APPENDIX 4-C

Air Quality Modelling Technical Summary

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4.C-1   INTRODUCTION

This document provides detailed technical information regarding the methods and results used to assess Project-related effects to air quality from the Whale Tail Pit and Haul Road Project (the Project). Specifically, information on the air quality dispersion model, meteorology, terrain, the method for converting oxides of nitrogen (NO_x) to nitrogen dioxide (NO_2), particulate matter and gas deposition, and the modelling results is provided. The air quality modelling was conducted separately for the Whale Tail Pit and the haul road to the Meadowbank Mine. The emission sources associated with the mine site include emissions from the open pit (drilling and blasting, material handling, road dust), wind erosion from the ore pad and waste rock storage facility, road dust from transportation of waste-rock and ore, the power plant, and camp's diesel-fired heater. The haul road was modelled as a representative 1 kilometre (km) section of the road between the Whale Tail Pit and the Meadowbank Mine. The haul road section selected for modelling is aligned along a southwest to northeast direction, which is perpendicular to the dominant wind direction in the region.

4.C-2   AIR QUALITY MODELLING METHODS

The air quality modelling was completed using the AERMOD model, which is a plume dispersion model developed by the United States Environmental Protection Agency (US EPA 2004). The AERMOD model was selected for the air quality assessment because it has been accepted in many jurisdictions in Canada and the United States. In addition, this dispersion model is capable of local scale modelling of less than 50 km.

The air quality assessment is focused on predicting the change in air quality due to Project operations. Potential effects of the Project on air quality during the construction and decommissioning phases are not assessed as emissions during these periods are predicted to be well below emissions during the operations phase. Project air emissions for the year 2020 were selected as the basis for the air quality modelling. Year 2020 is predicted to have the highest ore production and therefore provides a conservative estimate of emissions for all years, including construction and operations phases of the Project. The air quality assessment for the Project includes the following steps:

1)   establishing the existing background concentrations of criteria air contaminants in the region (see Appendix 4-A);

2)   creating an air emissions inventory for the Whale Tail Pit and the haul road to the Meadowbank Mine for year 2020 (see Appendix 4-B);

3)   using the AERMOD model to predict ambient concentrations of criteria air contaminants and dust deposition as a result of the Project; and

4)   comparing the ambient air quality and dust deposition predictions to existing federal, provincial and territorial air quality standards and/or guidelines.

The criteria air contaminants (CACs) considered in this assessment include the following:

■   carbon monoxide (CO);

■   nitrogen dioxide (NO_2);

■   sulfur dioxide (SO_2);

- particulate matter, including:

  - total suspended particulate (TSP);

  - particulate matter with aerodynamic diameters less than 10 micrometers (μm) (PM_{10}); and

  - particulate matter with aerodynamic diameters less than 2.5 μm ($PM_{2.5}$).

4.C-2.1   Existing Air Quality Concentrations

Publicly available and Government of Nunavut Arctic air quality monitoring data were evaluated to estimate background concentrations of criteria air contaminants in the Kivalliq region of Nunavut (see Appendix 4-A). For compounds with 1-hour, 8-hour, and 24-hour averaged periods, the 90th percentiles of historic air quality observations were used as the background regional concentrations for CAC's. For the annual averaged period, the 50th percentile values were used (Table-C-1). Because there are no existing TSP and PM_{10} data, TSP and PM_{10} background concentrations were assumed to be the same as the $PM_{2.5}$ background concentrations.

Table 4-C-1: Background Air Quality Concentrations

Compound	Averaging Period	Percentile	Background Concentration	
			µg/m³	ppbv
CO	1-hr	90th	389	**0.3**
	8-hr	90th	385	**0.3**
NO$_2$	1-hr	90th	12.6	5.0
	24-hr	90th	11.4	4.5
	Annual	50th	5.0	1.9
SO$_2$	1-hr	90th	2.7	1.0
	24-hr	90th	2.7	1.0
	Annual	50th	0.3	0.1
PM$_{2.5}$	24-hr	90th	6.6	—
	Annual	50th	3.6	—

4.C-2.2   Ambient Air Quality Standards

A range of effects can result from air emissions introduced into the atmosphere by mining activities. The emissions can have direct and indirect effects on humans, animals, vegetation, soil, and water. For these reasons, federal and provincial environmental regulatory agencies have established ambient air quality standards and/or guidelines.

The Environmental Guideline for Ambient Air Quality was revised by the Department of Environment's Environmental Protection Division and approved by the Minister of Environment, Government of Nunavut in 2011 (Government of Nunavut 2011). The guideline established ambient air quality guidelines for criteria air contaminants including: fine particulate matter, total suspended particulate, nitrogen dioxide, sulfur dioxide and ground level ozone. Guidelines adopted by the Government of Nunavut are based on comparable standards established by the Federal Government and standards and/or guidelines in other Provinces and Territories. For

the criteria air contaminants (CACs) that are not included in the Guideline, the Federal ambient air quality criteria or ambient air quality standards from other Provinces and Territories were adopted (Table 4.C-2).

Table 4-C-2: Applicable Ambient Air Quality Criteria

Parameter	Nunavut Ambient Air Quality Standards[a]		Other Ambient Air Quality Standards or Guideline	
	µg/m³	ppbv	µg/m³	ppbv
SO₂				
1-hour	450	172	—[b]	—
24-hour	150	48	—	—
Annual	30	8	—	—
NO₂				
1-hour	400	159	—	—
24-hour	200	106	—	—
Annual	60	24	—	—
CO				
1-hour	—	—	15,000[c]	13000
8-hour	—	—	6,000[c]	5000
TSP				
24-hour	120	—	—	—
Annual	60	—	—	—
PM₁₀				
24-hour	—	—	50[d]	—
PM₂.₅				
24-hour	30	—	28[e] 27[f]	—
Annual	—	—	10[g], 8.8[h]	—
Dustfall mg/cm²/30-day				
1-month	—	—	0.51 to 1.58[d]	—
Annual	-	-	0.46[d]	

[a] Environmental Guideline for Ambient Air Quality (Government of Nunavut 2011).

[b] "—"   No criteria are available.

[c] Alberta Ambient Air Quality Objectives and Guidelines Summary (Government of Alberta 2013)

[d] Range for AB, BC and ON nuisance guidelines (Alberta Environment 2013; B.C. Ministry of Environment 2016; Ontario Ministry of the Environment 2012)

[e] 2015 achievement is based on the 98th percentile ambient measurement annually, averaged over 3 consecutive years (CCME 2013).

[f] 2020 achievement is based on the 98th percentile ambient measurement annually, averaged over 3 consecutive years (CCME 2013).

[g] 2015 achievement is based on 3-year average of the annual average concentrations (CCME 2013).

[h] 2020 achievement is based on 3-year average of the annual average concentrations (CCME 2013).

µg/m³: microgram per cubic metre

4.C-2.3 Meteorological Data

The use of the AERMOD model requires that an AERMET data set be created to simulate the meteorology in the region of the Project. This meteorology dictates the transport and dispersion of atmospheric emissions from the Project, as well as the resulting ground-level concentrations of CACs. The AERMET dataset was constructed using 2005 to 2009 hourly surface observations from the Environment Canada Baker Lake station, and upper air data from the Baker Lake station from the National Oceanic & Atmospheric Administration/Earth System Research Laboratory (NOAA/ESRL) Radiosonde Database.

Albedo, Bowen ratio, and surface roughness are AERMET preprocessor input parameters that are site-specific and dependent on the land use of the region around the facility to be modelled (e.g., urban area, farmland, woodlot, forest, swamp). The albedo is the fraction of total incident radiation reflected by the surface back to space without absorption. Typical values range from 0.1 for heavily forested areas (little solar radiation is reflected) to 0.9 for fresh snow (most radiation is reflected back to space). The daytime Bowen Ratio is the ratio of the sensible heat flux (transfer of heat upwards from the ground due to surface heating) to the latent heat flux (energy loss at the ground and gain aloft, due to evaporation and condensation of water). The surface roughness length is related to the height of obstacles that interfere with the wind flow. In general, trees and buildings have a high surface roughness, while sand and water have a low surface roughness. The AERMET component allows these surface parameters to be defined in all directions around the site being modelled. The surface parameters used in AERMET are listed in Table 4-C-3. The values of the surface parameters were based on a mixture of four land types (Swamp: 10%; Water: 25%; Grassland: 30%; Desert shrubland:35%) with values of each land type given in the Alberta air quality modelling guideline (Government of Alberta 2009).

