APPENDIX 7-A

Air Quality Modeling Report

REPORT N^{O} 161-02631-00

IDM MINING - RED MOUNTAIN UNDERGROUND GOLD PROJECT

AIR QUALITY MODELLING REPORT

APRIL 2017

IDM MINING - RED MOUNTAIN UNDERGROUND GOLD PROJECT

AIR QUALITY ASSESSMENT

Project no: 161-02631-00
Date: June 2017

WSP Canada Inc.
200 – 1985 West Broadway
Vancouver, BC, Canada V6J 4Y3

Phone: +1 604-736-5421
Fax: +1 604-736-1519
www.wspgroup.com

SIGNATURES

PREPARED BY

<Original signed by>

Curtis Wan, M.A.Sc., P.Eng.
Air Quality Engineer, Environment

<Original signed by>

Sally Pang, B.Sc., EPt
Air Quality Specialist, Environment

REVIEWED BY

<Original signed by>

Tyler Abel, M.Sc.
Project Manager, Air Quality Specialist, Environment

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1 INTRODUCTION

IDM Mining Ltd. (IDM) is proposing to develop the proposed Red Mountain Underground Gold Project (the Project), as described in the Project Description: http:/a100.gov.bc.ca/appsdata/epic/html/deploy/epic_document_436_39515.html

The proposed Project is an underground gold and silver mine located in northwest British Columbia (BC), approximately 15 km northeast of Stewart. Since the proposed Project is a mine that will have a production capacity of approximately 1,000 tonnes per day (tpd) and 365,000 tonnes per year, it is subject to a provincial environmental assessment (EA) under Part 8 of the Reviewable Projects Regulation (BC Reg 370/02) of the *BC Environmental Assessment Act*.

WSP Canada Inc. (WSP) was retained by IDM to conduct the following tasks: characterize emission sources at the facility, identify air contaminants to be considered for the assessment, quantify emissions from the Project, conduct air dispersion modelling, and compare predicted ground-level ambient air concentrations with applicable ambient air quality objectives.

2 AIR EMISSION SOURCES

In this assessment, an emissions inventory was prepared for the Project to quantify air contaminant emissions associated with the Project during two scenarios, during construction and operations. For the Construction Phase, the year 2019 (Project Year -1) was chosen which reflects the highest level of construction activity, including the site development and Tailings Management Facility (TMF) construction. For the Operation Phase, the year 2022 (Project Year +3) was chosen as this year will have the highest throughput levels, and thus be the worst-case scenario in terms of emissions. The best available activity data from IDM and the most appropriate emission models and factors available to-date were used to compile the emissions inventory.

2.1 PRIMARY SOURCES

Emissions from the following sources were included in this air quality assessment:

- Construction Scenario
  - Unpaved Roads
  - Material Handling
  - Explosives
  - Non-road Equipment
  - Onroad Vehicles
- Operation Scenario
  - Unpaved Roads

- Material Handling
- Non-road Equipment
- Onroad Vehicles
- Process Plant Sources
- Portal Vents

Wind erosion from the run-of-mill (ROM) stockpile and developmental stockpile was deemed to be insignificant. The particle size of the waste rock and ore are quite large, therefore the potential for wind erosion to occur is very unlikely. Fine material with the potential to be released as fugitive dust would be released during the material transfer to and from the piles. Therefore, stockpile fugitive emissions were not considered for the purposes of this assessment.

The following sub-sections detail the activity data that was used in this emissions inventory and dispersion modelling assessment.

2.1.1 UNPAVED ROADS

Vehicles travelling on unpaved roads generate a significant amount of fugitive dust. To estimate dust emissions from this source silt content, mean vehicle weight, and vehicle kilometers travelled are required. The silt content was determined from US EPA AP-42, Table 13.2.2-1, assuming the unpaved roads behave similarly to a Western surface coal mining, Haul road to/from pit[1]. A summary of the activity metrics for unpaved roads operations are shown below in Table 2-1.

Table 2-1 Activity Metrics for Unpaved Roads

SCENARIO	PRIMARY SOURCE	DESCRIPTION	METRIC	PROJECT
Construction (2019)	Unpaved Roads – Freight Trucks	Mean Vehicle Weight	(tonnes)	40
		Silt Fraction	(%)	8.4
		Annual Number of Freight Loads	(#/year)	647
		Total Roundtrip Distance from Highway 37A to the Underground Mines	(km)	54.0
		Annual Vehicular Kilometers Travelled	(km/year)	34,964
Operations (2022)	Unpaved Roads – Freight Trucks	Mean Vehicle Weight	(tonnes)	40
		Silt Fraction	(%)	8.4
		Annual Number of Freight Loads	(#/year)	615
		Total Roundtrip Distance from Highway 37A to the Underground Mines	(km)	54.04
		Annual Vehicular Kilometers Travelled	(km/year)	33,235

[1] *US EPA, 2006. "Unpaved Roads", Chapter 13.2.2. AP-42 Manual, November 2006.*

SCENARIO	PRIMARY SOURCE	DESCRIPTION	METRIC	PROJECT
	Unpaved Roads – Ore Haulage	Mean Vehicle Weight	(tonnes)	51
		Silt Fraction	(%)	8.4
		Annual Number of Truck Trips	(#/year)	12,167
		Total Roundtrip Distance from Process Plant Area to the Underground Mines	(km)	26.5
		Annual Vehicular Kilometers Travelled	(km/year)	322,684

Further details on the emissions methodology for the unpaved roads are shown in Appendix A.

2.1.2 MATERIAL HANDLING

Whenever material is transferred (e.g., to stockpiles, hoppers, conveyors, or trucks) fugitive dust emissions are generated. The material's moisture content determined from US EPA AP-42, Table 13.2.4-1, assumed to be similar to Western surface coal mining[2]. The mean wind speed was obtained from the on-site weather meteorological station operated by WSP. A summary of the activity metrics for unpaved roads operations is shown below in Table 2-2.

Table 2-2 Activity Metrics for Material Handling

SCENARIO	PRIMARY SOURCE	DESCRIPTION	METRIC	PROJECT
Construction (2019)	Material Handling	Moisture Content	(%)	6.9
		Average Wind Speed	(m/s)	4.9
		Portal Haul Trucks to Developmental Stockpile	(tonnes/year)	52,000
Operations (2022)	Material Handling	Moisture Content	(%)	6.9
		Average Wind Speed	(m/s)	4.876
		Portal Haul Trucks to Stockpile Near Portal Throughput	(tonnes/day)	2,253
			(tonnes/year)	365,000
		Stockpile Near Portal to Surface Haul Trucks Throughput	(tonnes/day)	2,253
			(tonnes/year)	365,000
		Stockpile Near Portal to Surface Haul Trucks Throughput	(tonnes/day)	2,253
			(tonnes/year)	365,000
		Surface Haul Truck to ROM Stockpile Throughput	(tonnes/day)	2,253
			(tonnes/year)	365,000

[2] *US EPA, 2006. "Aggregate Handling and Storage Piles", Chapter 13.2.2. AP-42 Manual, November 2006.*

Further details on the emissions methodology for the material handling are shown in Appendix A.

2.1.3 NON-ROAD EQUIPMENT

Non-road emissions sources include vehicles or pieces of equipment that operate exclusively within the site and are not licensed to travel on public roads. Details of the non-road equipment and their activity metrics were provided by IDM and are shown in Table 2-3 and Table 2-4 below. All equipment considered in this assessment were diesel vehicles. The US EPA model, NONROAD was used to develop emission factors based on a representative non-road equipment category. Load factors were matched according to the non-road default classifications.[3]

Table 2-3 Activity Metrics for Non-Road Equipment (Construction Scenario)

EQUIPMENT DESCRIPTION	QUANTITY	ENGINE POWER (KW)	OPERATING HOURS PER YEAR	NON-ROAD EQUIPMENT CLASSIFICATION
Construction Power Plant - CAT XQ1000	1	994	7,884	Excavators
Construction Power Plant - CAT XQ2000	1	1,989	7,884	Excavators
Excavator (~2.0 CU.M) CAT 345D	1	192	3,060	Excavators
Track Dozer - CAT D6T	2	153	3,060	Crawler Tractor/Dozers
Wheel Loader - CAT 966K	1	211	2,700	Rubber Tire Loaders
40 tonne Articulated Trucks CAT 740	4	348	3,060	Off-highway Trucks
Vibrating Packer - Cat CS56	1	100	1,800	Rollers
Top Percussion Drill - DX800	2	168	3,060	Bore/Drill Rigs
5 T Fork Lift Zoom-Boom - Terex GTH-5519	1	110	2,457	Rough Terrain Forklifts
65 FT Man-Lift - Genie S-65	1	36	2,457	Aerial Lifts
85 FT Man-Lift - Genie S-85	1	47	4,308	Aerial Lifts
125 FT Man-Lift Straight Boom - Genie S-125	1	55	2,457	Aerial Lifts
125 FT Man-Lift Articulating Boom - Genie ZX-135/70	1	55	2,457	Aerial Lifts
Mobile Crane - RT60 - Tadano	1	201	1,862	Cranes
Mobile Crane - RT100 - Tadano GR1000-XL2	2	201	3,723	Cranes
Tool Carrier - Cat 966K (c/w Attachments)	1	211	3,351	Tractors/Loaders/Backhoes

[3] *US EPA, 2002. "Median Life, Annual Activity, and Load Factor Values for Nonroad Engine Emissions Modeling", EPA420-P-02-014, December 2002, NR-005b.*

EQUIPMENT DESCRIPTION	QUANTITY	ENGINE POWER (KW)	OPERATING HOURS PER YEAR	NON-ROAD EQUIPMENT CLASSIFICATION
Tractor w/ Deck Trailer	2	317	1,117	Off-Highway Tractors
Portable Diesel Light Plants	1	10	7,446	Generator Sets
Scissor Lift - Genie GS4069RT	4	22	2,457	Aerial Lifts
Air Compressor	1	91	4,914	Air Compressors
Concrete Mixer Truck	2	317	918	Cement & Mortar Mixers
Concrete Pump Truck	1	317	918	Pumps

Table 2-4 Activity Metrics for Non-Road Equipment (Operations Scenario)

EQUIPMENT DESCRIPTION	QUANTITY	ENGINE POWER (KW)	OPERATING HOURS PER YEAR	NON-ROAD EQUIPMENT CLASSIFICATION
30t Haul Truck - Sandvik - TH430	6	310	2,945	Off-highway Trucks
LHD - 7.5yd - Sandvik LH 514	2	256	2,590	Rubber Tire Loaders
2 Boom Jumbo - Sandvik DD321-40	1	110	1,476	Bore/Drill Rigs
Bolter - Sandvik DS311	1	62	3,140	Bore/Drill Rigs
Explosives Truck - AC3 Emulsion Charger	1	110	1,050	Off-highway Trucks
Longhole Drill - Sandvik DL311	2	74	1,631	Bore/Drill Rigs
Scissor Lift - Maclean SL-2	1	103	1,780	Aerial Lifts
Shotcrete Sprayer - Maclean SS-2	1	110	1,705	Other General Industrial Eqp
Personnel Carrier - Maclean PC3	1	110	972	Off-highway Trucks
Lube Service Truck - Maclean FL-3	1	110	2,430	Off-highway Trucks
Boom Truck - Maclean BT-3	1	150	1,944	Off-highway Trucks
Transmixer - Maclean TM3	1	150	1,705	Cement & Mortar Mixers
Motor Grader - CAT12K	1	123	1,944	Graders
Utility Vehicle - Etrac 1300	1	55	1,458	Other General Industrial Eqp
Backhoe with Rockbreaker - JCB 3cx Compact	1	63	972	Tractors/Loaders/Backhoes
Telehandler - JCB 535-140	1	74	1,458	Rough Terrain Forklifts
Sand Truck / Plow truck	1	317	745	Off-highway Trucks
Water Truck	1	317	1,862	Off-highway Trucks
Tool Carrier - Cat 966K (c/w Attachments)	1	211	1,489	Tractors/Loaders/Backhoes
Skid Steer Loader (1Cu.M)	1	90	745	Rubber Tire Loaders

EQUIPMENT DESCRIPTION	QUANTITY	ENGINE POWER (KW)	OPERATING HOURS PER YEAR	NON-ROAD EQUIPMENT CLASSIFICATION
3 T Forklift - Warehouse - CAT 2DP6000	1	63	745	Rough Terrain Forklifts
Grader - Cat 14M	1	172	372	Graders
Portable Diesel Light Plant	1	10	3,723	Generator Sets
Portable Diesel Heater	2	10	745	Generator Sets
Tool Carrier - Cat 966K (c/w Attachments)	1	211	1,489	Tractors/Loaders/Backhoes
Tool Carrier - Cat 966K (c/w Attachments)	1	211	3,792	Tractors/Loaders/Backhoes

Further details on the emissions methodology for the non-road equipment are shown in Appendix A.

2.1.4 ON-ROAD FACILITY VEHICLES

Vehicles travelling on unpaved roads are themselves a source of emissions. The vehicle exhaust and particulate matter emissions generated from brake and tire wear were assessed for on-road vehicles. The total vehicle kilometers travelled for the haul trucks was determined by anticipated tonnage of ore to be moved (365,000 tonnes/year) rather than its assumed travel speed. A summary of the activity metrics for on-road facility vehicles is shown below in Table 2-5.

Table 2-5 Activity Metrics for On-Road Facility Vehicles

SCENARIO	PRIMARY SOURCE	DESCRIPTION	METRIC	PROJECT
Construction (2019)	Supervisor Pickup – Ford F-350	Fuel Type		Diesel
		Number of Equipment	(#)	1
		Operating Hours per Year	(hr/year)	3,060
		Assumed Operating Speed	(km/hr)	15
		Total Vehicle Kilometres Travelled	(km/year)	45,900
		MOVES Equipment Classification		Light Commercial Truck
	Truck – Toyota PC	Fuel Type		Diesel
		Number of Equipment	(#)	2
		Operating Hours per Year	(hr/year)	4,468
		Assumed Operating Speed	(km/hr)	15
		Total Vehicle Kilometres Travelled	(km/year)	8,935
		MOVES Equipment Classification		Light Commercial Truck
	Freight Trucks	Fuel Type		Diesel
		Total Number of Truck Trips per Year	(trucks/year)	647
		Round trip Distance from Highway	(km)	54.04

SCENARIO	PRIMARY SOURCE	DESCRIPTION	METRIC	PROJECT
		37A to the Processing Plant		
		Total Vehicle Kilometres Travelled	(km/year)	34,964
		MOVES Equipment Classification		Single Unit Short-Haul
Operations (2022)	46 Passenger Bus	Fuel Type		Diesel
		Number of Equipment	(#)	1
		Operating Hours per Year	(hr/year)	1,117
		Assumed Operating Speed	(km/hr)	15
		Total Vehicle Kilometres Travelled	(km/year)	16,754
		MOVES Equipment Classification		Single Unit Short-Haul
	Truck – Toyota PC	Fuel Type		Diesel
		Number of Equipment	(#)	2
		Operating Hours per Year	(hr/year)	3,723
		Assumed Operating Speed	(km/hr)	15
		Total Vehicle Kilometres Travelled	(km/year)	7,446
		MOVES Equipment Classification		Light Commercial Truck
	30t Haul Truck - Freightliner	Fuel Type		Diesel
		Total Number of Truck Trips per Year	(trucks/year)	12,167
		Round trip Distance from the Mine to the Processing Plant	(km)	26.5
		Total Vehicle Kilometres Travelled	(km/year)	322,684
		MOVES Equipment Classification		Single Unit Short-Haul
	Freight Trucks	Fuel Type		Diesel
		Total Number of Truck Trips per Year	(trucks/year)	615
		Round trip Distance from Highway 37A to the Processing Plant	(km)	54.0
		Total Vehicle Kilometres Travelled	(km/year)	33,235
		MOVES Equipment Classification		Single Unit Short-Haul

Further details on the emissions methodology for the on-road facility vehicles are shown in Appendix A.

2.1.5 PROCESS PLANT SOURCES

A number of sources are operating at the Process Plant, which produce emissions. A summary of the activity data for the Process Plant sources, which operate only during the Operation scenario, is shown below in Table 2-6.

Table 2-6 Activity Metrics for Process Plant Sources

PRIMARY SOURCE	SOURCE DESCRIPTION	DESCRIPTION	METRIC	PROJECT
Process Plant Sources (Operation Scenario Only)	Primary Crusher Dust Collector Stack	Annual Hours of Operation	(hr/year)	8760
		Volumetric Flow Rate	(m^3/s)	16.96
	Secondary Crusher Dust Collector Stack	Annual Hours of Operation	(hr/year)	8760
		Volumetric Flow Rate	(m^3/s)	16.96
	Tertiary Crusher Dust Collector Stack	Annual Hours of Operation	(hr/year)	8760
		Volumetric Flow Rate	(m^3/s)	16.96
	Stockpile and Reclaim Dust Collector Stack or Bin	Annual Hours of Operation	(hr/year)	8760
		Volumetric Flow Rate	(m^3/s)	16.96
	Carbon Regeneration Kiln – Off-Gas	Annual Hours of Operation	(hr/year)	8760
		Volumetric Flow Rate	(m^3/s)	1.06
	Reagent - Lime - Fume Extraction	Annual Hours of Operation	(hr/year)	8760
		Volumetric Flow Rate	(m^3/s)	0.39
	Reagent - Zinc/Copper Sulphate - Fume Extraction	Annual Hours of Operation	(hr/year)	8760
		Volumetric Flow Rate	(m^3/s)	0.39
	Reagent - PAX - Fume Extraction	Annual Hours of Operation	(hr/year)	8760
		Volumetric Flow Rate	(m^3/s)	0.39
	Reagent - SMBS - Fume Extraction	Annual Hours of Operation	(hr/year)	8760
		Volumetric Flow Rate	(m^3/s)	0.39
	Reagent - Caustic - Fume Extraction	Annual Hours of Operation	(hr/year)	8760
		Volumetric Flow Rate	(m^3/s)	0.39
	Reagent - Test - Fume Extraction	Annual Hours of Operation	(hr/year)	8760
		Volumetric Flow Rate	(m^3/s)	0.39
	Reagent - Cyanide (Mixing and Storage) - Fume Extraction	Annual Hours of Operation	(hr/year)	8760
		Volumetric Flow Rate	(m^3/s)	0.39
	Smelting Furnace - Bag House - Stack	Annual Hours of Operation	(hr/year)	8760
		Volumetric Flow Rate	(m^3/s)	1.06
	Assay Lab	Annual Hours of Operation	(hr/year)	8760
		Volumetric Flow Rate	(m^3/s)	3.27
	Fire Water - Standby Diesel Pump	Annual Hours of Operation	(hr/year)	8760
		Volumetric Flow Rate	(m^3/s)	0.08

Full details on the emissions methodology for the processing plant sources are shown in Appendix A.

2.1.6 EXPLOSIVES

Explosives will be used during the construction of the Access Road, Haul Road, and Portals. It has been assumed that blasting on the surface is not expected during Operation, and emissions from underground blasting will be accounted for in the emissions from the air raises from the portal vents source.

A summary of the activity data for the blasting operation is shown below in Table 2-7.

Table 2-7 Activity Metrics for Blasting Sources

PRIMARY SOURCE	SOURCE DESCRIPTION	DESCRIPTION	METRIC	PROJECT
Explosives (Construction Scenario Only)	Site Development	Area Per Blast	(m^2)	911
		Annual Number of Blasts	(blasts/year)	87
		Total Bulk Explosive Required	(kg/year)	65,370
	TMF Construction	Area Per Blast	(m^2)	736
		Annual Number of Blasts	(blasts/year)	93
		Total Bulk Explosive Required	(kg/year)	202,950

Full details on the emissions methodology for the explosives sources are shown in Appendix A.

2.1.7 PORTAL VENTS

Portal vents are located at the Upper and Lower Portal to facilitate fresh air recirculation into the underground workings. As there will be workers present within these portals, the concentration of air contaminates within these portals cannot exceed occupational standards set by the Ministry of Energy and Mines[4] and WorksafeBC[5]. Therefore, the worst-case emissions represent the upper bound of the occupational exposure limits, which is likely a conservative estimate.

There are two portal exhausts in total: one for the Upper Portal and one for the Lower Portal. A summary of the activity data for the portal vent exhausts, which operate only during the Operation scenario, is shown below in Table 2-8.

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[4] *Ministry of Energy, Mines and Petroleum Resources (2008). "Health, Safety, and Reclamation Code for Mines in British Columbia", 2008.*

[5] *WorkSafeBC (2017). "Guidelines Part 05. Chemical Agents and Biological Agents", accessed from https://www.worksafebc.com/en/law-policy/occupational-health-safety/searchable-ohs-regulation/ohs-guidelines/guidelines-part-05. Last retrieved: April 12, 2017.*

Table 2-8 Activity Metrics for Portal Vent Sources

PRIMARY SOURCE	SOURCE DESCRIPTION	DESCRIPTION	METRIC	PROJECT
Portal Vents (Operation Scenario Only)	Upper Ventilation Portal Exhaust	Annual Hours of Operation	(hr/year)	8760
		Volumetric Flow Rate	(m^3/s)	5
	Lower Ventilation Portal Exhaust	Annual Hours of Operation	(hr/year)	8760
		Volumetric Flow Rate	(m^3/s)	130

Full details on the emissions methodology for the portal vents are shown in Appendix A.

