APPENDIX 4-C

Air Quality Modelling Technical Summary

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
SO_2				
1-hour	450	172	—[b]	—
24-hour	150	48	—	—
Annual	30	8	—	—
NO_2				
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	—	—	—
PM_{10}				
24-hour	—	—	50[d]	—
$PM_{2.5}$				
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

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.

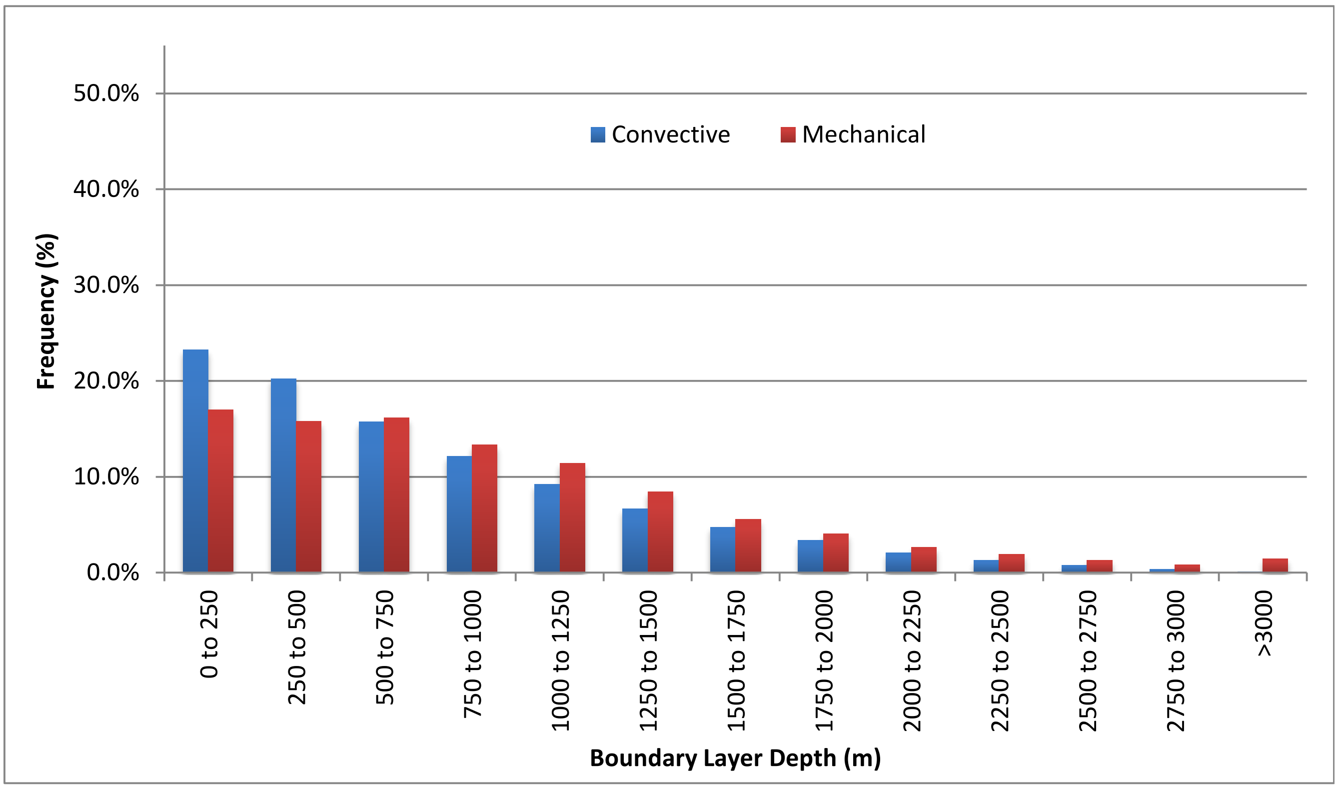


Figure 4-C-1: AERMET Derived Mixing Heights

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.

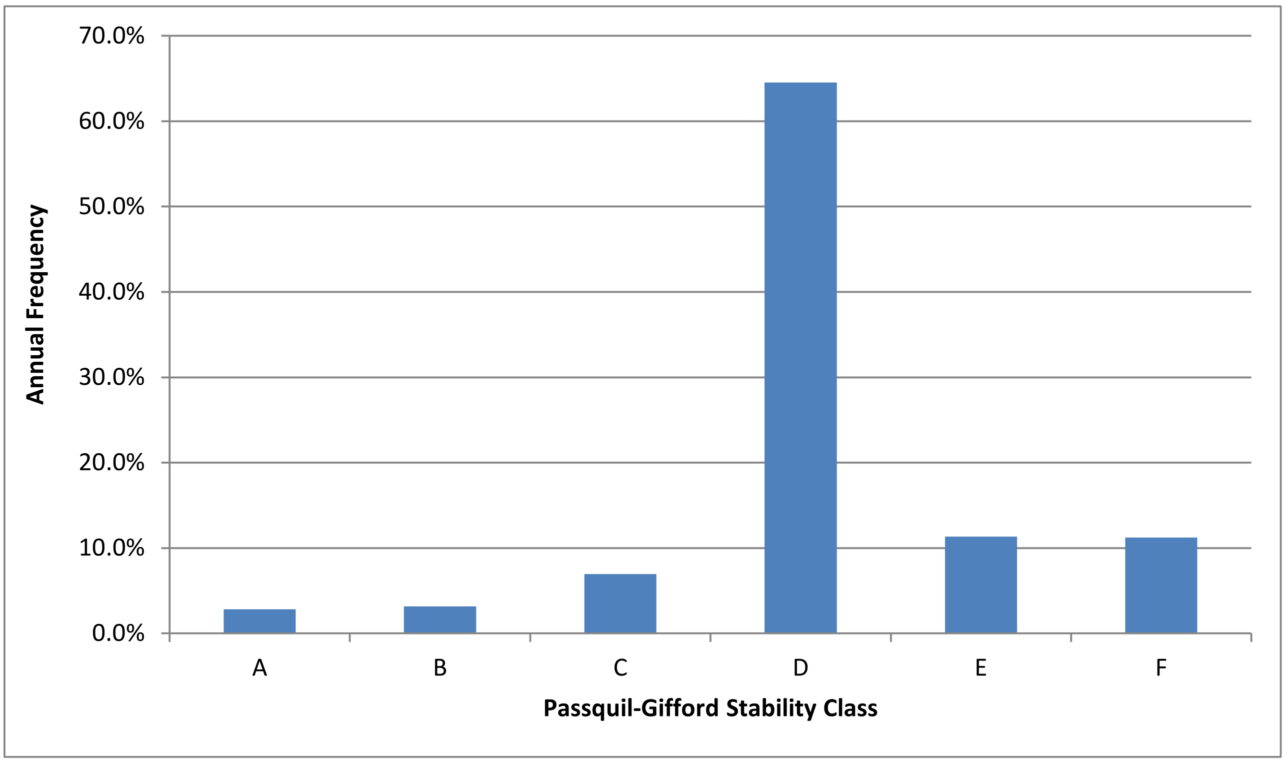
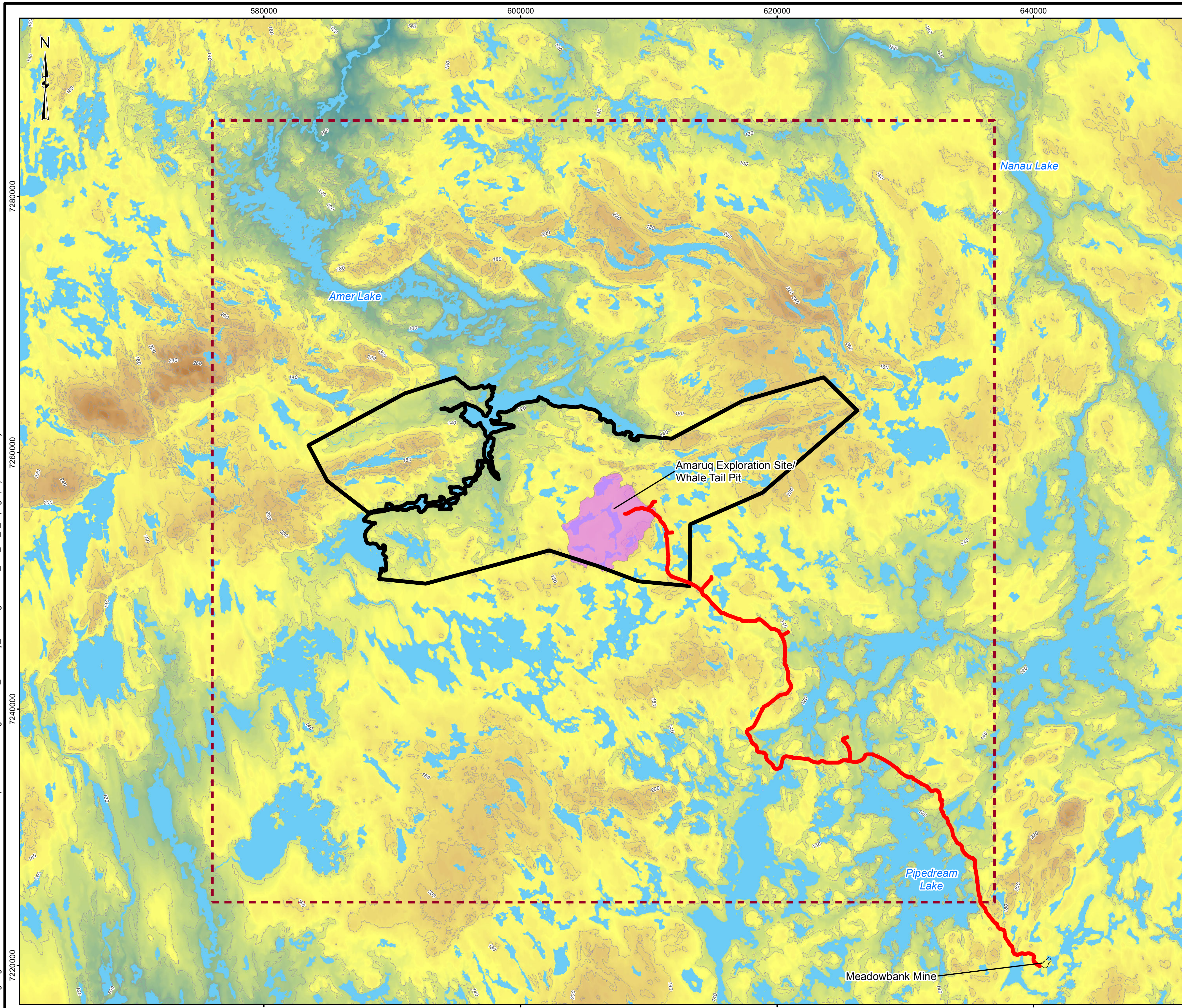


Figure 4-C-2: AERMET Derived Stability Classes

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.



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

REFERENCE

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

6 0 6
KILOMETRES

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

TITLE

TOPOGRAPHY WITHIN THE STUDY AREA

Golder Associates

PROJECT		1541520	FILE No.	
DESIGN	ZY	2016-03-02	SCALE AS SHOWN	REV. A
GIS	SBM	2016-05-11	FIGURE 4-C-3	
CHECK	CMc	2016-05-11		
REVIEW	CM	2016-05-11		

\\golder.gds\gal\Saskatoon\GIS\GIS\2015\1524321 AEM Amaruq Whale Tail EIS\Figures\1400_AirQuality_Modeling\1541520_FIG_4C_3_Topography within Study Area.mxd

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 ($Pa\text{-}m^3/mol$)	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; $Pa\text{-}m^3/mol$ = Pascal meters cubed per mol

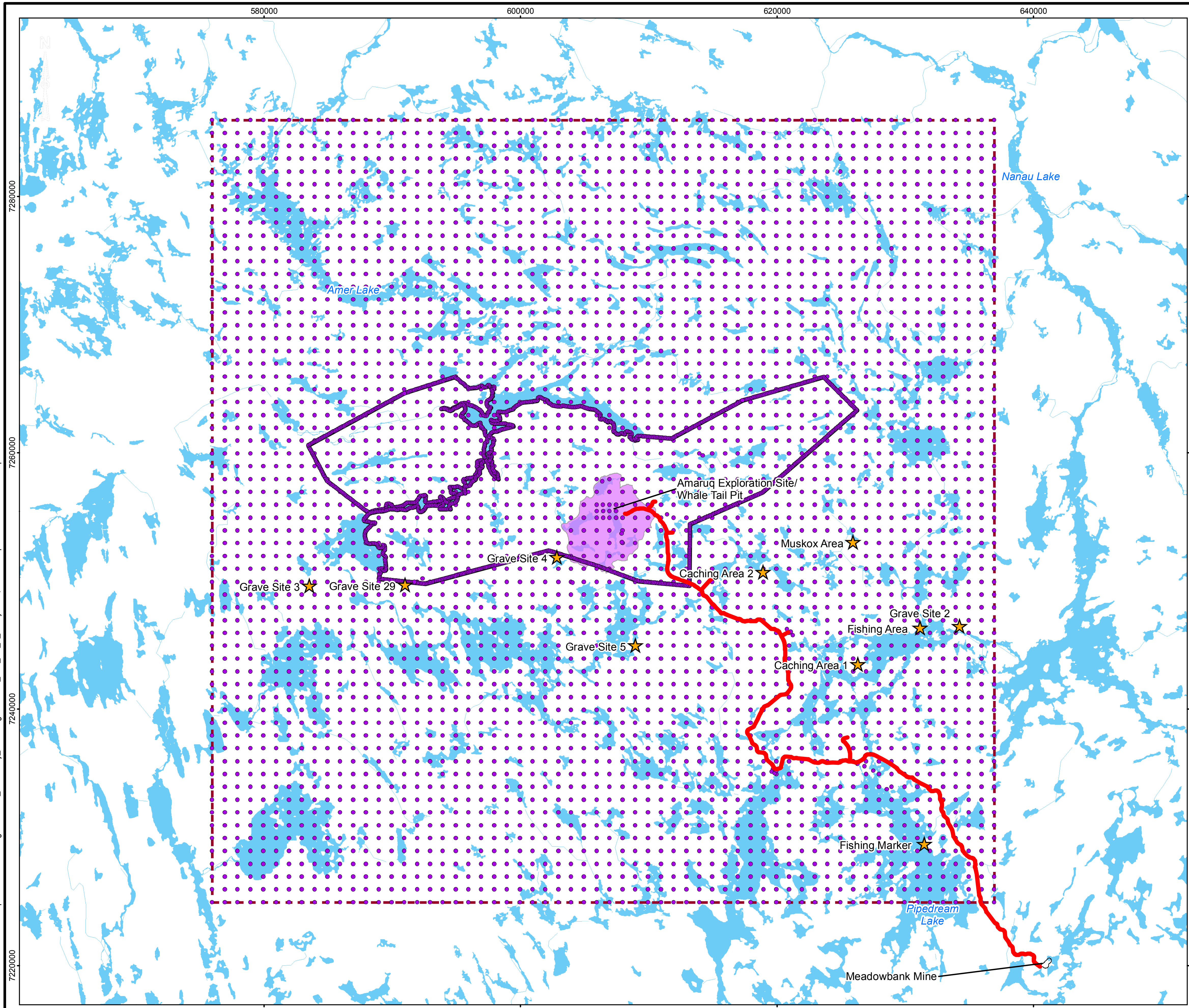
4.C-7 AIR QUALITY MODELLING FOR THE WHALE TAIL OPEN PIT

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



LEGEND

- MODEL GRID RECEPTORS
- DISCRETE RECEPTOR
- PROPERTY BOUNDARY
- MODEL BOUNDARY
- PROPOSED WHALE TAIL PIT HAUL ROAD
- WATERCOURSE
- WATERBODY
- DISTURBANCE AREA

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.