Appendix 4-A includes comparisons of AERMET and baseline meteorology for air temperature, wind speed and direction, and precipitation. The following subsections document mixing heights and atmospheric stability classes, which are additional meteorological inputs required by the AERMOD model.

Table 4-C-3: Surface Parameters Used in AERMET

Month	Albedo	Bowen Ratio	Roughness Length
January	0.418	3.075	0.058
February	0.418	3.075	0.058
March	0.201	1.205	0.140
April	0.201	1.205	0.140
May	0.201	1.205	0.140
June	0.191	1.675	0.155
July	0.191	1.675	0.155
August	0.191	1.675	0.155
September	0.209	2.435	0.128
October	0.209	2.435	0.128
November	0.209	2.435	0.128
December	0.418	3.075	0.058

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4.C-2.3.1 Mixing Height

Mixing height or boundary layer depth is the depth of the surface layer in which the majority of air dispersion will occur. The depth of this well-mixed layer is a function of surface (convective) heating and wind (mechanical) turbulence. Low boundary layer depths provide little vertical room for dispersion and can result in elevated concentrations at ground level. Convective and mechanical boundary layer depths were determined by AERMET from surface and upper level temperatures and winds, respectively.

Figure 4-C-1 provides a summary of the convective and mechanical boundary layer depths calculated by AERMET. Convective boundary layer depths were calculated only for daytime hours that have convective meteorological conditions (i.e., 31.7% of the time), while mechanical boundary layer depths were calculated for every hour, except for hours with missing meteorological data. AERMOD uses the mechanical boundary layer depth in the absence of a convective boundary layer depth.
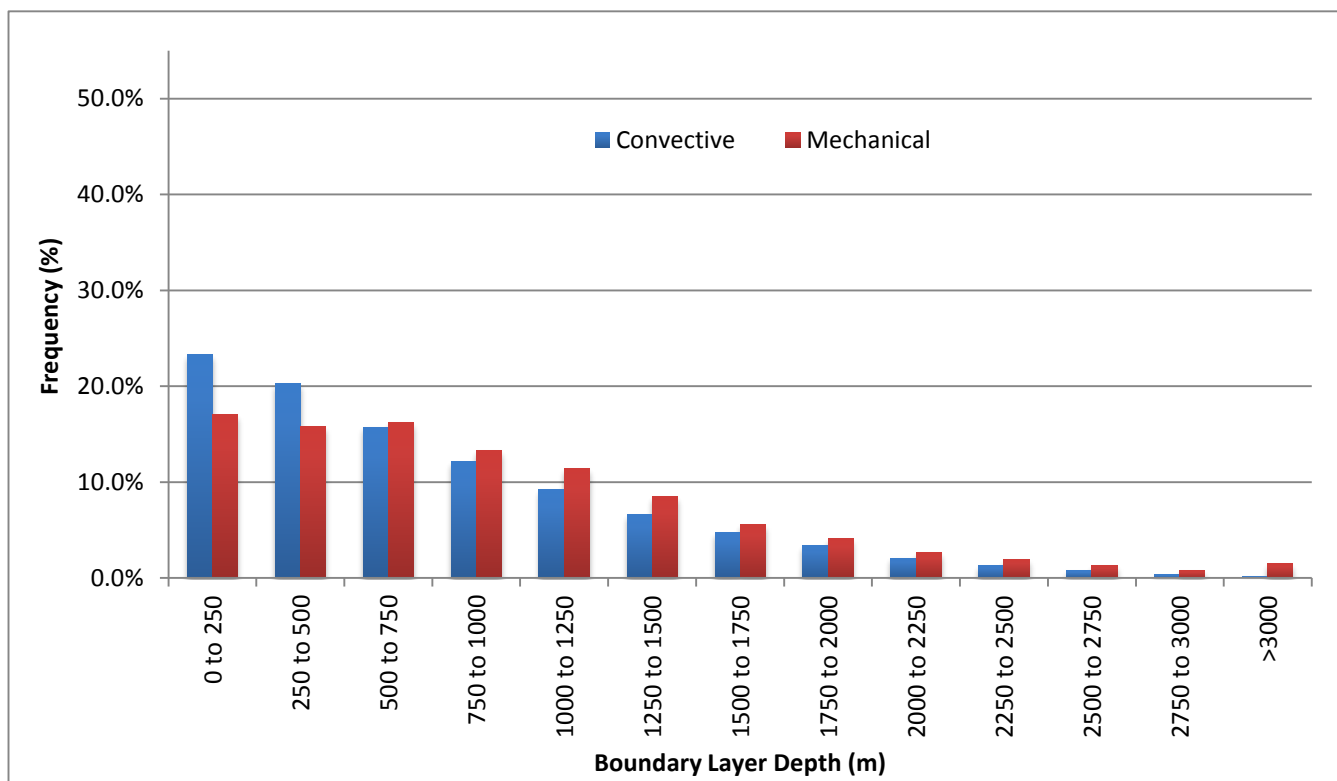

Figure 4-C-1: AERMET Derived Mixing Heights

4.C-2.3.2 Stability Class

Atmospheric stability can be viewed as a measure of the atmosphere's capability to disperse air pollutants. The amount of turbulence in the atmosphere plays an important role in the dilution of a plume as it is transported by the wind. Turbulence can be generated by either thermal or mechanical processes. Surface heating or cooling by radiation contributes to the generation or suppression of thermal turbulence, while high wind speeds contribute to the generation of mechanical turbulence.

The Pasquill-Gifford stability classification scheme is one classification of the atmosphere. The classification ranges from Unstable (Stability Classes A, B, and C) to Neutral (Stability Class D) to Stable (Stability Classes E and F). Unstable conditions are primarily associated with daytime heating conditions, which result in enhanced turbulence levels (enhanced dispersion). Stable conditions are associated primarily with nighttime cooling conditions, which result in suppressed turbulence levels (more limited dispersion). Neutral conditions are primarily associated with higher wind speeds or overcast conditions.

The stability conditions predicted for the Project site are presented in Figure 4-C-3 and summarized as follows:

■ Unstable (A, B and C) conditions are predicted to occur 12.9% of the time.

■ Neutral (D) conditions are predicted to occur 64.5% of the time.

■ Stable (E and F) conditions are predicted to occur 22.5% of the time.
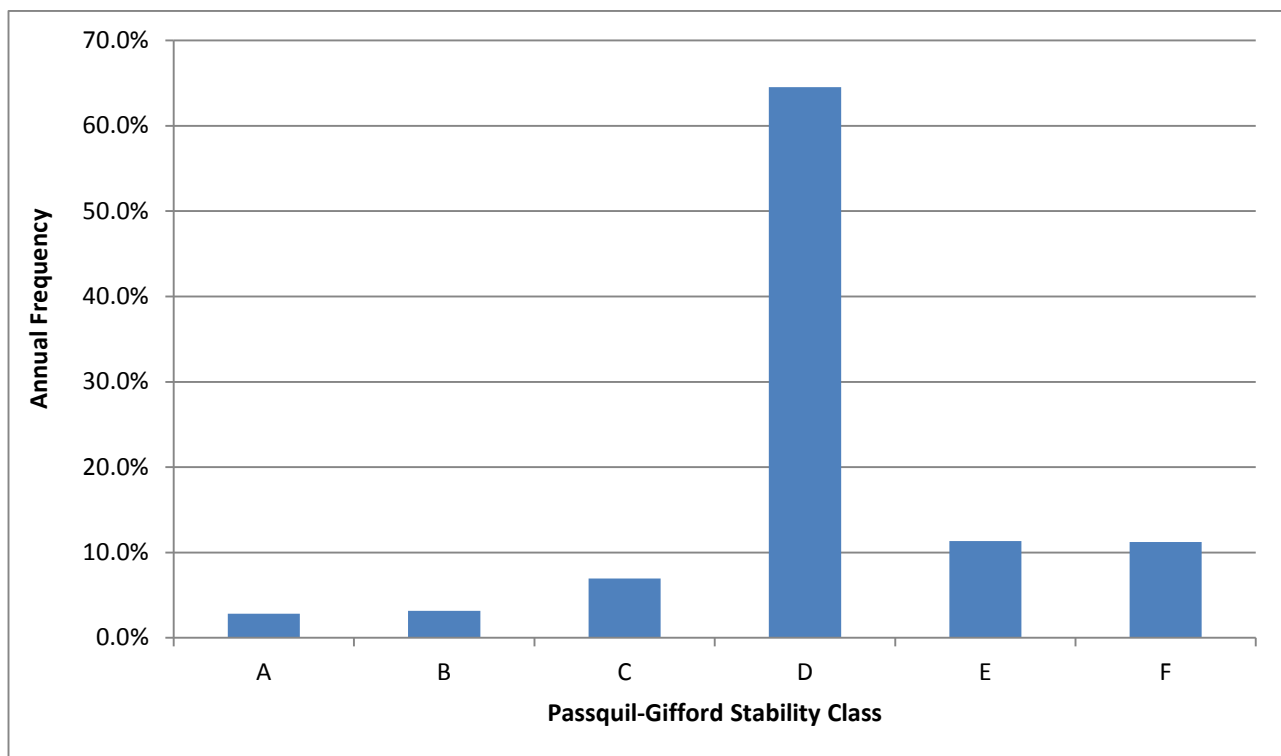