3 EMISSIONS INVENTORY RESULTS

For each of the emission sources, where applicable, the air contaminants that were inventoried included the following Criteria Air Contaminants (CACs), Greenhouse Gases (GHGs), and climate forcers.

<u>Criteria Air Contaminants:</u>

- Carbon Monoxide (CO);
- Nitrogen Oxides (NO_x);
- Sulphur Oxides (SO_x);
- Total Suspended Particulate (TSP);
- Particulate matter less than 10 microns in diameter (PM_{10}); and
- Particulate matter less than 2.5 microns in diameters ($PM_{2.5}$);

<u>Greenhouse Gases and Climate Forcers:</u>

- Carbon Dioxide (CO_2);
- Methane (CH_4); and
- Nitrous Oxides (N_2O).

For reporting purposes, emissions of GHGs have been estimated on a CO_2 equivalent tonnes based on the 100-year time horizon (CO_2e_{100}) and the 20-year time period (CO_2e_{20}). The Global Warming Potentials shown in Table 3-1 below were applied to determine CO_2 equivalent emissions for these two time horizons. For CH_4 and N_2O, the Global Warming Potentials shown are based on the Fourth

Assessment Report from the Intergovernmental Panel on Climate Change[6] and adopted by the BC Ministry of Environment.

Table 3-1 Global Warming Potentials

GHG	20-YEAR	100-YEAR
CH_4	72	25
N_2O	289	298

In this assessment, a facility emissions inventory was prepared for the Construction and Operation Project scenarios in order to quantify air contaminant emissions associated with these scenarios. 2019 was chosen as the Construction baseline year and 2022 was the Operation baseline year. The best available activity data from IDM and the most appropriate emission models and factors available to-date were used to compile the facility emissions inventory. The development of the emissions inventory is based on the emission sources and activity data presented in Section 2 and the emissions methodology in Appendix A.

Emissions for the Construction scenario are shown in Table 3-2, while the emissions for the Operation scenario are shown in Table 3-3.

Table 3-2 Emissions Inventory for the Construction Scenario (tonnes/year)

AIR CONTAMINANT	UNPAVED ROADS – FREIGHT LOADS	MATERIAL HANDLING	EXPLOSIVES	NON-ROAD EQUIPMENT	ONR-OAD VEHICLES	ON-ROAD FREIGHT VEHICLES	TOTAL
CO			9.1	14.9	0.09	0.04	24.2
NO_x			2.2	51.9	0.06	0.12	54.2
SO_x			0.02	0.09	0.00	0.00	0.10
VOCs				4.6	0.01	0.02	4.6
TSP	15.0	0.02	0.93	2.1	0.01	0.02	18.1
PM_{10}	4.3	0.01	0.49	2.1	0.01	0.02	6.9
$PM_{2.5}$	0.43	0.00	0.03	2.0	0.00	0.01	2.5
NH_3					0.00	0.00	0.00
DPM				2.0	0.00	0.01	2.1
CO_2				12,088	29.2	45.9	12,163
CH_4				0.07	0.00	0.00	0.07
N_2O					0.00	0.00	0.00
CO_2e_{20}				12,093	29.4	46.2	12,168

[6] *IPCC, 2012, "IPCC Fourth Assessment Report (AR4) - Climate Change 2007: Working Group I: The Physical Science Basis". http://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch2s2-10-2.html#table-2-14*

CO_2e_{100}				12,089	29.3	46.0	12,165

Table 3-3 Emissions Inventory for the Operation Scenario (tonnes/year)

AIR CONTAMINANT	UNPAVED ROADS – FREIGHT LOADS	UNPAVED ROADS – ORE HAULAGE	MATERIAL HANDLING	DUST COLLECTORS	NON-ROAD EQUIPMENT	ON-ROAD VEHICLES	ON-ROAD FREIGHT VEHICLES	PROCESSING PLANT STACKS	TOTAL EMISSIONS
CO					2.90	0.39	0.03	0.10	3.4
NO_x					6.37	0.72	0.08	0.41	7.6
SO_x					0.03	0.00	0.00	0.02	0.05
VOCs					1.37	0.08	0.01		1.5
TSP	14.2	154	0.43	42.8	0.42	0.13	0.02	4.6	217
PM_{10}	4.06	44.0	0.20	21.4	0.42	0.13	0.02	2.3	72.6
$PM_{2.5}$	0.41	4.40	0.03	10.7	0.41	0.04	0.00	1.2	17.2
NH_3						0.01	0.00		0.01
DPM					0.41	0.00	0.00		0.41
CO_2					4,478	416	42.6		4,933
CH_4					0.02	0.03	0.00		0.05
N_2O						0.00	0.00		0.00
CO_2e_{20}					4,475	419	42.8		4,937
CO_2e_{100}					4,474	418	42.7		4,934

4 AMBIENT AIR QUALITY OBJECTIVES (AAQOS)

4.1 CRITERIA AIR CONTAMINANTS (CACS)

The management of air quality in Canada is accomplished primarily through federal and provincial government collaboration. At the federal level, the Canadian Council of Ministers of the Environment (CCME) acts as a forum for provincial governments to jointly undertake initiatives to address major environmental issues. In regards to air quality, the CCME approved a new air quality management system (AQMS) in 2012. The AQMS is a comprehensive approach for improving air quality in Canada and is the product of collaboration by the federal, provincial, and territorial governments and stakeholders. As part of the AQMS, the CCME has issued / is developing new Canadian Ambient Air Quality Standards (CAAQS) for ambient air quality management across the country. They have also established a new framework for air zone management within provinces that enables action tailored to specific sources of air emissions of concern in a given area.

As a result of these new Canadian initiatives, BC has adopted or updated several air quality objectives for a number of contaminants under the *Environmental Management Act* (2003). The BC Ministry of Environment uses air quality objectives as limits on the acceptable presence of contaminants in the atmosphere to protect human health and the environment. Provincially, air quality objectives are used to:

- Gauge current and historical air quality;
- Guide decisions on environmental effects assessments and authorizations;
- Guide airshed planning efforts;
- Inform regulatory development; and
- Develop and apply episode management strategies, such as air quality advisories.

The most recent update to the BC Ambient Air Quality Objectives (BCAAQO, BCMOE 2016) has better aligned the provincial objectives with the new guidance provided by established CAAQS from the CCME. Table 4-1 below presents the relevant BCAAQOs used in this assessment. Where federal and provincial air quality objectives are presented, the air quality assessment used the lower, or more stringent, objective is provided.

Table 4-1 Relevant BC Ambient Air Quality Objectives

CONTAMINANT	AVERAGING PERIOD	AIR QUALITY OBJECTIVE µG/M^3)	SOURCE
Nitrogen Dioxide (NO_2)	1-hour	188	Interim Provincial Air Quality Objective (AQO)
	Annual	60	

CONTAMINANT	AVERAGING PERIOD	AIR QUALITY OBJECTIVE µG/M^3)	SOURCE
Sulphur Dioxide (SO_2)	1-hour	196	Interim Provincial Air Quality Objective (AQO)
	1-hour	183	CAAQS
	Annual	13	CAAQS
Particulate Matter < 2.5 microns ($PM_{2.5}$)	24-hour	25	BC AAQO
	24-hour	28	CAAQS
	Annual	8	BC AAQO
	Annual	10	CAAQS
Particulate Matter < 10 microns ($PM_{2.5}$)	24-hour	50	BC AAQO
Total Suspended Particulate (TSP)	24-hour	120	National Ambient Air Quality Objective (NAAQO)
	Annual	60	NAAQO

Air quality objectives are meant to be protective of human health, including sensitive individuals such as the elderly, infants, or those with health conditions. Therefore, when evaluating air dispersion modelling predictions, it is typical to apply those standards at a “fenceline” that represents the area accessible to the general public. Air quality effects within the fenceline are assumed to be applicable to and regulated by occupational health and safety codes that will apply to the Project.

4.2 DUSTFALL

Provincial air quality objectives for dustfall are not included in the most recent release from the BC Ministry of Environment. The previous provincial objectives that have been used as an indicator in other regional environmental assessments were those adopted from the BC Pollution Control Objectives that defined dustfall rate limits for mining, smelting, and related industries. A lower range objective for discharges as applied to sensitive environmental situations was set at 1.7 mg/dm^2/day and an upper range for that limited unacceptable deleterious changes at 2.9 mg/dm^2/day. Since new provincial objectives have not been set for dustfall, these historical limits will be used as indicators in this assessment.

5 BASELINE AMBIENT AIR QUALITY

The BC Ministry of Environment has recently compiled a series of air zone reports. The proposed Project sits along the border of the Coastal Air Zone and Central Interior Air Zone. The remote Project location is likely more represented by the Coastal Air Zone, which is relatively undeveloped outside of Prince Rupert, Terrace, and Kitimat[7]. Air quality measurements and concerns identified in the air zone report are focused on emissions from industrial sources and woodstoves within these communities, concerns that would not be applicable to Project location. Despite this, air zone management levels for $PM_{2.5}$ were classified as "green", the classification given for air zones that are the lowest in comparison to ambient air quality objectives, based on monitoring conducted in the major population centres in the zone. It is reasonable to assume that the proposed Project location, a remote area with few anthropogenic sources, would be less affected by air emissions than these centres.

The method that is adopted to define the necessary baseline concentrations for the Air Quality Effects Assessment is a method that has been accepted for the EAs conducted and approved for other mining projects in the region. Most of these EAs have relied on historical regional data collected to define an appropriate baseline for remote areas with few anthropogenic sources. This method to define baseline pollutant concentrations was confirmed with the BC Ministry of Environment in the Project Dispersion Modelling Plan.

The approach uses data from monitoring stations that are representative of remote project areas typical of mining locations in northwest BC, including the Project location. The Project will be located in an area that is similar to both recent projects (Brucejack[8] and Kemess Underground[9]) and historical projects (KSM[10]) that have used this approach to baseline characterization. Common traits with these areas are:

- Remote and undeveloped locations;
- Located in complex terrain: steep valleys dominated by forest cover at lower elevations and rock, snow, and ice at higher elevations;
- No specific anthropogenic sources of emissions can be identified near the site beyond limited access for recreational or commercial activities along the current access road off Highway 37A; and
- Located within the same biogeoclimatic zone in BC and subject to similar season climatic regimes.

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[7] *BC MOE, 2015. Coastal Air Zone Report (2011-2013). http://www.bcairquality.ca/reports/pdfs/Coastal_Air_Zone_Report_2011-2013-v2.pdf*

[8] *ERM, 2014. Brucejack Gold Mine Project: Application for Environmental Assessment Certificate. Prepared for Pretium Resources Inc. by ERM. Vancouver, BC. http://a100.gov.bc.ca/appsdata/epic/html/deploy/epic_document_395_37914.html*

[9] *ERM. 2016. Kemess Underground Project: Application for Environmental Assessment Certificate. Prepared for Aurico Metals by ERM. Vancouver, BC http://a100.gov.bc.ca/appsdata/epic/html/deploy/epic_document_412_40387.html*

[10] *Rescan. 2012. KSM Project: Application for Environmental Assessment Certificate. Prepared for Seabridge Gold Inc. by Rescan Environmental Services Ltd.: Vancouver, BC http://a100.gov.bc.ca/appsdata/epic/html/deploy/epic_document_322_35961.html*

In order to perform air quality dispersion modelling as part of the EA, ambient background concentrations of air contaminants must be considered. The order of priority of information sources used to establish the background concentration levels is stated in the Guidelines for Air Quality Dispersion Modelling in British Columbia[11]):

1. A network of long-term ambient monitoring stations near the source under study;
2. Long-term ambient monitoring at a different location that is adequately representative; and
3. Modelled background.

Recent and historical projects that utilized this approach to define baseline pollutant concentrations relied on a combination of ambient background concentrations from stations at various locations, which are adequately representative of the background concentrations at the Project site.

For representative SO_2 concentrations, other regional mining EAs have relied upon the available estimates of remote ambient background concentrations as published by the Canadian Air and Precipitation Monitoring Network (CAPMoN). CAPMoN is a non-urban air quality monitoring network, with siting criteria designed to ensure that the measurement locations are regionally representative (i.e., not affected by local sources of air pollution). There are currently 28 measurement sites in Canada and one in the United States. The closest CAPMoN site to the Project is the Saturna station, off the southern tip of Vancouver Island in the middle of the Strait of Georgia. Although the station is almost 1,000 km southeast of the Project, it provides the best estimate of background concentration available for BC. Daily measurements of SO_2 concentrations are available from the Saturna monitoring station from 1996 to 2002 (1997 is not available). The average annual SO_2 concentration for that period was reported as 2.3 μg/m^3. However, ambient NO_2 concentrations were not measured at the Saturna station.

Since CAPMoN does not provide background concentrations for all pollutants, ambient background concentrations were also determined from other representative locations. A summary of those concentrations as submitted for the previous assessments and the recommended baseline concentrations for the proposed Project's Air Quality Effects Assessment is provided in Table 5-1 below (Table recreated from ERM, 2014[8]).

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[11] *BC MOE, 2015. Guidelines for Air Quality Dispersion Modelling in British Columbia. http://www.bcairquality.ca/pdf/bc-dispersion-modelling-guideline-2015.pdf*

Table 5-1 Summary of Baseline Air Quality Concentrations

Pollutant	Averaging Period	Concentration (µg/m³) Brucejack	Saturna	Diavik	Galore	Kitsault	Baseline representing Red Mountain
SO_2	1-hour	-	-	4.0	-	-	4.0
	24-hour	-	-	4.0	-	-	4.0
	30-day	0.13[a]	-	-	-	-	-
	Annual	-	2.3	2.0	-	-	2.0
NO_2	1-hour	-	-	21	-	-	21
	24-hour	-	-	21	-	-	21
	30-day	0.09 to 4.1	-	-	-	-	-
	Annual	-	-	5.0	-	-	5.0
CO	1-hour	-	-	100	-	-	100
	8-hour	-	-	100	-	-	100
TSP	24-hour	-	-	10	-	3.5	10
	Annual	-	-	10	-	-	10
PM_{10}	24-hour	-	-	10	3.4	2.5	3.4
$PM_{2.5}$	24-hour	-	-	-	1.3	2.3	1.3
	Annual	-	-	-	-	-	1.3

The Diavik Diamond Mine (Diavik) is in the Northwest Territories, located about 300 km northeast of Yellowknife. In the Diavik Diamond Mine EA[12], ambient background concentrations for NO_2, SO_2, and particulates were estimated based on surveys and assumptions. These ambient concentrations have been considered to be typical background concentrations for remote areas with few anthropogenic sources. The Galore Greek Mine Project (Galore) is located approximately 170 km northwest of the proposed Project. The baseline monitoring conducted in 2005 included measurements of ambient PM_{10} and $PM_{2.5}$ concentrations[13]. The Kitsault Mine Project (Kitsault) is located on the northwest coast of BC, approximately 140 km north of Prince Rupert and 60 km south of the proposed Project. TSP, PM_{10}, and $PM_{2.5}$ were measured on site[14].

The Brucejack Gold Mine Project EA relied on the same baseline air quality representation as presented above and this mine is located approximately 65 km north-northwest of the proposed Project. The Kemess Underground Project also relied on the same baseline air quality representation and is located approximately 225 km northeast of the proposed Project. It is recommended, as with the previous assessments referenced, that the baseline concentrations for the proposed Project's Air Quality Effects Assessment adopt ambient concentrations from these representative remote sites.

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[12] *Cirrus, 1998. Diavik Diamond Project – Environmental effects report, climate and air quality. Yellowknife, NT: Report prepared for Diavik Diamond Mines Inc. by Cirrus Consultants*

[13] *Rescan, 2006. Galore Creek Project: Application for Environmental Assessment Certificate. Prepared for NovaGold Inc. by Rescan Environmental Services Ltd.: Vancouver, BC*

[14] *AMEC, 2011. Kitsault Mine Project Environmental Assessment. Appendix 6.2-A Atmospheric Environmental Baseline Report.*

1-hour and 24-hour SO_2 concentrations of 4.0 μg/m^3 are from the Diavik Diamond Mine EA. In the Brucejack EA, the passive collection of SO_2 concentrations revealed a 30-day SO_2 concentration of 0.13 μg/m^3. Comparing this to the annual concentrations of 2.3 and 2.0 μg/m^3 from Saturna and Diavik, ambient SO_2 concentrations at the Project area were deemed to be much lower. Therefore, the concentrations from Diavik are conservatively assumed to represent the Project area.

As with the Brucejack EA, the 30-day NO_2 concentration of 0.09 μg/m^3 was collected at the Project's proposed mine site while the concentration of 4.1 μg/m^3 was collected within 5 km of Higway 37A. Comparing with the background concentrations from Diavik, the NO_2 concentrations at the Project area are also much lower. The concentrations from Diavik are conservatively assumed to represent the Project area.

There are currently no CO ambient concentrations available other than from Diavik, and therefore the background concentrations of 100 μg/m^3 from Diavik are assumed to represent the Project area.

For suspended particulates, a wider range of concentration variation was observed between Diavik and Kitsault. Thirty 24-hour samples were collected at Diavik, while for Kitsault, the monitoring durations for TSP, PM_{10}, and $PM_{2.5}$ were each approximately 7.5 hours. Data collected from Diavik is deemed to be a more accurate representation of the 24-hour averages and is used to represent the Project area. The Diavik study did not provide clear information on whether the PM_{10} concentration was assumed to be the same as TSP. Since the latter is more likely, PM_{10} concentration from Galore are assumed to be representative of the Project area. Concentration of $PM_{2.5}$ from Galore is also selected to represent the Project area. With the absence of available annual $PM_{2.5}$ concentrations, 24-hour $PM_{2.5}$ concentrations from Galore are conservatively assumed to represent $PM_{2.5}$ annual concentration.

Following submission of the Project's Application for an Environmental Assessment Certificate / Environmental Impact Statement, as part of the adaptive management of air quality for the Red Mountain Underground Gold Project, baseline air quality conditions relevant to the adaptive management plan will be characterized prior to construction. These baseline air quality conditions will be used to establish air quality adaptive management criteria or triggers for the construction and operations of the Project. This baseline monitoring, prior to construction, will also serve as a comparative check on the assumptions made in characterizing air quality existing conditions based on available information from other regional EAs and remote monitoring stations.

Dust deposition rates will be modelled to support other valued component effects assessments. As with the Kemess Underground Mine assessment[9], dustfall monitoring was not conducted at the Project site; therefore, background dustfall levels from other projects were used. Baseline dustfall data have been collected at the Kerr-Sulphuret-Mitchell (KSM) Project, approximately 75 km north of the Project, and at the Brucejack, Galore, Kitsault, and the Schaft Creek Projects, located 180 km northwest of the Project. At KSM, dust deposition rates were monitored from June 2008 to October 2011 at five to ten locations, depending on the year[10]. The deposition rates varied from below-detection limit to 2.75 mg/dm^2/day. Sampling took place during the summer and early fall, which are typically the driest time of the year and therefore dustfall is not mitigated by precipitation. The average dustfall rate for individual stations measured between 2008 and 2011 ranged from 0.12 to 1.22 mg/dm^2/day. At Brucejack, dustfall rates were monitored at six stations in 2012. The average dust deposition rates for each station ranged from 0.18 to 1.53 mg/dm^2/day[8]. At Galore, dustfall was monitored in 2012. The average for each of the five sites ranged from 0.09 to 0.96 mg/dm^2/day[15]. At Kitsault, the air quality baseline monitoring data showed that the highest dustfall rate was 0.46 mg/dm^2/day in July 2009 and the average is 0.21 mg/dm^2/day[14]. At Schaft Creek, dustfall was monitored in 2007 (July, August, and September) and 2008 (June, July, August, and November) at eight stations. Dust deposition ranged from below-detection limit of 0.1 mg/dm^2/day to 2.5 mg/dm^2/day, and the average for each station ranged from 0.18 to 0.93 mg/dm^2/day. Dust deposition rates from various projects are summarized in the table below. The average dust deposition rates from each of the sites were calculated and the average of the five sites is 0.56 mg/dm^2/day. This dustfall deposition rate, representing remote areas, will be used to represent baseline dustfall rates in the Project LSA.

