APPENDIX 4-B

Air Emissions Inventory

4.B-1 INTRODUCTION

This document provides detailed technical information regarding the methods used to estimate air emissions from the proposed Whale Tail Pit Project (the Project). The air emissions are used as input to the AERMOD air quality dispersion model to predict potential Project related effects on regional ambient air quality.

The air emission inventory includes the emissions from mining activities in the Whale Tail Pit and from vehicle traffic along the haul road from the Whale Tail Pit to the existing Meadowbank Mine. The primary sources of air emissions from Project operations include the following:

- in pit drilling and blasting;
- un-paved road dust from the pit;
- exhaust from off-road equipment operating in the pit;
- material handling;
- wind erosion from ore pad and Whale Tail Waste Rock Storage Facility (WRSF);
- power plant and camp heater;
- un-paved road dust from haul road; and
- exhaust from on-road vehicle travelling on the haul road.

The in pit unpaved road and the unpaved road inside the Project boundary will be watered twice a day in the unfrozen season (May – October) to mitigate the dust emission. A control efficiency of 70% was applied in the calculation of the unpaved road dust emission. This assessment assumes the haul road to transport ore from the Whale Tail Pit to Meadowbank Mill outside of the Project boundary is not mitigated.

4.B-2 IN PIT DRILLING, BLASTING, AND EXPLOSIVES COMBUSTION EMISSIONS

The following three subsections summarizes the methods used to estimate air emissions from drilling and blasting activities. Details used to estimate the emissions from drilling, blasting, and explosives use are as follows:

- drilling emissions factors are based on wet drilling operations;
- two blasts per day;
- implementation of a blasting plan that includes the following details:
  - blast hole diameter = 165 millimetre (mm);
  - drilled burden = 5.0 metre (m);
  - drilled spacing = 5.7 m;
  - explosives mass per hole = 215 kilogram (kg);
  - number of rows of holes = 5;

- number of holes per row = 10;
- holes per blast = 5 * 10 = 50;
- blasting area = Drilled burden x Drilled spacing x Number of holes = 5.0 x 5.7 x 50 = 1425 m^2; and
- explosives per blast = 215 kg/hole * 50 holes /1000 = 10.8 tonnes.

4.B-2.1 Drilling Emissions

The following Emission Factors were used to estimate the particulate matter (PM) emissions created from the drilling of explosive charge holes prior to blasting. The emission factors were taken from the Environment Canada NPRI toolbox (Environment Canada 2016).

- TSP Emission Factor (kg/hole) = *EF(TSP)* = 0.59 kg/hole
- PM_{10} Emission Factor (kg/hole) = $EF(PM_{10})$ = 0.31 kg/hole
- $PM_{2.5}$ Emission Factor (kg/hole) = $EF(PM_{2.5})$ = 0.31kg/hole

Portable internal combustion engine powered drills are used for drilling charge holes; however, these emissions are calculated separately in the off-road vehicle exhaust emission estimate. The hourly, daily, and annual emissions from drilling are summarized in Table 4-B-1.

Table 4-B-1: Particulate Matter Emissions from Drilling

Compounds	Emissions		
	Hourly (kg/hour)	Daily (kg/day)	Annual (tonnes/year)
TSP	2.46	59.00	21.54
PM_{10}	1.29	31.00	11.32
$PM_{2.5}$	1.29	31.00	11.32

TSP = 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; kg/hour = kilograms per hour; kg/day = kilogram per day; tonnes/year = metric tonnes per year.

4.B-2.2 Emissions from Blasting

The following emissions factors (EF) were used to estimate PM emissions from the displacement (fracturing, loosening or shifting) of solid rock through the use of explosives (Environment Canada 2016). An estimate of emissions from the horizontal area displaced by blasting (A) is required:

TPM Emission Factor (kg/blast) = *EF(TPM)* = 0.00022 $(A)^{1.5}$

PM_{10} Emission Factor (kg/blast) = $EF(PM_{10})$ = (0.00022 $(A)^{1.5}$) x 0.52

$PM_{2.5}$ Emission Factor (kg/blast) = $EF(PM_{2.5})$ = (0.00022 $(A)^{1.5}$) x 0.03

Where,

A: horizontal area (m^2), with blasting depth ≤ 21 m.