6 0 6
KILOMETRES

PROJECT

AGNICO EAGLE MINES LIMITED:
MEADOWBANK DIVISION
WHALE TAIL PIT PROJECT

TITLE

STUDY AREA, GRID RECEPTORS AND SELECTED DISCRETE RECEPTORS

PROJECT		1541520	FILE No.	
DESIGN	ZY	2016-03-02	SCALE AS SHOWN	REV. A
GIS	SBM	2016-05-13	**FIGURE 4-C-4**	
CHECK	CMc	2016-05-13		
REVIEW	CM	2016-05-13		

G:\2015\1524321 AEM Amaruq Whale Tail EIS\Figures\1400_AirQuality_Modeling\1541520_FIG_4C_4_Study Area, Grid Receptors and Discreet receptors.mxd

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

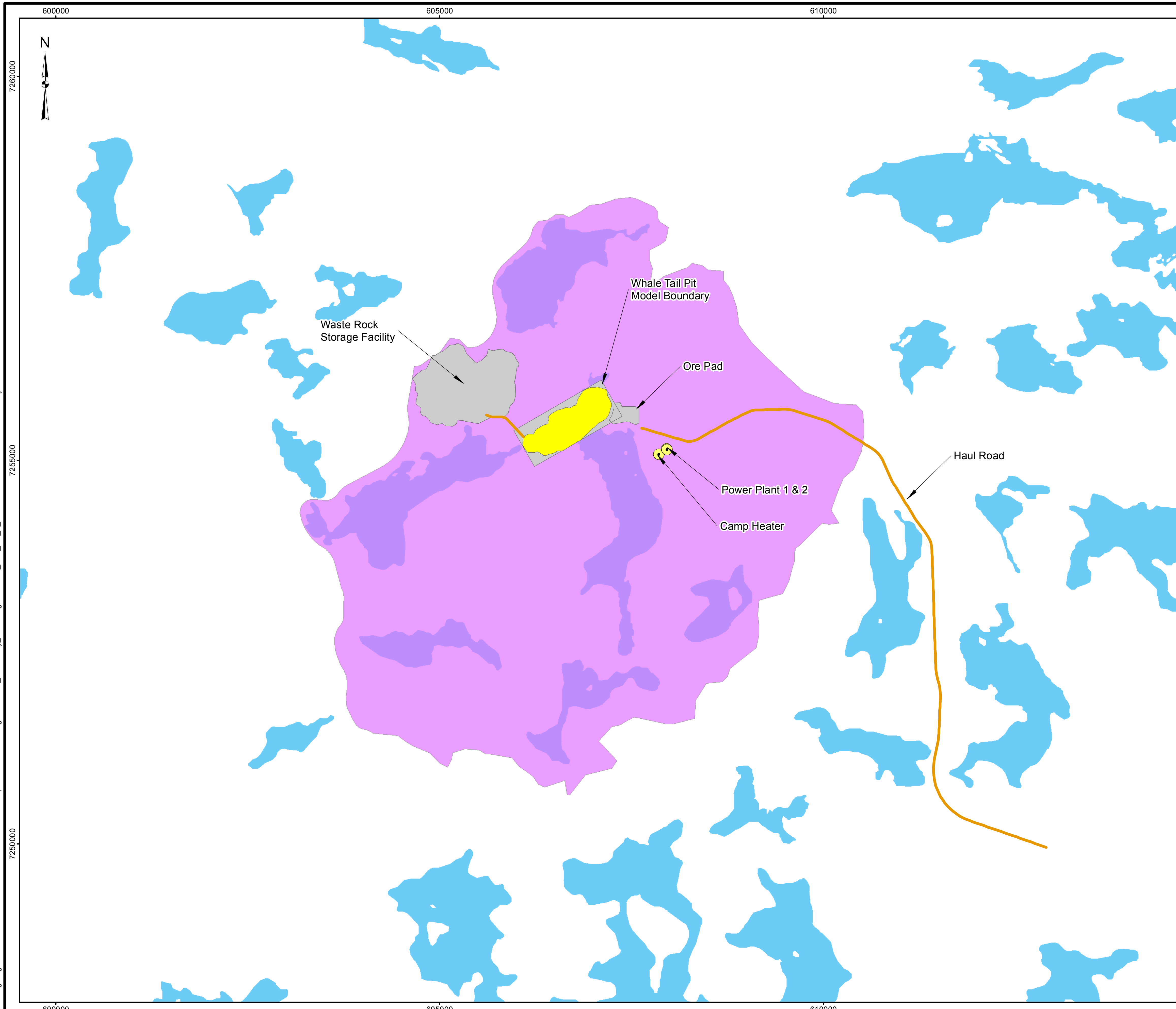
Figure 4-C-5 illustrates the locations of the emission sources associated with the operation of the Whale Tail Pit. Within the AERMOD model, these emissions are modelled as "open pit". The depth of the open pit in 2020 is planned at 50 m. The total volume of the open pit is 25,235,546 m^3. As AERMOD 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

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

AGNICO EAGLE MINES LIMITED:
MEADOWBANK DIVISION
WHALE TAIL PIT PROJECT

TITLE

EMISSION SOURCES FOR THE AIR QUALITY MODELING OF WHALE TAIL PIT

Golder Associates

PROJECT		1541520	FILE No.
DESIGN	ZY	2016-03-02	SCALE AS SHOWN REV. A
GIS	SBM	2016-05-11	**FIGURE 4-C-5**
CHECK	CMc	2016-05-11	
REVIEW	CM	2016-05-11	

\\golder.gds\gal\Saskatoon\GIS\GIS\2015\1524321 AEM Amaruq Whale Tail EIS\Figures\1400_AirQuality_Modeling\1541520_FIG_4C_5_Emission Sources for the Air Quality Model.mxd

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

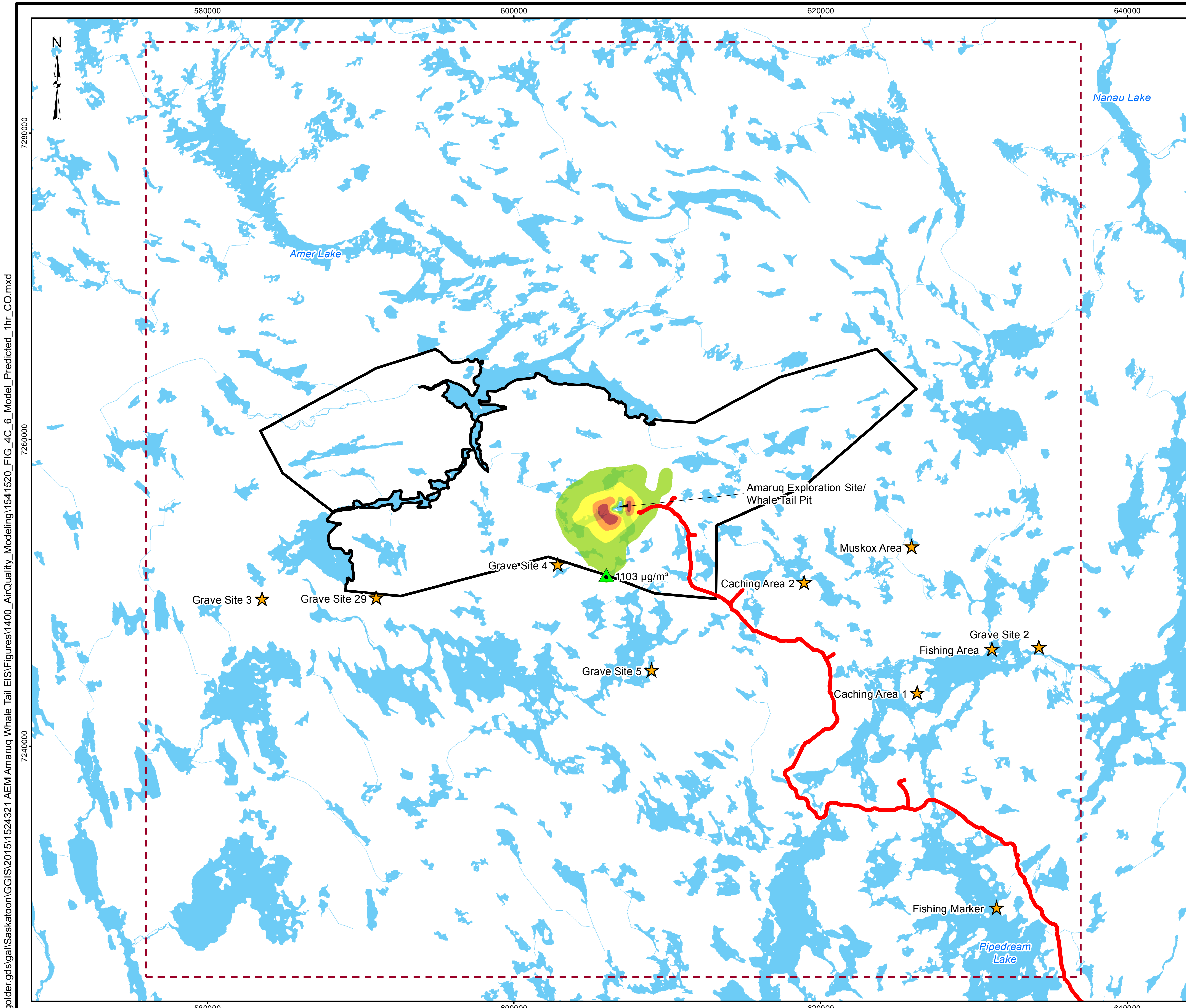
Results	1-hour	8-hr
Peak CO Concentration (µg/m³)	2181	391
Maximum CO Concentration (µg/m³)	714	174
Project Contribution Combined With Background Concentration		
Peak CO Concentration (µg/m³)	2,570	776
Maximum CO Concentration (µg/m³)	1,103	559
Number of occurrences above criteria	0	0
Distance (km)	3.8	3.8
Direction	S	S
Ambient Air Quality Standards (µg/m³)	**15,000**	**6,000**

µg/m³ = micrograms per cubic metre; km = kilometre

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

Health Receptor	1-hour Peak (µg/m³)	1-hour Maximum (µg/m³)	8-hour Peak (µg/m³)	8-hour Maximum (µg/m³)
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

µg/m³ = 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

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.

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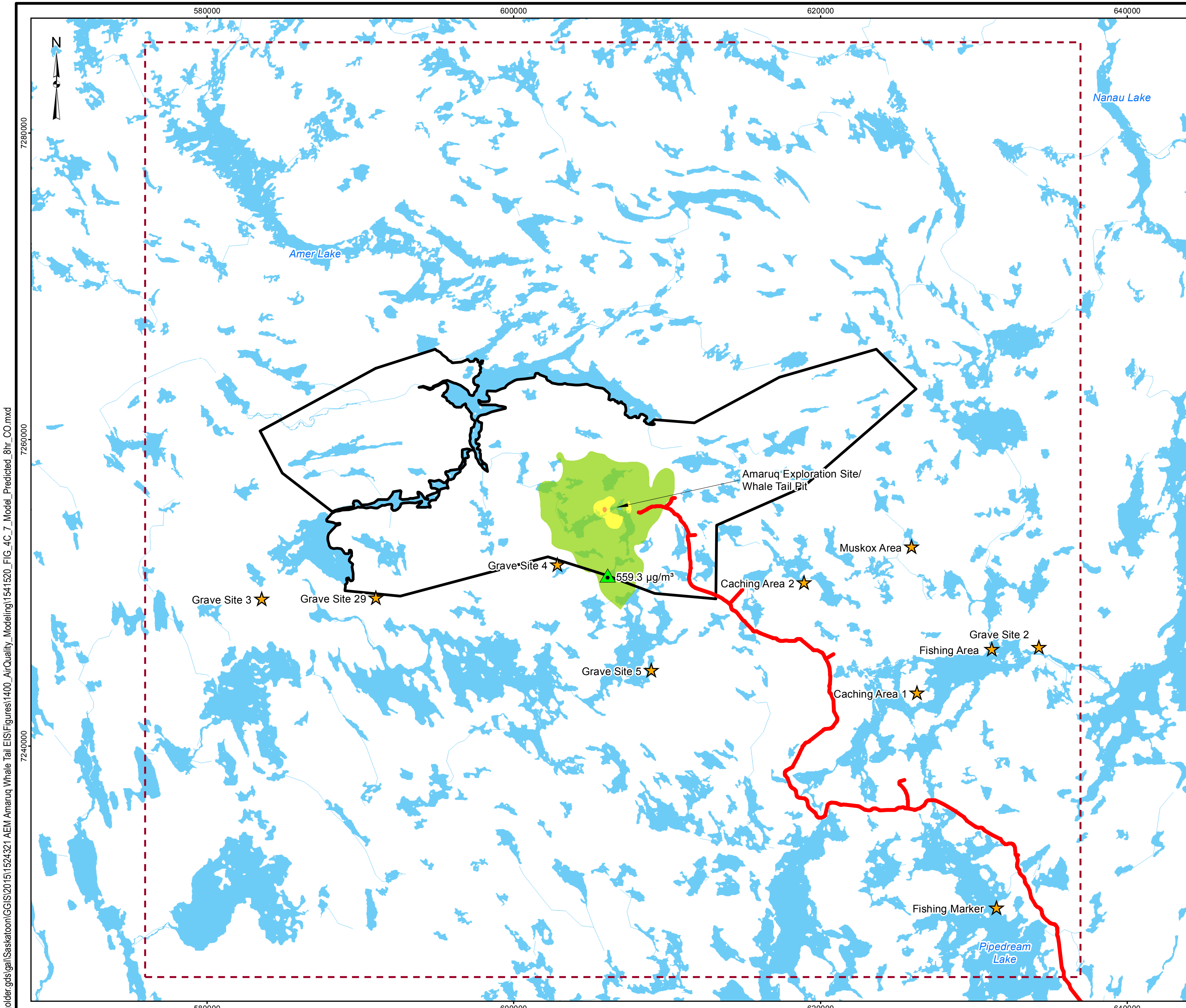
PROJECT
AGNICO EAGLE
AGNICO EAGLE MINES LIMITED:
MEADOWBANK DIVISION
WHALE TAIL PIT PROJECT

TITLE
MODEL PREDICTED 1-HOUR CO CONCENTRATIONS

Golder Associates

PROJECT		1541520	FILE No.	
DESIGN	ZY	2016-03-02	SCALE AS SHOWN	REV. A
GIS	SBM	2016-05-11	**FIGURE 4-C-6**	
CHECK	CMc	2016-05-11		
REVIEW	CM	2016-05-11		



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

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.