Figure 4-C-2: AERMET Derived Stability Classes

4.C-3   TERRAIN DATA

The terrain information required by the AERMOD dispersion model is generated by the AERMAP pre-processor. An AERMAP file was developed based on 1:250,000 Digital Elevation Model (DEM) data for the Project study area obtained from Geobase (Geobase 2015). The terrain in the effects study area is relatively flat with elevations ranging from approximately 315 to 544 metres above sea level (masl). The topography in the effects study area is shown in Figure 4-C-3.
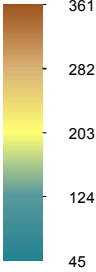
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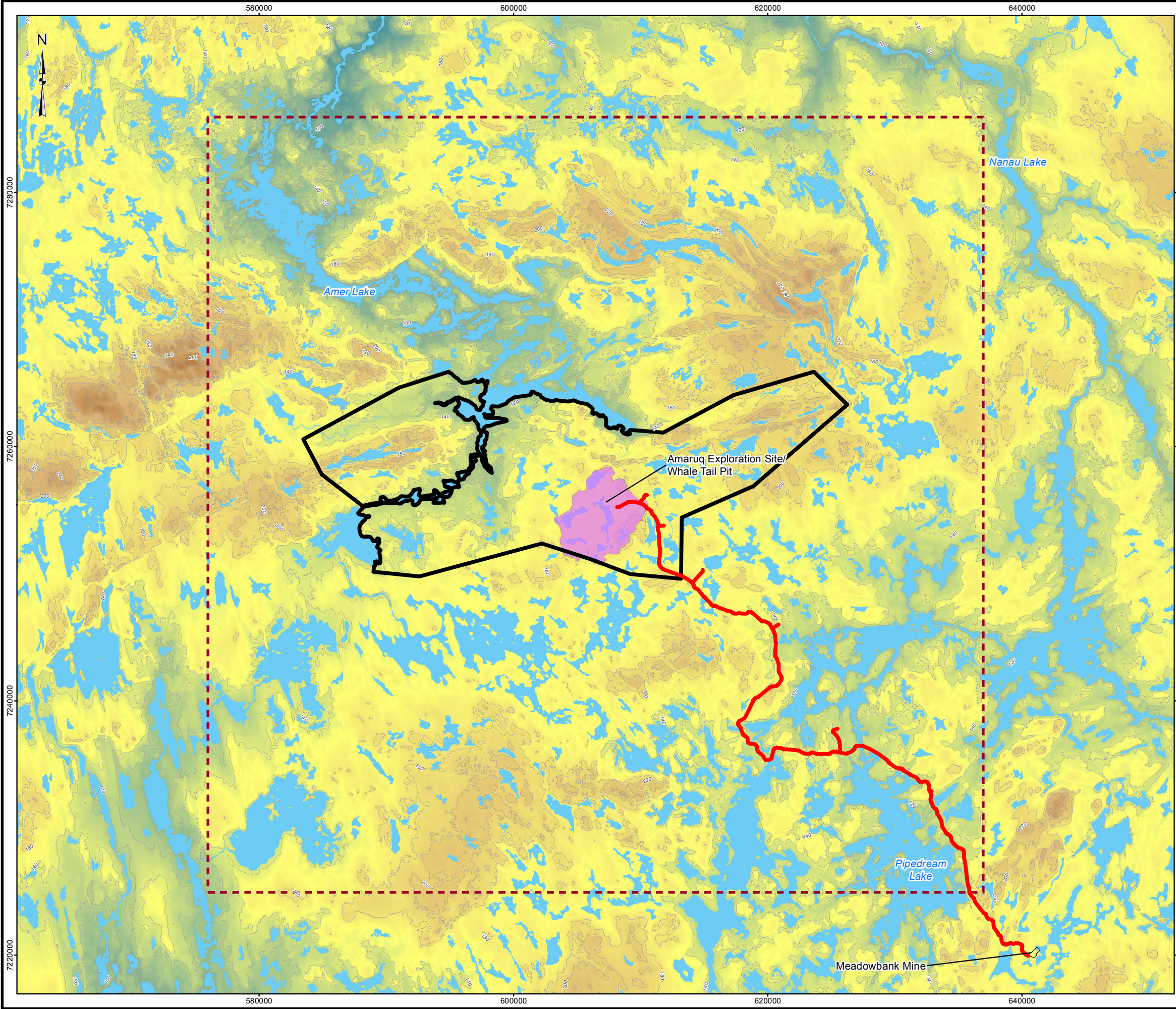
LEGEND

CONTOUR (20m INTERVAL)

PROPERTY BOUNDARY

MODEL BOUNDARY

PROPOSED WHALE TAIL PIT HAUL ROAD

PROJECT DISTURBANCE AREA

WATERBODY

ELEVATION (MASL)

361
282
203
124
45

Nanau Lake

Amer Lake

Amaruq Exploration Site/
Whale Tail Pit

*Pipedream
Lake*

Meadowbank Mine

REFERENCE
1. PROJECT BASE DATA OBTAINED FROM AGNICO EAGLE MINES LIMITED.
2. WATERCOURSE, WATERBODY AND TOPOGRAPHIC DATA OBTAINED FROM CANVEC
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6   0   6
KILOMETRES

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED:
MEADOWBANK DIVISION
WHALE TAIL PIT PROJECT

TITLE

TOPOGRAPHY WITHIN THE STUDY AREA

PROJECT	1541520	FILE No.		
DESIGN	ZY	2016-03-02	SCALE AS SHOWN	REV. A
GIS	SBM	2016-05-11		
CHECK	CMc	2016-05-11		
REVIEW	CM	2016-05-11		

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FIGURE 4-C-3

4.C-4   NO$_X$ TO NO$_2$ CONVERSION

The oxides of nitrogen (NO$_x$) emissions from the Project are a mixture of nitrogen oxide (NO) and nitrogen dioxide (NO$_2$). However, NO is an unstable molecule and reacts quickly in the atmosphere to form NO$_2$. Since ambient air quality criteria are based on NO$_2$ concentrations, estimating the fraction of NO that has transformed into NO$_2$ is necessary. The AERMOD model's Ozone Limiting Method (OLM) was used to convert NO$_x$ to NO$_2$. Background monthly ozone (O$_3$) concentrations are needed as input to the OLM calculations. Monthly average O$_3$ concentrations were calculated from National Air Pollution Station (NAPS) data for the Kivalliq region of Nunavut (see also Section 4.A-3.2 of Appendix 4-A). The background monthly O$_3$ concentrations used in the model are summarized in Table 4-C-4.