EF: Emission factor for corresponding PM (kg/blast)

The same blasting plan details as outlined in Section 4.B-2.1 were used to estimate emissions from blasting. The hourly, daily, and annual emissions are summarized in Table 4.B-2.

Table 4-B-2: Particulate Matter Emissions from Blasting

Compounds	Emissions		
	Hourly (kg/hour)	Daily (kg/day)	Annual (tonnes/year)
TSP	0.60	14.46	5.28
PM_{10}	0.31	7.52	2.74
$PM_{2.5}$	0.02	0.43	0.16

TSP = 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; kg/hour = kilograms per hour; kg/day = kilogram per day; tonnes/year = metric tonnes per year.

4.B-2.3 Emissions from Explosives Detonation

Table 13.3.1 of the US EPA document - AP 42, Fifth Edition, Volume I, Chapter 13.3: Explosives Detonation (US EPA 1980) provides emission factors according to the type of explosives and their uses. The emission factors for NO_x, CO, and SO_2 are available but no EFs for PM are listed. Particulate matter produced from the use of explosives will include primarily $PM_{2.5}$ material; however, these emissions will be small compared to total PM emissions from drilling and blasting (see previous Sections). Table 4-B-3 summaries the emission factors of CO, NO_x, SO_2 assuming the explosive used for the Project is an ammonium nitrate and fuel oil mixture (ANFO).

Table 4-B-3: Emissions from the Use of Explosives

Compounds	Emission Factor (kg/tonne)	Emissions		
		Hourly (kg/hour)	Daily (kg/day)	Annual (tonnes/year)
CO	34	30.46	60.92	22.23
NO_x	8	7.17	14.33	5.23
SO_2	1	0.90	1.79	0.65

CO = carbon monoxide; NOx = oxides of nitrogen, nitrogen oxide (NO) and nitrogen dioxide (NO_2); SO_2 = sulfur dioxide; kg/tonne = kilograms per tonne of explosives; kg/hour = kilograms per hour; kg/day = kilogram per day; tonnes/year = metric tonnes per year.

4.B-3 MATERIAL HANDLING EMISSIONS

Material handling, such as loading ore and waste rock, into haul trucks will generate fugitive PM emissions. The PM emissions from this operation were estimated based on methods described in the US EPA document - AP 42, Fifth Edition, Volume I, Chapter 13.2.4 Aggregate Handling and Storage Piles (US EPA 2006a). The emission factor of material handling was calculated from the following equation:

$$E = k(0.0016)\frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}$$

Where:

E = emission factor in kg per tonnes of material handled (kg/t);

k = particle size multiplier (k_{TSP} = 0.74; k_{PM10} = 0.35; $k_{PM2.5}$ = 0.053);

U = mean wind speed meters per second (m/s);

M = material moisture content (%).

The materials handled in pit include ore and waste rock. The ore tonnages from the Whale Tail Pit in maximum production years of 2020 and 2021 were used to estimate air emissions. The annual ore tonnages were 3,285,000 tonnes. The throughput of the ore from the open pit is 9,000 tonnes per day. The averaged strip ratio of the open pit mining is 6.25. Therefore the daily throughput of waste rock from the Whale Tail Pit is 56,250 tonnes. Material handling emissions are also generated from the ore pad and Whale Tail WRSF, which have material throughputs of 9,000 tonnes of ore and 56,250 tonnes of waste rock per day, respectively. The mean wind speed (U) and the ore moisture content (M) were assumed to be the same as those used in the Meadowbank Environmental Impact Statement (Cumberland 2005).

- mean wind speed (U) = 5.0 meters per second (m/s); and
- ore moisture content (M) = 5.0 percent (%).

The PM emissions from in pit material handling are listed in Table 4.B-4.

Table 4-B-4: Particulate Matter Emissions from In Pit Material Handling

Emission Source	Daily Emission rates (kg/day)		
	TSP	**PM_{10}**	**$PM_{2.5}$**
In pit material handling	2.59	1.23	0.18
Ore pad material handling	0.36	0.17	0.02
Waste Rock Storage Facility material handling	2.24	1.06	0.16

TSP = 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; kg/day = kilograms per day.