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

TITLE
MODEL PREDICTED 8-HOUR CO CONCENTRATIONS

Golder Associates

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

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/m³, 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

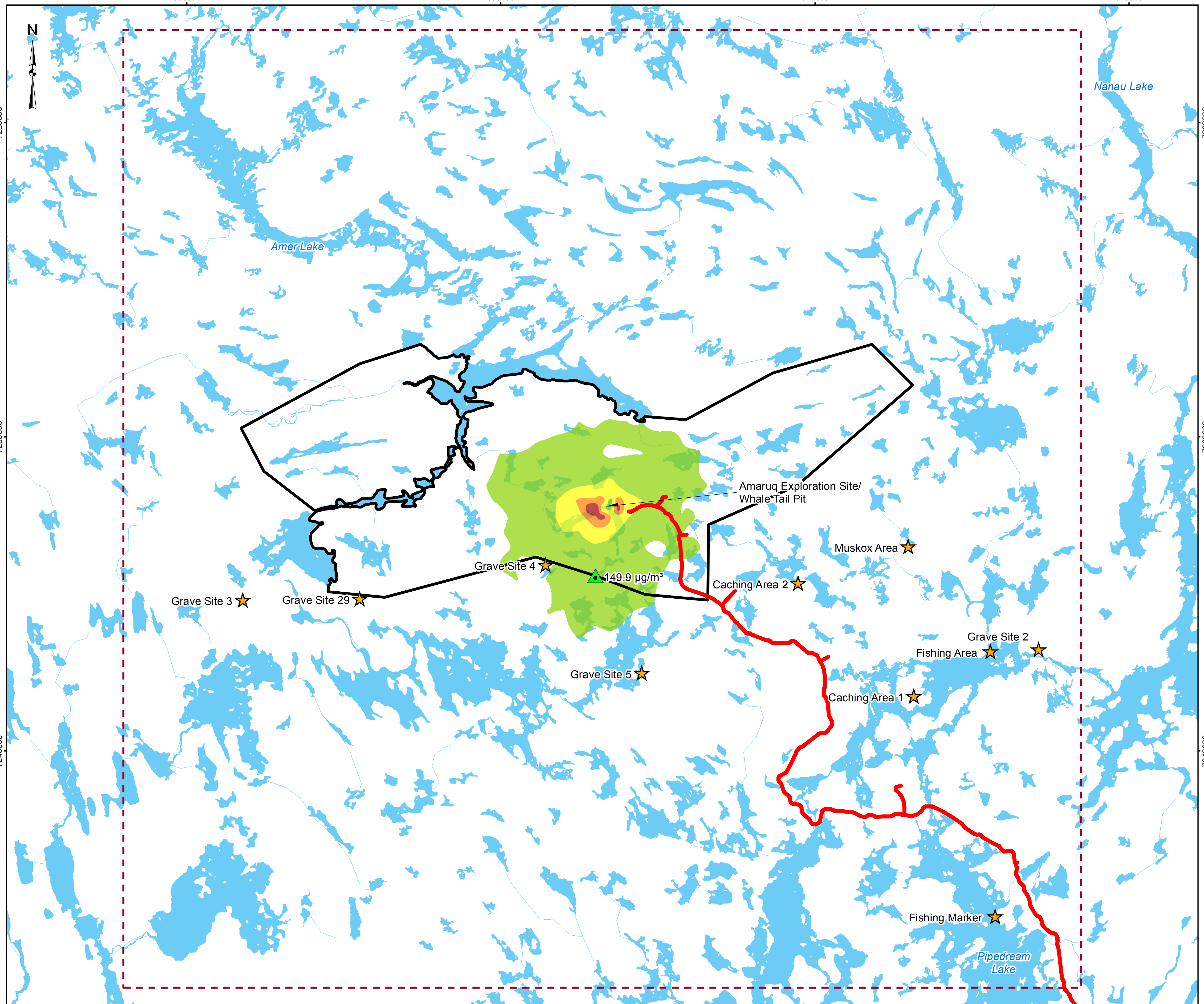
Results	1-hour	24-hour	Annual
Peak NO_2 Concentration (µg/m³)	329	53.2	—
Maximum NO_2 Concentration (µg/m³)	137	46.5	3.5
Project Contribution Combined With Background Concentration			
Peak NO_2 Concentration (µg/m³)	342	64.6	—
Maximum NO_2 Concentration (µg/m³)	150	57.9	8.5
Number of occurrences above criteria	0	0	0
Distance (km)	3.8	4.1	4.1
Direction	S	S	S
Ambient Air Quality Standards (µg/m³)	**400**	**200**	**60**

µg/m³ = 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/m³)	1-hour Maximum (µg/m³)	24-hour Peak (µg/m³)	24-hour Maximum (µg/m³)	Annual (µg/m³)
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/m³ = micrograms per cubic metre



\\golder.gds\gal\Saskatoon\GIS\2015\1524321 AEM Amaruq Whale Tail EIS\Figures\1400_AirQuality_Modeling\1541520_FIG_4C_8_Model_Predicted_1hr_NO2.mxd

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

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.

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AGNICO EAGLE

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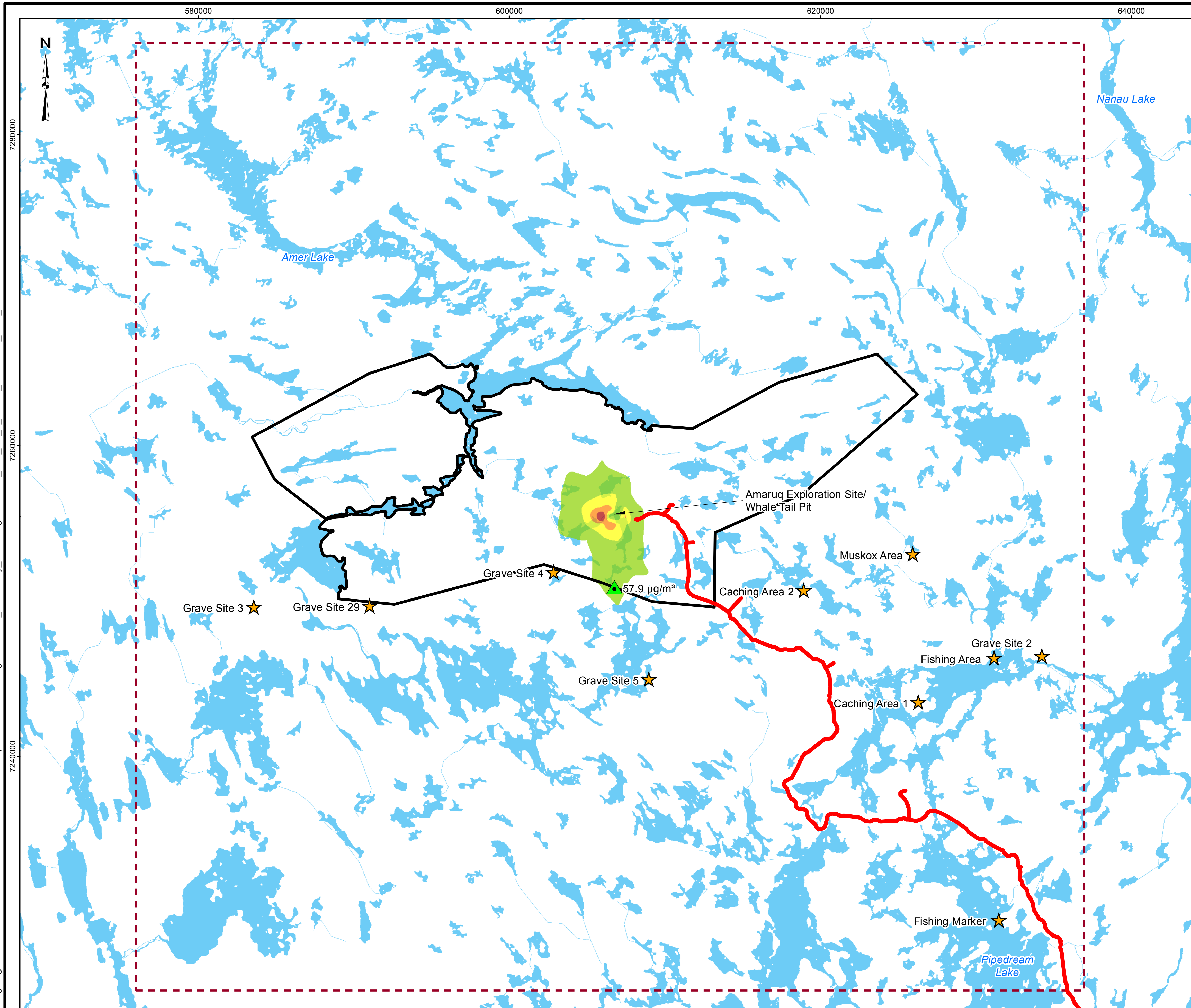
MEADOWBANK DIVISION
WHALE TAIL PIT PROJECT

TITLE

MODEL PREDICTED 1-HOUR NO_2 CONCENTRATIONS

Golder Associates

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	**FIGURE 4-C-8**
REVIEW	CM	2016-05-11	



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LEGEND

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

CONCENTRATION (µg/m³)

- 0 - 50
- 50 - 100
- 100 - 150
- 150 - 200
- > 200

REFERENCE

1. PROJECT BASE DATA OBTAINED FROM AGNICO EAGLE MINES LIMITED.
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PROJECT
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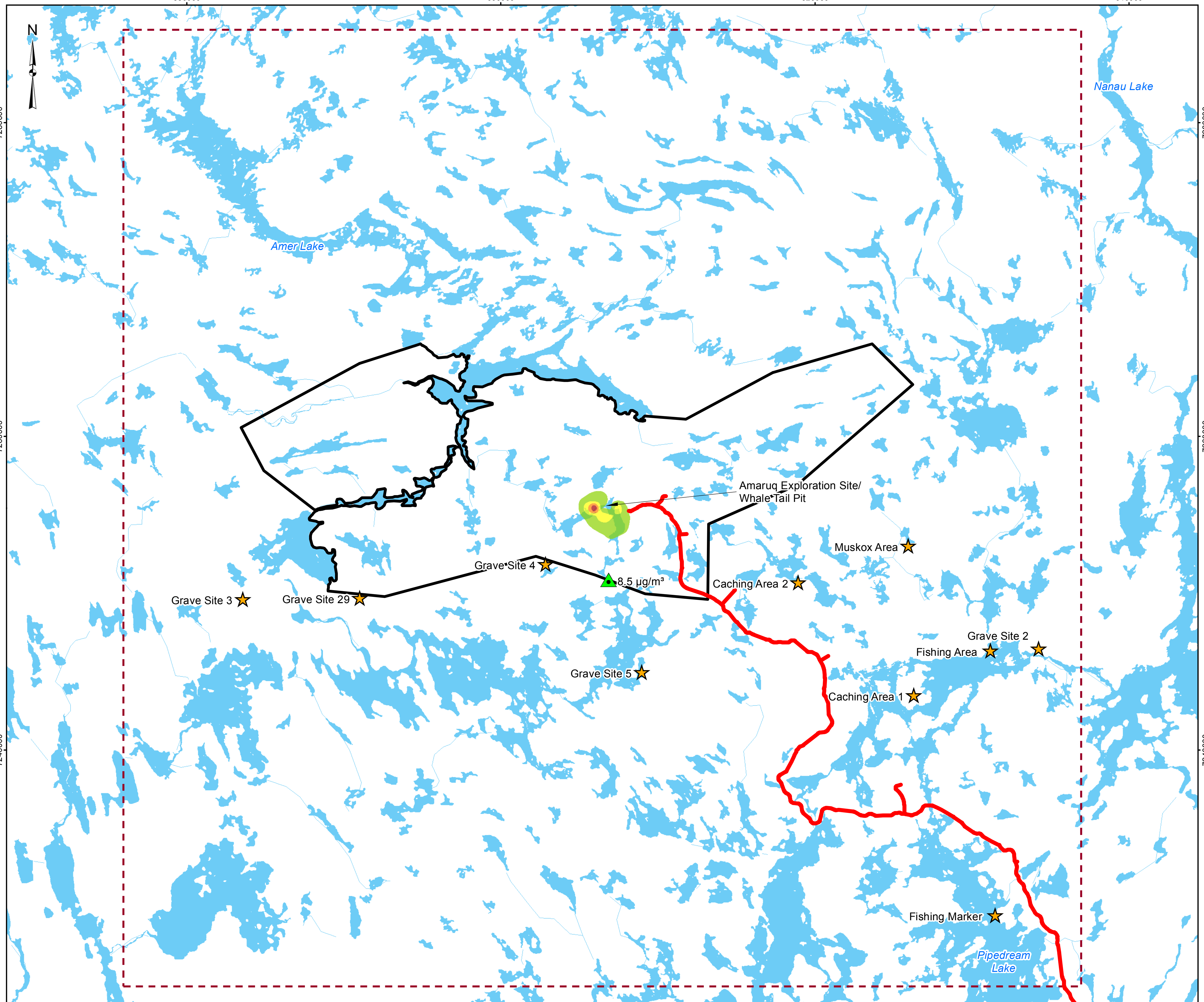
AGNICO EAGLE MINES LIMITED:
MEADOWBANK DIVISION
WHALE TAIL PIT PROJECT

TITLE

MODEL PREDICTED 24-HOUR
NO_2 CONCENTRATIONS

Golder Associates

PROJECT		1541520	FILE No.
DESIGN	ZY	2016-03-02	SCALE AS SHOWN REV. A
GIS	SM/LS	2016-05-11	
CHECK	CMc	2016-03-10	**FIGURE 4-C-9**
REVIEW	CM	2016-05-11	



LEGEND

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

CONCENTRATION (µg/m³)

- 0 - 15
- 15 - 30
- 30 - 45
- 45 - 60
- > 60

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.