Table 4-C-4: Background Monthly Ozone Concentrations

Month	O$_3$ (ppbv)
January	24.0
February	25.5
March	25.5
April	30.6
May	30.4
June	25.7
July	20.0
August	17.7
September	17.3
October	19.1
November	22.7
December	22.8

4.C-5   PARTICULATE MATTER DEPOSITION

The AERMOD model includes two methods for predicting dry and/or wet deposition of particulate matter emissions. Method 1 is used when the particle size distribution is known or when a significant fraction (greater than about 10%) of the total particulate mass has an aerodynamic diameter of 10 micrometers (µm) or larger. Method 2 is used when the particle size distribution is not well known and when a small fraction (less than 10% of the mass) has a diameter of 10 µm or larger (US EPA, 2004). Method 2 was used in this assessment to model the deposition of TSP, PM$_{10}$, PM$_{2.5}$. The mass-mean aerodynamic particle diameters assumed for TSP, PM$_{10}$, and PM$_{2.5}$ in this assessment are: 5 µm, 2.5 µm, and 1.25 µm, respectively. For TSP and PM$_{10}$, the fractions of particles with size less than 2.5 µm were calculated by dividing the PM$_{2.5}$ emission rates by the TSP and PM$_{10}$ emission rates.

4.C-6   GAS DEPOSITION

The gas deposition algorithms incorporated into AERMOD are based on the draft Argonne National Laboratory (ANL) report (Wesely et al. 2002). The general gas deposition parameters specified for SO$_2$ and NO$_x$ are as follows:

- pollutant reactivity factor: 0.1;

- fraction of maximum green LAI (Autumn): 0.5; and

- fraction of Maximum green LAI (Transition Spring): 0.25.

The gas deposition algorithms of AERMOD include gas deposition resistance terms based on seasons and land use type (US EPA, 2004). Months of the year were separated into seasonal categories based on the Baker Lake climate normal data. The separation of months into seasons are as follows:

- Midsummer: July and August;

- Late Autumn: September and October;

- Winter: November, December, January, February, March, April, and May; and

- Transitional Spring: June.

The land use category of the region was classified as '8 – Barren land, mostly desert'. This determination is consistent with the Northern Arctic ecozone of Canada being classified as a 'Polar Desert' (see Section 4.A-2 of Appendix 4-A). Specific gas deposition parameters for SO_2 and NO_x are listed in Table 4-C-5 (Carbonell et al. 2010).

Table 4-C-5: AERMOD Gas Deposition Parameters for SO_2 and NO_x

Parameters	SO_2	NO_x
Diffusivity in air, cm^2/s	0.1509	0.1656
Diffusivity in water, cm^2/s	1.83×10^{-5}	1.4×10^{-5}
Cuticular resistance, s/cm	80	200
Henry's Law constant (Pa-m^3/mol)	72.37	84.43×10^3

SO_2 = sulfur dioxide; NO_x = oxides of nitrogen; cm^2/s = centimeters squared per second; s/cm = seconds per centimeter; Pa-m^3/mol = Pascal meters cubed per mol

4.C-7 AIR QUALITY MODELLING FOR THE WHALE TAIL OPEN PIT

4.C-7.1 Study Area and Air Quality Receptors

A 60 km x 60 km study area centered at the Whale Tail Pit was created to assess the effects of the Project on air quality. Receptors with 100 m spacing were placed along the Project boundary and a receptor grid with 1000 m spacing was used in the remainder of the domain. The boundary of the property owned by Agnico Eagle was used as the Project boundary where model-predicted concentrations of CACs are compared to the applicable ambient air quality guidelines or standards. Ground-level concentrations are also modelled at selected other locations (i.e., receptors) in the air quality study area. These discrete potential receptors include sites of historical and cultural significance to local Inuit including grave sites and locations representing traditional fishing and food caching areas located outside of the Project boundary. These receptors were identified based on Inuit Qaujimajatuqangit (IQ) workshops. These additional discrete receptors are listed in the Table 4-C-6 and plotted along with the other receptors in Figure 4-C-4.
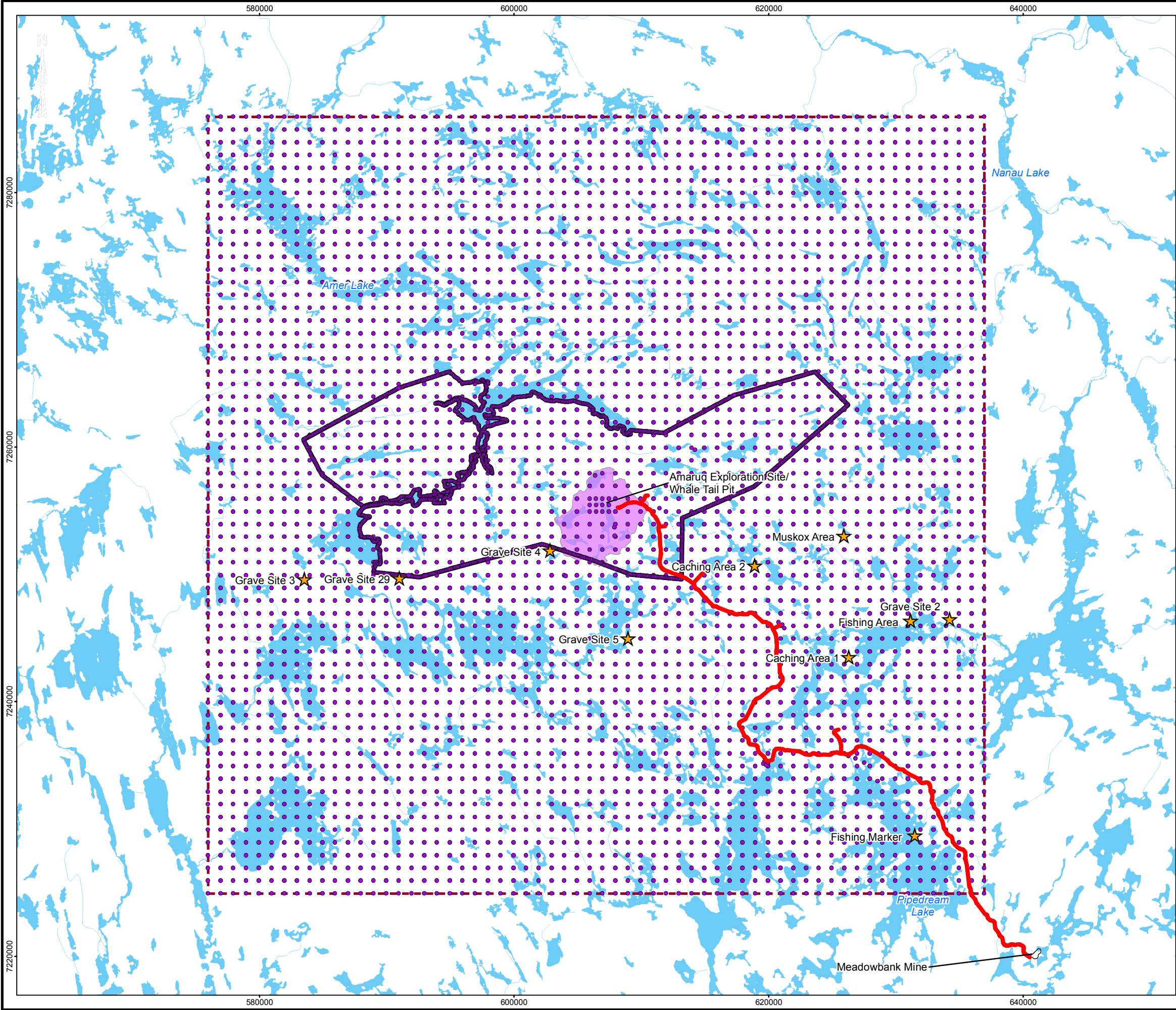
Table 4-C-6: Selected Discrete Potential Receptors

Name	UTM Easting, m	UTM Northing, m
Grave site 2	634234.21	7246485.51
Grave site 3	583533.29	7249634.93
Grave site 4	602839.54	7251874.51
Grave site 5	608952.28	7244984.88
Grave site 29	590991.49	7249714.39
Fishing marker	631472.21	7229489.38
Muskox area	625924.90	7253042.95
Fishing area	631153.61	7246367.03
Caching area 1	626295.73	7243523.39
Caching area 2	618910.00	7250697.00

4.C-7.2   Emission Sources Modelled for the Whale Tail Open Pit

The primary sources of air emissions from Project operations include the following:

- Whale Tail Pit, including:
    - in pit drilling and blasting;
    - in pit material handling;
    - un-paved road dust from the pit; and
    - exhaust from off-road equipment operating in the pit.
- wind erosion from ore pad and waste storage pile;
- power plant and camp heater; and
- un-paved road dust and vehicle exhaust from the section of haul road within the Project boundary;

Detailed methods associated with the Project's air emissions inventory are summarized in Appendix 4-B. The emission rates of the primary sources associated with the operation of the Whale Tail Pit are summarized in Table 4-C-7.