4.B-4 IN PIT UN-PAVED ROAD DUST

The haul trucks travelling on the un-paved road within the Whale Tail Pit will generate fugitive road dust. These PM emissions were estimated using emission factors in the US EPA AP-42, Fifth Edition, Volume I, Chapter 13.2.2: Un-paved Roads (US EPA 2006b). The emission factors were calculated using the following equation.

$$E = \left[k\left(\frac{s}{12}\right)^a\left(\frac{W}{3}\right)^b\right] * 281.9$$

Where:

E = size specific emission factor in kilograms per vehicle kilometer travelled (kg/VKT);

k, a, b = empirical constants;

s = silt content (%); and

W = mean vehicle weight (tons).

The empirical constants are listed in Table 4-B-5.

Table 4-B-5: Empirical Constants for Un-paved Road Dust Emission Calculation

Constants	TSP	PM_{10}	$PM_{2.5}$
k (lb/VMT) :	4.9	1.5	0.15
a	0.7	0.9	0.9
b	0.45	0.45	0.45

VMT = vehicle miles travelled; TSP = 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.

Table 4-B-6 summarizes equipment expected to operate within the Whale Tail Pit. This inventory is based on the current equipment inventory from Meadowbank Mine.

Table 4-B-6: In Pit Equipment

Vehicle Name	Quantity	Horse power (hp)	US EPA Emission Standard	Operating Hours Per Day	Operating Hours Per Year	% Time in Pit	Average Truck Weight (kg)
Excavator - Terex - RH120	2	1,400	Tier 3	20	7,300	1	175,000
Wheel Loader - Cat - 992G	2	880	Tier 3	20	7,300	1	94,927
Excavator - Cat - 390D L	1	1,080	Tier 3	20	7,300	1	86,190
Mining Truck - Caterpillar 777F	11	939	Tier 3	20	7,300	0.5	119,386
Prod. Drill - ATLAS-DM45	4	630	Tier 3	20	7,300	1	43,091
Motor Grader - Cat - 16M	3	297	Tier 3	20	7,300	1	26,959
Wheel Dozer - Cat - 834H	1	523	Tier 3	20	7,300	1	47,106
Track Dozer - Cat - D9T	4	464	Tier 3	20	7,300	1	47,900
Excavator - Cat - 345D	2	380	Tier 3	20	7,300	1	45,375
Water Truck - CAT - 773D	1	600	Tier 3	8	2,920	0.5	37,800

hp = horsepower; % = percent; kg = kilograms.

The following assumptions were made to calculate the production of in pit fugitive road dust:

- road silt content = 6.1%;
- daily watering of un-paved road will provide a control efficiency of 70%;
- natural mitigation of road dust was based on the days with precipitation > 0.2 mm in unfrozen season (Baker Lake meteorology station);
- a 90% natural mitigation efficiency was applied when there is snow cover on the ground; and
- one-way haul truck travel distance in pit = 1.5 km.

Road silt content (6.1%) is based on the average silt content of 11 assays of Esker material considered for use as haul road construction material for the Project (Englobe 2015). The estimated in pit road dust emissions are summarized in Table 4-B-7.

Table 4-B-7: In Pit Un-paved Road Dust Emissions

Compounds	Emissions		
	Hourly (kg/hour)	Daily (kg/day)	Annual (tonnes/year)
TSP	128	3,072	1,121
PM_{10}	34.2	822	300
$PM_{2.5}$	3.42	82.2	30.0

TSP = 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; kg/hour = kilograms per hour; kg/day= kilograms per day; tonnes/year = metric tonnes per year.

4.B-5 IN PIT OFF-ROAD VEHICLES EXHAUST

The US EPA's NONROAD method was finalized in 2005 and provides the most current and representative method of calculating vehicle emissions (US EPA 2005). The NONROAD estimates emission rates for a single vehicle were based on the following equation:

$$\begin{aligned} \text{Vehicle Emissions} = {} & \text{Vehicle Horsepower} \times \text{Steady State Emission Factor} \times \text{Gross Operating Hours} \times \\ & \text{Load Factor} \times \text{Transient Adjustment Factor} \times \text{Deterioration Factor} \end{aligned}$$

The NONROAD method includes several key elements. First, it has developed emission factors for different vehicle types and ratings representing steady-state vehicle operation. Second, NONROAD includes a load factor, accounting for the fact that off-road vehicles cannot constantly operate at their maximum rated horsepower. Last, it incorporates the emissions profile for a mobile engine during transient operating conditions and takes into consideration the engine's deterioration over time.