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PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED:
MEADOWBANK DIVISION
WHALE TAIL PIT PROJECT

TITLE

MODEL PREDICTED ANNUAL NO_2 CONCENTRATIONS

Golder Associates

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	**FIGURE 4-C-10**
REVIEW	CM	2016-05-11	

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4.C-7.3.3 Sulfur Dioxide (SO_2) Predictions

The model predicted 1-hour, 24-hour, and annual SO_2 concentrations are summarized in Table 4-C-12 and shown in Figures 4-C-11 to 4-C-13. The maximum model predicted 1-hour, 24-hour, and annual SO_2 concentrations outside the Project boundary are 17.8, 5.8, and 0.4 µg/m^3, respectively. The maximum 1-hour, 24-hour, and annual SO_2 concentrations occur along the southern Project boundary. The maximum 1-hour, 24-hour, and annual SO_2 concentrations and the concentrations at the selected receptors (Table 4-C-13) are all lower than the respective air quality standards.

Table 4-C-12: Summary Table of Model Predicted SO_2 Concentrations

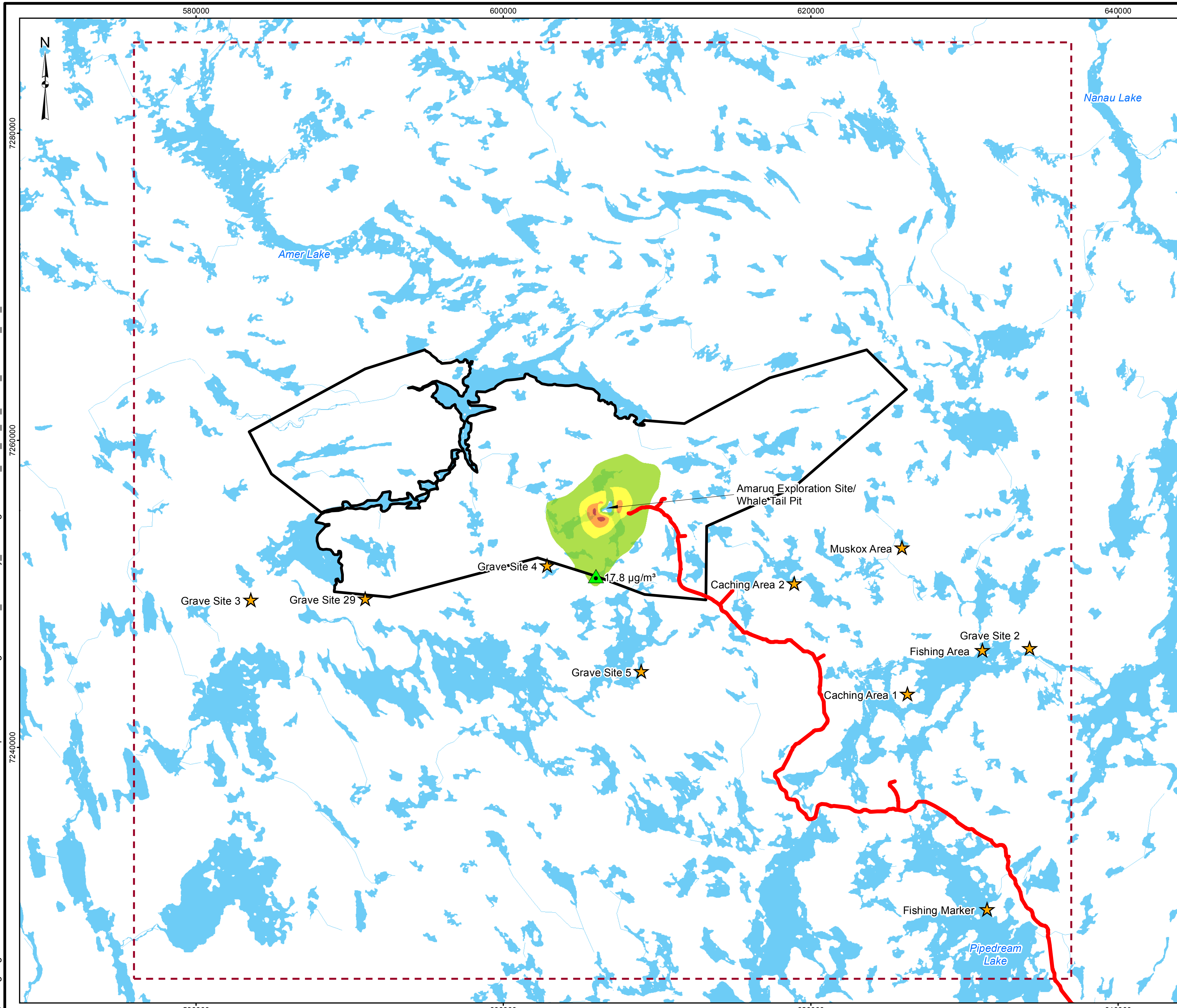
Results	1-hour	24-hr	Annual
Peak SO_2 Concentration (µg/m^3)	47.8	3.7	—
Maximum SO_2 Concentration (µg/m^3)	15.1	3.2	0.1
Project Contribution Combined With Background Concentration			
Peak SO_2 Concentration (µg/m^3)	50.4	6.3	—
Maximum SO_2 Concentration (µg/m^3)	17.8	5.8	0.4
number of occurrences above criteria	0	0	0
Distance (km)	3.8	3.8	4.1
Direction	S	S	S
Current Ambient Air Quality Standards (µg/m^3)	**450**	**150**	**30**

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

Table 4-C-13: Model Predicted SO_2 Concentrations at Selected Potential Receptor Locations

Health Receptor	1-hr Peak (µg/m^3)	1-hr Maximum (µg/m^3)	24-hr Peak (µg/m^3)	24-hr Maximum (µg/m^3)	Annual (µg/m^3)
Grave site 2	6.8	3.2	2.9	2.7	0.27
Grave site 3	7.0	3.5	3.2	2.9	0.27
Grave site 4	29.5	7.1	4.4	3.7	0.29
Grave site 5	18.3	6.9	3.6	3.4	0.30
Grave site 29	11.2	3.6	3.1	2.8	0.27
Fishing marker	4.7	3.3	2.8	2.8	0.27
Muskox	6.6	3.7	2.9	2.8	0.27
Fishing area	4.8	3.3	2.8	2.8	0.27
Caching area 1	4.8	3.5	2.8	2.8	0.27
Caching area 2	8.7	4.9	3.0	2.9	0.28

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 - 15
- 15 - 30
- 30 - 45
- 45 - 60
- 60 - 75

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.

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

TITLE
MODEL PREDICTED 1-HOUR SO_2 CONCENTRATIONS

Golder Associates

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	FIGURE 4-C-11
REVIEW	CM	2016-05-11	

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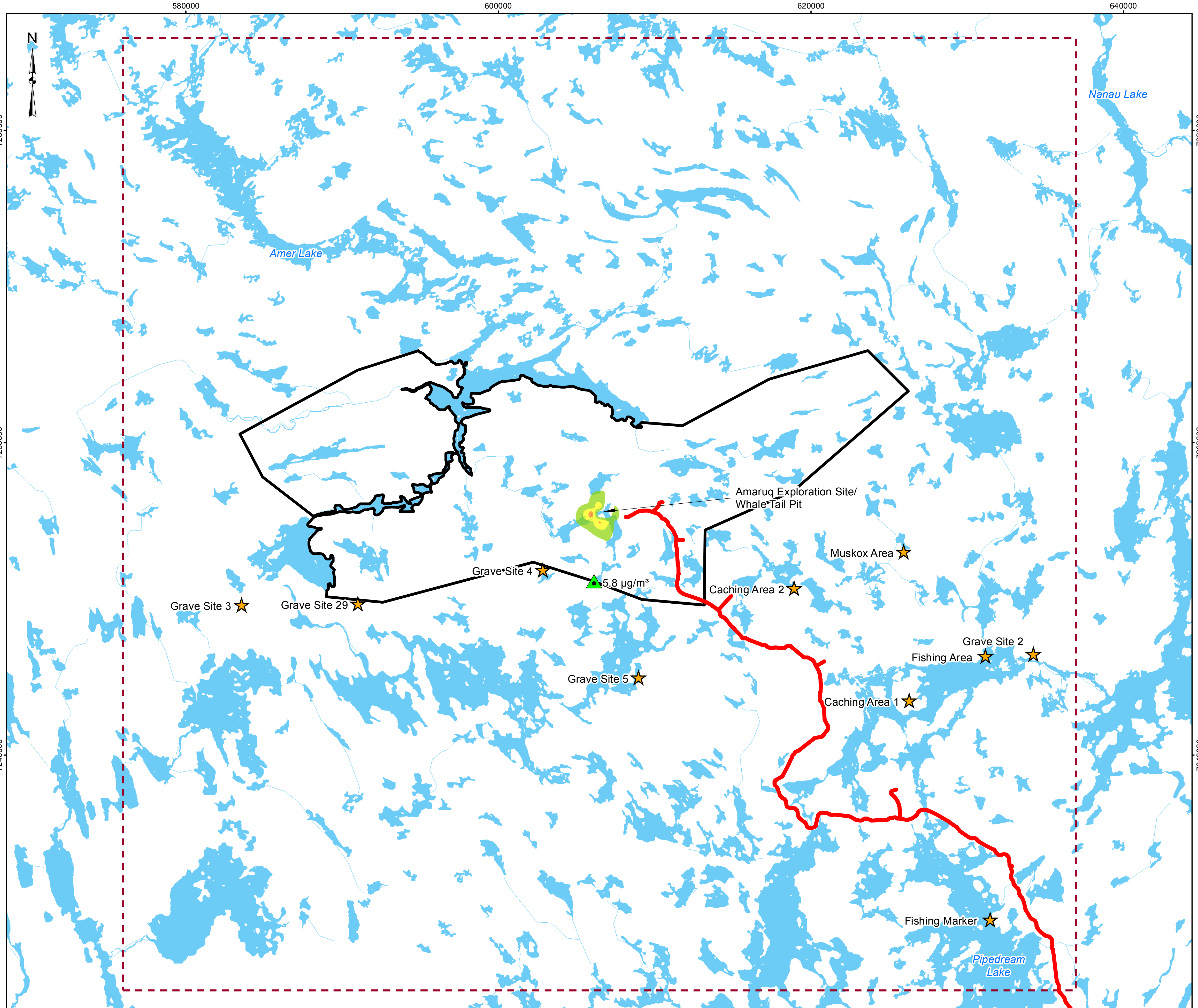

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LEGEND

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

CONCENTRATION (µg/m³)

- 0 - 10
- 10 - 15
- 15 - 20
- 20 - 25
- > 25

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.

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PROJECT
AGNICO EAGLE

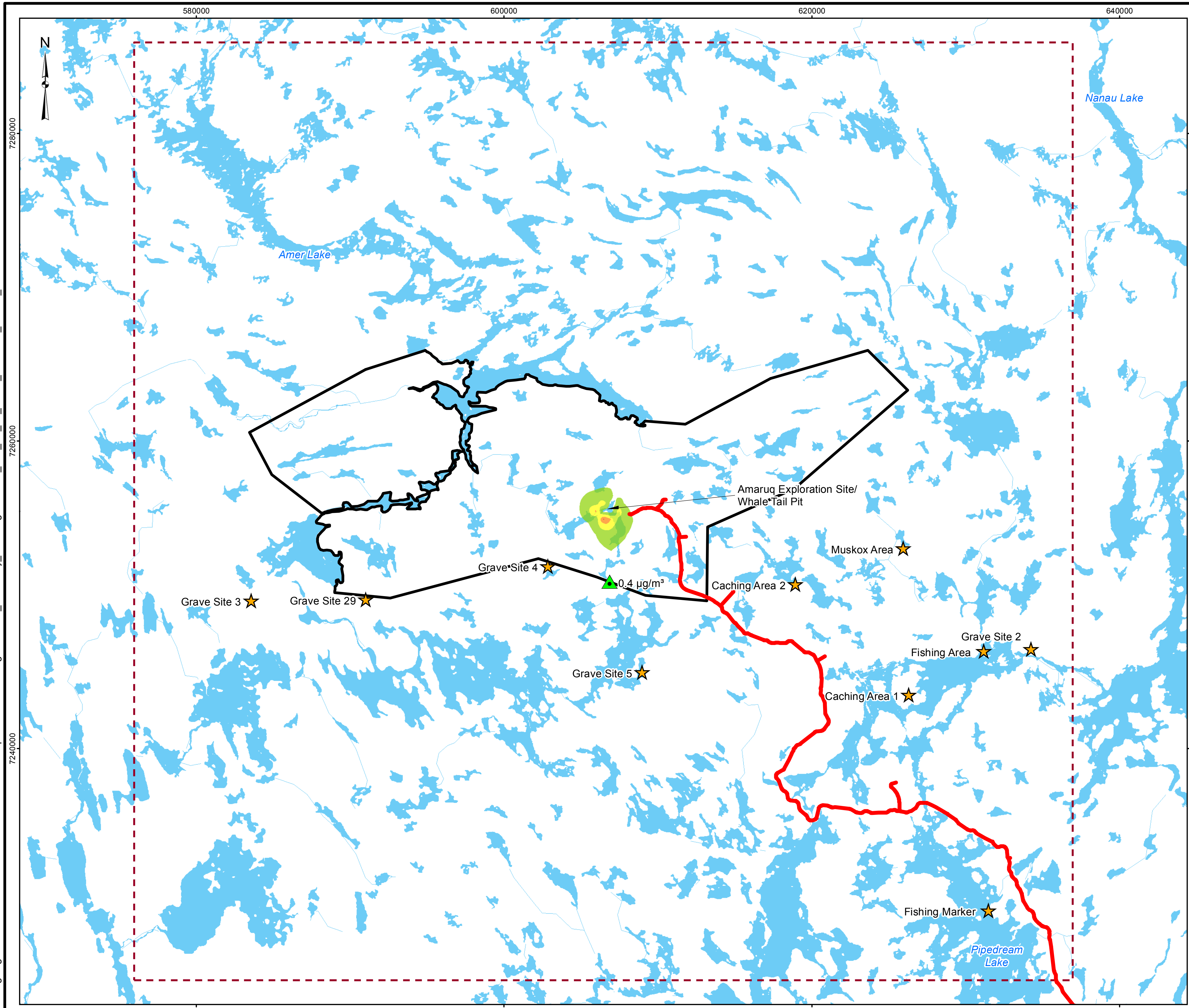
AGNICO EAGLE MINES LIMITED:
MEADOWBANK DIVISION
WHALE TAIL PIT PROJECT

TITLE

MODEL PREDICTED 24-HOUR SO_2 CONCENTRATIONS

Golder Associates

PROJECT		1541520	FILE No.	
DESIGN	ZY	2016-03-02	SCALE AS SHOWN	REV. A
GIS	SM/LS	2016-05-11	**FIGURE 4-C-12**	
CHECK	CMc	2016-05-11		
REVIEW	CM	2016-05-11		



LEGEND

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

CONCENTRATION (µg/m³)

- 0 - 0.5
- 0.5 - 1
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5

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.