Snow cover and frozen ground during winter months provides natural mitigation of windblown fugitive dust and fugitive road dust from un-paved roads. Therefore, monthly variable emission rates for the Whale Tail Pit, haul road, and the road from Whale Tail Pit to the waste storage pile were used in the air quality model. The months classified as unfrozen season are June to October; months classified as the frozen season are November to May.

Table 4-C-7: Emission Rates Associated with Operation of the Whale Tail Pit

Source ID	Total Emission Rate in Unfrozen Season, g/s						Total Emission Rate in Frozen Season, g/s					
	TSP	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	TSP	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO
Hal_ROAD_IN	33.04	8.84	0.89	0.09	0.00	0.02	3.31	0.89	0.09	0.10	0.00	0.03
WHLPIT	37.36	10.84	1.88	15.60	0.27	12.15	5.36	2.28	1.03	15.60	0.27	12.15
ORE_PAD	2.04	1.04	0.23	1.30	0.00	0.33	2.04	1.04	0.23	1.30	0.00	0.33
ROAD2W	12.42	3.57	0.66	6.11	0.01	1.40	1.55	0.67	0.36	6.11	0.01	1.40
WASTE_PAD	1.42	0.69	0.10	0.00	0.00	0.00	1.42	0.69	0.10	0.00	0.00	0.00
POWERP1	0.19	0.19	0.18	6.38	0.03	1.46	0.19	0.19	0.18	6.38	0.03	1.46
POWERP2	0.19	0.19	0.18	6.38	0.03	1.46	0.19	0.19	0.18	6.38	0.03	1.46
Heater	0.01	0.00	0.00	0.08	0.01	0.02	0.01	0.00	0.00	0.08	0.01	0.02

g/s = grams per secondTSP = total suspended particulate; PM_{10} = particulate matter smaller than 10 micrometers in aerodynamic diameter; $PM_{2.5}$ = particulate matter smaller than 2.5 micrometers in aerodynamic diameter; NO_x = oxides of nitrogen; SO_2 = sulfur dioxide; CO = carbon monoxide

Figure 4-C-5 illustrates the locations of the emission sources associated with the operation of the Whale Tail Pit. Within the AERMOD model, these emissions are modelled as "open pit". The depth of the open pit in 2020 is planned at 50 m. The total volume of the open pit is 25,235,546 m^3. As AERMOD can only model a rectangular open pit, the Whale Tail Pit was modelled as a rectangle (1320m x 540m). The model pit's rectangle was then rotated 30 degrees to enclose and better represent the actual Whale Tail Pit. By conserving the overall volume of the pit, the effective depth of the modelled pit is 35.4 m. Since the actual pit will be approximately 50 m, not 35.4 m, emissions from the Whale Tail open pit are modelled relatively conservatively (i.e., less emissions are expected to leave the pit than those predicted in the assessment)
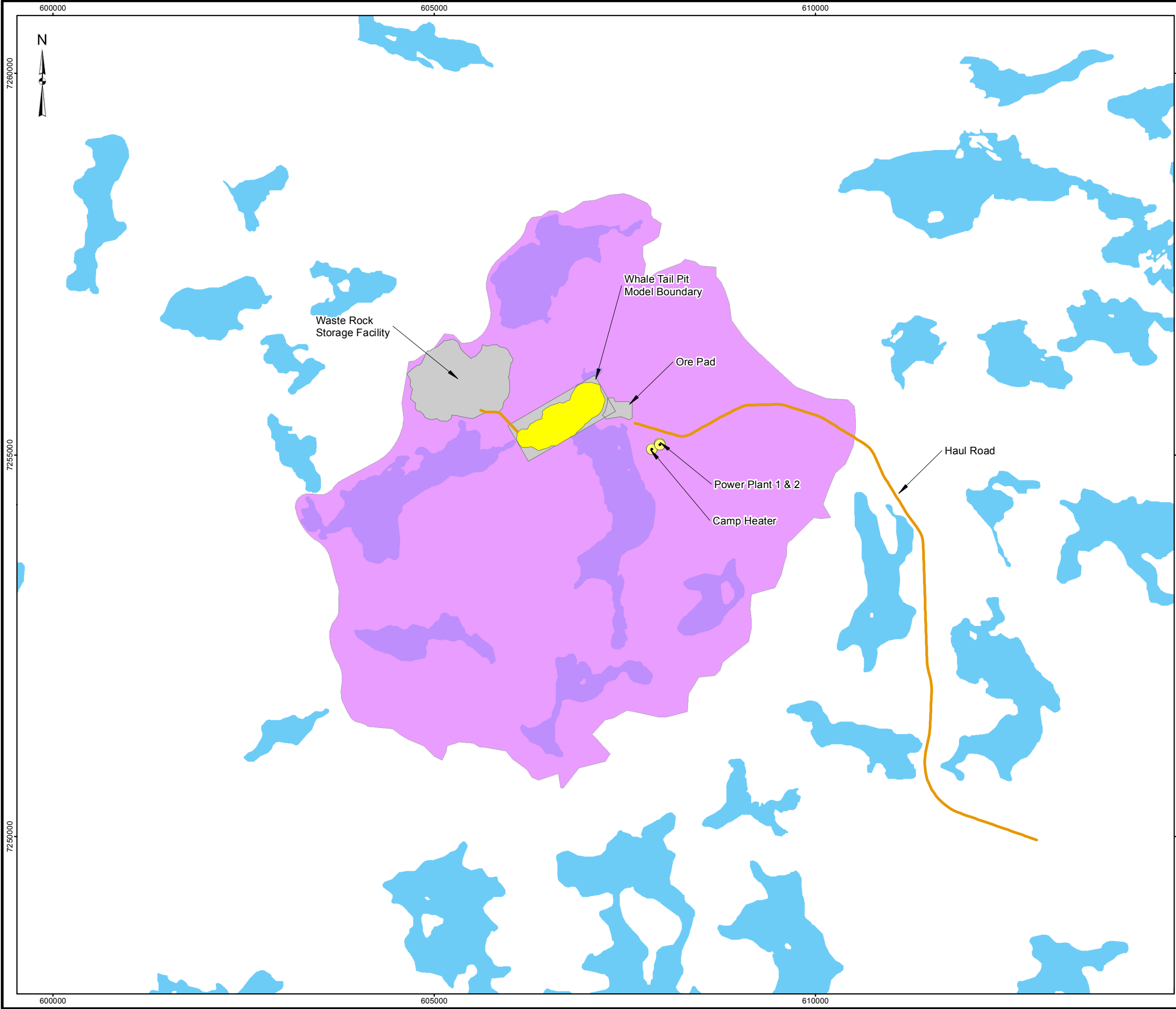
The haul road inside the Project boundary and the haul road from the pit to waste storage pile were modelled as a series of volume sources. The volume sources parameters were calculated from the vehicle height (5.1 m) and road width (9.5 m) (US EPA 2012). The volume source parameters are as follows:

■ emissions release height: 4.33 m;

■ initial vertical dimension: 4.03 m; and

■ initial lateral dimension: 14.39 m and 14.09 m for haul road and road from the pit to waste storage pile, respectively.

The ore pad and waste storage piles were modelled as area polygon sources. It was assumed that the emissions occur at the ground level. The power plant and camp heater emissions were modelled as point sources. The stack parameters for these sources are as follows:

■ Release height: 30.5 m;

■ Gas exit temperature: 600 K;

■ Stack inside diameter: 1.2 m; and

■ Gas exit velocity: 17.3 m/s.