The steady-state emission factors, transient adjustment factors, and deterioration factors from NONROAD are summarized in Table 4-B-8 through Table 4.B-10. The off-road mobile equipment exhaust emissions are summarized in Table 4.B-11.

Table 4-B-8: Steady-State Emission Factors for Off-road Diesel Engines

Category of Vehicle	Emission Factors (zero-hour, steady-state) (g/bhp-hr)		
	NO_X	CO	PM
Vehicles 300 to 600 bhp			
tier 1	6.015	1.306	0.201
tier 2	4.335	0.843	0.132
tier 3	2.500	0.843	0.150
tier 4 final	0.276	0.084	0.009
Vehicles 600 to 750 bhp			
tier 1	5.822	1.327	0.220
tier 2	4.100	1.327	0.132
tier 3	2.500	1.327	0.150
tier 4 final	0.276	0.133	0.009
Vehicles >750 bhp			
tier 1	6.153	0.764	0.193
tier 2	4.100	0.764	0.132
tier 3	4.100	0.764	0.132
tier 4 final	2.392	0.076	0.069[a]

Source: US EPA (2004).

[a] Tier 4 transitional emission factors that are more conservative than tier 4 final emission factors are used for PM emissions.

g/bhp-hr = grams per brake horsepower hour; - = No criteria available; PM = particulate matter; CO = carbon monoxide; NO_x = oxides of nitrogen, nitrogen oxide (NO) and nitrogen dioxide (NO_2).

Table 4-B-9: Transient Adjustment and Deterioration Factors for Off-road Diesel Engines

Category of Vehicle	NO_X	CO	PM
Transient adjustment factors			
tier 1	0.95	1.53	1.23
tier 2	0.95	1.53	1.23
tier 3	1.04	1.53	1.47
tier 4[a]	–	–	–
Deterioration factors[b]			
tier 1	1.024	1.101	1.473
tier 2	1.009	1.101	1.473
tier 3	1.008	1.151	1.473
tier 4	1.008	1.151	1.473

Source: US EPA (2004).

[a] There is no transient adjustment factor for tier 4 engines since transient emission control is expected to be an integral part of all tier 4 engines.

[b] Engines are assumed to be at the end of their median life to have conservative deterioration factors in calculations.

Table 4-B-10: Load Factors for Off-road Diesel Engines

Category of Vehicle	Load Factor[a]
Agricultural Tractor	0.78
Crawler Dozer	0.58
Rubber-tired Loader	0.48
Excavator	0.53
Backhoe Loader	0.21
Skid-steer Loader	0.23
Arc Welder	0.19
Generator set	0.43
Bore Drill Rig	0.43
Grader	0.59

Source: US EPA (2004).

[a] If an equipment specific load factor is not present in the above table, the crawler dozer load factor must be utilized.

Table 4-B-11: Off-road Mobile Equipment Exhaust Emissions

Off-Road Vehicle Exhaust	Hourly Emissions (kg/hr)	Daily Emissions (kg/day)	Annual Emissions (tonnes/year)
TSP	3.19	62.6	22.8
PM_{10}	3.19	62.6	22.8
$PM_{2.5}$	3.09	60.7	22.2
NOx	49.0	969	354
SO_2	0.06	1.26	0.46
CO	13.3	259	94.4

TSP = 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; CO = carbon monoxide; NO_x = oxides of nitrogen, nitrogen oxide (NO) and nitrogen dioxide (NO_2); SO_2 = sulfur dioxide; kg/hour = kilograms per hour; kg/day = kilogram per day; tonnes/year = metric tonnes per year.