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PROJECT

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MEADOWBANK DIVISION
WHALE TAIL PIT PROJECT

TITLE

MODEL PREDICTED ANNUAL SO_2 CONCENTRATIONS

Golder Associates

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	FIGURE 4-C-13
REVIEW	CM	2016-05-11	

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4.C-7.3.4 Total Suspended Particulate Predictions

The model predicted 24-hour and annual TSP concentrations are summarized in Table 4-C-14 and shown in Figures 4-C-14 and 4-C-15. The maximum model predicted 24-hour and annual TSP concentrations outside the Project boundary are 174 and 16.9 µg/m^3, respectively. The predicted maximum plus background 24-hour TSP concentrations exceed the ambient air quality standard of 120 µg/m^3. The maximum annual TSP concentrations and the maximum 24-hr and annual average concentrations at the selected receptors (Table 4-C-15) are all lower than the respective air quality standards.

The maximum TSP concentration outside of the Project boundary occurs for meteorology observed in 2005 at a receptor 8.5 km southeast of the Whale Tail Pit (Figure 4-C-14). At this receptor, there is a total of three days that the TSP concentrations are predicted to exceed the air quality standard of 120 µg/m^3. The two small areas outside of the Project boundary that have TSP concentrations that exceed ambient air quality standards are near the southern Project boundary and the southeast corner of the Project boundary near the location where the haul road to the Meadowbank Mine leave the Project boundary.

The small areas outside the Project boundary that have concentrations that are predicted to exceed the 24-hour TSP air quality standard are not likely to present a risk to human health. There are no residences within the areas predicted to have high TSP concentrations, nor is it likely that people will be present within these areas for more than 24 consecutive hours.

Table 4-C-14: Summary Table of Model Predicted TSP Concentrations

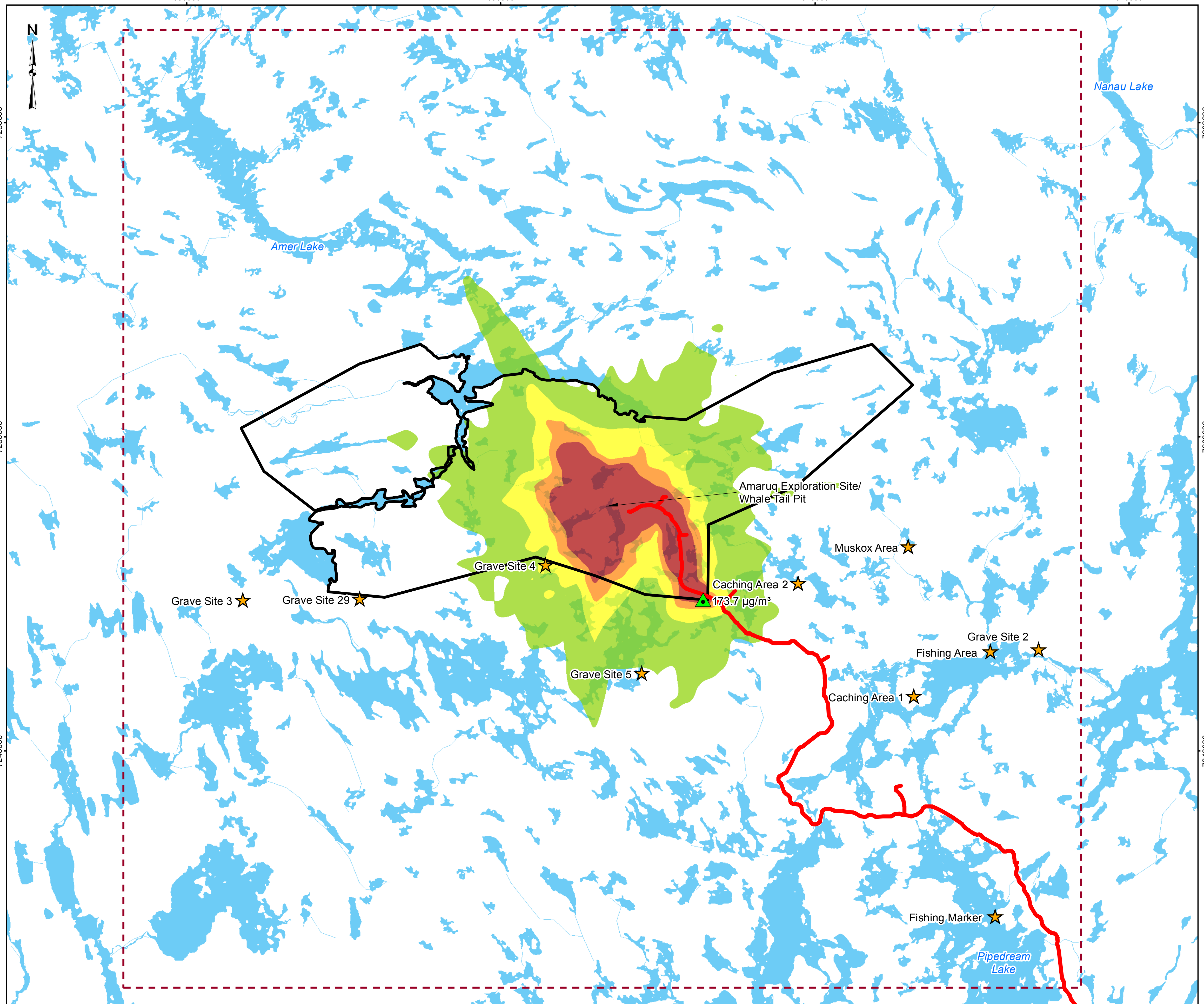
Results	24-hr	Annual
Peak TSP Concentration (µg/m^3)	225	—
Maximum TSP Concentration (µg/m^3)	167	13.3
Project Contribution Combined With Background Concentration		
Peak TSP Concentration (µg/m^3)	231	—
Maximum TSP Concentration (µg/m^3)	174	16.9
Number of occurrences above criteria	3	0
Distance (km)	8.5	8.2
Direction	SE	SE
Ambient Air Quality Standards(µg/m^3)	**120**	**60**

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

Table 4.C-15: Model predicted TSP concentrations at Selected Potential Receptor Locations

Health Receptor	24-hour Peak ($\mu g/m^3$)	24-hour Maximum ($\mu g/m^3$)	Annual ($\mu g/m^3$)
Grave site 2	12.2	10.1	3.7
Grave site 3	13.9	10.3	3.7
Grave site 4	78.5	74.7	5.0
Grave site 5	34.9	27.5	5.2
Grave site 29	19.5	16.8	3.9
Fishing marker	12.5	9.8	3.8
Muskox	13.4	11.5	3.8
Fishing area	14.3	12.2	3.8
Caching area 1	18.8	15.2	3.9
Caching area 2	26.6	22.2	4.3

$\mu g/m^3$ = 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 - 30
- 30 - 60
- 60 - 90
- 90 - 120
- > 120

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.

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KILOMETRES

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED:
MEADOWBANK DIVISION
WHALE TAIL PIT PROJECT

TITLE

MODEL PREDICTED 24-HOUR TSP CONCENTRATIONS

Golder Associates

PROJECT		1541520	FILE No.	
DESIGN	ZY	2016-03-02	SCALE AS SHOWN	REV. A
GIS	SM/LS	2016-05-11	FIGURE 4-C-14	
CHECK	CMc	2016-05-11		
REVIEW	CM	2016-05-11		

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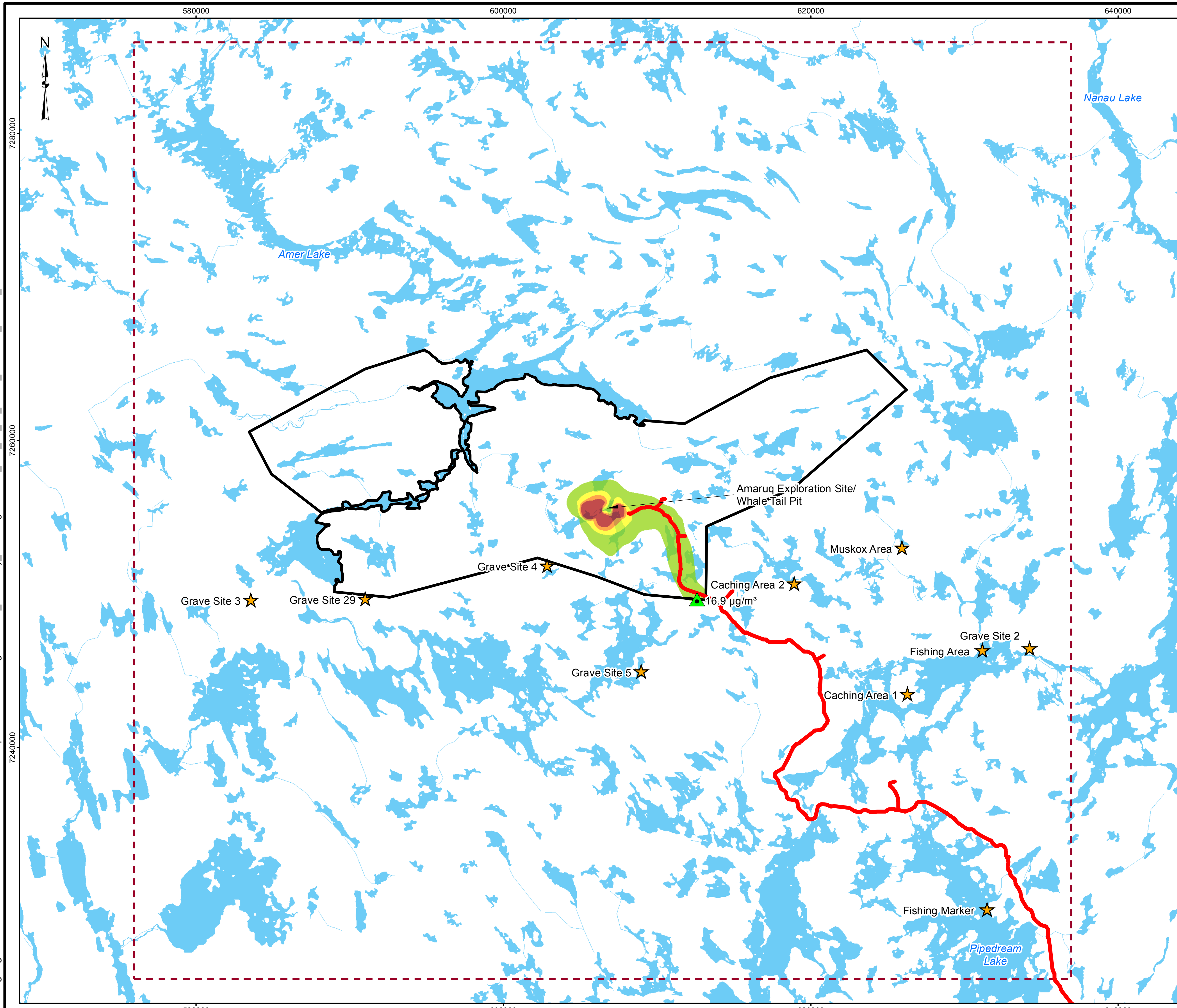

LEGEND

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

CONCENTRATION (µg/m³)

- 0 - 15
- 15 - 30
- 30 - 45
- 45 - 60
- > 60

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.

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MEADOWBANK DIVISION
WHALE TAIL PIT PROJECT

TITLE

MODEL PREDICTED ANNUAL TSP CONCENTRATIONS

Golder Associates

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	**FIGURE 4-C-15**	
REVIEW	CM	2016-05-11		

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4.C-7.3.5 PM_{10} Predictions

The model predicted 24-hour PM_{10} concentrations are summarized in Table 4-C-16 and shown in Figure 4.C-16. The maximum model predicted 24-hour outside the Project boundary is 52.4 µg/m³. The maximum 24-hour PM_{10} concentrations occur along the southern Project boundary. The maximum PM_{10} concentration outside of the Project boundary occurs at a receptor 3.8 km south of the Whale Tail Pit. At this receptor, there is only 1 day that the PM_{10} concentrations are predicted to exceed the relevant ambient air quality standard (i.e., 50 µg/m³). The area outside of the Project boundary that has a predicted PM_{10} exceedance is very small and there are no residences or community receptors identified within this area.

The maximum 24-hour PM_{10} concentrations at the selected receptors (Table 4-C-17) are all lower than the respective air quality standard.