LEGEND

- ⊙ EMISSION POINT SOURCE
- — EMISSION LINE SOURCE (MODEL)
- ▮ WHALE TAIL PIT
- ▮ EMISSION AREA SOURCE (MODEL)
- ▮ PROJECT DISTURBANCE AREA
- ▮ WATERBODY

Waste Rock Storage Facility

Whale Tail Pit Model Boundary

Ore Pad

Power Plant 1 & 2

Camp Heater

Haul Road

N

REFERENCE
1. BASE DATA OBTAINED FROM AGNICO EAGLE MINES LIMITED.
2. WATERCOURSE AND WATERBODY DATA OBTAINED FROM CANVEC © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
3. INSET MAP DATA OBTAINED FROM ESRI
DATUM: NAD 83 CSRS PROJECTION: UTM ZONE 14

1   0   1
KILOMETRES

PROJECT
AGNICO EAGLE MINES LIMITED:
MEADOWBANK DIVISION
WHALE TAIL PIT PROJECT

AGNICO EAGLE

TITLE
EMISSION SOURCES FOR THE AIR QUALITY MODELING OF WHALE TAIL PIT

PROJECT	1541520	FILE No.		
DESIGN	ZY	2016-03-02	SCALE AS SHOWN	REV. A
GIS	SBM	2016-05-11		
CHECK	CMc	2016-05-11		
REVIEW	CM	2016-05-11		

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FIGURE 4-C-5

4.C-7.3 Air Quality Model Results for the Whale Tail Open Pit

To aid in interpretation of the air quality dispersion modelling results, the results are presented in tabular format. The summary tables include model predictions, model predictions plus background concentrations of the relevant CAC's, and the ambient air quality criteria for the CAC. In addition, isopleth maps showing the 1-hour, 8-hour, 24-hour, or annual maximum predictions are included in the assessment. For clarity, the isopleth maps for most compounds present contour levels for 100%, 50%, and 25% of the applicable air quality guideline or standard. For those compounds that have low model predicted concentrations compared to air quality standards, contour levels that best represent the spatial patterns of the model results were used.

The following sections present the predicted CO, NO_2, SO_2, $PM_{2.5}$, PM_{10}, and TSP concentrations from the AERMOD model. For each compound, the peak model predicted concentration refers to the highest 1-hour, 8-hour, and 24-hour concentration over the 5-year simulation. The maximum model predicted concentration refers to the following:

■ For 1-hour predictions, the maximum concentrations represent the maximum 9th highest concentration over the 5-year simulation.

■ For 8-hour predictions, the maximum concentrations represent the maximum 5th highest concentration over the 5-year simulation.

■ For the 24-hour (daily) predictions of $PM_{2.5}$, the maximum concentrations represent the maximum 98th percentile of model predicted concentration over the 5-year simulation.

■ For the 24-hour (daily) predictions of all other pollutants, the maximum concentrations represent the maximum 2nd highest concentration over 5-year simulation; and

■ For averaging times longer than 24-hours, no modelled concentrations are eliminated from the maximum predicted value. The maximum concentrations represent the maximum 1st highest concentration over the 5-year simulation.

The maximum modelled predicted concentrations outside the Project boundary for each averaging period were then compared with the applicable ambient air standards outlined in Table 4.C-2. This means of expressing the maximum predicted concentrations is consistent with reporting requirements from other jurisdictions within Canada, for example the Alberta and Saskatchewan Air Quality Modelling Guidelines.

4.C-7.3.1 Carbon Monoxide (CO) Predictions

The model predicted 1-hour and 8-hour CO concentrations are summarized in Table 4-C-8 and shown in Figures 4-C-6 and 4-C-7. The peak and maximum CO concentrations outside the Project boundary are all lower than the ambient air standards. The maximum 1-hour and 8-hour CO concentrations occur at the southern Project boundary. Both the 1-hour and 8-hour maximum concentrations are less than 10% of the ambient standards. The 1-hour and 8-hour CO concentrations at the selected receptors (Table 4-C-9) are all lower than the respective air quality standards.

Table 4-C-8: Summary Table of Model Predicted CO Concentrations Outside Project Boundary

| Results	1-hour	8-hr
Peak CO Concentration ($\mu g/m^3$)	2181	391
Maximum CO Concentration ($\mu g/m^3$)	714	174
Project Contribution Combined With Background Concentration		
Peak CO Concentration ($\mu g/m^3$)	2,570	776
Maximum CO Concentration ($\mu g/m^3$)	1,103	559
Number of occurrences above criteria	0	0
Distance (km)	3.8	3.8
Direction	S	S
Ambient Air Quality Standards ($\mu g/m^3$)	**15,000**	**6,000**

$\mu g/m^3$ = micrograms per cubic metre; km = kilometre

Table 4-C-9: Model Predicted CO Concentration at Selected Potential Receptor Locations

Health Receptor	1-hour Peak ($\mu g/m^3$)	1-hour Maximum ($\mu g/m^3$)	8-hour Peak ($\mu g/m^3$)	8-hour Maximum ($\mu g/m^3$)
Grave site 2	633	416	426	390
Grave site 3	593	432	436	394
Grave site 4	1,615	604	583	454
Grave site 5	1,113	590	522	438
Grave site 29	900	432	470	401
Fishing marker	485	418	401	391
Muskox	581	440	412	399
Fishing area	491	420	400	393
Caching area 1	489	429	403	392
Caching area 2	676	499	424	405

$\mu g/m^3$ = micrograms per cubic metre
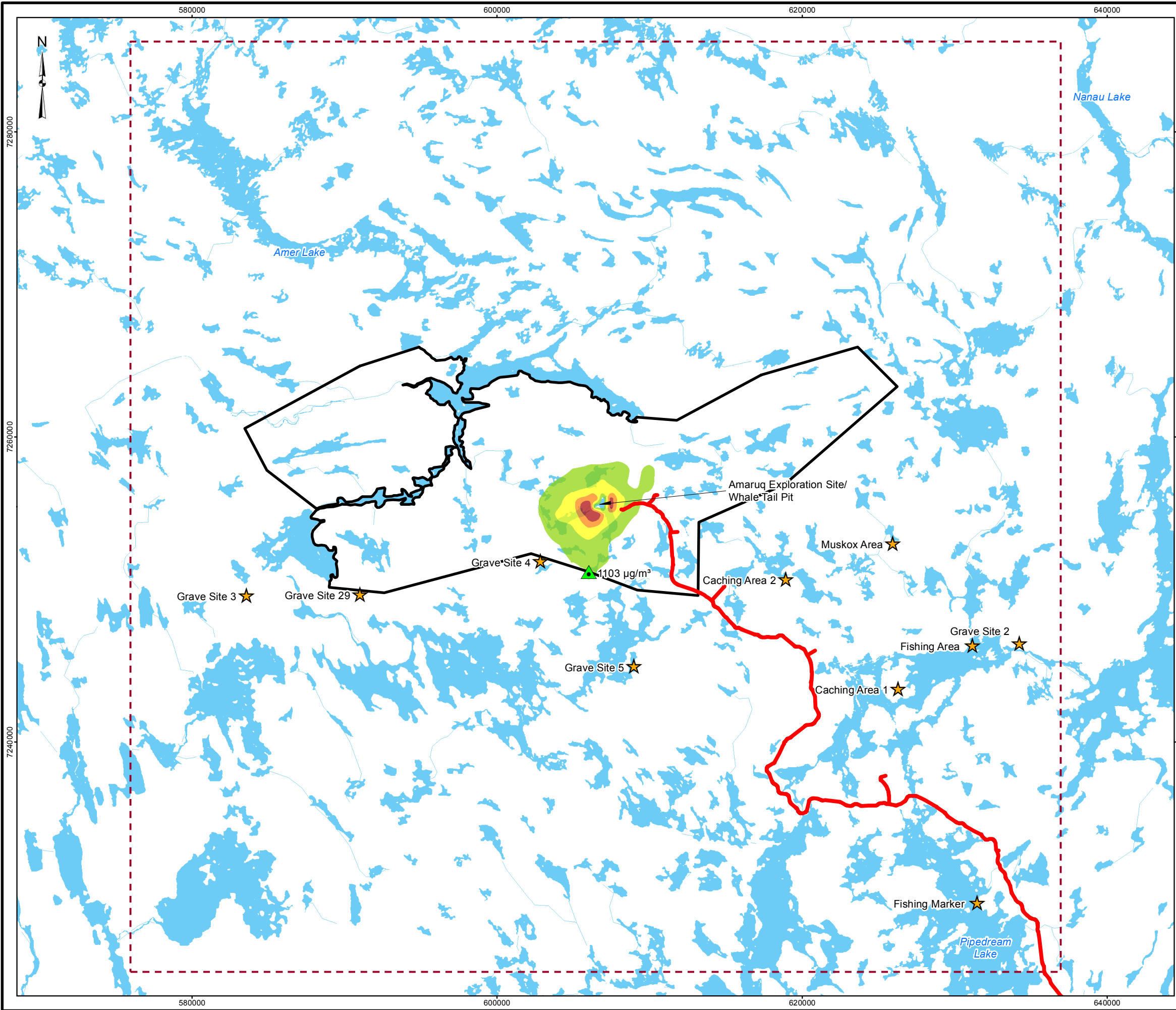
LEGEND