4.B-6 WIND EROSION EMISSIONS FROM ORE PAD AND WASTE ROCK STORAGE FACILITY

The wind erosion dust emission from the ore pad and Whale Tail WRSF was calculated with the methods described in the US EPA document - AP 42, Fifth Edition, Volume I, Chapter 13.2.5 Industrial Wind Erosion (US EPA 2006c). The emission factor for wind-generated particulate emission from mixtures of erodible and nonerodible surface material subject to disturbance is expressed in units of grams per square metre (g/m^2) per year as follows:

$$Emission\ factor = k \sum_{i=1}^{N} P_i$$

Where:

k = particle size multiplier (k =1 for TSP; k = 0.5 for PM_{10}, and k = 0.075 for $PM_{2.5}$);

N = number of disturbances per year;

P_i = erosion potential corresponding to the observed (or probable) fastest mile of wind for the i^{th} period between disturbances, g/m^2.

The erosion potential function for a dry, exposed surface is:

$$P = 58\ (u^* - u_t^*)^2 + 25(u^* - u_t^*)$$

$$P = 0\ for\ u^* \leq u_t^*$$

Where:

u^* = friction velocity (m/s)

u_t^* = threshold friction velocity (m/s)

The following information and assumptions were used to calculate the wind erosion emission from the ore pad and Whale Tail WRSF:

- the threshold friction velocity (1.33 m/s) of both ore and waste were taken from the AP-42 document (US EPA 2006c, Table 13.2.5-2) for Scoria (roadbed material);
- the hourly friction velocity was calculated from the hourly wind speed derived from the Project AERMET data:
  - the hourly wind speed was converted into gust 3-second wind speed by a factor of 1.52 (Durst 1960);
  - the gust 3-second wind speed was converted into fastest mile wind speed by a factor of 1.2 (Simiu et al. 2003); and
  - the friction velocity was calculated from the fasted mile wind speed from the following equation:

$$u^* = 0.4\ u(z)/\ln(\frac{z}{z_0})$$

where:

u(z) = fastest mile wind speed at z level (z = 10m); and

z_0 = surface roughness length (m).

- snow mitigation was applied assuming there is no erosion emission potential when there is snow cover on the ground; the snow cover data from the Baker Lake climate normal data were used;
- the ore pad was assumed to be disturbed every hour;

- the Whale Tail WRSF was separated into active and inactive:
  - the active Whale Tail WRSF was assumed to be 18,000 m^2 while the rest of Whale Tail WRSF was assumed to be inactive;
  - the active Whale Tail WRSF was assumed to be disturbed every hour; and
  - the inactive Whale Tail WRSF was assumed to be disturbed once every year. The maximum hourly wind erosion emission factor was used for the active area.

The wind erosion dust emissions calculated for the ore pad and Whale Tail WRSF are listed in Table 4-B-12.

Table 4-B-12: Wind Erosion Emissions from Ore Pad and Whale Tail Waste Rock Storage Facility

Storage Pile	Area (m^2)	TSP ($g/m^2/s$)	PM_{10}, ($g/m^2/s$)	$PM_{2.5}$, ($g/m^2/s$)
Ore pad	79,564	2.0E-05	9.9E-06	1.5E-06
Whale Tail WRSF, active	18,000	2.0E-05	9.9E-06	1.5E-06
Whale Tail WRSF, inactive	1,075,000	4.1E-07	2.0E-07	3.1E-08
Total waste	**1,093,000**	**7.3E-07**	**3.6E-07**	**5.4E-08**

WRSF = waste rock storage facility; m^2 = square meters; $g/m^2/s$ = grams per square meter per second; TSP = 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.

4.B-7 POWER PLANT AND CAMP HEATER

There will be four Caterpillar 3516 generators installed in the power plant to provide power for the mine site: two running and two on standby. The generators to be installed will be 1,825 kilowatt (kW) units, each expected to normally produce 1,551 kW of electricity with a power factor of 85%. The diesel fuel consumption was calculated with a diesel heating value of 19,300 British thermal units per pound (Btu/lb).

The emissions from the power plant were estimated from US EPA AP-42 Chapter 3.4 Large Stationary Diesel and All Stationary Dual-fuel Engines (US EPA 2006d). The emission factors and the emission rates are summarized in Table 4-B-13.