Table 5-2 Summary of Baseline Dustfall Deposition Rates

	DUSTFALL DEPOSITION RATE (MG/DM^2/DAY)					
POLLUTANT	KSM	BRUCEJACK	GALORE	KITSAULT	SCHAFT CREEK	BASELINE REPRESENTING RED MOUNTAIN
Dust deposition	0.12 - 1.22	0.18 - 1.53	0.09 - 0.96	0.21	0.13 - 0.93	0.56

[15] *Rescan, 2013. Galore Creek Project: 2012 Air Quality Baseline Report. Prepared for Galore Creek Mining Corporation by Rescan Environmental Services Ltd.: Vancouver, BC.*

6 AIR DISPERSION MODELLING RESULTS

Air dispersion modelling was conducted following the methods recommended in the *British Columbia Air Quality Dispersion Modelling Guideline*[11]. The CALPUFF air dispersion modelling suite was used to model air emissions and predicted ambient concentrations of air contaminants from the sources described in Section 2. Further details regarding the dispersion modelling methodology are in Appendix B, while the CALPUFF modelling parameters used are in Appendix C.

For the purposes of dispersion modelling, only the CACs with ambient air quality objectives (seen in the next section) were modelled. The following CACs and dustfall were modelled.

Criteria Air Contaminants:

- Carbon Monoxide (CO);
- Nitrogen Oxides (NO_x);
- Sulphur Oxides (SO_x);
- Total Particulate Matter (TSP);
- Particulate matter less than 10 microns in diameter (PM_{10}); and
- Particulate matter less than 2.5 microns in diameters ($PM_{2.5}$);

Additional Air Contaminant:

- Dustfall

A summary of model results for CACs and dustfall is presented below in Table 6-1. Table 6-1 shows the maximum predicted modelled concentrations for each averaging period with and without ambient background concentrations.

All predicted CAC concentrations were below their respective BC AAQO. Contour plots of maximum predicted concentrations, including background, are provided in Appendix D.

Table 6-1 Predicted Maximum Criteria Air Contaminant Concentrations with and without Background

AIR CONTAMINANT	AVERAGING TIME	BC AAQO (µg/m^3)	BACK-GROUND (µg/m^3)	MAXIMUM PREDICTED CONCENTRATION (µg/m^3)			MAXIMUM PREDICTED CONCENTRATION + BACKGROUND (µg/m^3)		
				ROAD DUST	ALL OTHER SOURCES EXCEPT ROAD DUST	TOTAL	ROAD DUST	ALL OTHER SOURCES EXCEPT ROAD DUST	TOTAL
NO_2 (OLM[a])	1-Hour	188	21.0			166			187
NO_2 (100%)	Annual	60	5.0			42			47
SO_2	1-Hour	196	4.0			74			78
	Annual	13	2.0			4.5			6.5
CO	1-Hour	14,300	100			505			605
	8-Hour	5,500	100			371			471
$PM_{2.5}$	24-Hour	25	1.3	1.2	16.9	17.3	2.5	18.2	18.6
	Annual	8	1.3	0.34	2.97	3.1	1.6	4.3	4.4
PM_{10}	24-Hour	50	3.4	18.5	35.6	39.3	21.9	39.0	42.7
TSP	24-Hour	120	10.0	64.9	68.7	81.3	74.9	78.7	91.3
	Annual	60	10.0	12.0	9.1	14.6	22.0	19.1	24.6
Total Dustfall	Annual	1.7 mg/dm^2 /day	0.56	0.41	0.079	0.42	0.97	0.64	0.98
Wet Deposition	Annual			0.050	0.019	0.054	0.61	0.58	0.61
Dry Deposition	Annual			0.38	0.076	0.39	0.94	0.64	0.95

[a] Based on an Ozone background of 100 µg/m^3.

7 CONCLUSION

Air dispersion modelling was conducted for the proposed Project. The operations year 2022, representing Project year 3, and associated emission sources were modelled using the CALPUFF model. Predicted pollutant concentrations were compared to BC AAQOs.

Predicted pollutant concentrations were all lower than the applicable AAQOs. Dustfall deposition rates were also predicted to be lower than the historical provincial dustfall objectives.

Appendices

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A EMISSIONS ESTIMATION METHODOLOGY

The following sections detail the emissions quantification methods used and the assumptions applied for each primary emissions source category for the Project Construction and Operation scenarios. Primary sources consist of fugitive dust sources, road equipment, on-road facility vehicles, and Process Plant sources.

A.1 FACILITY SOURCES

Emissions are released from a variety of facility sources, which are shown in Table A-1, for both Construction and Operation scenarios.

Table A-1 Summary of Facility Emission Sources

YEAR	SOURCE	SOURCE DESCRIPTION
Construction (2019)	Unpaved Roads	Unpaved Roads – Freight Trucks
	Material Handling	Loading & Unloading Operations
	Explosives	Blasting
	Non-Road Equipment	Temporary Infrastructure Equipment
		Earthwork Equipment
		Construction Equipment
	On-Road Vehicles	Pick-up Trucks
		Freight Trucks
Operation (2022)	Unpaved Roads	Unpaved Roads – Freight Trucks
		Unpaved Roads – Ore Haulage
	Material Handling	Loading & Unloading Operations
	Non-Road Equipment	Surface Support Equipment
		Process Support Equipment
		Ore Haulage Equipment
	On-Road Vehicles	Passenger Bus
		Pick-up Trucks
		Freight Trucks
	Process Plant Sources	Crusher Dust Collector Stacks
		Reclaim Stockpile Dust Collector Stack
		Process Plant Stacks
		Standby Diesel Pump
	Portal Vents	Mine Portal Air Exhausts

Details on the emissions quantification methodologies used for each of the source types listed in Table A-1 are presented in the following sections.

A.2 UNPAVED ROADS

The unpaved road dust was calculated using AP-42 emission factors from the USEPA for unpaved roads[1]. The following equations were used to estimate the particulate emissions from vehicles travelling on unpaved industrial roads:

$$ER = EF * VKT * (1- CE)$$

$$EF = k\ (s/12)^a * (W/2.72)^b * (365-p) / 365$$

where:

ER	=	*Emission rate (kg/year)*
EF	=	*Emission factor (kg/VKT)*
VKT	=	*Vehicle kilometers travelled (km)*
CE	=	*Control efficiency*
k,a,b	=	*Equation constants for TSP,* PM_{10}*, and* $PM_{2.5}$
s	=	*Surface material silt content (%)*
W	=	*Mean vehicle weight (tonnes)*
p	=	*Number of days in a year with at least 0.254 mm of precipitation*

Activity data used in these equations is shown in Section 2 of the main report. A control efficiency of 70%[2] was assumed, based on watering more than twice a day.

Annual particulate emissions were brought to a daily and hourly emission averaging periods assuming no dust control from natural precipitation (i.e. p = 0).

A.3 MATERIAL HANDLING

Material handling emissions were calculated using AP-42 emission factors for Aggregate Handling and Storage Piles[3]. The fugitive dust released from these sources were estimated based on the following general equation:

$$E_i = EF_i * Activity * (1 – CE)$$

where:

E_i	=	*Emissions of pollutant i*

[1] *US EPA, 2006. "Unpaved Roads", Chapter 13.2.2. AP-42 Manual, November 2006.*
[2] *Environment Canada, 2008. "Unpaved Industrial Road Calculator", November 2008.*
[3] *US EPA, 2006. "Aggregate Handling and Storage Piles", Chapter 13.2.2. AP-42 Manual, November 2006.*

EF_i = *Emission factor for pollutant i*

Activity = *Quantity of materials handled/processed*

CE = *Control equipment efficiency (fraction)*

The activity data associated with the Construction and Operation scenarios has been presented in the main report while the emission factors used to determine source-specific releases are shown in Table A-2. The emission factors in Table A-2 were derived using an average wind speed of 5 m/s based on an analysis of local meteorological data, an assumed material moisture content of 6.9% assuming the ore rock behaves similarly to Coal from Western Surface Mining[3]. Additionally, an assumed control efficiency of 50%[4] based on watering of piles was used.

Annual particulate emissions were brought to a daily and hourly emission averaging periods based on the maximum daily throughput values.

Table A-2 Material Handling Particulate Emission Factors for Construction and Operations

ACTIVITY	TSP (KG/TONNE)	PM_{10} (KG/TONNE)	$PM_{2.5}$ (KG/TONNE)	REFERENCE
Material Handling - Ore	0.00059	0.00028	0.000042	AP-42 Chapter 13.2.4

A.4 NON-ROAD EQUIPMENT

Non-road emission sources include vehicles or pieces of equipment that operate exclusively within the site and are not licensed to travel on public roads. Diesel-fired non-road equipment at the Project include heavy duty equipment such as forklifts, front-end loaders, tractors, excavators and others.

The equipment type, age, horsepower ratings, and equipment operating hours were estimated based on information from IDM. Emissions for these equipment were estimated using the NONROAD model generated emission factors and the emissions calculation is based on the following general equation:

$$E_i = EF_i * HP * LF * H * TM * C$$

where:

E_i = *Emissions of a given pollutant (t/y)*

EF_i = *EPA NONROAD Model emission factor for a given pollutant i and for a specific non-road equipment category (g/HP-hr)*

HP = *Equipment horsepower rating (HP)*

LF = *Engine loading factor (fraction)*

H = *Equipment operating hours (h/y)*

TM = *Total equipment count*

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[4] *Countess Environment (2006). WRAP Fugitive Dust Handbook, Prepare for: Western Governor's Association. September, 2006.*

C = *Unit conversion factor to tonnes (10^{-6} tonne/g)*

Engine characteristics and activity data have been provided in the Main Report. The NONROAD model emission factors applied for each non-road equipment type during construction and operation scenarios are shown in Tables A-3 and A-4, respectively. The PM_{10} emission factor has been assumed to be the same as the TSP factor while the $PM_{2.5}$ emission factor has been approximated to be 97% of the PM_{10} factor. For GHG emission factors, these were based on a recent US EPA publication[5].

Annual emission rates were based on the percentage of hourly annual operating hours for each piece of equipment. The hourly and daily emission rates were generated for the entire averaging period.

Table A-3 Construction Non-Road Model Emission Factors (g/HP-h)

EQUIPMENT DESCRIPTION	LOAD FACTOR	CO	NO_X	SO_2	TSP/PM_{10}	$PM_{2.5}$	CO_2	CH_4
Construction Power Plant - CAT XQ1000	0.43	0.77	2.90	0.00	0.10	0.10	536	0.00
Construction Power Plant - CAT XQ2000	0.43	0.77	2.90	0.00	0.10	0.10	536	0.00
Excavator (~2.0 CU.M) CAT 345D	0.59	0.19	0.67	0.00	0.03	0.03	536	0.00
Track Dozer - CAT D6T	0.59	0.24	0.82	0.00	0.04	0.04	536	0.00
Wheel Loader - CAT 966K	0.59	0.38	1.14	0.00	0.07	0.07	536	0.00
40 tonne Articulated Trucks CAT 740	0.59	0.22	0.66	0.00	0.03	0.03	536	0.00
Vibrating Packer - Cat CS56	0.59	0.54	1.25	0.00	0.12	0.12	536	0.00
Top Percussion Drill - DX800	0.43	0.19	0.67	0.00	0.03	0.03	536	0.00
5 T Fork Lift Zoom-Boom - Terex GTH-5519	0.59	0.63	1.48	0.00	0.15	0.14	536	0.00
65 FT Man-Lift - Genie S-65	0.21	4.61	4.94	0.01	0.69	0.67	692	0.02
85 FT Man-Lift - Genie S-85	0.21	4.19	4.90	0.01	0.58	0.56	693	0.01
125 FT Man-Lift Straight Boom - Genie S-125	0.21	4.19	4.90	0.01	0.58	0.56	693	0.01
125 FT Man-Lift Articulating Boom - Genie ZX-135/70	0.21	4.19	4.90	0.01	0.58	0.56	693	0.01
Mobile Crane - RT60 - Tadano	0.43	0.26	1.21	0.00	0.05	0.05	531	0.00
Mobile Crane - RT100 - Tadano GR1000-XL2	0.43	0.26	1.21	0.00	0.05	0.05	531	0.00
Tool Carrier - Cat 966K (c/w Attachments)	0.21	1.47	2.86	0.00	0.28	0.27	625	0.01
Tractor w/ Deck Trailer	0.59	0.67	1.62	0.00	0.10	0.10	536	0.00
Portable Diesel Light Plants	0.43	2.57	4.79	0.01	0.39	0.38	589	0.01
Scissor Lift - Genie GS4069RT	0.21	6.03	5.77	0.01	0.85	0.82	691	0.02

[5] *US EPA, 2010,"Exhaust and Crankcase Emission Factors for Nonroad Engine Modelling – Compression-Ignition", Assessment and Standards Division, Office of Transportation and Air Quality, July.*

EQUIPMENT DESCRIPTION	LOAD FACTOR	CO	NO_X	SO_2	TSP/PM_{10}	$PM_{2.5}$	CO_2	CH_4
Air Compressor	0.43	0.46	1.68	0.00	0.11	0.11	530	0.00
Concrete Mixer Truck	0.43	0.93	3.32	0.00	0.13	0.13	530	0.00
Concrete Pump Truck	0.43	0.92	3.13	0.00	0.14	0.14	530	0.00

Table A-4 Operation Non-Road Model Emission Factors (g/HP-h)

EQUIPMENT DESCRIPTION	LOAD FACTOR	CO	NO_X	SO_2	TSP/PM_{10}	$PM_{2.5}$	CO_2	CH_4
30t Haul Truck - Sandvik - TH430	0.59	0.16	0.37	0.00	0.02	0.01	536	0.00
LHD - 7.5yd - Sandvik LH 514	0.59	0.54	1.29	0.00	0.08	0.08	536	0.00
2 Boom Jumbo - Sandvik DD321-40	0.43	0.69	2.55	0.00	0.16	0.16	530	0.00
Bolter - Sandvik DS311	0.43	1.53	2.75	0.00	0.26	0.26	589	0.00
Explosives Truck - AC3 Emulsion Charger	0.59	0.14	0.29	0.00	0.01	0.01	536	0.00
Longhole Drill - Sandvik DL311	0.43	1.53	2.75	0.00	0.26	0.26	589	0.00
Scissor Lift - Maclean SL-2	0.21	1.72	3.09	0.00	0.33	0.32	625	0.01
Shotcrete Sprayer - Maclean SS-2	0.43	0.27	0.96	0.00	0.06	0.06	531	0.00
Personnel Carrier - Maclean PC3	0.59	0.14	0.29	0.00	0.01	0.01	536	0.00
Lube Service Truck - Maclean FL-3	0.59	0.14	0.29	0.00	0.01	0.01	536	0.00
Boom Truck - Maclean BT-3	0.59	0.12	0.29	0.00	0.01	0.01	536	0.00
Transmixer - Maclean TM3	0.43	0.62	2.62	0.00	0.13	0.12	530	0.00
Motor Grader - CAT12K	0.59	0.20	0.45	0.00	0.03	0.03	536	0.00
Utility Vehicle - Etrac 1300	0.43	0.87	3.15	0.00	0.10	0.10	590	0.00
Backhoe with Rockbreaker - JCB 3cx Compact	0.21	3.36	2.50	0.01	0.44	0.43	694	0.01
Telehandler - JCB 535-140	0.59	1.02	1.04	0.00	0.11	0.11	596	0.00
Sand Truck / Plow truck	0.59	0.16	0.37	0.00	0.02	0.01	536	0.00
Water Truck	0.59	0.16	0.37	0.00	0.02	0.01	536	0.00
Tool Carrier - Cat 966K (c/w Attachments)	0.21	1.11	2.08	0.00	0.20	0.20	625	0.01
Skid Steer Loader (1Cu.M)	0.59	0.28	0.69	0.00	0.05	0.05	536	0.00
3 T Forklift - Warehouse - CAT 2DP6000	0.59	1.02	1.04	0.00	0.11	0.11	596	0.00
Grader - Cat 14M	0.59	0.15	0.43	0.00	0.02	0.02	536	0.00
Portable Diesel Light Plant	0.43	2.46	4.64	0.01	0.37	0.36	589	0.01
Portable Diesel Heater	0.43	2.46	4.64	0.01	0.37	0.36	589	0.01
Tool Carrier - Cat 966K (c/w Attachments)	0.21	1.11	2.08	0.00	0.20	0.20	625	0.01

EQUIPMENT DESCRIPTION	LOAD FACTOR	CO	NO_X	SO_2	TSP/PM_{10}	$PM_{2.5}$	CO_2	CH_4
Tool Carrier - Cat 966K (c/w Attachments)	0.21	1.11	2.08	0.00	0.20	0.20	625	0.01

A.5 ON-ROAD VEHICLES

The on-road vehicles used on-site will be passenger trucks, passenger buses, ore haul trucks, and freight trucks for deliveries. The emission factor approach used to estimate vehicle fuel combustion emissions resulting from the operation of these vehicles is as follows:

The fleet of vehicles and their respective activity data is described in the Main Report. The emission factors was generated from the USEPA MOVES model[6], and they are shown in Tables A-5 and A-6 for the construction and operations phase, respectively.

Daily and hourly emission rates for light duty vehicles were calculated for the vehicles operating for the entire averaging period duration.

Table A-5 MOVES Model Emission Factors the Construction Phase (g/VkmT)

POLLUTANT	LIGHT COMMERCIAL TRUCK, DIESEL, 15 KM/HR, 2019	SINGLE UNIT SHORT-HAUL TRUCK, DIESEL, 15 KM/HR, 2019
CO	3.19	2.00
NO_x	2.12	5.50
SO_x	0.0087	0.018
TSP	0.23	0.94
PM_{10}	0.23	0.94
$PM_{2.5}$	0.12	0.36
CO_2	1,024	2,113
CH_4	0.050	0.14
N_2O	0.0058	0.0083

[6] *USEPA, 2014, "MOVES (Motor Vehicle Emission Simulator)", Version 2014a.* *https://www3.epa.gov/otaq/models/moves/*

Table A-6 MOVES Model Emission Factors the Operations Phase (g/VkmT)

POLLUTANT	LIGHT COMMERCIAL TRUCK, DIESEL, 15 KM/HR, 2022	SINGLE UNIT SHORT-HAUL TRUCK, DIESEL, 15 KM/HR, 2022	SINGLE UNIT SHORT-HAUL TRUCK, DIESEL, 20 KM/HR, 2022
CO	2.40	1.38	1.06
NO_x	1.47	3.74	2.90
SO_x	0.0081	0.017	0.014
TSP	0.19	0.80	0.54
PM_{10}	0.19	0.80	0.54
$PM_{2.5}$	0.078	0.23	0.17
CO_2	961	2,061	1,637
CH_4	0.054	0.15	0.10
N_2O	0.0057	0.0083	0.0055

A.6 EXPLOSIVES

Particulate emissions resulting from blasting operations was calculated using AP-42 emissions factors for Western Surface Coal Mining[7]. The particulate dust emissions released from these blasting operations was estimated based on the following equation. Scaling factors of 0.52 and 0.03 were used to convert TSP emission rates for PM_{10} and $PM_{2.5}$, respectively, assuming the material behaves similar to coal or overburden.

$$ER = 0.00022 *(A)^{1.5}$$

where:

ER = Emission rate (kg/blast)

A = Area of the blast (m^2)

Emissions from other pollutants due to blasting operations was calculated using AP-42 emission factors for Explosives Detonation[8], assuming that the explosives used is Ammonia nitrate with 5.8-8% fuel oil (ANFO). A summary of emission factors is shown below in Table A-7.

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[7] *US EPA, 1998. "Western Surface Coal Mining Chapter 11.9. AP-42 Manual, October, 1998.*
[8] *US EPA, 1995. "Explosives Detonation Chapter 13.3. AP-42 Manual, January, 1995.*

Table A-7 Explosives Emission Factors (kg/tonne explosive)

AIR CONTAMINANT	EMISSION FACTOR
CO	34
NO_X	8
SO_2	0.06

A.7 PROCESS PLANT SOURCES

During the Project Operation Phase, a number of stacks will be located near or on the Process Plant building that will emit emissions during the processing of material. The emission rates for the first four stack sources, the dust collectors, were generated assuming a 20 mg/m^3 concentration limit for TSP. PM_{10} was assumed to be 50% of the TSP emission rate, and $PM_{2.5}$ was assumed to be 50% of the PM_{10} emission rate. The rest of the Process Plant emission rates were provided directly from JDS Energy & Mining based on their experience in designing other mines and / or from equipment vendor specifications. A summary of emission factors is shown below in Table A-8.