- ▲ MAXIMUM POINT OF IMPINGEMENT
- ★ DISCRETE RECEPTOR
- —— PROPERTY BOUNDARY
- - - - MODEL BOUNDARY
- —— PROPOSED WHALE TAIL PIT HAUL ROAD
- WATERCOURSE
- WATERBODY

CONCENTRATION (µg/m³)

- 0 - 1,000 (BLANK)
- 1,000 - 1,500
- 1,500 - 2,000
- 2,000 - 2,500
- > 2,500

Nanau Lake

Amer Lake

Amaruq Exploration Site/
Whale Tail Pit

Muskox Area ★

Grave Site 4 ★
▲ 1103 µg/m³

Caching Area 2 ★

Grave Site 3 ★
Grave Site 29 ★

Grave Site 2 ★
Fishing Area ★

Grave Site 5 ★

Caching Area 1 ★

Fishing Marker ★

Pipedream Lake

REFERENCE

1. PROJECT BASE DATA OBTAINED FROM AGNICO EAGLE MINES LIMITED.
2. WATERCOURSE AND WATERBODY DATA OBTAINED FROM CANVEC © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.

5   0   5
KILOMETRES

PROJECT
AGNICO EAGLE

AGNICO EAGLE MINES LIMITED:
MEADOWBANK DIVISION
WHALE TAIL PIT PROJECT

TITLE

MODEL PREDICTED 1-HOUR CO CONCENTRATIONS

PROJECT	1541520	FILE No.	
DESIGN	ZY	2016-03-02	SCALE AS SHOWN	REV. A
GIS	SBM	2016-05-11		
CHECK	CMc	2016-05-11		
REVIEW	CM	2016-05-11		

Golder Associates

FIGURE 4-C-6

LEGEND

△ MAXIMUM POINT OF IMPINGEMENT

☆ DISCRETE RECEPTOR

——— PROPERTY BOUNDARY

− − − MODEL BOUNDARY

——— PROPOSED WHALE TAIL PIT HAUL ROAD

WATERCOURSE

WATERBODY

CONCENTRATION (µg/m³)

☐	0 - 500
🟩	500 - 1,000
🟨	1,000 - 1,500
🟧	1,500 - 2,000
🟥	2,000 - 2,500

Nanau Lake

Amer Lake

Amaruq Exploration Site/
Whale Tail Pit

Muskox Area ☆

△ 559.3 µg/m³

Grave Site 4 ☆

Caching Area 2 ☆

Grave Site 3 ☆

Grave Site 29 ☆

Grave Site 2 ☆
Fishing Area ☆

Grave Site 5 ☆

Caching Area 1 ☆

Fishing Marker ☆

Pipedream Lake

REFERENCE

1. PROJECT BASE DATA OBTAINED FROM AGNICO EAGLE MINES LIMITED.
2. WATERCOURSE AND WATERBODY DATA OBTAINED FROM CANVEC © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.

5   0   5
KILOMETRES

PROJECT

AGNICO EAGLE

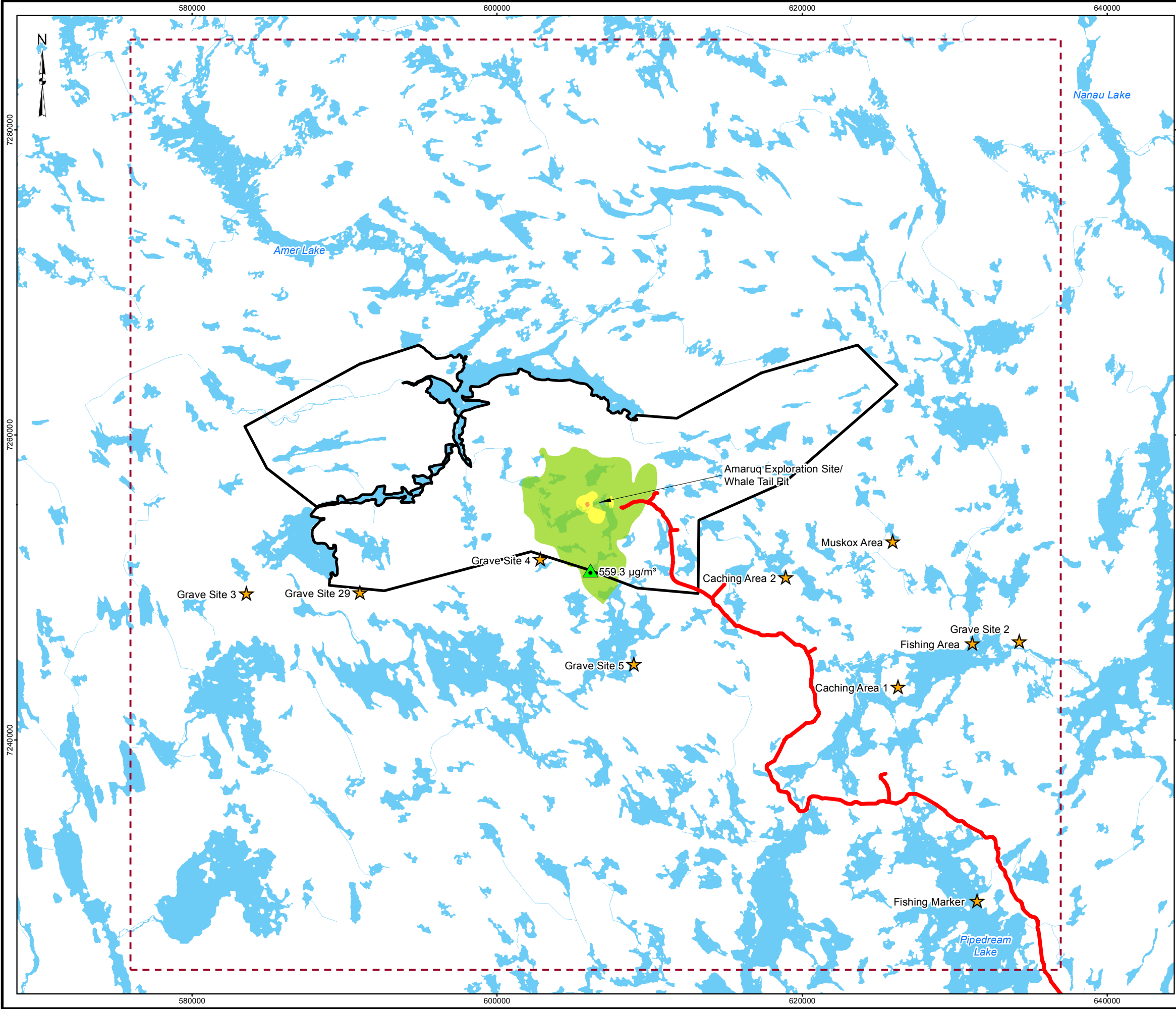AGNICO EAGLE MINES LIMITED:
MEADOWBANK DIVISION
WHALE TAIL PIT PROJECT

TITLE

**MODEL PREDICTED 8-HOUR
CO CONCENTRATIONS**

		PROJECT	1541520	FILE No.	
		DESIGN	ZY	2016-03-02	SCALE AS SHOWN	REV. A
Golder Associates		GIS	SBM	2016-05-11		
		CHECK	CMc	2016-05-11		
		REVIEW	CM	2016-05-11	**FIGURE 4-C-7**

4.C-7.3.2 Nitrogen Oxidie (NO$_2$) Predictions

The model predicted 1-hour, 24-hour, and annual NO$_2$ concentrations are summarized in Table 4-C-10 and shown in Figures 4-C-8 to 4-C-10. The maximum model predicted 1-hour, 24-hour, and annual NO$_2$ concentrations outside the Project boundary are 150, 57.9, and 8.5 µg/m^3, respectively. The maximum 1-hour, 24-hour, and annual NO$_2$ concentrations occur along the southern Project boundary. The maximum 1-hour, 24-hour, and annual NO$_2$ concentrations and the concentrations at the selected receptors (Table 4.C-11) are all lower than the respective air quality standards.