Table 4-C-16: Summary Table of Model Predicted PM_{10} Concentrations

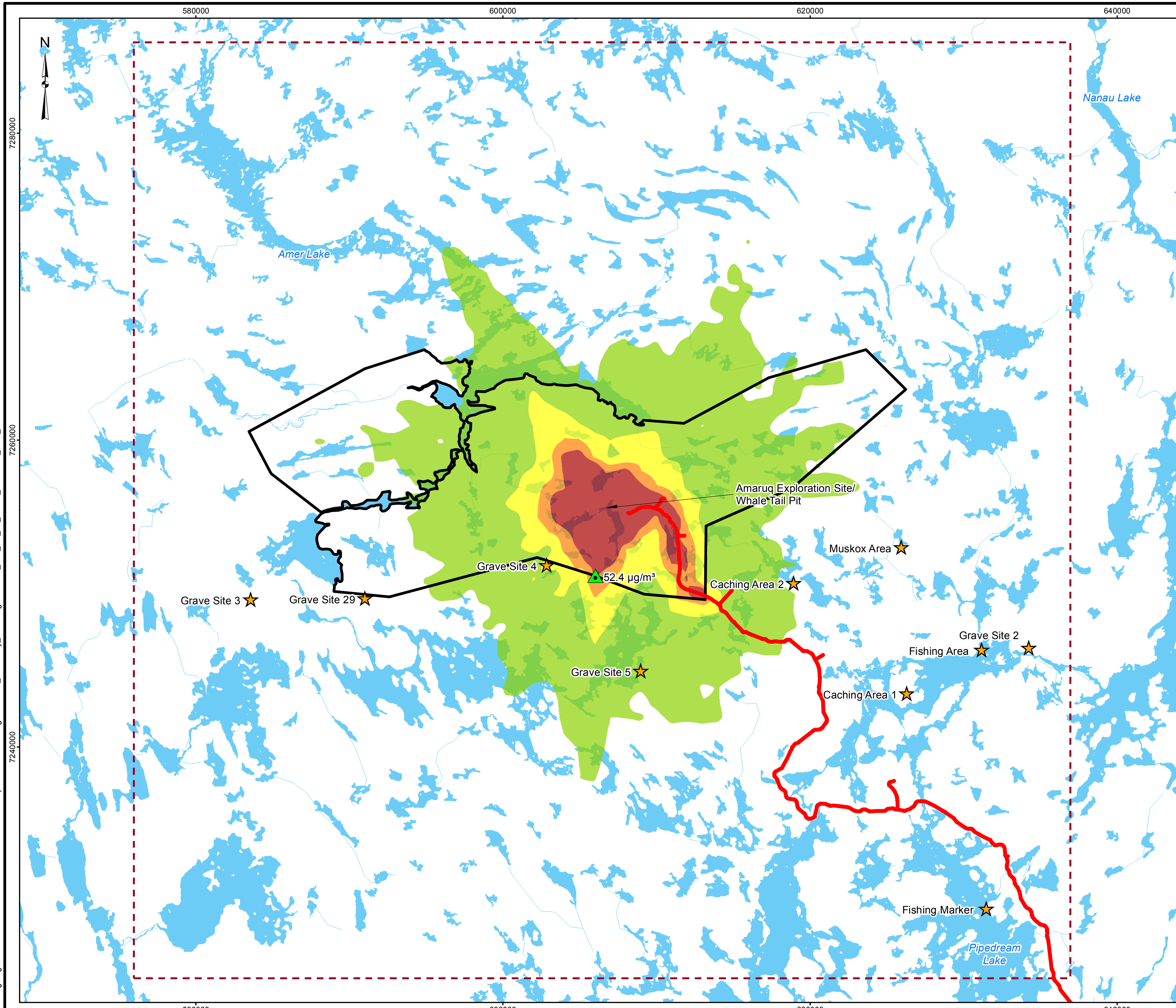
Results	**24-hour**
Peak PM_{10} Concentration (µg/m³)	63.1
Maximum PM_{10} Concentration (µg/m³)	45.7
Project Contribution Combined With Background Concentration	
Peak PM_{10} Concentration (µg/m³)	69.8
Maximum PM_{10} Concentration (µg/m³)	52.4
Number of occurrences above criteria	1
Distance (km)	3.8
Direction	S
Ambient Air Quality Standards (µg/m³)	**50**

µg/m³ = micrograms per cubic metre; km = kilometre

Table 4.C-17: Model predicted PM_{10} concentrations at Selected Potential Receptor Locations

Health Receptor	**24-hour Peak (µg/m³)**	**24-hour Maximum (µg/m³)**
Grave site 2	8.5	7.9
Grave site 3	9.1	8.9
Grave site 4	30.4	28.8
Grave site 5	18.5	13.2
Grave site 29	10.9	10.2
Fishing marker	8.5	7.8
Muskox	9.5	8.4
Fishing area	9.2	8.6
Caching area 1	10.6	9.4
Caching area 2	13.0	11.7

µg/m³ = 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 - 12.5
- 12.5 - 25.0
- 25.0 - 37.5
- 37.5 - 50.0
- > 50

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 24-HOUR
PM_{10} CONCENTRATIONS

Golder Associates

PROJECT		1541520	FILE No.	
DESIGN	ZY	2016-03-02	SCALE AS SHOWN	REV. A
GIS	SBM	2016-05-11		
CHECK	CMc	2016-05-11	**FIGURE 4-C-16**	
REVIEW	CM	2016-05-11		

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4.C-7.3.1 $PM_{2.5}$ Predictions

The model predicted 24-hour and annual $PM_{2.5}$ concentrations are summarized in Table 4-C-18 and shown in Figures 4-C-17 and 4-C-18. Compliance with territorial and national 24-hour ambient air quality standards is based on the 98th percentile value over three years. For the Project, this value is 13.5 µg/m^3, which is below the air quality standard (i.e., 28 µg/m^3). The maximum 24-hour (20.1 µg/m^3) and annual (4.3 µg/m^3) $PM_{2.5}$ concentrations are also predicted to be below the 28 µg/m^3 (3-year, 98th percentile) 24-hour and 8.8 µg/m^3 annual air quality standards, respectively.

The maximum 24-hour, annual $PM_{2.5}$ concentrations, and the concentrations (Table 4-C-19) at the selected receptors are also all lower than their respective air quality standards.

Table 4.C-18: Summary Table of Model Predicted $PM_{2.5}$ Concentrations

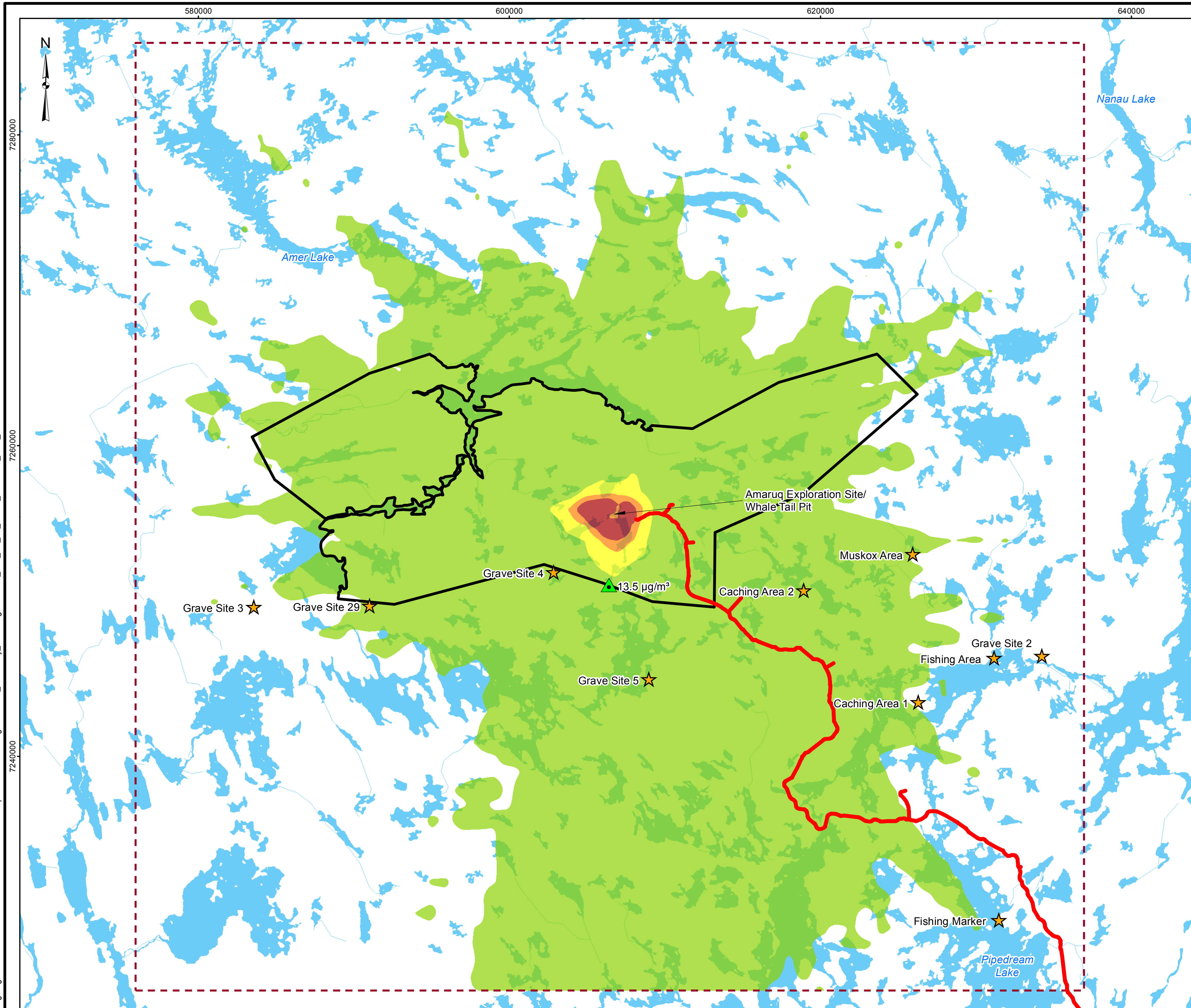
Results	**24-hr**	**Annual**
Peak $PM_{2.5}$ Concentration (µg/m^3)	15.8	—
Maximum $PM_{2.5}$ Concentration (µg/m^3)	13.4	0.7
98th percentile $PM_{2.5}$ Concentration (µg/m^3)	6.8	—
Project Contribution Combined With Background Concentration		
Peak $PM_{2.5}$ Concentration (µg/m^3)	22.5	—
Maximum $PM_{2.5}$ Concentration (µg/m^3)	20.1	4.3
98th percentile $PM_{2.5}$ Concentration (µg/m^3)	13.5	—
Number of occurrences above criteria	0	0
Distance (km)	3.9	4.0
Direction	S	S
Current Ambient Air Quality Standards (µg/m^3)	**28**	**8.8**

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

Table 4.C-19: Model Predicted $PM_{2.5}$ Concentrations at Selected Potential Receptor Locations

Health Receptor	**24-hour Peak (µg/m^3)**	**24-hour Maximum (µg/m^3)**	**Annual (µg/m^3)**
Grave site 2	7.1	6.8	3.6
Grave site 3	8.0	6.9	3.6
Grave site 4	13.5	8.4	3.8
Grave site 5	10.2	8.6	3.8
Grave site 29	8.1	7.1	3.6
Fishing marker	7.2	6.9	3.6
Muskox	7.6	7.0	3.6
Fishing area	7.2	7.0	3.6
Caching area 1	7.4	7.0	3.6
Caching area 2	8.0	7.5	3.7

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 - 7
- 7 - 14
- 14 - 21
- 21 - 28
- > 28

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.

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KILOMETRES

PROJECT
AGNICO EAGLE

AGNICO EAGLE MINES LIMITED:
MEADOWBANK DIVISION
WHALE TAIL PIT PROJECT

TITLE

MODEL PREDICTED 24-HOUR
$PM_{2.5}$ CONCENTRATIONS

Golder Associates

PROJECT		1541520	FILE No.
DESIGN	ZY	2016-03-02	SCALE AS SHOWN REV. A
GIS	SBM	2016-05-11	
CHECK	CMc	2016-05-11	**FIGURE 4-C-17**
REVIEW	CM	2016-05-11	

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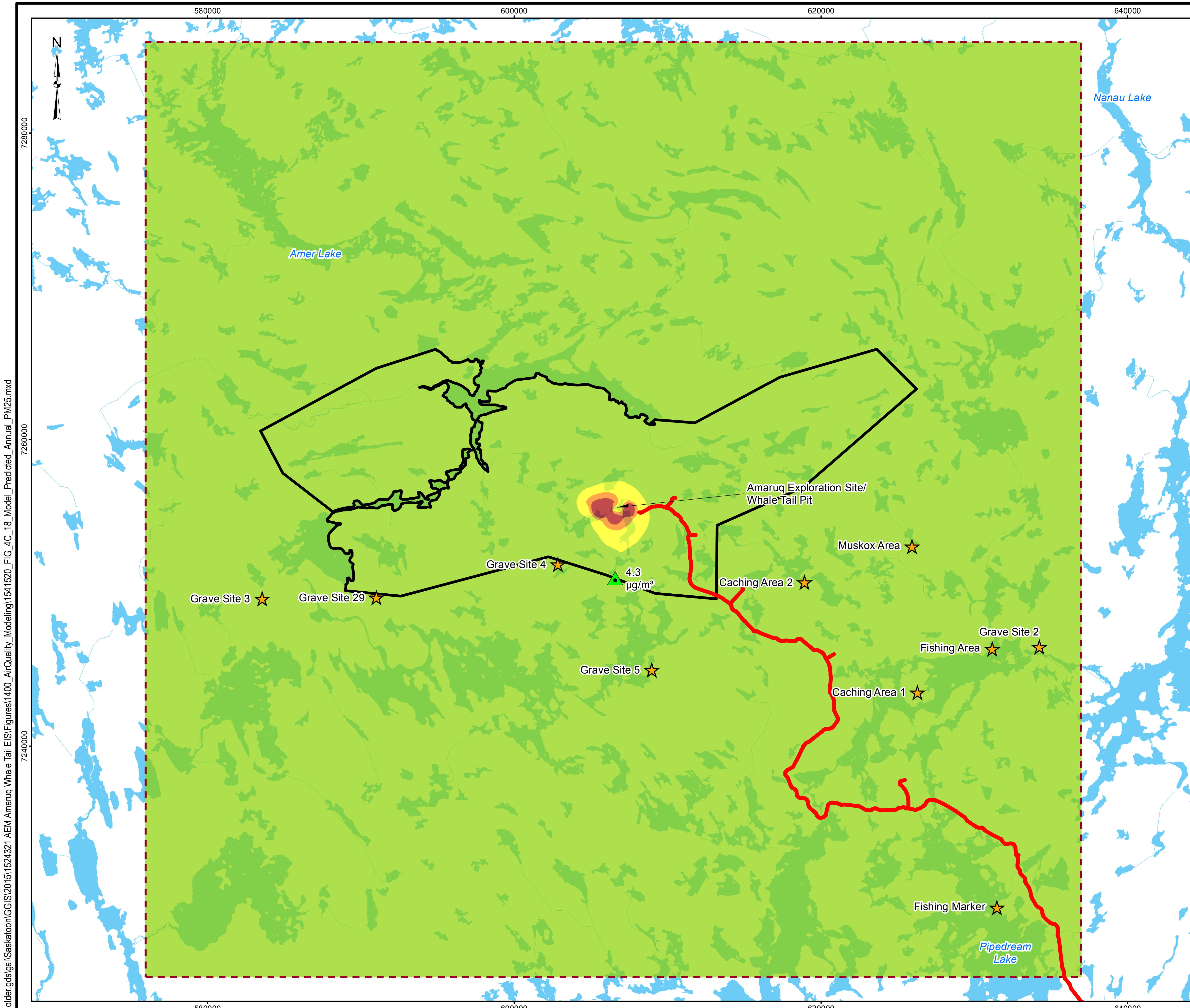

LEGEND

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

CONCENTRATION (µg/m³)

- < 3.6 (BASELINE)
- 3.6 - 5.0
- 5.0 - 7.5
- 7.5 - 10.0
- > 10

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.