Table A-8 Process Plant Sources Emission Rates (g/s)

STACK	CO	NOX	SO2	TSP	PM10	$PM_{2.5}$
Primary Crusher Dust Collector Stack				0.34	0.17	0.085
Secondary Crusher Dust Collector Stack				0.34	0.17	0.085
Tertiary Crusher Dust Collector Stack				0.34	0.17	0.085
Stockpile and Reclaim Dust Collector Stack or Bin				0.34	0.17	0.085
Carbon Regeneration Kiln – Off-Gas				0.004	0.003	0.002
Reagent - Lime - Fume Extraction				0.008	0.004	0.002
Reagent - Zinc/Copper Sulphate - Fume Extraction				0.008	0.004	0.002
Reagent - PAX - Fume Extraction				0.008	0.004	0.002
Reagent - SMBS - Fume Extraction				0.008	0.004	0.002
Reagent - Caustic - Fume Extraction				0.008	0.004	0.002
Reagent - Test - Fume Extraction				0.008	0.004	0.002
Reagent - Cyanide (Mixing and Storage) - Fume Extraction				0.008	0.004	0.002
Smelting Furnace - Bag House - Stack		0.0004		0.000	0.000	0.000
Assay Lab				0.021	0.011	0.005
Fire Water - Standby Diesel Pump	0.013	0.0001	0.003	0.065	0.033	0.016

A.8 PORTAL VENTS

Located at the Upper and Lower Portals are ventilation portals used as exhaust vents to facilitate circulation of fresh air into the portals. As there will be workers present within these portals, the concentration of air contaminates within these portals cannot exceed occupational standards set by the Ministry of Energy and Mines[9] and WorksafeBC[10]. Therefore, the worst-case emission rate will represent the upper bound of the occupational exposure limits, multiplied by the volume of air leaving the portal vents. The activity data for the volume of air exchanges is shown in the Main report. Table A-9 below summaries the occupational air contaminant concentrations considered.

Table A-9 Occupational Exposure Limits

AIR CONTAMINANT	OCCUPATIONAL EXPOSURE LIMIT (MG/M3)
CO	29
NO_X	37[a]
SO_X	5.2
TSP	10
PM_{10}	5[b]
$PM_{2.5}$	3

[a] Sum of the nitric oxide and nitrogen dioxide exposure limits, does not include nitrous oxide
[b] Assumed to be 50% of TSP

[9] *Ministry of Energy, Mines and Petroleum Resources (2008). "Health, Safety, and Reclamation Code for Mines in British Columbia", 2008.*
[10] *WorkSafeBC (2017). "Guidelines Part 05. Chemical Agents and Biological Agents", accessed from https://www.worksafebc.com/en/law-policy/occupational-health-safety/searchable-ohs-regulation/ohs-guidelines/guidelines-part-05. Last retrieved: April 12, 2017.*

B DISPERSION MODELLING METHODOLOGY

B.1 MODEL SELECTION

CALPUFF is a suite of numerical models (CALMET, CALPUFF, and CALPOST) that are used in series to determine the effect of emissions in the vicinity of a source or group of sources. Detailed three-dimensional meteorological fields are produced by the diagnostic computer model CALMET, based on inputs such as: surface, marine and upper air meteorological data, digital land use data and terrain data, and prognostic meteorological data. The three-dimensional fields produced by CALMET are used by CALPUFF, a three-dimensional, multi-species, non-steady-state Gaussian puff dispersion model that can simulate the effects of time and space varying meteorological conditions on pollutant transport. Finally post-processing utilities CALSUM, POSTUTIL, and CALPOST were used to post-process and summarize the modelling output from CALPUFF.

B.2 WRF

Three-dimensional prognostic meteorological data from the Weather Research and Forecasting (WRF) Nonhydrostatic Mesoscale Model (NMM) was used in the CALMET model. WRF-NMM prognostic data used for this dispersion modelling analysis was run by Exponent and provided as CALMET-ready for 2015 with 4 km grid resolution, encompassing the CALMET domain. Exponent ran WRF-NMM in “analysis mode”, using historical data snapshots from the National Centers for Environmental Prediction (NCEP) North American Mesoscale (NAM) Model as initial and boundary conditions. This historical data includes all available observations, such as satellite, radar, balloon borne, surface, and tower observations.

B.3 CALMET

CALMET Version 6.5.0 (Level 150223), an updated version of the United States Environmental Protection Agency (US EPA) approved CALMET Version 5.8.5 (Level 151214), was run to calculate meteorological fields for the modelled time period from January 1, 2015 through December 31, 2015.

Three-dimensional prognostic meteorological data from WRF-NMM was used as the meteorological input into the CALMET model, which was run in NO-OBS mode. Surface station data was not incorporated into CALMET as despite regular inspection and maintenance, the surface meteorological data collected onsite contains significant data gaps, related to instrument and datalogger errors and the harsh monitoring environment for meteorological parameters. In addition, given the complex terrain in the area, even if the surface station provided a more completed data record, the surface station influence would have to be limited by a small R1 area to restrict the influence of the station at inappropriate elevations. Thus, most of the mine footprint would likely fall outside the station influence, and therefore, CALMET was run using NO-OBS using the provincial WRF dataset as input.

The CALMET output for this modelling period were assessed following the Quality Assurance and Quality Control (QA/QC) procedures outlined in Section 9 of the *British Columbia Air Quality*

Dispersion Modelling Guideline (AQMG[11]). A description of the CALMET methods and data sets follows.

B.3.1 CALMET MODELLING DOMAIN

The Universal Transverse Mercator (UTM, NAD 83) coordinate system was used for this model application. The CALMET domain is a 40 km by 30 km domain, as shown in Figure B-1. The WRF domain incorporated into the CALMET modelling extends well beyond the CALMET domain. The CALMET model was run with a 250 m grid resolution. The modelling domain and grid resolution were chosen to encompass the main topographical features for generating the CALMET three-dimensional diagnostic meteorological fields. In the vertical axis, 11 atmospheric layers were chosen, the height of which are given in Table B-1.

[11] *BC MOE (2015), British Columbia Air Quality Dispersion Modelling Guideline. British Columbia Ministry of Environment, Environmental Protection Division, Environmental Standards Branch, Clean Air Section, Victoria, British Columbia. November 2015.*

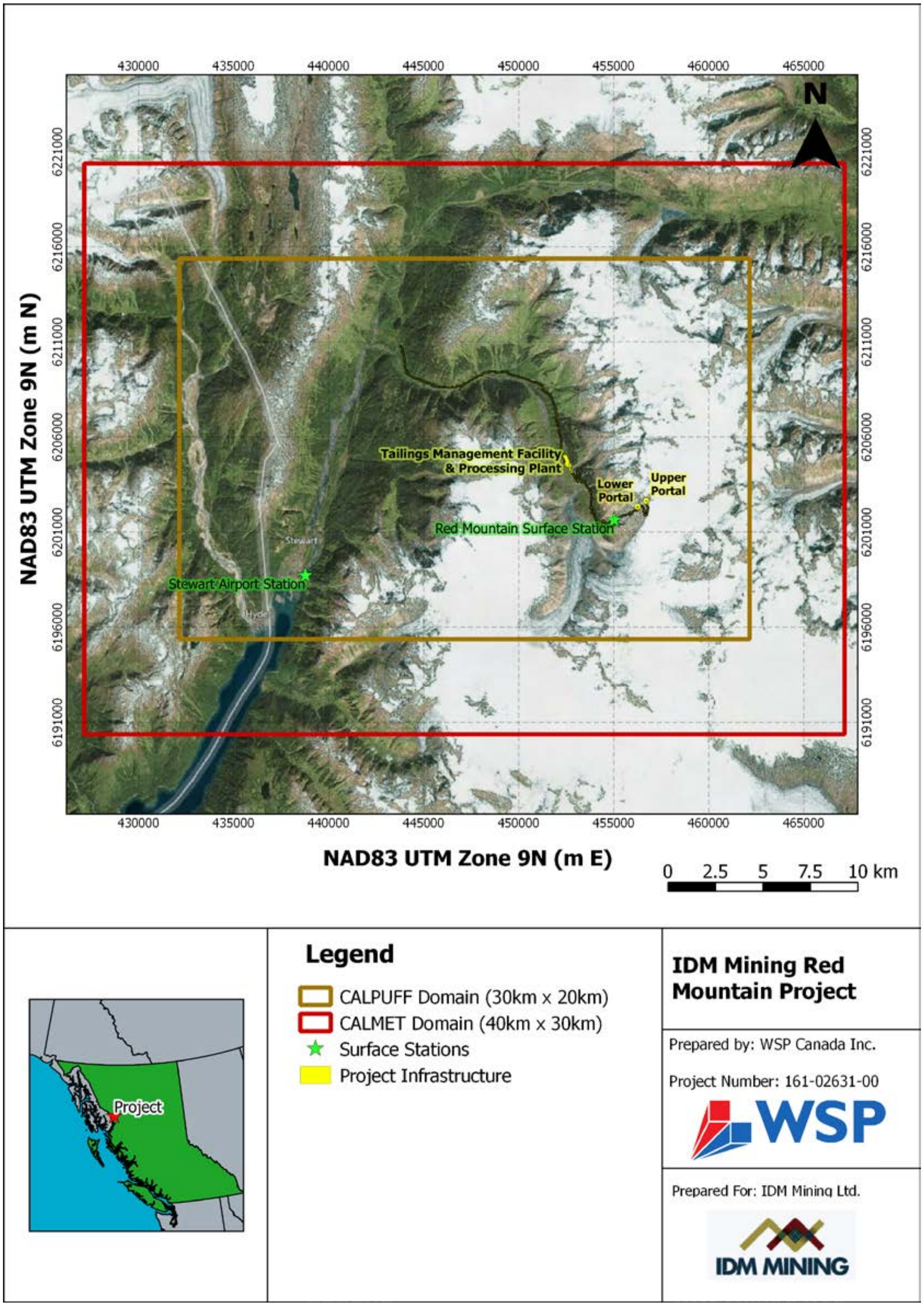


Figure B-1 CALMET and CALPUFF Domains

Table B-1 Heights of CALMET Model Layers

VERTICAL LAYER NUMBER	HEIGHT AT TOP OF LAYER (M)
1	20
2	40
3	80
4	160
5	320
6	600
7	1,000
8	1,500
9	2,000
10	3,000
11	4,000

B.3.2 TERRAIN ELEVATION AND LAND USE DATA

Digital terrain and land use data covering the model domain was included in the CALMET input data set.

Canadian digital terrain files with a 1:50,000 scale were used to generate inputs for each CALMET grid point. American terrain data was obtained from the ASTER Global Digital Elevation Mode V002, having a root-mean-squared error (RMSE) accuracies between 10 – 25 m. These two datasets were combined and a plot of the digital terrain data used in CALMET is shown in Figure B-2.

Canadian land use characteristics for each grid cell were based on LandData BC data. American land use data was obtained from the NLDC 2011 Land Cover for Alaska dataset. The land use class codes were translated into the land use class codes used by CALMET according to the procedures in the AQMG. These two datasets were combined and a plot of the land use data used in CALMET are shown in shown in Figure B-3.

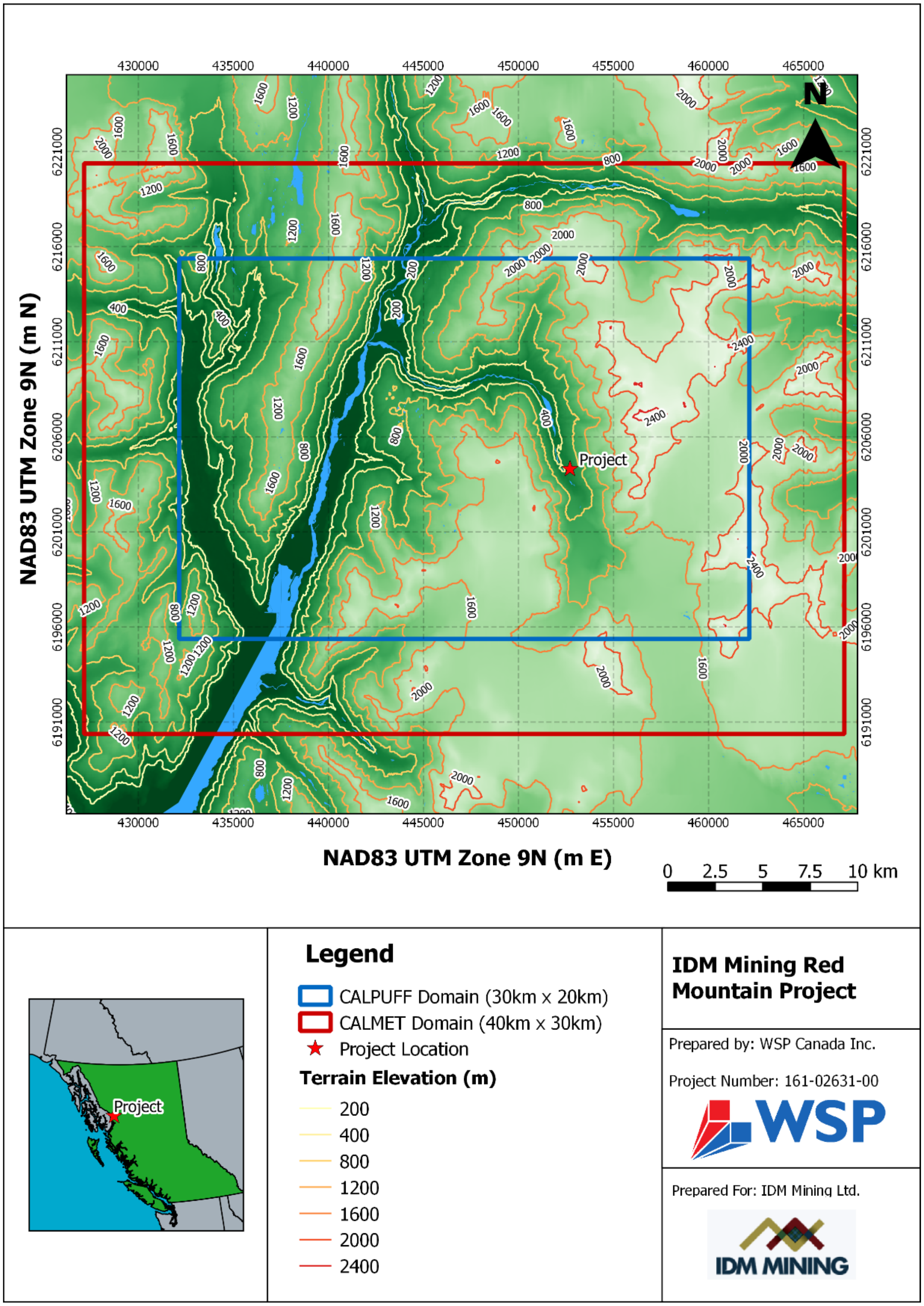


Figure B-2 Terrain Data Used in CALMET

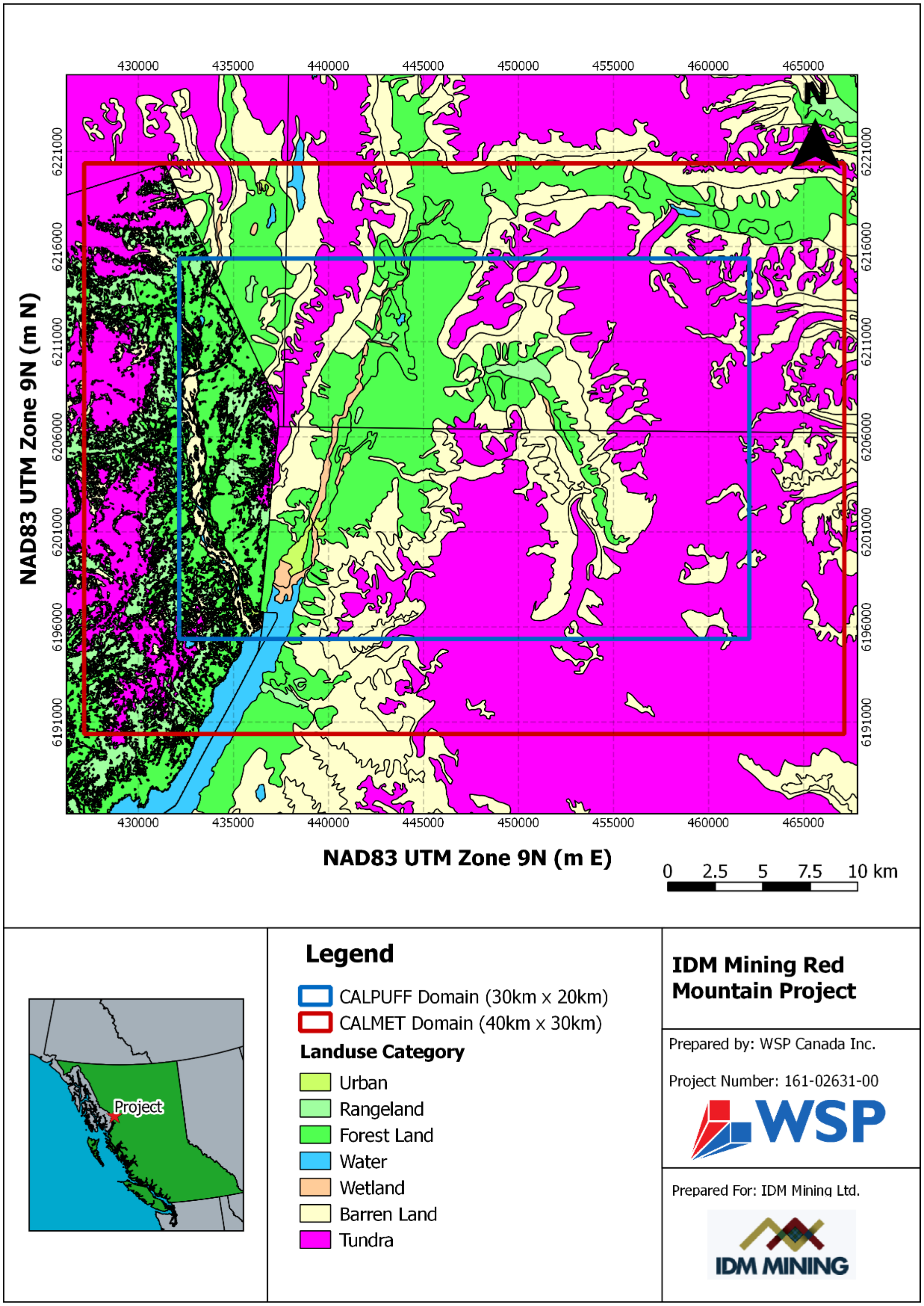


Figure B-3 Land Use Data Used in CALMET

B.3.3 CALMET MODEL OPTIONS

The CALMET model has a number of user-specified input switches and options that determine how the model handles terrain effects, interpolation of observational input data, etc. The differences in the modelled and measured meteorological fields were examined, and this analysis was used to determine which model options were appropriate for modelling period. Table B-2 outlines the CALMET options used in modelling. The 2015 AQMG default parameters were used whenever applicable.

Table B-2 Selected CALMET Model Options

CALMET MODEL OPTION	PARAMETER	OPTION SELECTED	AQMG DEFAULT
Determines whether observation data are used, or in combination with NWP model output, or NWP data only	NOOBS	2 (No surface, overwater, or upper air observations Use MM4/MM5/3D for surface, overwater, and upper air data)	No default
Cloud Data Option: 1,2,3,4	MCLOUD	4 (Gridded cloud cover from Prognostic Rel. Humidity at all levels (MM5toGrads algorithm)	✓
Wind field model selection variable	IWFCOD	1 (Yes)	✓
Compute Froude number adjustment effects?	IFRADJ	1 (Yes)	✓
Compute kinematic effects?	IKINE	0 (No)	✓
Use O'Brien procedure for adjustment of the vertical velocity?	IOBR	0 (No)	✓
Compute slope flows?	ISLOPE	1 (Yes)	✓
Extrapolate surface wind observations to upper layers?	IEXTRP	Unused	✓
Extrapolate calm winds aloft?	ICALM	0 (No)	✓
Layer-dependent biases	BIAS	Not active with NOOBS = 2	No default
Minimum distance between upper air station and surface station for which extrapolation of surface winds will be allowed	RMIN2	-1 (Set to -1 for IEXTRP = +/- 4)	✓
Gridded prognostic wind field model output fields	IPROG	14 (Yes, use wind fields from MM5/3D.dat file as initial guess field)	✓
Use varying radius of influence?	LVARY	F (No)	✓
Maximum radius of influence over land of the surface layer	RMAX1	Unused	No default
Maximum radius of influence over land aloft	RMAX2	Unused	No default
Maximum radius of influence over water	RMAX2	Unused	No default

CALMET MODEL OPTION	PARAMETER	OPTION SELECTED	AQMG DEFAULT
Maximum radius of influence of over water – all layers	RMAX3	Unused	No default
Minimum radius of influence used in the wind field interpolation	RMIN	0.1	✓
Radius of influence of terrain features	TERRAD	5.0 km	No default
Distance from a surface station at which the station observations and 1st guess field are equally weighted	R1	Unused	No default
Distance from an upper air station at which the observations and 1st guess field are equally weighted	R2	Unused	No default
Relative weighting of the prognostic wind field data	RPROG	0	No default
Maximum acceptable divergence in the divergence minimum procedure.	DIVLIM	$5*10^{-6}$	✓
Maximum number of iterations in the divergence minimum procedure.	NITER	50	✓
Number of passes in the smoothing procedure	NSMTH	2, 4, …, 4	✓
Maximum number of stations used in each layer for the interpolation of data to a grid point	NINTR2	99	✓
Critical Froude number	CRITFN	1	✓
Empirical factor controlling the influence of kinematic effects	ALPHA	0.1	✓
Multiplicative scaling factor for extrapolation of surface observations to upper layers	FEXTR2	Unused	✓
Number of barriers to interpolation of the wind fields	NBAR	Unused	✓
X and Y coordinates of barriers	XBBAR, YBBAR, XEBAR, YEBAR	Unused	✓
Diagnostic module surface temperature option	IDIOPT1	0 (Compute internally from hourly surface observations or prognostic fields)	✓
Diagnostic module surface station to use for the surface station temperature	ISURFT	Unused	✓
Diagnostic module domain-averaged lapse rate option	IDIOPT2	0 (Compute internally from (at least) twice-daily upper air observations or prognostic fields	✓
Diagnostic module upper air station to use for	IUPT	Unused	✓

CALMET MODEL OPTION	PARAMETER	OPTION SELECTED	AQMG DEFAULT
lapse rate to use			
Depth through which the domain-scale lapse rate is computed	ZUPT	200	✓
Initial guess field wind components	IDIOPT3	0	✓
Upper air station to use for domain-scale winds	IUPWND	Unused	✓
Bottom and top of layer through which the initial guess winds are computed	ZUPWND	1,1000	✓

B.4 CALPUFF

CALPUFF Version 7.2.1 (Level 150618), an updated version of the US EPA approved CALPUFF Version 5.8.5 (Level 151214), was run for the modelled time period from January 1, 2015 through December 31, 2015. The CALPUFF model was used to simulate dispersion of emissions from the emission sources from the Project, based on the meteorological wind fields developed by CALMET.

