide standards except for a 600-m diameter polygon centered on the haul road.*
- *The maximum 1-hour and 8-hour CO concentrations were predicted to be above the desirable NAAQOs but below the acceptable NAAQOs.*

Modelling was performed without the particulate emissions from the haul roads and mobile emissions. The maximum NO_2 and CO concentrations were reduced by more than 50% and the maximum TSP concentration was reduced by approximately 38%. Indicating that road dust and mobile emissions dominate the maximum predicted concentrations. It needs to be highlighted that the emission factors used to estimate haul road particulate and mobile emissions are conservative and that the ambient air quality impacts are local to the Project facilities.

Since dispersion modelling has predicted concentrations of particulate matter, NO_2, and CO to be above the most stringent standards, monitoring is recommended for dustfall, PM_{10}, $PM_{2.5}$, NO_2, and CO.

8.0 REFERENCES

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