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KILOMETRES

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED:
MEADOWBANK DIVISION
WHALE TAIL PIT PROJECT

TITLE

MODEL PREDICTED ANNUAL
$PM_{2.5}$ CONCENTRATIONS

Golder Associates

PROJECT		1541520	FILE No.	
DESIGN	ZY	2016-03-02	SCALE AS SHOWN	REV. A
GIS	SBM	2016-05-11	**FIGURE 4-C-18**	
CHECK	CMc	2016-05-11		
REVIEW	CM	2016-05-11		

4.C-8 AIR QUALITY MODELLING FOR THE HAUL ROAD

The Whale Tail Pit is connected to the Meadowbank Mine by an un-paved, 62 km haul road. With the exception of $PM_{2.5}$, combustion related emissions (e.g., CO, NO_2, SO_2) from light and heavy duty gasoline and diesel vehicles travelling along the haul road have low potential to affect air quality because the amount of emissions is low. Fugitive road dust generated by these vehicles does have the potential to affect air quality adjacent to the road, and atmospheric deposition of fugitive road dust has the potential to affect soil and water quality adjacent to the road. This section of Appendix 4-C discusses the methods used to evaluate particulate matter concentrations and atmospheric deposition of particulate matter along the haul road, and the results of this analysis.

4.C-8.1 Methods

Air quality model predictions for the haul road were created to evaluate atmospheric concentrations and atmospheric deposition of particulate matter as a function of distance from the centre of the haul road. To evaluate potential Project related effects of the haul road on air quality, emissions along a representative 1 km long section of the haul road were simulated.

The representative section is aligned along a southwest to northeast transect, an orientation perpendicular to the prevailing winds. The emissions include particulate matter emissions from vehicle exhaust, and fugitive road dust from the un-paved road surface, which are summarized in Section 4.B-8 of Appendix 4-B. The simulation of the haul road is identical to the simulation of the portion of the haul road that resides within the Project boundary. However, the representative 1-km haul road simulation excludes the application of any dust mitigation measures (i.e., it excludes an assumed 70% reduction in fugitive dust due to road watering), and includes only a natural 90% reduction in fugitive dust during winter months when the road bed is frozen. Inclusion of natural wintertime mitigation reduces annual particulate matter concentrations and dust deposition, but does not affect predictions of the maximum 24-hour concentrations or daily dust deposition rates.

Air quality modelling receptors with 20 metre (m) intervals were placed along the road in rows with distances of 25 m, 50 m, 75 m, 100 m, 300 m, 500 m, 750 m, 1,000 m, 1,500 m, and 2,000 m from the centre of the haul road. Using the maximum daily emission estimates for the unfrozen season, the ground level concentrations of all CACs were predicted for the receptors using the air quality model.

4.C-8.2 Results

Low level emissions of CO, NO_2, and SO_2 will be produced by vehicles using the haul road. The model predicted ground level concentrations of CO, NO_2, and SO_2 are low compared to baseline and to their relevant ambient air quality standards. Thus, only model predictions for particulate matter are considered in further detail.

Table 4-C-20 summarizes maximum predicted particulate matter (TSP, PM_{10}, $PM_{2.5}$) concentrations as a function of distance from the haul road. All PM size classes will experience decreases in their concentration with distance due to atmospheric mixing (i.e., dilution). However, only PM_{10} and TSP have appreciable atmospheric deposition within a few 1000 meters from the haul road.

Figures 4-C-19 and 4-C-20 show the predicted decrease in maximum 24-hour and annual TSP concentrations with increasing distance from the haul road. In the near field, maximum TSP concentrations adjacent to the road are predicted to exceed the 24-hour average ambient air quality standard (120 $\mu g/m^3$) at distances of up to 1,500 m from the road. Maximum predicted 24-hour PM_{10} concentrations are predicted to exceed the ambient air quality standard (50 $\mu g/m^3$) at distances of up to 1,000 to 1,500 m from the road. Maximum predicted 24-hour $PM_{2.5}$

concentrations are only predicted to exceed the ambient air quality standard (28 µg/m³) within the first 100 m from the road. Maximum annual TSP concentrations are predicted to exceed the ambient air quality standard (60 µg/m³) within the first 100 to 300 meters from the road. Maximum annual $PM_{2.5}$ concentrations are not predicted to exceed the ambient air quality standard (8.8 µg/m³). There is no annual PM_{10} ambient air quality standard.

Table 4-C-20: Maximum Predicted PM Concentrations with Distance From the Haul Road

Distance (m)	Maximum predicted PM concentrations (µg/m³)				
	24-hour TSP	Annual TSP	24-hour PM_{10}	24-hour $PM_{2.5}$	Annual $PM_{2.5}$
25	1739	172	464	37.2	6.9
50	1330	118	354	28.6	5.0
75	1171	91.4	312	21.9	3.9
100	1041	73.5	277	17.9	3.2
300	499	26.7	134	8.3	1.2
500	358	15.4	95.6	4.5	0.7
750	254	9.7	68.9	3.3	0.4
1000	212	6.4	57.1	2.7	0.2
1500	92.4	3.2	25.5	1.2	0.1
2000	52.7	1.9	14.6	0.9	0.1
Ambient Air Quality Standards	**120**	**60**	**50**	**28**	**8.8**

m = metres; µg/m³ = micrograms per cubic metre

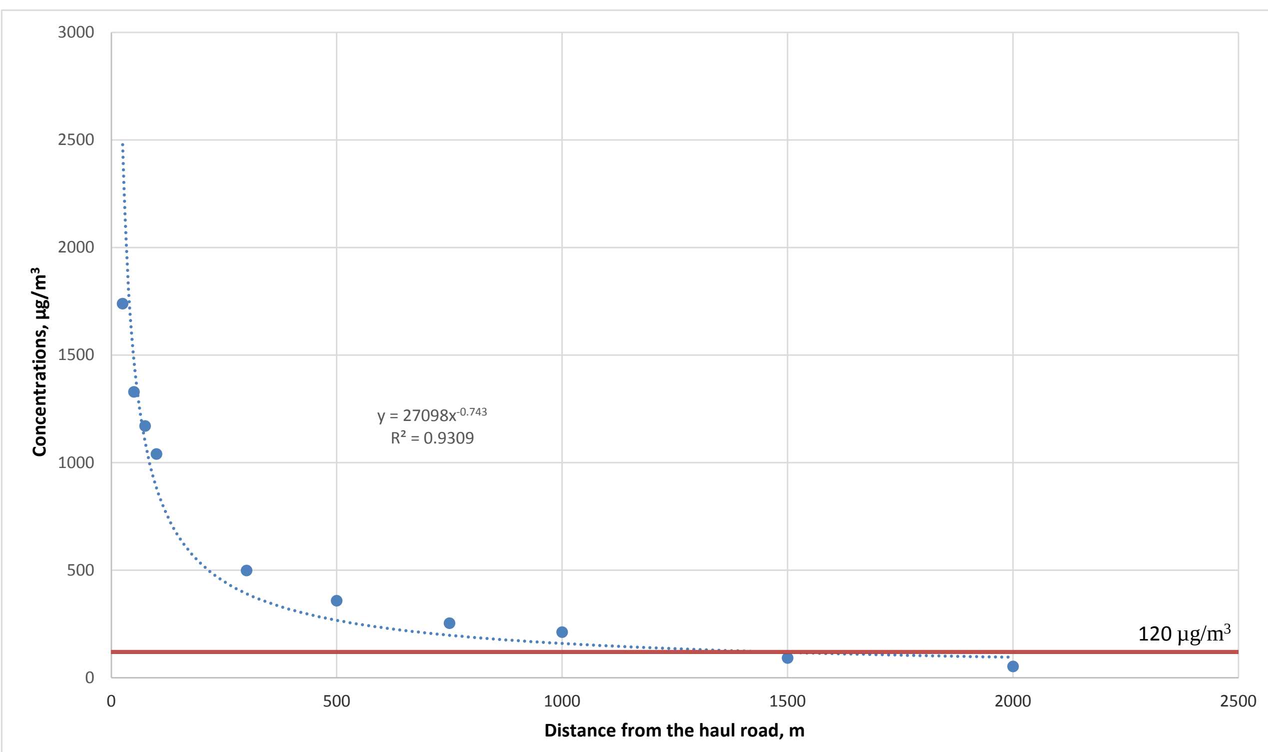

Figure 4-C-19: Maximum Predicted 24-Hour TSP Concentrations with Distance From the Haul Road

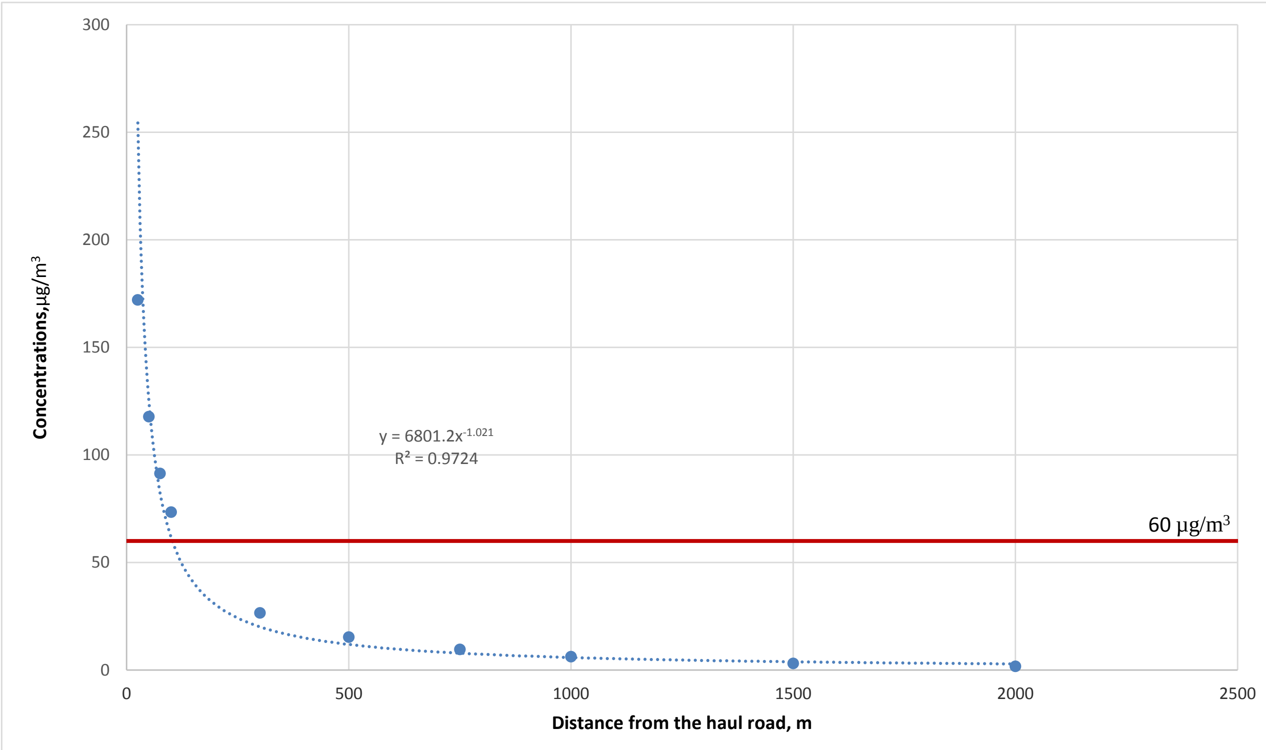

Figure 4-C-20: Maximum Predicted Annual TSP Concentrations with Distance From the Haul Road

There are no dust deposition rate standards for Nunavut Territory. The British Columbia lower and upper dust fall standard for mining is 1.7 milligrams per decimeter squared per day (mg/dm^2/day) and 2.9 mg/dm^2/day (BC Ministry of Environment 2016). These values correspond to deposition rates of 0.51 mg/cm^2/30-days and 0.87 mg/cm^2/30-days. The Alberta Environment Department's recreational/residential and industrial/commercial area dustfall guidelines of 0.53 mg/cm^2/30-days and 1.58 mg/cm^2/30-days are indicated for total dustfall (Alberta Environment 2013). The monthly and annual Ontario dust fall criteria are 0.7 mg/cm^2/30-days and 0.46 mg/cm^2/30-days, respectively (Ontario Ministry of the Environment 2012). As summarized in Table 4.C-21, the most stringent 30-day and annual dustfall criteria are the 30-day British Columbia deposition rate of 0.51 mg/cm^2/30-days and the Ontario annual deposition rate of 0.46 mg/cm^2/30-days.