B.4.1 CALPUFF MODEL OPTIONS

Table B-3 outlines dispersion options used in the CALPUFF modelling. Unless otherwise stated in Table B-3, the applicable default regulatory options recommended in the 2015 AQMG were used as those were the regulatory options in effect.

Table B-3 Selected CALPUFF Model Options

OPTION	PARAMETER	OPTION SELECTED	AQMG DEFAULT
Vertical distribution used in the near field	MGAUSS	1 (Gaussian)	✓
Terrain adjustment method	MCTADJ	3 (Partial plume path adjustment)	✓
Subgrid-Scale complex terrain flag	MCTSG	0 (Not Modelled)	✓
Near-field puffs modelled as elongated?	MSLUG	0 (No)	✓
Transitional Plume Rise modelled?	MTRANS	1 (Yes)	✓
Stack-tip downwash?	MTIP	1 (Yes)	✓
Method selected to compute plume rise for point sources not subject to downwash.	MRISE	1 (Briggs)	✓
Method used to simulate building downwash?	MBDW	2 (Prime)	✓
Vertical wind shear modelled above stack top?	MSHEAR	0 (No)	✓

OPTION	PARAMETER	OPTION SELECTED	AQMG DEFAULT
Puff splitting allowed?	MSPLIT	0 (No)	✓
Chemical Transformation Scheme?	MCHEM	0 (Not Modelled)	
Aqueous phase transformation flag (only used in MCHEM =1 or 3)	MAQCHEM	Unused	✓
Liquid Water Content Flag	MLWC	Unused	✓
Wet removal modelled?	MWET	1 (Yes)	✓
Dry deposition modelled?	MDRY	1 (Yes)	✓
Gravitational settling (plume tilt)?	MTILT	0 (No)	✓
Method used to compute dispersion coefficients	MDISP	2 (Dispersion coefficients from internally calculated sigma v, sigma w using micrometeorological variables (u*, w*, L, etc.)	✓
Sigma measurements used?	MTURBVW	Unused	✓
Back-up method used to compute dispersion when measured turbulence data are missing	MDISP2	Unused	✓
Method used for Lagrangian time scale for Sigma-y	MTAULY	0 (Draxler default)	✓
Advective-Decay timescale for turbulence	MTAUADV	0 (No turbulence advection)	✓
PG sigma y,z adjusted for roughness	MROUGH	0 (Yes)	✓
Partial plume penetration of elevated inversion?	MPARTL	1 (Yes)	✓
Strength of temperature inversion provided in PROFILE.DAT extended records?	MTINV	0 (No)	✓
Probability Distribution Function used for dispersion under convective conditions?	MPDF	1 (Yes)	✓
Sub-grid TIBL module used for shore line?	MSGTIBL	Unused	✓
Boundary conditions (concentration) modelled?	MBCON	0 (No)	✓
Configure for FOG Model output?	MFOG	0 (No)	✓
Test options specified to see if they conform to regulatory values?	MREG	0 (No)	✓

OPTION	PARAMETER	OPTION SELECTED	AQMG DEFAULT
Minimum turbulence velocities, sigma v and sigma w for each stability class over land and water	SVMIN SWMin	Default	✓

B.4.2 MODEL DOMAIN AND RECEPTORS

A 30 km x 20 km subset of the CALMET domain was used for the CALPUFF modelling (Figure B-1).

Receptor grid spacing followed the recommendations specified in the 2015 AQMG for the Project, shown in Figure B-4 below. For the purposes of air quality modelling, the fence line is assumed to be a 500 metre buffer around the Process Plant, Tailings Management Facility (TMF), and Portals. The roadway buffer to the fence line is 50 metres.

- 20 m receptor spacing along the fence line
- 50 m spacing within 500 m of the fence line
- 250 m spacing within 2 km of the fence line
- 500 m spacing within 5 km of the fence line
- 1000 m spacing beyond 5 km of the fence line

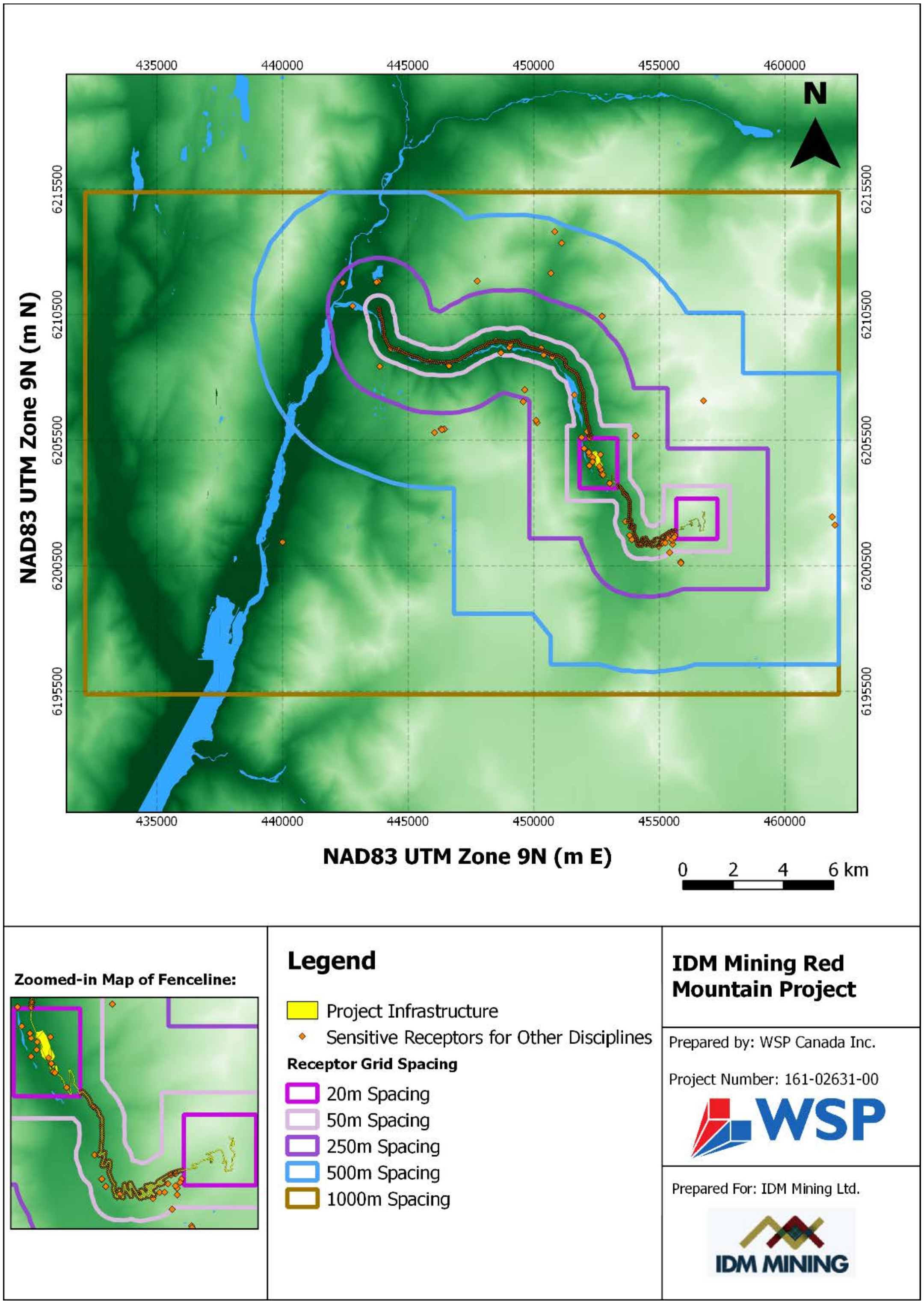


Figure B-4 CALPUFF Receptor Grid – Gridded and Sensitive Receptors

B.4.3 BUILDING DOWNWASH

Buildings or other solid structures may impact air pollution plume flows in the vicinity of a source due to the formation of turbulent eddies on the downwind side of the building. On the downwind side of a structure, a recirculating cavity of air forms and it does not mix with other air efficiently. This cavity has the potential to reduce plume rise and impact dispersion. The flow that is affected by the obstruction is known as the “wake”.

The CALPUFF model accounts for building downwash with enhanced plume dispersion coefficients due to the turbulent wake and reduced plume rise caused by a combination of the descending streamlines in the lee of the building and the increased entrainment on the wake. Building downwash was considered in this assessment using the US EPA Building Profile Input Program (BPIP-PRIME).

C CALPUFF MODELLING PARAMETERS

This section detail the modelling parameters and emission rates used for the point, area, volume, and road sources as presented in the tables below.

C.1 POINT SOURCES

PARAMETER	METRIC	SECONDARY DUST COLLECTOR STACK	STOCKPILE AND RECLAIM DUST COLLECTOR STACK	REAGENT MIXING STACK	SMELTING FURNACE STACK	ASSAY LAB STACK	FRESH/FIRE WATER TANK DISEL PUMP
Stack Orientation	(H/V)	V	V	V	V	V	H
Stack Location (UTM NAD 83)	(mE)	452,747	452,717	452,700	452,693	452,730	452,684
	(mN)	6,204,138	6,204,208	6,204,290	6,204,306	6,204,270	6,204,327
Base Elevation	(m)	505	502.0	502.0	501.0	505.0	500.0
Stack Height	(m)	7.0	7.0	22.2	24.9	5.0	1.3
Stack Diameter	(m)	1.20	1.20	0.18	0.30	0.53	0.41
Stack Exit Volumetric Flow	(m^3/s)	17.0	17.0	0.39	1.06	3.27	0.082
Stack Exit Velocity	(m/s)	15.0	15.0	15.2	15.0	14.8	0.62
Stack Exhaust Gas Temperature	(K)	283	283	283	273	283	366
HOURLY / DAILY / ANNUAL EMISSION RATE (g/s)							
CO							3.21E-03
NO_x							1.29E-02
SO_x					1.13E-02		1.37E-04
TSP		3.39E-01	3.39E-01	5.42E-02	2.12E-02	6.53E-02	2.12E-03
PM_{10}		1.70E-01	1.70E-01	2.71E-02	1.06E-02	3.27E-02	1.29E-03
$PM_{2.5}$		8.48E-02	8.48E-02	1.35E-02	5.30E-03	1.63E-02	8.35E-04

PARAMETER	METRIC	UPPER VENILATION (EXHAUST)	LOWER VENTILATION PORTAL (EXHAUST)	PRIMARY CRUSHER DUST COLLECTOR STACK	TERTIARY CRUSHER DUST COLLECTOR STACK	CARBON REGENERATION KILN OFF-GAS
Stack Orientation	(H/V)	V	V	V	V	V
Stack Location (UTM NAD 83)	(mE)	456,677	456,255	452,753	452,747	452,702
	(mN)	6,202,664	6,202,341	6,204,151	6,204,133	6,204,291
Base Elevation	(m)	500.0	500.0	507.0	505.0	502.0
Stack Height	(m)	0.0	0.0	7.0	7.0	24.9
Stack Diameter	(m)	5.64	5.64	1.20	1.20	0.30
Stack Exit Volumetric Flow	(m^3/s)	5	130	17	17	1.06
Stack Exit Velocity	(m/s)	0.2	5.2	15	15	15
Stack Exhaust Gas Temperature	(K)	240	240	283	283	347
HOURLY / DAILY / ANNUAL EMISSION RATE (g/s)						
CO		1.45E-01	3.77E+00			
NO_x		1.85E-01	4.81E+00			
SO_x		2.60E-02	6.76E-01			
TSP		5.00E-02	1.30E+00	3.39E-01	3.39E-01	4.24E-03
PM_{10}		2.50E-02	6.50E-01	1.70E-01	1.70E-01	2.57E-03
$PM_{2.5}$		1.50E-02	3.90E-01	8.48E-02	8.48E-02	1.67E-03

C.2 AREA SOURCES

Table C-1 Area Source Parameters and Modelled Emission Rates

PARAMETER	METRIC	NON-ROAD EQUIPMENT AT PROCESS PLANT		NON-ROAD EQUIPMENT AT LOWER PORTAL
Northwest Coordinate	(mE)	452,621	452,603	456,151
	(mN)	6,204,223	6,204,352	6,202,366
Northeast Coordinate	(mE)	452,750	452,732	456,381
	(mN)	6,204,241	6,204,370	6,202,366
Southeast Coordinate	(mE)	452,768	452,750	456,381
	(mN)	6,204,112	6,204,241	6,202,236
Southwest Coordinate	(mE)	452,639	452,621	456,151
	(mN)	6,204,094	6,204,223	6,202,236
Surface Area	(m^2)	16,900	16,900	29,900
Base Elevation	(m)	495.8	495.6	1714.6
Effective Release Height	(m)	4.50	4.50	4.50
Initial Sigma z_o	(m)	2.09	2.09	2.09
HOURLY / DAILY EMISSION RATE ($g/m^2/s$)				
CO		6.05E-02	6.05E-02	4.07E-01
NO_x		1.01E-01	1.01E-01	1.46E+00
SO_x		5.13E-04	5.13E-04	3.23E-03
TSP		7.94E-03	7.94E-03	5.85E-02
PM_{10}		7.94E-03	7.94E-03	5.85E-02
$PM_{2.5}$		7.16E-03	7.16E-03	5.68E-02
ANNUAL EMISSION RATE ($g/m^2/s$)				
CO		1.22E-02	1.22E-02	2.74E-01
NO_x		1.66E-02	1.66E-02	1.01E+00
SO_x		7.89E-05	7.89E-05	1.79E-03
TSP		1.45E-03	1.45E-03	3.74E-02
PM_{10}		1.45E-03	1.45E-03	3.74E-02
$PM_{2.5}$		1.17E-03	1.17E-03	3.63E-02

C.3 VOLUME SOURCES

Table C-2 Volume Source Parameters and Modelled Emission Rates

PARAMETER	METRIC	PORTAL HAUL TRUCKS TO STOCKPILE NEAR LOWER PORTAL	STOCKPILE NEAR LOWER PORTAL TO SURFACE HAUL TRUCKS	SURFACE HAUL TRUCK TO ROM STOCKPILE	ROM STOCKPILE (FRONT END LOADER) TO CRUSHING / GRINDING
Stack Location (UTM NAD 83)	(mE)	456,211	456,227	452,801	452,763
	(mN)	6,202,291	6,202,263	6,204,090	6,204,152
Base Elevation	(m)	1,689	1,689	1,682	502
Effective Release Height	(m)	1.50	12.0	1.50	14.0
Initial Sigma y_o	(m)	2.33	0.74	2.33	0.74
Initial Sigma z_o	(m)	0.35	0.47	0.35	0.47
Hourly / Daily Emission Rate (g/s)					
TSP		7.67E-03	7.67E-03	7.67E-03	3.41E-03
PM_{10}		3.63E-03	3.63E-03	3.63E-03	1.61E-03
$PM_{2.5}$		5.50E-04	5.50E-04	5.50E-04	2.44E-04
Annual Emission Rate (g/s)					
TSP		3.41E-03	3.41E-03	3.41E-03	3.41E-03
PM_{10}		1.61E-03	1.61E-03	1.61E-03	1.61E-03
$PM_{2.5}$		2.44E-04	2.44E-04	2.44E-04	2.44E-04

C.4 ROAD SOURCE

Table C-3 Road Source Parameters and Modelled Emission Rates

PARAMETER	METRIC	HAUL ROAD (TOTAL)	HAUL ROAD (ROAD DUST)	ACCESS ROAD (TOTAL)	ACCESS ROAD (ROAD DUST)
Effective Release Height	(m)	8.50	8.50	8.50	8.50
Initial Sigma y_o	(m)	7.44	7.44	7.44	7.44
Initial Sigma z_o	(m)	7.91	7.91	7.91	7.91
HOURLY / DAILY EMISSION RATE (g/s/m)					
CO		2.71E-06		3.92E-07	
NO_x		6.21E-06		1.06E-06	
SO_x		2.30E-08		4.93E-09	
TSP		5.05E-04	5.04E-04	4.26E-05	4.23E-05
PM_{10}		1.45E-04	1.44E-04	1.23E-05	1.21E-05
$PM_{2.5}$		1.48E-05	1.44E-05	1.27E-06	1.21E-06
ANNUAL EMISSION RATE (g/s/m)					
CO		1.15E-06		6.65E-08	
NO_x		2.62E-06		1.81E-07	
SO_x		9.64E-09		8.37E-10	
TSP		3.89E-04	3.89E-04	1.68E-05	1.68E-05
PM_{10}		1.11E-04	1.11E-04	4.82E-06	4.78E-06
$PM_{2.5}$		1.13E-05	1.11E-05	4.89E-07	4.78E-07

HAUL ROAD LINK #	UTM EASTING (M)	UTM NORTHING (M)	BASE ELEVATION (M)
1	452,806	6,204,085	502
2	452,898	6,204,018	544
3	452,910	6,203,979	547
4	452,941	6,203,958	563
5	452,985	6,203,795	567
6	453,034	6,203,741	573
7	453,098	6,203,630	586
8	453,128	6,203,638	608
9	453,100	6,203,745	609
10	453,099	6,203,882	633
11	453,096	6,203,964	637
12	453,096	6,204,126	644
13	453,073	6,204,150	632
14	453,072	6,204,176	636
15	453,089	6,204,184	641
16	453,104	6,204,176	652
17	453,166	6,204,060	676
18	453,196	6,203,943	687
19	453,175	6,203,872	679
20	453,283	6,203,746	723
21	453,277	6,203,709	720
22	453,310	6,203,644	712
23	453,328	6,203,648	712
24	453,334	6,203,675	724
25	453,385	6,203,697	747
26	453,499	6,203,567	761
27	453,548	6,203,485	778
28	453,558	6,203,429	778
29	453,574	6,203,394	765
30	453,651	6,203,338	775
31	453,714	6,203,281	770
32	453,753	6,203,218	763
33	453,741	6,203,182	760
34	453,766	6,203,152	763

HAUL ROAD LINK #	UTM EASTING (M)	UTM NORTHING (M)	BASE ELEVATION (M)
35	453,822	6,203,084	786
36	453,810	6,202,930	783
37	453,823	6,202,724	791
38	453,793	6,202,331	798
39	453,735	6,202,258	804
40	453,783	6,202,247	816
41	453,881	6,202,324	811
42	453,864	6,202,176	856
43	453,811	6,202,030	866
44	453,822	6,202,007	866
45	453,866	6,202,005	872
46	453,913	6,202,043	888
47	453,944	6,202,108	891
48	453,975	6,202,121	885
49	453,998	6,202,110	888
50	453,997	6,201,949	923
51	453,978	6,201,933	920
52	453,972	6,201,852	939
53	454,043	6,201,676	966
54	454,101	6,201,595	987
55	454,087	6,201,512	992
56	454,071	6,201,488	999
57	454,087	6,201,446	1,004
58	454,113	6,201,384	1,009
59	454,122	6,201,322	1,003
60	454,166	6,201,289	1,013
61	454,205	6,201,474	1,024
62	454,220	6,201,454	1,043
63	454,234	6,201,373	1,053
64	454,277	6,201,293	1,059
65	454,294	6,201,284	1,061
66	454,308	6,201,294	1,073
67	454,308	6,201,307	1,073
68	454,294	6,201,357	1,088