Table 4-B-13: Emissions Factors and Emission Rates of Generators

Contaminant	Emission Factor (g/HP-hr)	Daily Emission Rate (kg/day)
NO_x	10.9	1,102
CO	2.49	252
SO_2	0.06	5.57
TSP	0.32	32.1
PM_{10}	0.32	32.1
$PM_{2.5}$	0.31	31.2

TSP = 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; CO = carbon monoxide; NO_x = oxides of nitrogen, nitrogen oxide (NO) and nitrogen dioxide (NO_2); SO_2 = sulfur dioxide; g/hp-hr = gram per horse power per hour; kg/day = kilogram per day.

A 500 kW diesel-fired heater will be used to heat the camp at the Project. Fuel consumption was calculated assuming a consumption rate of 0.25 liters per kilowatt-hour (L/kWh). The emissions from the diesel-fired heater were calculated using the emission factors presented in US EPA AP-42 Chapter 1.3 Fuel oil combustion (US EPA

2006e). The emission factors for distillate oil fired boilers with a capacity of less than 100 million Btu/hr were used. The emission factors and the daily emission rates are listed in Table 4.B-14.

Table 4-B-14: Emissions Factors and Emission Rates of Camp Heater

Contaminant	Emission Factor (lb/10^3 gal)	Daily Emission Rate (kg/day)
NO_x	20.00	7.19
CO	5.00	1.80
SO_2	2.13	0.77
TSP	2.00	0.72
PM_{10}	1.00	0.36
$PM_{2.5}$	0.25	0.09

TSP = 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; CO = carbon monoxide; NO_x = oxides of nitrogen, nitrogen oxide (NO) and nitrogen dioxide (NO_2); SO_2 = sulfur dioxide; lb/10^3 gal = pound per 1000 gallon; kg/day = kilogram per day.

4.B-8 HAUL ROAD EMISSIONS

The proposed haul road links the Whale Tail Pit to the Meadowbank Mine and has a length of 63 km. The estimated number of days per year that there will be traffic on the road is 337 days. The anticipated range of daily vehicle traffic for each type of vehicle using the haul road is presented in Table 4-B-15 (SNC 2015). The higher end (the Upper 95%) of daily vehicle passages data was used when calculating the daily emissions from haul road to be conservative, while the average daily vehicle passages was used for calculating the annual emissions. Additional information concerning vehicle types using the haul road is summarized in Table 4.B-16.

Table 4-B-15: Daily Vehicle Traffic on the Haul Road

Category	Lower 5%	Average	Upper 95%
Long haul	64	154	173
Explosive	2	4	5
Fuel	1	2	4
Cargo	4	7	10
Pickup	12	20	26
Bus	0	2	4
Oversize	0	1	4
Maintenance	0	2	4

Table 4-B-16: Vehicle Information

Make	Model	Year	Weight Empty	Weight Loaded	Type
Cat	777F	2008	450,000 lbs	1,000,000 lbs	Tow haul
Western Star	4800SB	2012	66,000 lbs	92,048 lbs	Explosive truck
Blue Bird	VISION SL	2014	27,507 lbs	+ 54 passenger	Bus
Kenworth	T800	2013	40,000 lbs	126,000lbs	Fuel truck
Ford	F250	2013	10,000 lbs	+4 passengers +light equipment	Pickup
Kenworth	C500B	2006	128,000 lbs	172,000 lbs	Truck w/float
Western Star	6900XD	2015	188,100 lbs	573,100 lbs	Road haul truck

lbs = pounds.

Un-paved road dust emissions from the haul road were estimated using the emission factors in the US EPA AP-42 Chapter 13.2.2: Un-paved Roads (US EPA 2006b). The following assumptions were made in order to calculate the estimated road dust emissions from the haul road:

- silt content = 6.1% (Englobe 2015);
- natural mitigation of road dust was based on the days with precipitation > 0.2 mm (Baker lake meteorology station) in unfrozen season;
- for frozen season with snow cover, it is assumed a 90% of natural mitigation efficiency; and
- one-way trip haul truck travel distance = 63 km.

The overall road dust emission factor for the haul road is 5,213 grams per vehicle kilometre travelled (g/VKT). The total fleet travels 11,860 km/day. The daily un-paved road dust emissions are listed in Table 4-B-17.