Table 4-C-21: Dust fall criteria (mg/cm^2/30-days)

Averaging Time	Alberta Residential and Recreation Areas	BC Lower Level	BC Upper Level	Alberta Commercial and Industrial Areas	Ontario
30 days	0.53	**0.51**	0.87	1.58	0.7
Annual	—	—	—	—	**0.46**

The maximum 24-hour and annual total deposition of TSP was modelled at the same receptors as those used to predict ambient concentrations of TSP with distance from the haul road. At the receptors closest to the haul road (i.e., 25 m), the maximum 24-hour and annual total TSP deposition rates are 0.40 grams per meter squared per day ($g/m^2/day$) and 18.4 grams per metre squared per year ($g/m^2/year$), respectively. The maximum 24-hour and annual total TSP deposition rates can be converted to equivalent deposition rates over a 30-day period, and are equivalent to 1.19 $mg/cm^2/30$-days and 0.15 $mg/cm^2/30$-days, respectively. The conversion of 24-hour deposition rates to 30-day deposition rates is conservative as it assumes that the maximum 24-hour deposition rate occurs every day for the 30-day period.

The dust deposition modelling results are summarized in Table 4-C-22 and illustrated in Figures 4-C-21, and 4-C-22. The maximum predicted dust deposition rates are predicted to be below the 24-hour BC total dustfall standard within 300 m of the haul road. Maximum predicted annual dust deposition rates at 25 m from the haul road are predicted to be less than the Ontario annual dust fall standard.

Note that 24-hour particulate matter concentrations and dustfall rates presented in this section correspond to the maximum predicted values, not average values. There are also inherent uncertainties in modelling fugitive wind-blown dust generated from un-paved roads. During the November through May “frozen” season, 24-hour particulate matter concentrations and dustfall rates are expected to be approximately 1/10th of the maximum predicted values.

Table 4-C-22: Maximum Predicted TSP Total Deposition with Distance From the Haul Road

Distance (m)	24-hour ($g/m^2/day$)	Monthly ($mg/cm^2/30$-days)	Annual ($g/m^2/year$)	Annual ($mg/cm^2/30$-days)
25	0.40	1.19	18.4	0.15
50	0.26	0.77	11.7	0.10
75	0.22	0.65	8.46	0.07
100	0.19	0.56	6.61	0.05
300	0.09	0.26	2.23	0.02
500	0.06	0.18	1.27	0.01
750	0.05	0.14	0.79	0.01
1000	0.04	0.11	0.51	0.00
1500	0.02	0.07	0.26	0.00
2000	0.02	0.05	0.17	0.00
Dust fall criteria	—	0.51	—	0.46

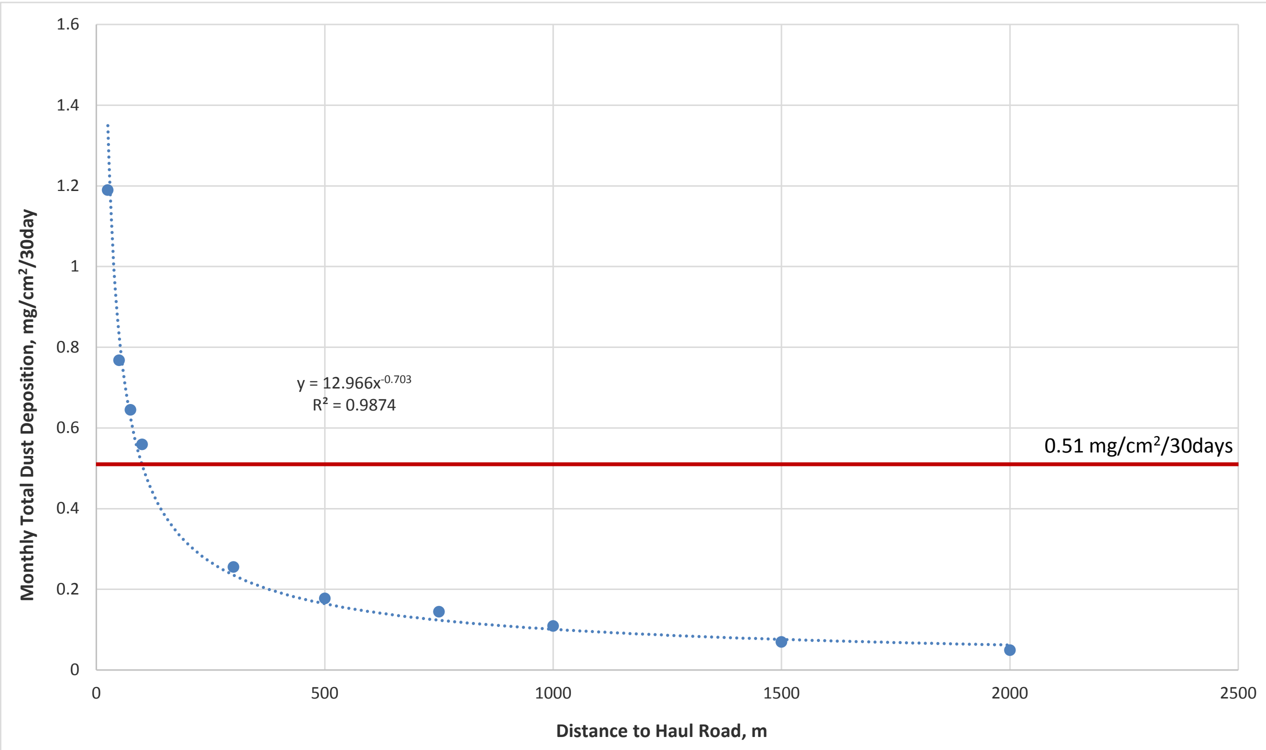

Figure 4-C-21: Maximum Predicted Daily Dust Deposition with Distance From the Haul Road

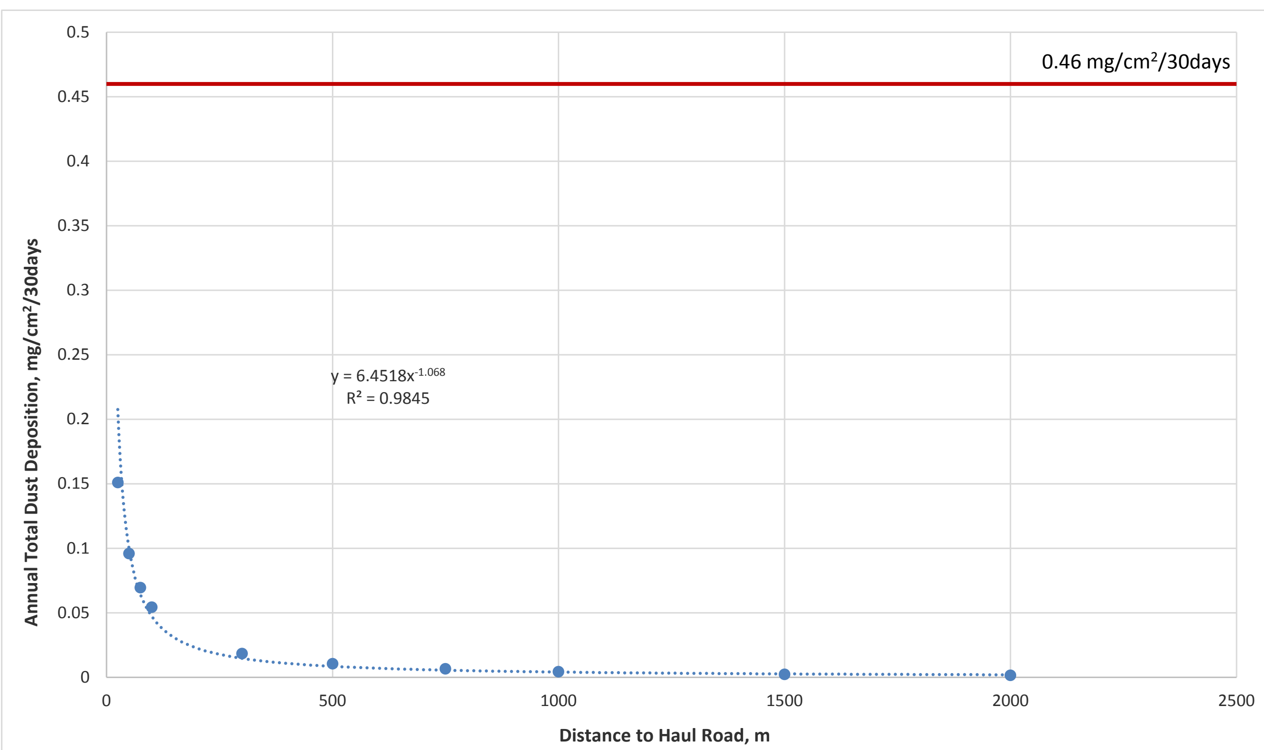

Figure 4-C-22: Maximum Predicted Annual Dust Deposition with Distance From the Haul Road

4.C-8.3 Discussion on Haul Road Dust Mitigation

Elders have expressed concern about the effects of fugitive windblown dust. Daily summertime road watering is proposed as a mitigation measure for the haul roads in the vicinity of the Whale Tail Pit, the ore storage pad and the waste rock storage facility. For conservatism, the assessment assumes no road dust mitigation along the haul road from the Whale Tail Pit to the Meadowbank Mill.

Results of the fugitive wind-blown dust modelling indicate that ambient dust concentrations may exceed ambient air quality criteria at distances of up to 1,000 to 1,500 m from the road on the driest, windiest days. Results of the fugitive wind-blown dust modelling indicate that atmospheric deposition of nuisance dust may exceed monthly recreational/residential guidelines within 300 m of the haul road, but are not expected to exceed monthly industrial/commercial guideline at distances greater than approximately 100 m from the haul road.

The proposed haul road construction material is sand and gravel sourced from regional eskers composed of local country rock materials. No mining waste rock or tailings from the existing Meadowbank Mine are proposed for use as road construction material.

Since there are no residences or other human health receptors within 1,500 m of the haul road, the potential impacts on air quality on the driest windiest days is predicted to be low. Since the road material is sourced from local eskers, and this material does not contain elevated concentrations of deleterious substances (Golder 2014), the potential impacts of dust deposition is predicted to be low.

Potential mitigation options for fugitive dust being generated along the haul road include the following:

1) daily road watering;
2) road watering on a strategic basis, such as:
    a) watering during dry or windy periods;
    b) spot watering at locations where the road tends to generate excessive dust (e.g., due to variation in the composition of the roadbed material used during construction); or
    c) spot watering near sensitive areas, such as near major watercourses.
3) application of a chemical suppressants (e.g., calcium chloride or EK-35).

Daily road watering during the summer months will contribute to additional air emissions from the combustion of fuel used in the watering trucks, be time consuming, and potentially expensive. Other drawbacks to daily road watering include:

1) Large volumes of water will be needed to spray the 62 km haul road twice daily to achieve a predicted 70% reduction in fugitive dust emissions.
2) Extracting road-water from local lakes and streams may have unintended consequences on the local hydrology or aquatic habitat.
3) Evaporation of the water from the road surface will deposit salts found naturally in the road-water and can lead to chemical weathering of the road bed material. This can result in the generation of additional dust-sized salt and mineral particulate in the future.

4) Leaching and runoff from the road during rain events or the spring thaw has the potential to increase total suspended solids and total dissolved solids loadings to the terrestrial and aquatic ecosystems along the haul road.

The application of chemical suppressants may also cause unintended environmental impacts to local terrestrial and aquatic habitats. Chemical suppressants include both inorganic salts and organic hydrocarbons derived from natural or synthetic products.

Inorganic chemical dust suppressants such as the salt calcium chloride ($CaCl_2$) are not found locally at the surface near the Project. Reapplication of $CaCl_2$ is required approximately annually to replace material that is blown away with the road dust, and because $CaCl_2$ can be leached from the road surface by precipitation and during the spring melt. The $CaCl_2$ that leaches from the road surface can reach aquatic habitats where it could affect water quality, including alkalinity and total dissolved solids concentrations.

Man-made organic chemical dust suppressants are also an option for dust mitigation (e.g., EK-35). The chemical dust suppressant EK-35 is manufactured from a synthetic iso-alkane (a branched hydrocarbon) and tall oil pitch and rosin. The materials safety data sheet for EK-35 indicates that it has no human health effects due to inhalation, skin contact or ingestion, but may become irritating to the eyes with prolonged contact. The potential for eco-toxicity and food chain concentration (i.e., bioaccumulation) is considered low. However, there are no known studies on the long-term effects of the use of this synthetic product, or its potential impacts on Arctic ecosystems specifically. This option is not recommended and is likely cost prohibitive.

The proposed mitigation along the haul road includes strategic watering of fugitive dust hot spots along the haul road (as identified by haul truck drivers etc.), and haul road watering during periods of prolonged drought and/or high winds. This will enable the use of inexpensive locally abundant water, while minimizing water quantities withdrawn from local lakes and streams.

4.C-9 REFERENCES

Alberta Environment. 2013. Alberta ambient air quality objectives and guidelines summary. Air policy, Alberta Environment.

British Columbia (BC) Ministry of Environment. 2016. British Columbia Ambient Air Quality Objectives. Environmental Standards Branch. B.C Ministry of Environment.

CCME (Canadian Council of Ministers of the Environment). 2013. Air Quality Management System, available online at: http://www.ccme.ca/ourwork/air.html?category_id=146.

Carbonell, L.M.T., M.S. Gacita., J.J.R. Oliva., L.C. Garea., N.D. Rivero, E.M. Ruiz. 2010. Methodological guide for implementation of the AERMOD system with incomplete local data. Atmospheric Pollution Research, 1: 102-111.

Golder (Golder Associates Ltd.). 2014. Geochemical assessment of proposed construction material for the road to the Amaruq deposit, Meadowbank Mine, Nunavut. Prepared for: Agnico Eagle Mines.

Government of Alberta, Climate Change, Air and Land Policy Branch. 2009. Air Quality Model Guideline.

Government of Nunavut, Department of Environment. 2011. Environmental Guideline for Ambient Air Quality.

NRCan (Natural Resources Canada). 2016. GeoSpatial Data extraction. Available at http://geogratis.gc.ca/site/eng/extraction. Accessed March 2016.

Ontario Ministry of Environment. 2012. Ontario’s ambient air quality criteria. Standards development branch, Ontario ministry of the environment.

US EPA. 2012. Haul road workgroup final report submission to EPA-OAQPS. United States Environmental Protection Agency, Research Triangle Park, NC.

Wesely, M.L, P.V. Doskey, and J.D. Shannon, 2002: Deposition Parameterizations for the Industrial Source Complex (ISC3) Model. Draft ANL report ANL/ER/TRB01/003, DOE/xxnnnn, Argonne National Laboratory, Argonne, Illinois 60439.