HAUL ROAD LINK #	UTM EASTING (M)	UTM NORTHING (M)	BASE ELEVATION (M)
69	454,295	6,201,382	1,091
70	454,310	6,201,421	1,100
71	454,314	6,201,567	1,102
72	454,326	6,201,599	1,106
73	454,356	6,201,496	1,131
74	454,361	6,201,470	1,127
75	454,389	6,201,448	1,138
76	454,412	6,201,413	1,147
77	454,451	6,201,363	1,149
78	454,478	6,201,311	1,166
79	454,490	6,201,320	1,173
80	454,479	6,201,398	1,157
81	454,457	6,201,484	1,188
82	454,437	6,201,534	1,188
83	454,438	6,201,605	1,191
84	454,439	6,201,611	1,191
85	454,441	6,201,617	1,191
86	454,446	6,201,621	1,191
87	454,452	6,201,624	1,201
88	454,460	6,201,624	1,201
89	454,467	6,201,621	1,201
90	454,473	6,201,614	1,211
91	454,540	6,201,472	1,243
92	454,597	6,201,405	1,262
93	454,614	6,201,347	1,253
94	454,684	6,201,274	1,269
95	454,701	6,201,272	1,269
96	454,712	6,201,284	1,269
97	454,709	6,201,299	1,274
98	454,699	6,201,318	1,274
99	454,698	6,201,334	1,275
100	454,709	6,201,344	1,277
101	454,731	6,201,334	1,280
102	454,757	6,201,299	1,277

HAUL ROAD LINK #	UTM EASTING (M)	UTM NORTHING (M)	BASE ELEVATION (M)
103	454,781	6,201,294	1,290
104	454,790	6,201,314	1,297
105	454,731	6,201,417	1,307
106	454,699	6,201,433	1,301
107	454,690	6,201,452	1,302
108	454,711	6,201,469	1,308
109	454,721	6,201,465	1,315
110	454,875	6,201,312	1,315
111	454,903	6,201,313	1,339
112	454,889	6,201,381	1,343
113	454,850	6,201,433	1,364
114	454,868	6,201,449	1,380
115	454,998	6,201,340	1,358
116	455,012	6,201,363	1,363
117	454,815	6,201,536	1,387
118	454,809	6,201,543	1,387
119	454,807	6,201,550	1,387
120	454,808	6,201,557	1,387
121	454,814	6,201,564	1,387
122	454,822	6,201,568	1,401
123	454,831	6,201,566	1,401
124	454,943	6,201,493	1,425
125	454,961	6,201,490	1,411
126	454,971	6,201,504	1,436
127	454,953	6,201,539	1,438
128	454,907	6,201,558	1,422
129	454,896	6,201,575	1,425
130	454,905	6,201,588	1,438
131	454,922	6,201,592	1,438
132	454,943	6,201,588	1,448
133	454,964	6,201,579	1,445
134	454,980	6,201,564	1,450
135	454,991	6,201,539	1,440
136	455,009	6,201,520	1,441

HAUL ROAD LINK #	UTM EASTING (M)	UTM NORTHING (M)	BASE ELEVATION (M)
137	455,024	6,201,521	1,443
138	455,033	6,201,540	1,459
139	455,027	6,201,579	1,448
140	455,037	6,201,596	1,463
141	455,054	6,201,596	1,470
142	455,091	6,201,578	1,464
143	455,142	6,201,579	1,458
144	455,207	6,201,608	1,469
145	455,216	6,201,617	1,469
146	455,218	6,201,624	1,469
147	455,212	6,201,638	1,475
148	455,189	6,201,645	1,479
149	455,103	6,201,619	1,484
150	455,084	6,201,632	1,482
151	455,081	6,201,649	1,480
152	455,088	6,201,657	1,488
153	455,392	6,201,843	1,514
154	455,556	6,201,895	1,528
155	455,873	6,201,952	1,563
156	455,955	6,201,957	1,572
157	455,972	6,201,979	1,581
158	455,956	6,201,993	1,580
159	455,868	6,202,003	1,589
160	455,851	6,202,014	1,587
161	455,851	6,202,028	1,587
162	455,865	6,202,039	1,588
163	455,997	6,202,061	1,608
164	456,084	6,202,128	1,621
165	456,297	6,202,176	1,656
166	456,323	6,202,208	1,666
167	456,208	6,202,274	1,684
168	456,202	6,202,285	1,689
169	456,211	6,202,293	1,689
170	456,236	6,202,294	1,688

HAUL ROAD LINK #	UTM EASTING (M)	UTM NORTHING (M)	BASE ELEVATION (M)
171	456,249	6,202,301	1,695
172	456,264	6,202,301	1,706
173	456,295	6,202,310	1,697
174	456,344	6,202,330	1,709
175	456,367	6,202,328	1,711
176	456,464	6,202,381	1,735
177	456,478	6,202,379	1,734
178	456,502	6,202,381	1,735
179	456,551	6,202,313	1,758
180	456,587	6,202,156	1,752
181	456,543	6,202,074	1,759
182	456,552	6,202,067	1,767
183	456,583	6,202,081	1,769
184	456,616	6,202,122	1,775
185	456,632	6,202,130	1,793
186	456,640	6,202,115	1,802
187	456,631	6,202,076	1,794
188	456,633	6,202,056	1,795
189	456,639	6,202,040	1,805
190	456,616	6,201,997	1,803
191	456,619	6,201,976	1,810
192	456,601	6,201,926	1,816
193	456,591	6,201,899	1,808
194	456,614	6,201,884	1,817
195	456,639	6,201,883	1,827
196	456,643	6,201,885	1,827
197	456,643	6,201,891	1,827
198	456,631	6,201,907	1,824
199	456,631	6,201,913	1,833
200	456,636	6,201,915	1,833
201	456,691	6,201,903	1,837
202	456,712	6,201,911	1,846
203	456,746	6,201,903	1,837
204	456,776	6,201,935	1,851

HAUL ROAD LINK #	UTM EASTING (M)	UTM NORTHING (M)	BASE ELEVATION (M)
205	456,743	6,201,958	1,855
206	456,738	6,201,990	1,851
207	456,751	6,202,018	1,853
208	456,780	6,202,050	1,863
209	456,766	6,202,154	1,865
210	456,777	6,202,198	1,858
211	456,828	6,202,230	1,841
212	456,805	6,202,326	1,847
213	456,748	6,202,369	1,864
214	456,721	6,202,436	1,862
215	456,769	6,202,577	1,869
216	456,764	6,202,600	1,868
217	456,735	6,202,627	1,866
218	456,695	6,202,666	1,874

ACCESS ROAD LINK #	UTM EASTING (M)	UTM NORTHING (M)	BASE ELEVATION (M)
1	443,798	6,210,750	110
2	443,839	6,210,747	114
3	443,855	6,210,738	112
4	443,866	6,210,710	116
5	443,878	6,210,469	121
6	443,884	6,210,443	117
7	443,954	6,210,338	120
8	443,980	6,210,093	126
9	443,984	6,210,046	131
10	444,028	6,209,858	132
11	444,028	6,209,819	130
12	444,012	6,209,700	139
13	444,026	6,209,632	151
14	444,112	6,209,509	153
15	444,131	6,209,473	142
16	444,144	6,209,415	159
17	444,220	6,209,274	160
18	444,263	6,209,231	155
19	444,368	6,209,172	165
20	444,589	6,209,079	145
21	444,698	6,209,057	157
22	444,762	6,209,034	157
23	444,855	6,208,975	163
24	444,941	6,208,937	158
25	445,335	6,208,801	168
26	445,375	6,208,799	165
27	445,409	6,208,786	165
28	445,582	6,208,682	159
29	445,686	6,208,655	181
30	445,776	6,208,629	163
31	446,008	6,208,629	166
32	446,295	6,208,601	179
33	446,431	6,208,599	178
34	446,512	6,208,619	182

ACCESS ROAD LINK #	UTM EASTING (M)	UTM NORTHING (M)	BASE ELEVATION (M)
35	446,590	6,208,604	179
36	446,670	6,208,604	196
37	446,840	6,208,665	191
38	446,979	6,208,675	192
39	447,018	6,208,687	206
40	447,039	6,208,701	220
41	447,092	6,208,755	216
42	447,201	6,208,806	226
43	447,414	6,208,949	214
44	447,543	6,209,008	231
45	447,574	6,209,036	236
46	447,611	6,209,081	236
47	447,665	6,209,103	227
48	447,761	6,209,131	229
49	447,807	6,209,170	243
50	447,968	6,209,246	277
51	448,028	6,209,246	276
52	448,089	6,209,274	256
53	448,104	6,209,305	263
54	448,104	6,209,305	263
55	448,110	6,209,333	265
56	448,126	6,209,356	274
57	448,150	6,209,364	276
58	448,166	6,209,366	274
59	448,192	6,209,378	282
60	448,227	6,209,385	289
61	448,275	6,209,377	301
62	448,316	6,209,383	306
63	448,430	6,209,426	313
64	448,505	6,209,444	309
65	448,606	6,209,450	280
66	448,675	6,209,446	264
67	448,743	6,209,436	262
68	448,837	6,209,403	248

ACCESS ROAD LINK #	UTM EASTING (M)	UTM NORTHING (M)	BASE ELEVATION (M)
69	448,877	6,209,397	246
70	448,977	6,209,386	250
71	449,188	6,209,448	280
72	449,288	6,209,445	275
73	449,364	6,209,462	276
74	449,403	6,209,460	279
75	449,427	6,209,434	263
76	449,429	6,209,402	267
77	449,424	6,209,357	261
78	449,442	6,209,320	260
79	449,681	6,209,242	265
80	449,837	6,209,218	268
81	450,000	6,209,166	299
82	450,058	6,209,142	279
83	450,326	6,209,073	294
84	450,513	6,209,003	307
85	450,751	6,208,896	313
86	450,949	6,208,871	327
87	451,190	6,208,749	359
88	451,255	6,208,666	371
89	451,258	6,208,528	359
90	451,291	6,208,432	376
91	451,351	6,208,378	374
92	451,662	6,208,198	371
93	451,775	6,208,005	373
94	451,826	6,207,768	370
95	451,867	6,207,687	379
96	451,910	6,207,534	387
97	451,963	6,207,449	386
98	451,973	6,207,171	388
99	451,962	6,207,027	383
100	452,097	6,206,490	397
101	452,106	6,206,291	388
102	452,138	6,206,138	388

ACCESS ROAD LINK #	UTM EASTING (M)	UTM NORTHING (M)	BASE ELEVATION (M)
103	452,188	6,206,024	393
104	452,200	6,205,928	382
105	452,239	6,205,750	382
106	452,211	6,205,634	389
107	452,226	6,205,535	399
108	452,211	6,205,450	392
109	452,202	6,205,337	399
110	452,238	6,205,230	409
111	452,335	6,205,003	423
112	452,316	6,204,936	454
113	452,389	6,204,875	451
114	452,450	6,204,706	468
115	452,433	6,204,665	468