Table 4-C-10: Summary Table of Model Predicted NO$_2$ Concentrations

| Results	1-hour	24-hour	Annual
Peak NO$_2$ Concentration (µg/m^3)	329	53.2	—
Maximum NO$_2$ Concentration (µg/m^3)	137	46.5	3.5
Project Contribution Combined With Background Concentration			
Peak NO$_2$ Concentration (µg/m^3)	342	64.6	—
Maximum NO$_2$ Concentration (µg/m^3)	150	57.9	8.5
Number of occurrences above criteria	0	0	0
Distance (km)	3.8	4.1	4.1
Direction	S	S	S
Ambient Air Quality Standards (µg/m^3)	**400**	**200**	**60**

µg/m^3 = micrograms per cubic metre; km = kilometre

Table 4-C-11: Model Predicted NO$_2$ Concentrations at Selected Potential Receptor Locations

Health Receptor	1-hour Peak (µg/m^3)	1-hour Maximum (µg/m^3)	24-hour Peak (µg/m^3)	24-hour Maximum (µg/m^3)	Annual (µg/m^3)
Grave site 2	87.9	50.0	16.1	15.0	5.1
Grave site 3	89.9	60.0	23.2	17.3	5.1
Grave site 4	215	94.5	26.5	24.0	5.6
Grave site 5	156	85.2	29.5	27.3	6.1
Grave site 29	120	60.8	17.3	17.3	5.2
Fishing marker	74.8	54.1	18.4	18.1	5.2
Muskox	86.6	63.8	15.9	15.8	5.2
Fishing area	79.7	54.1	15.8	14.9	5.1
Caching area 1	72.5	56.2	17.7	17.1	5.2
Caching area 2	100	75.8	20.6	17.6	5.4

µg/m^3 = micrograms per cubic metre
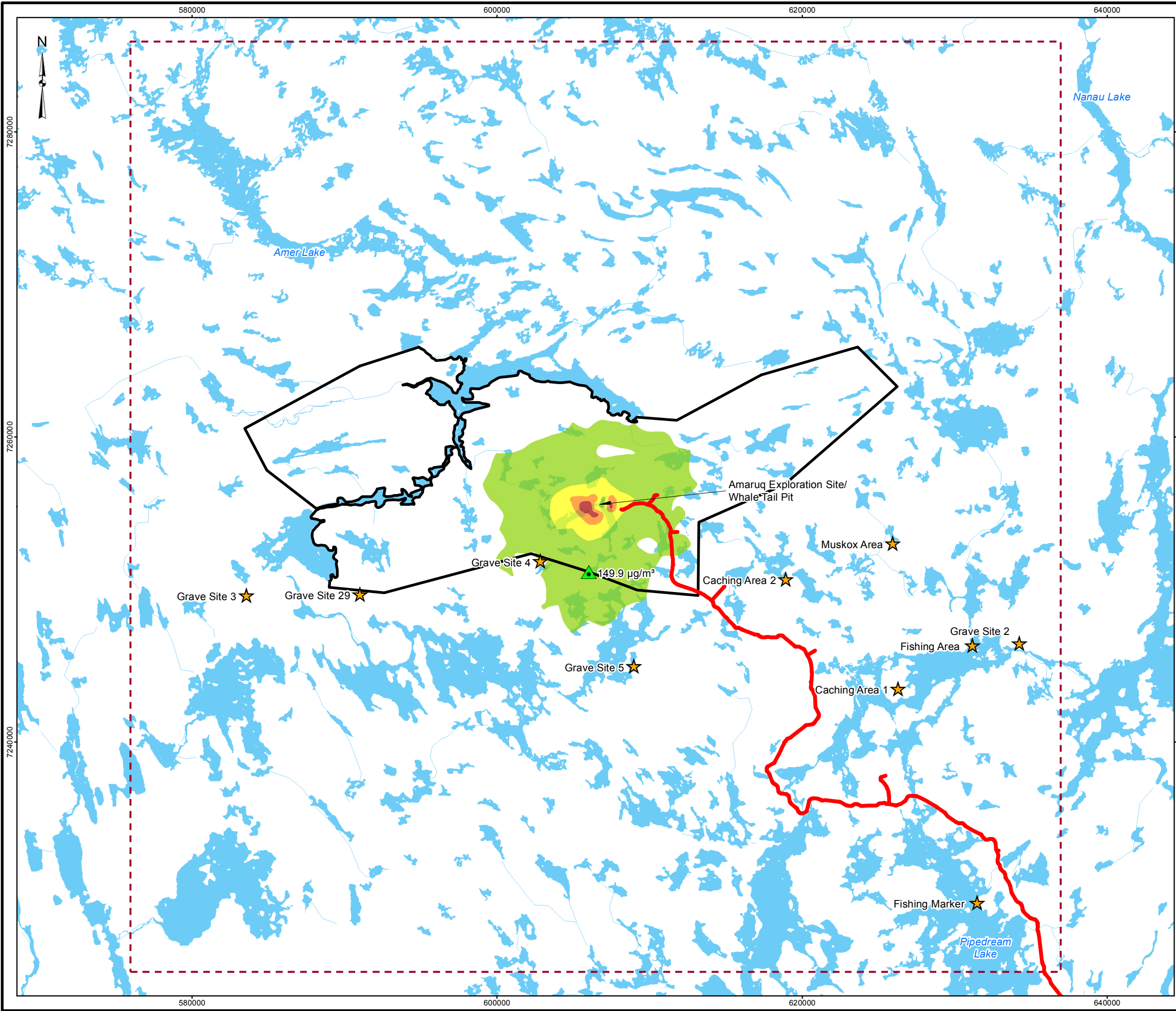
LEGEND

⬘ MAXIMUM POINT OF IMPINGEMENT

⭐ DISCRETE RECEPTOR

— PROPERTY BOUNDARY

- - - MODEL BOUNDARY

— PROPOSED WHALE TAIL PIT HAUL ROAD

WATERCOURSE

WATERBODY

CONCENTRATION (µg/m³)

☐ 0 - 100

☐ 100 - 200

☐ 200 - 300

☐ 300 - 400

☐ > 400

Nanau Lake

Amer Lake

Amaruq Exploration Site/
Whale Tail Pit

Muskox Area ⭐

Grave Site 4 ⭐

⬘ 149.9 µg/m³

Caching Area 2 ⭐

Grave Site 3 ⭐

Grave Site 29 ⭐

Grave Site 2 ⭐

Fishing Area ⭐

Grave Site 5 ⭐

Caching Area 1 ⭐

Fishing Marker ⭐

Pipedream Lake

REFERENCE

1. PROJECT BASE DATA OBTAINED FROM AGNICO EAGLE MINES LIMITED.
2. WATERCOURSE AND WATERBODY DATA OBTAINED FROM CANVEC © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.

5   0   5
KILOMETRES

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED:
MEADOWBANK DIVISION
WHALE TAIL PIT PROJECT

TITLE

**MODEL PREDICTED 1-HOUR
NO₂ CONCENTRATIONS**

PROJECT	1541520	FILE No.		
DESIGN	ZY	2016-03-02	SCALE AS SHOWN	REV. A
GIS	SM/LS	2016-05-11		
CHECK	CMc	2016-05-11		
REVIEW	CM	2016-05-11		

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FIGURE 4-C-8