Table 4-B-17: Daily Un-paved Road Dust Emissions

Particulate Matter	Emission factor (g/VKT)	Fleet distance (km)	Emission rates (kg/km)
TSP	5,213	11,860	990
PM_{10}	1,394		265
$PM_{2.5}$	139		26

TSP = 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; g/VKT = grams per vehicle kilometer travelled; km = kilometer; kg/km = kilograms per kilometer.

The on-road vehicle exhaust emissions are estimated based on the traffic data presented in Table 4-B-15 and Table 4-B-16, and emission factors derived from the Mobile Source Emission Factor Model (MOBILE) software (US EPA 2002). The MOBILE program was developed by the US EPA to address the need for a consistent on-road vehicle emission estimation approach across jurisdictions.

A series of MOBILE models have been developed by the US EPA and adopted for use in Canada by Environment Canada. The MOBILE version 6.2C was used in the air quality assessment, where "C" denotes the vehicular and emissions profiles have been modified to incorporate Canadian regulations and traffic conditions.

The MOBILE6.2C outputs emission rates based on a multitude of vehicle specific inputs. The following information was entered:

- vehicle fleet age;
- fleet composition;
- vehicle speed; and
- climatic conditions, such as average air temperature.

The daily road dust and exhaust emission factors are listed in Table 4-B-18 and Table 4-B-19, respectively.

Table 4-B-18: Daily Haul Road Emission for the Unfrozen Season (June – October)

Vehicle Type	Maximum Daily Travel Distance, km	Exhaust Factors (kg/day)					
		TSP	PM_{10}	$PM_{2.5}$	NO_X	SO_2	CO
Long-haul	9,613	1.4	1.4	1.2	44.8	0.1	12.1
Explosive	250	0.0	0.0	0.0	1.2	0.0	0.3
Fuel Truck	125	0.0	0.0	0.0	0.5	0.0	0.1
Cargo	437	0.1	0.1	0.1	2.0	0.0	0.5
Pickup	1,248	0.1	0.1	0.1	1.6	0.0	0.4
Bus	125	0.0	0.0	0.0	0.8	0.0	0.2
Oversize	62	0.0	0.0	0.0	0.3	0.0	0.1
Total Exhaust Emissions	**11,860**	**1.6**	**1.6**	**1.4**	**51.2**	**0.1**	**13.7**
Total Road Dust Emissions		**61824**	**16530**	**1,653**	**0.0**	**0.0**	**0.0**
Total Emissions		**61826**	**16532**	**1654**	**51.2**	**0.1**	**13.7**

TSP = 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; CO = carbon monoxide; NO_x = oxides of nitrogen, nitrogen oxide (NO) and nitrogen dioxide (NO_2); SO_2 = sulfur dioxide; km = kilometre; kg/day = kilogram per day.

Table 4-B-19: Daily Haul Road Emissions for the Frozen Season (November – May)

Vehicle Type	Maximum Daily Travel Distance, km	Exhaust Factors (kg/day)					
		TSP	PM_{10}	$PM_{2.5}$	NO_X	SO_2	CO
Long-haul	9,613	1.5	1.5	1.2	48.3	0.1	12.9
Explosive	250	0.0	0.0	0.0	1.3	0.0	0.3
Fuel Truck	125	0.0	0.0	0.0	0.5	0.0	0.1
Cargo	437	0.1	0.1	0.1	2.2	0.0	0.6
Pickup	1,248	0.1	0.1	0.1	1.7	0.0	0.4
Bus	125	0.0	0.0	0.0	0.8	0.0	0.2
Oversize	62	0.0	0.0	0.0	0.3	0.0	0.1
Total Exhaust Emissions	**11,860**	**1.7**	**1.7**	**1.4**	**55.1**	**0.1**	**14.6**
Total Road Dust Emissions		**6182**	**1653**	**165.3**	**0.0**	**0.0**	**0.0**
Total emissions		**6184**	**1655**	**166.7**	**55.1**	**0.1**	**14.6**

TSP = 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; CO = carbon monoxide; NO_x = oxides of nitrogen, nitrogen oxide (NO) and nitrogen dioxide (NO_2); SO_2 = sulfur dioxide; km = kilometre; kg/day = kilogram per day.

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