D CONTOUR MAPS

Figure D-1 Contour Plot of 1-Hour Maximum Predicted NO_2

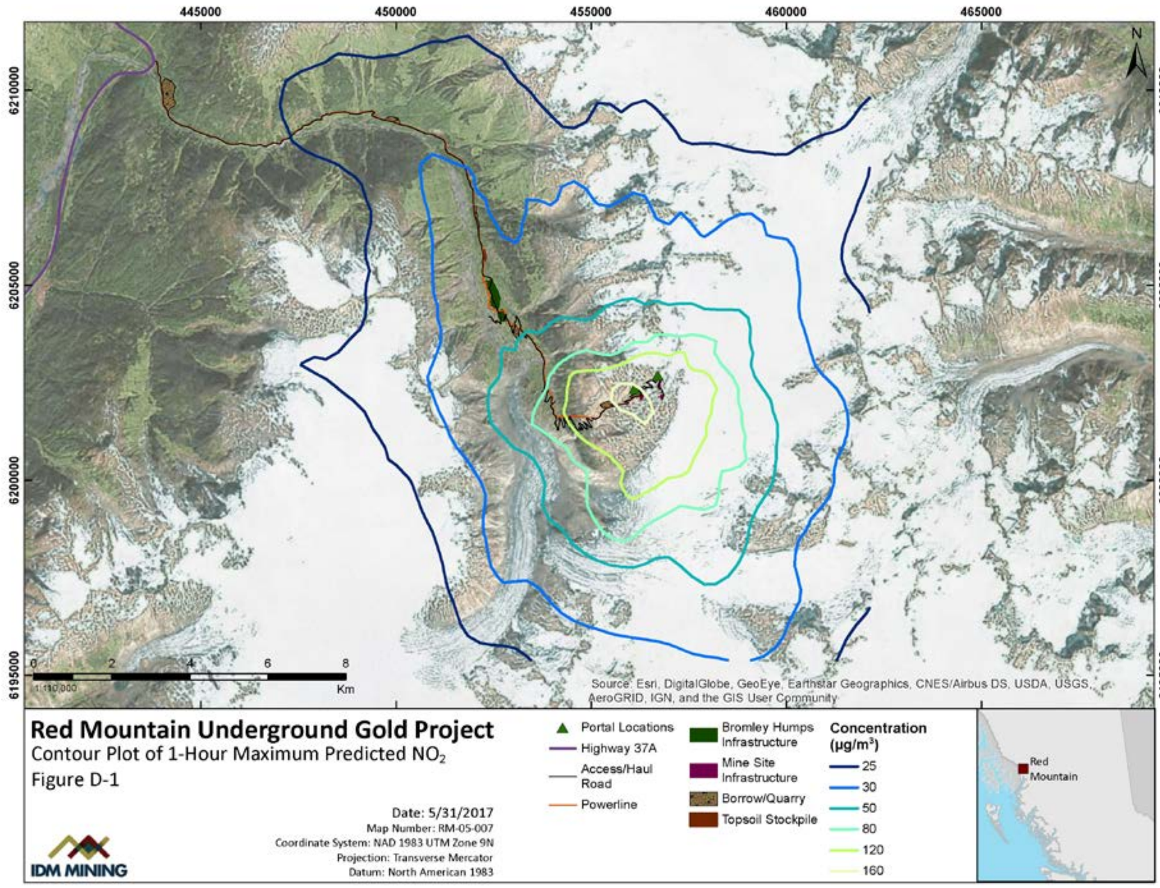


Figure D-2 Contour Plot of Annual Maximum Predicted NO_2

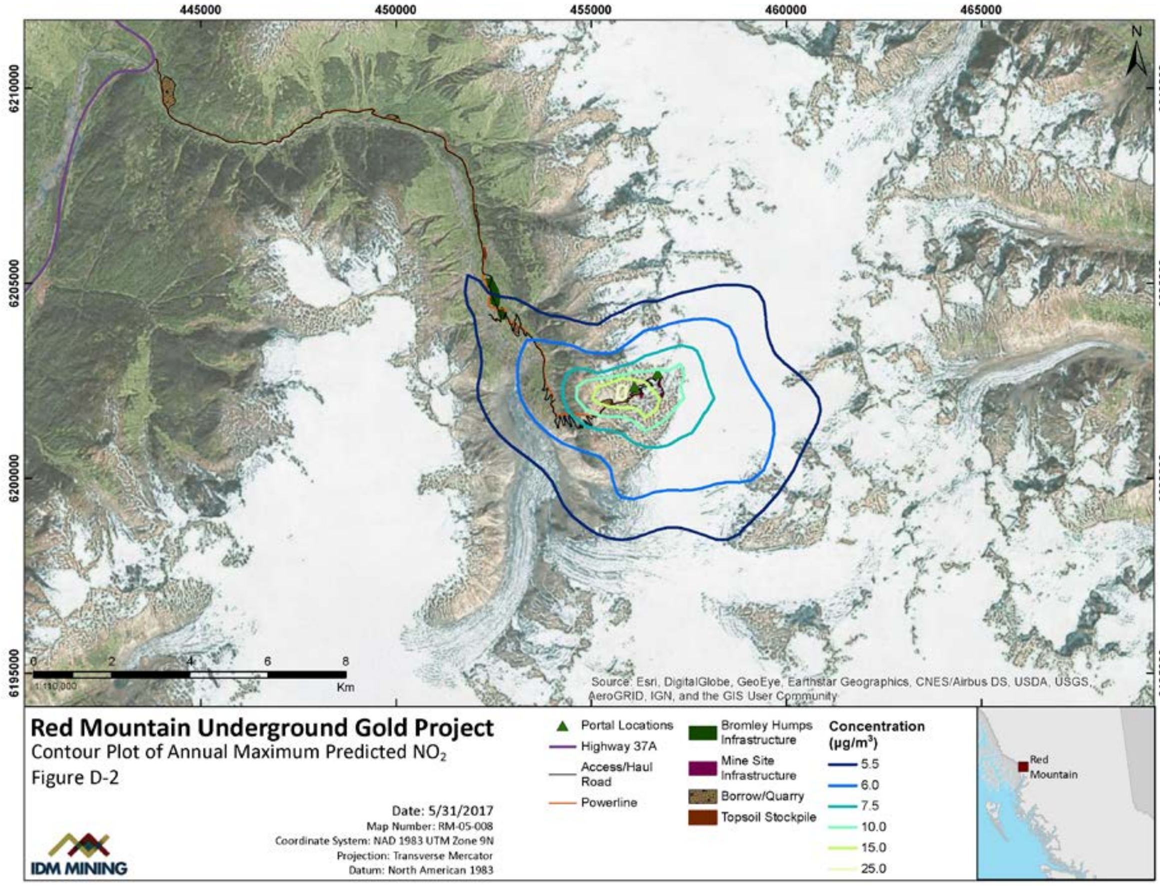


Figure D-3 Contour Plot of 1-Hour Maximum Predicted SO_2

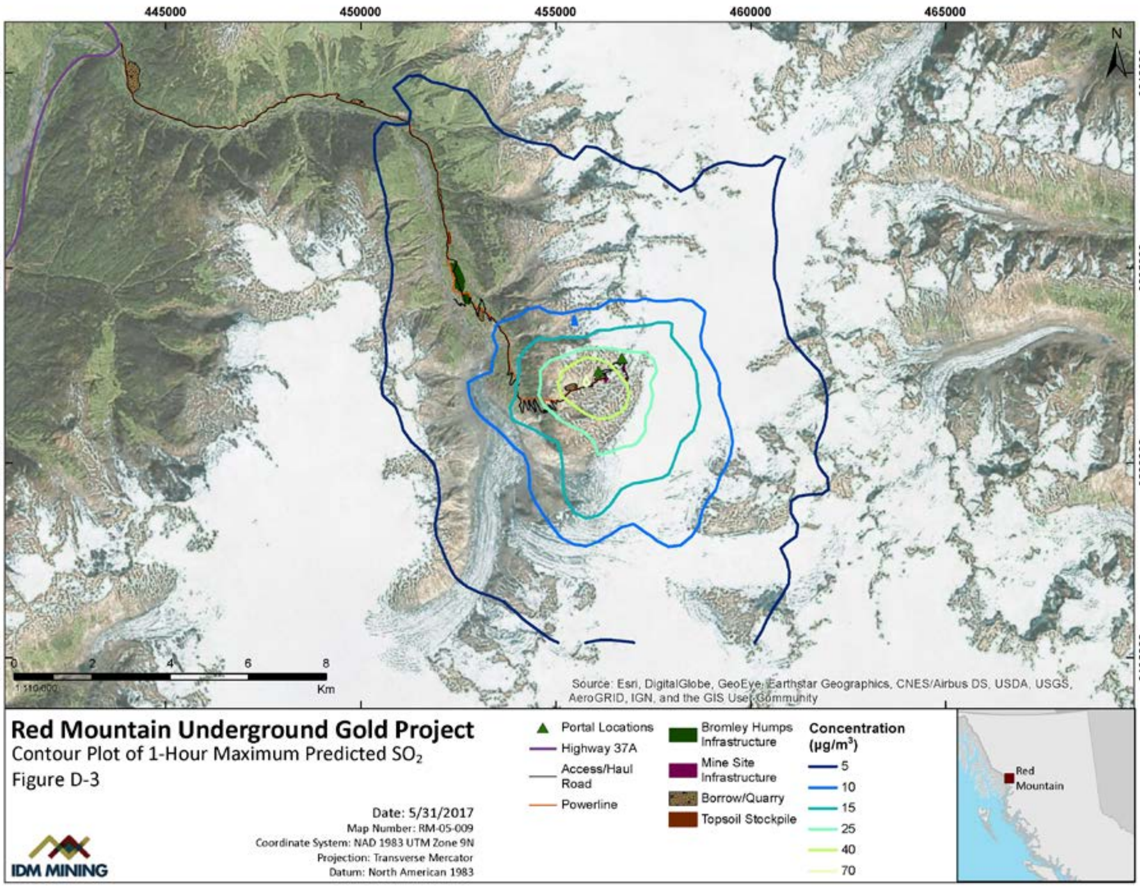


Figure D-4 Contour Plot of Annual Maximum Predicted SO_2

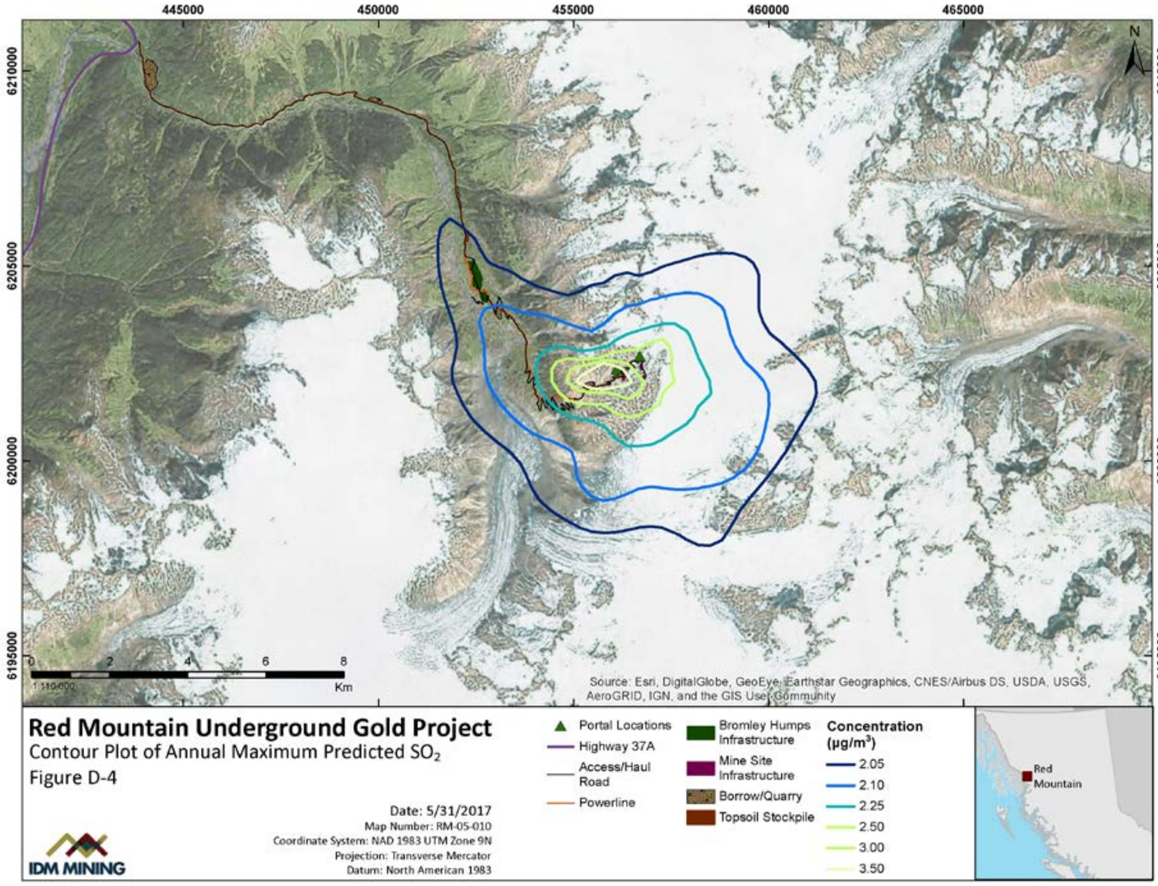


Figure D-5 Contour Plot of 1-Hour Maximum Predicted CO

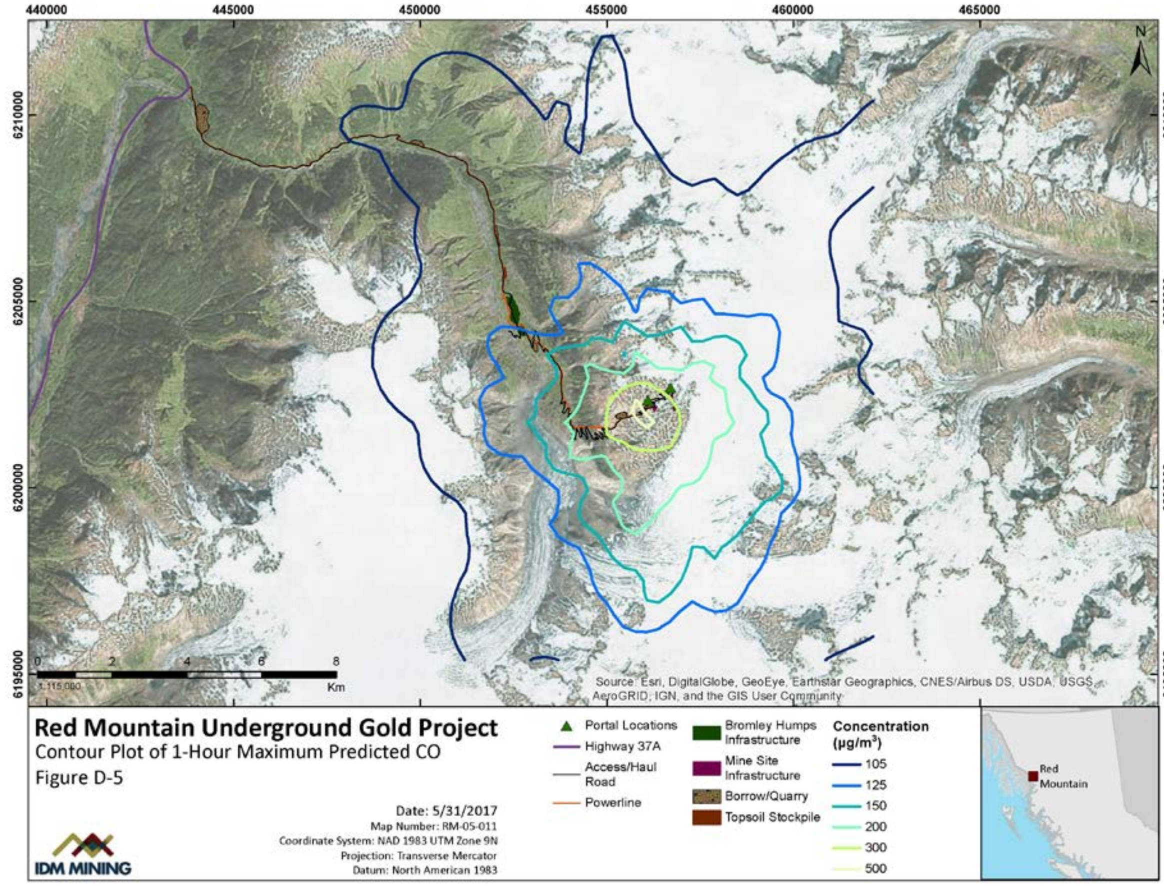


Figure D-6 Contour Plot of 8-Hour Maximum Predicted CO

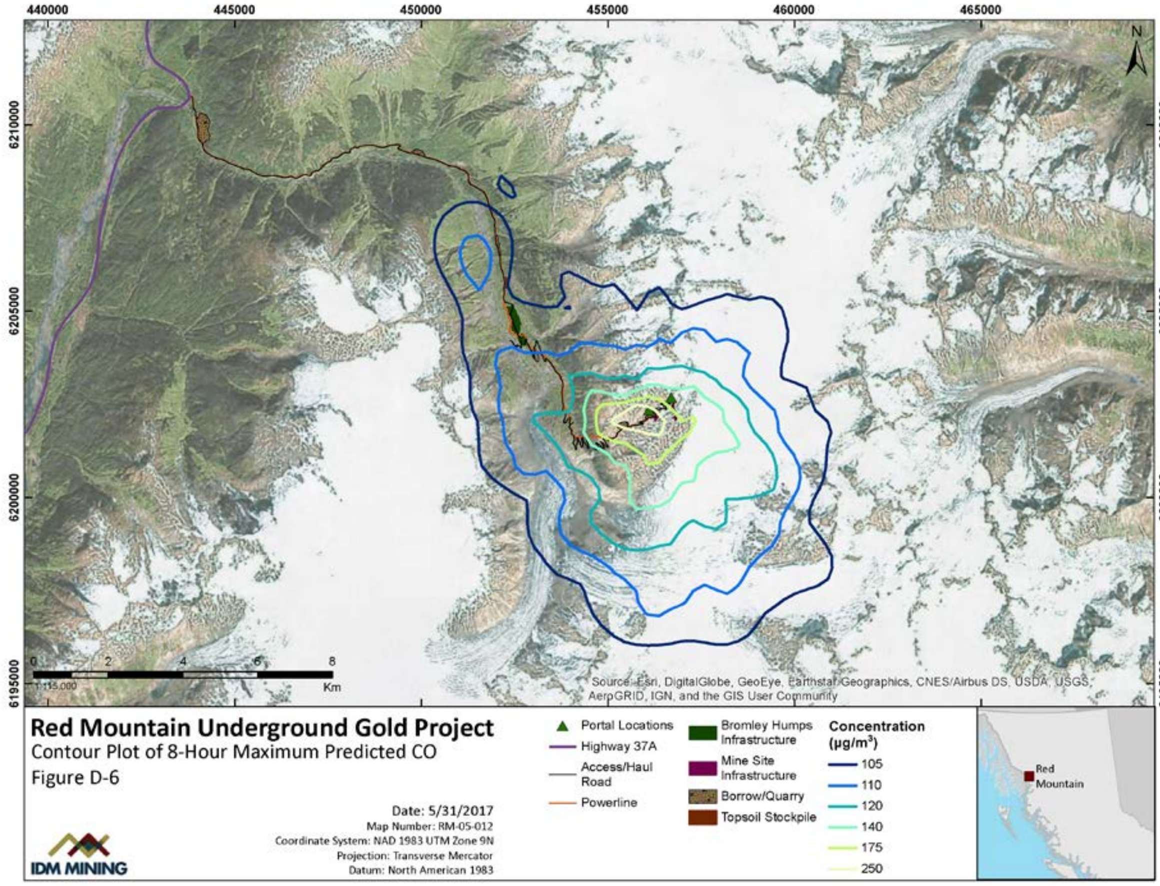


Figure D-7 Contour Plot of 24-Hour Maximum Predicted $PM_{2.5}$

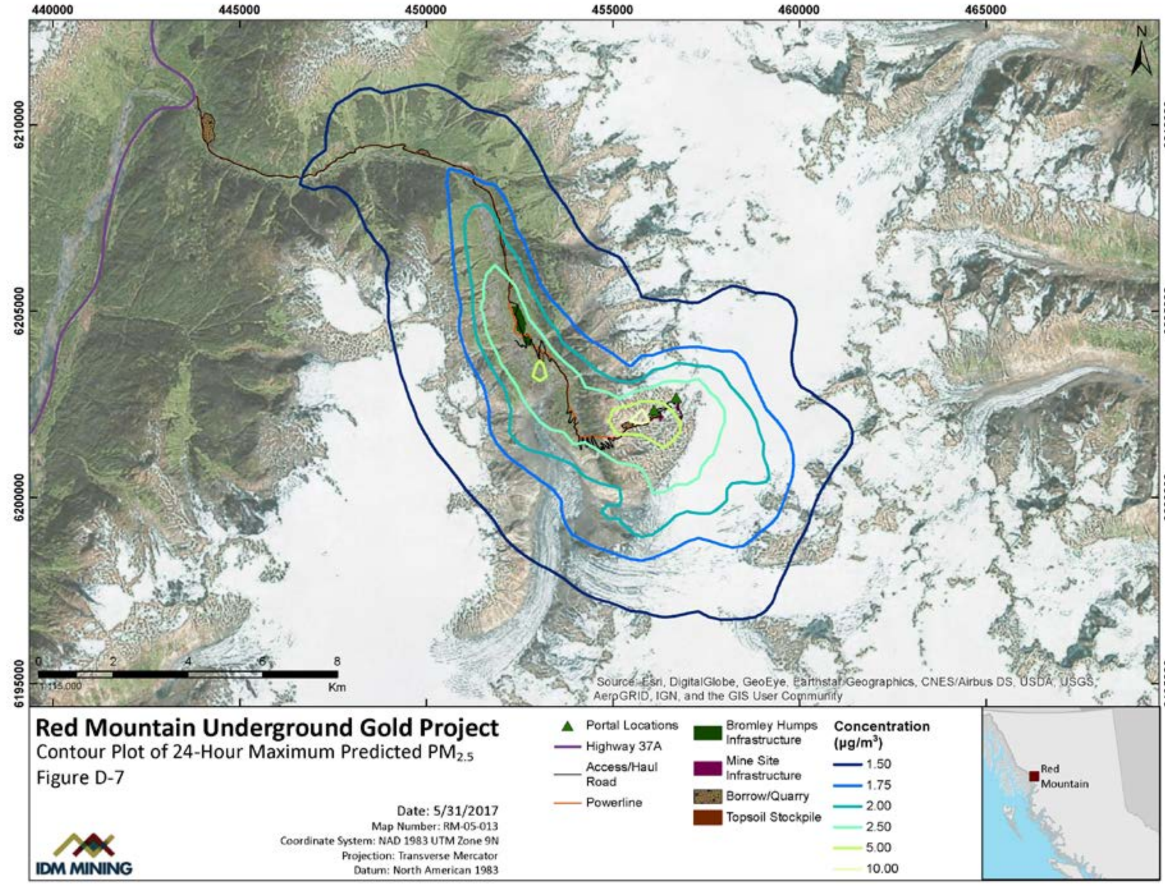


Figure D-8 Contour Plot of Annual Maximum Predicted $PM_{2.5}$

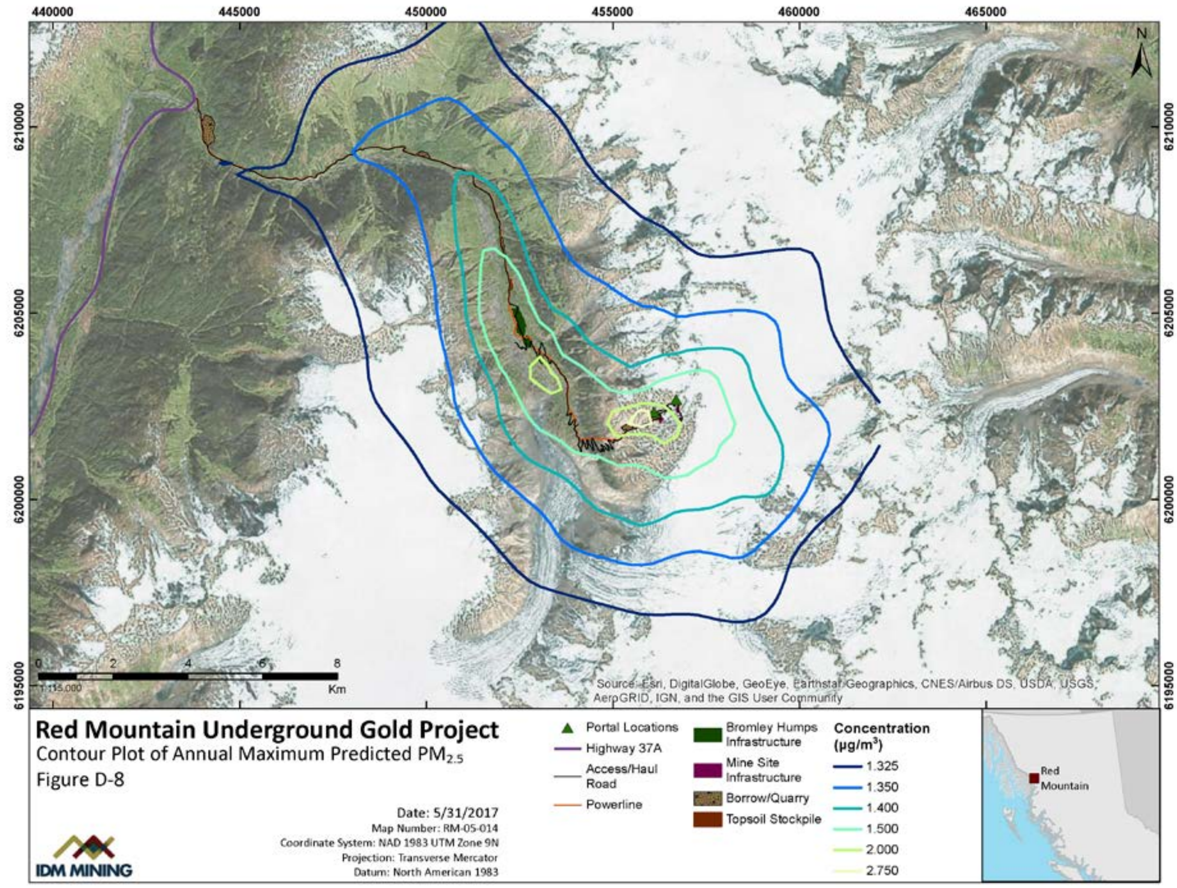


Figure D-9 Contour Plot of 24-Hour Maximum Predicted PM_{10}

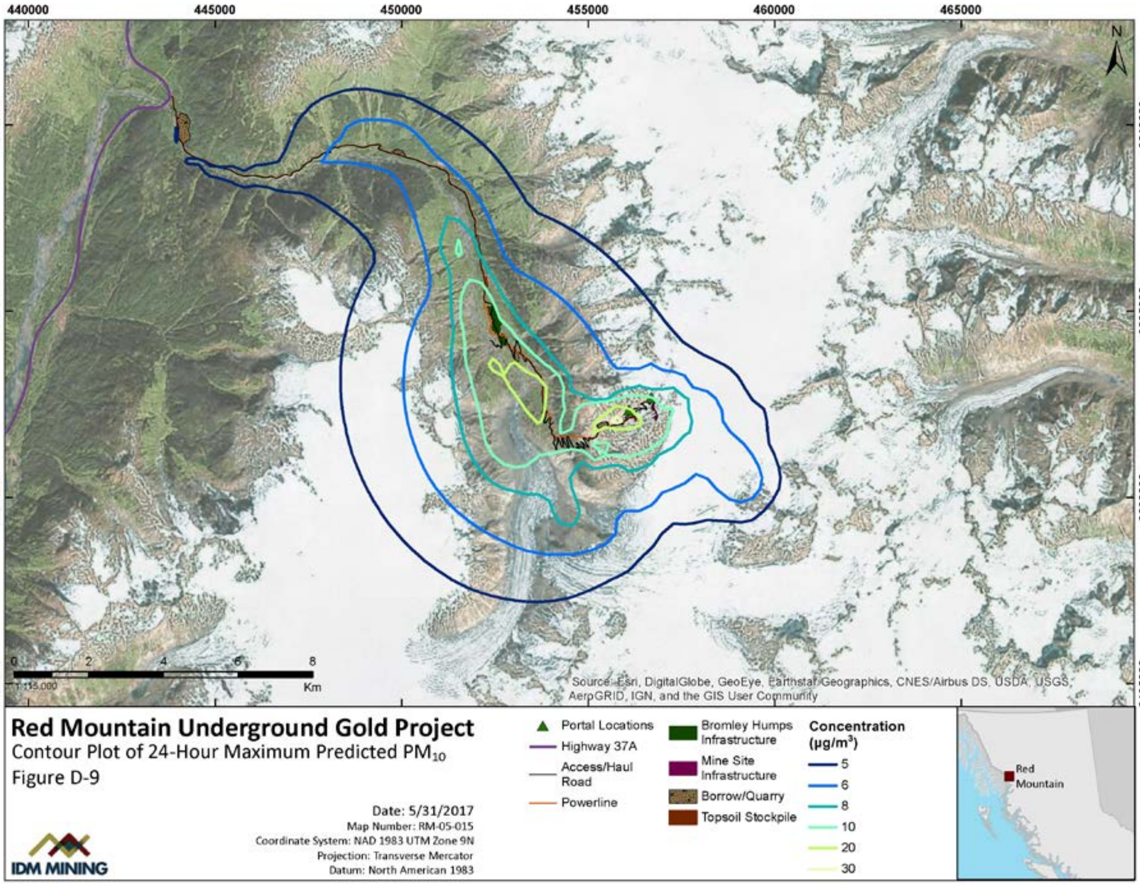


Figure D-10 Contour Plot of 24-Hour Maximum Predicted TSP

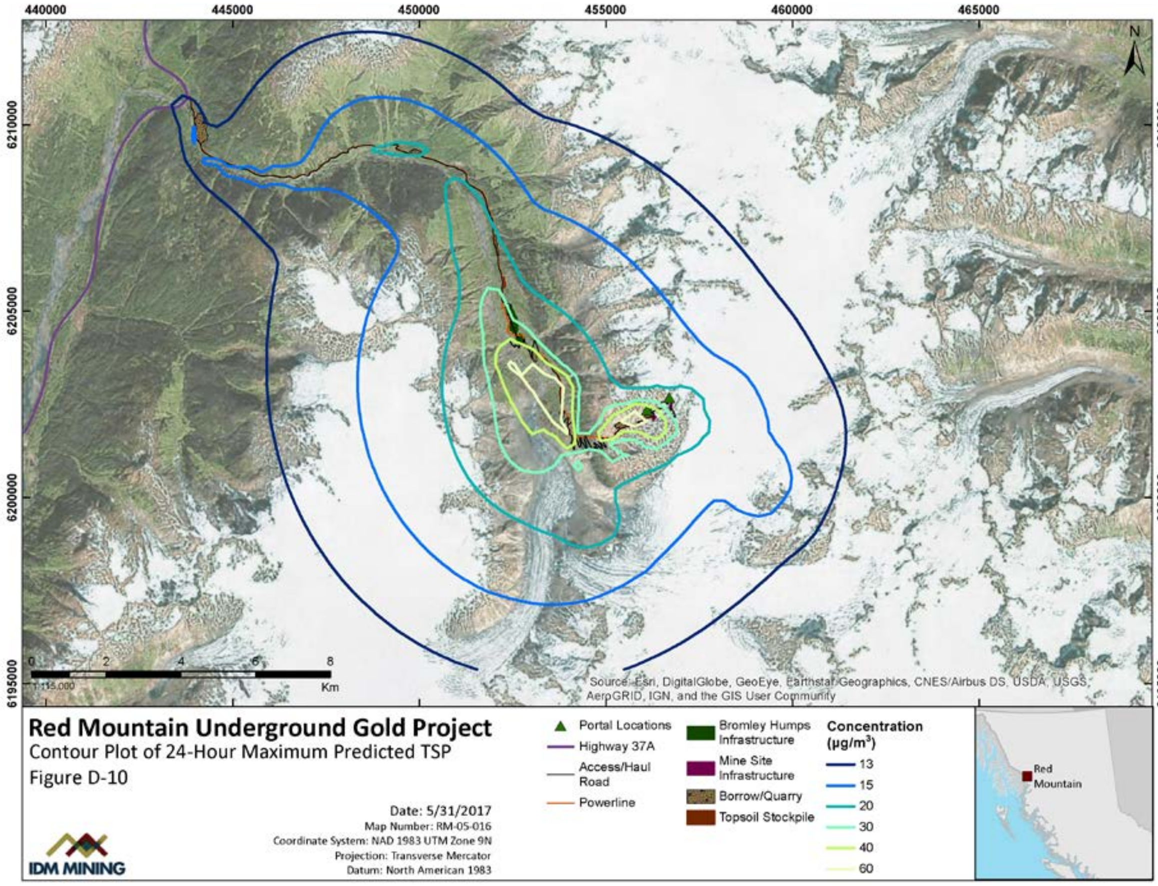


Figure D-11 Contour Plot of Annual Maximum Predicted TSP

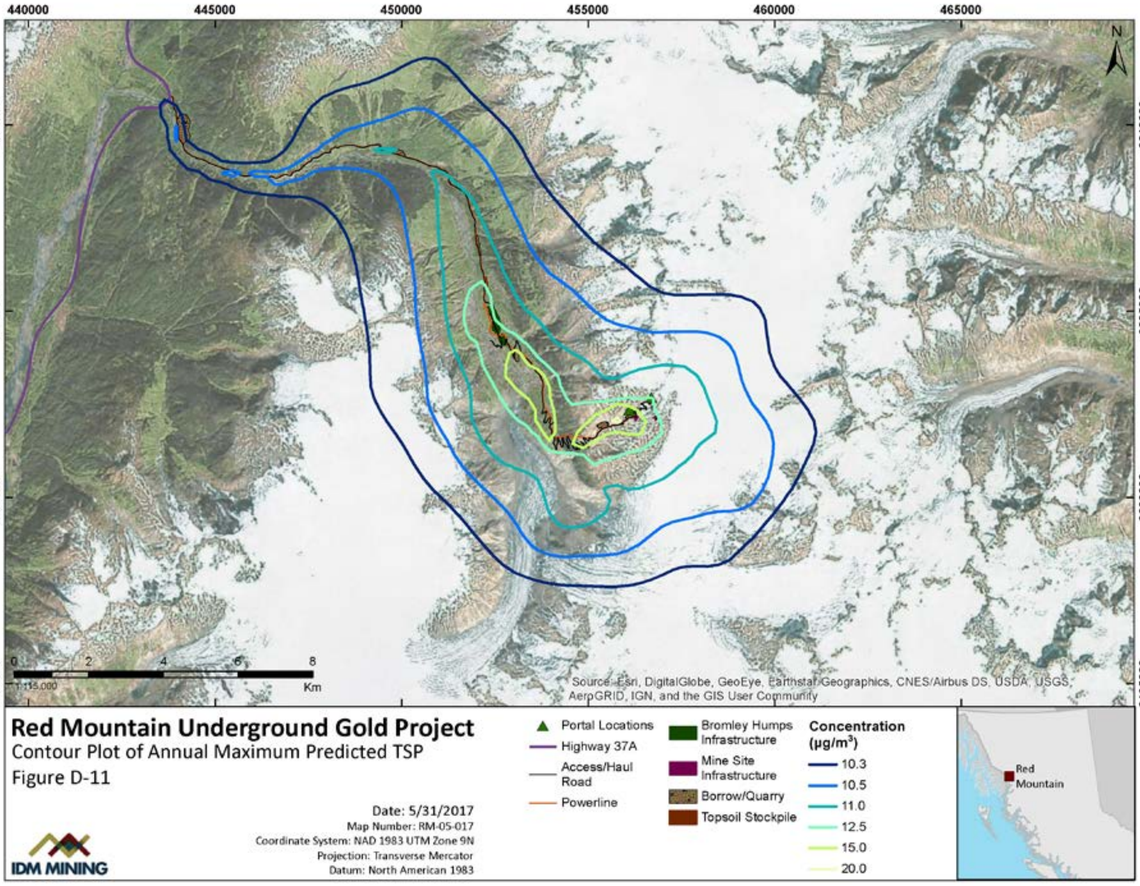


Figure D-12 Contour Plot of Annual Maximum Predicted Total Dustfall

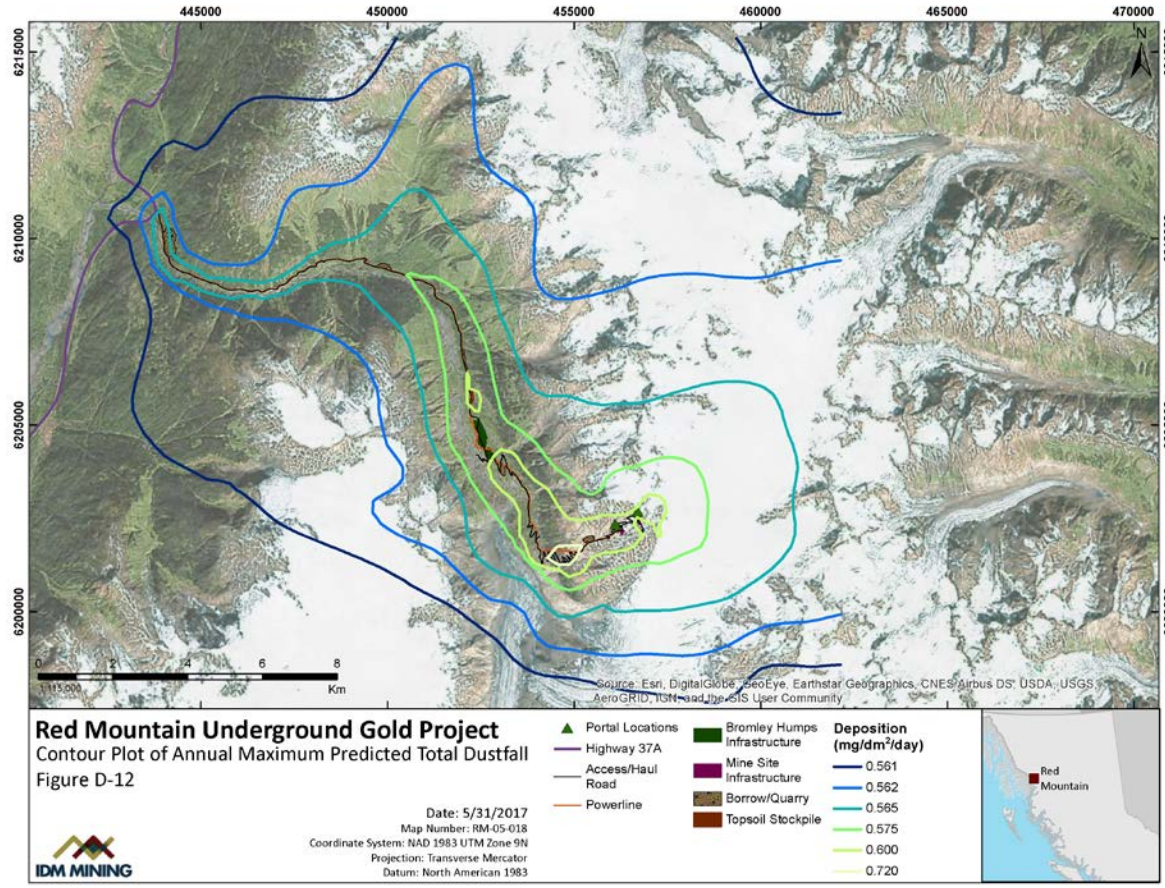


Figure D-13 Contour Plot of Annual Maximum Predicted Wet Deposition

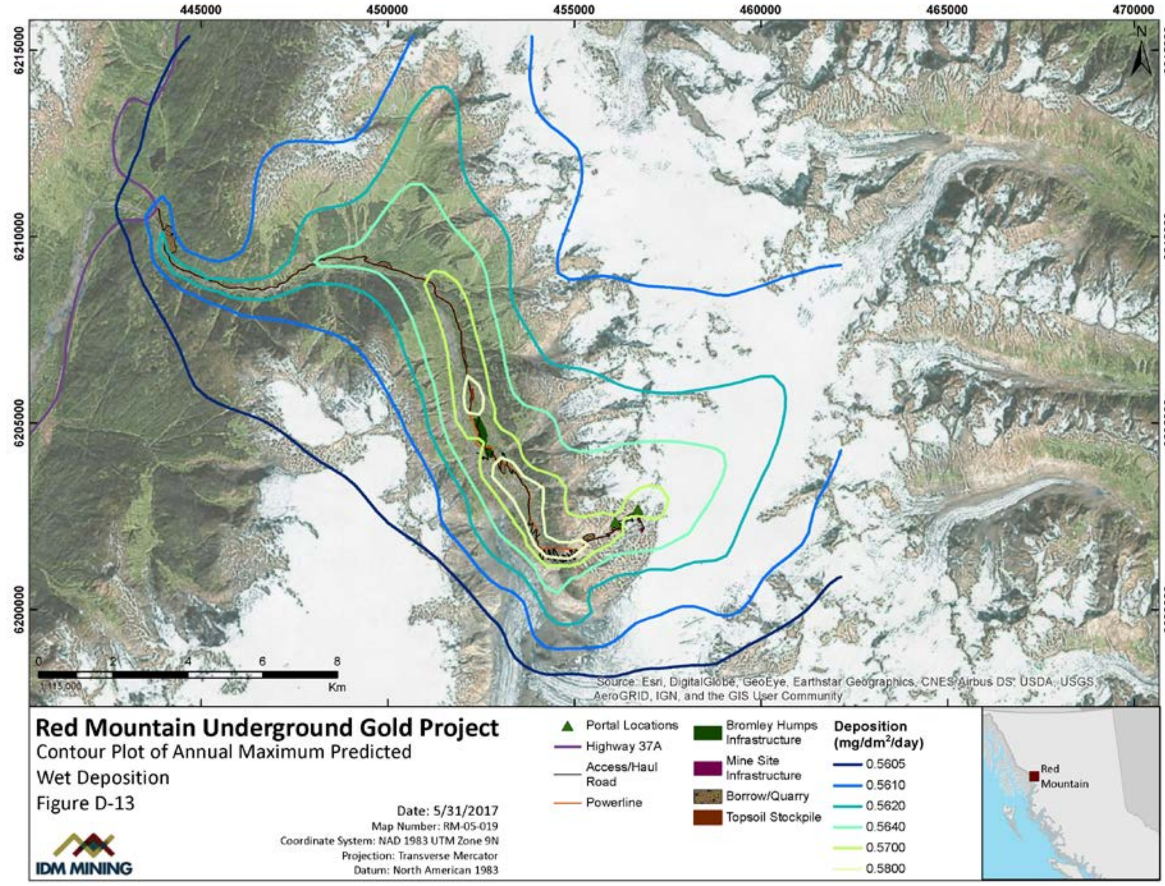
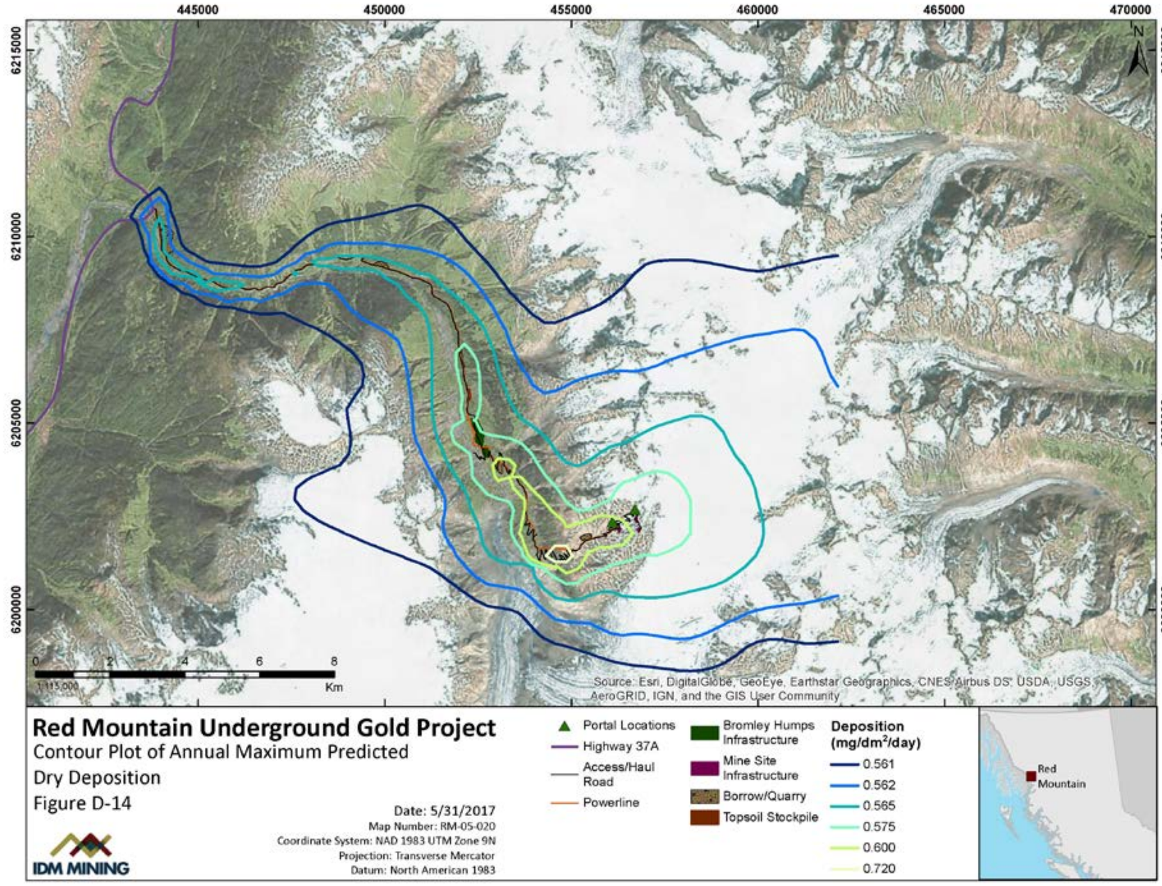


Figure D-14 Contour Plot of Annual Maximum Predicted Dry Deposition



ANNEX 1

Dispersion Modelling Plan

Dispersion Modelling Plan

An electronic version of this plan is available from:
www.bcairquality.ca/reports/model-plans-instructions.html

GENERAL

Date:

February 17, 2017

Facility Name, Company, Location (Lat, Long):

Red Mountain Underground Gold Project, IDM Mining, Location (55.964714°, -129.691112°), UTM NAD 83 9N (456858.00 m E, 6202368.00 m N)

Air Quality Consultant and Contact Name:

WSP Canada Inc.

Contact: Tyler Abel (Tyler.Abel@wspgroup.com , 604-736-5421)

Ministry Contact Name:

Donna Haga, Air Quality Meteorologist

Level of Assessment (1, 2 or 3) and also provide rational for the proposed level of assessment:

A level 2 Assessment, as defined in BC Modelling Guidelines (BC MoE 2015b), is proposed for the Project due to the anticipated complex meteorological conditions based on the local terrain and because the project is subject to a provincial Environmental Assessment, but that the area is remote in location and far from other industrial or urban sources.

Does this plan follow a modelling approach similar to that taken in a previous air quality assessment already reviewed and accepted by the Ministry? If so, provide the project name and Ministry contact:

The plan is consistent with modelling approaches used in the Environmental Assessment process for other mines in the region.

PROJECT DESCRIPTION AND GEOGRAPHIC SETTING

Provide an overview of the project description, including process description and the purpose of the dispersion modelling study.

The Proponent is proposing to develop the Red Mountain Underground Gold Project (the proposed Project), as described in the Project Description:
(http://a100.gov.bc.ca/appsdata/epic/html/deploy/epic_document_436_39515.html)

The proposed Project is an underground gold and silver mine located in northwest British Columbia, located approximately 18 km northeast of Stewart. Since the proposed Project is a mine that will have a production capacity of approximately 1,000 tonnes per day (tpd) and 275,000 tonnes per year, it is subject to a provincial EA review under Part 8 of the Reviewable Projects Regulation (BC Reg 370/02) of the Act.

The preliminary Project design is based on the following:

- Production from underground mining and surface milling will be at a rate of 1,000 tonnes per day (tpd);
- The mine would operate for approximately nine months per year;
- The estimated life-of-mine operational period is five years, based on environmental conditions and known resources with the possibility of an additional two years if a sufficient future metal price increase raises the ore cut-off grade (local surficial exploration has not identified additional resources at this time); and,
- Mine site decommissioning will commence in the year subsequent to the cessation of operations.

Off-Site Project Components consist of the following:

- 13 km of existing access road interconnecting with Highway 37A and following the Bitter Creek Valley;
- 7 km of new and/or upgraded seasonal access roads between Hartley Gulch and Otter Creek, connecting the existing access in the Bitter Creek Valley to the mine site and portals;
- A 34 kV power line aligned to the first 13 of the 20 km seasonal access road, and continuing to the mine site via a new alignment not necessarily adjacent to the remaining 7 km of road. The new alignment will be determined based on the safest, most direct route to the mine site. The power line will connect to existing BC Hydro infrastructure in the Bear Creek Valley;
- The existing core yard in Stewart; and,
- Off-site accommodation for workers (no accommodation will be constructed on-site).

On-Site Project Components consist of the following:

- Underground Mine Development:
    - One new portal and an existing portal;
    - Extension of stopes and underground workings;
- Mineral Processing Facilities, including a new 1000 tpd mill;
- Waste Management Facilities:
    - Temporary waste rock storage area;
    - New tailings management facility including;
    - Tailings dam;
    - Tailings pond;
    - Tailings drainage control structures; and
    - Tailings operations.
- Water Management Facilities
    - Water Diversions
    - Water treatment facility (if required);
- New surface warehouse and mine dry facilities;
- New power line and step down facilities on-site;
- New site offices;

- Upgraded and new on-site access;
- New sewage and septic works; and
- New surface maintenance shop.

The location of the proposed project components are provided in Figure 1 of the Draft Application Information Requirements (dAIR): http://a100.gov.bc.ca/appsdata/epic/documents/p436/1475186501554_9LswXtTY1GjRdxxJyx91Xj1vpylMHXLFrJ9lYG3jYxYCnBDThHJY!1900902072!1475186264944.pdf .

Provide a description of the following:

- Terrain characteristics within domain: flat terrain or complex terrain (i.e., will complex flow need to be considered?)

The terrain in the project area is classified as complex.

- Dominant land cover: urban, rural, industrial, agricultural, forested, rock, water, grassland

The dominant land cover in the area of the project is tundra, followed by barren land, and forest land.

DISPERSION MODEL

Selected Dispersion Model:

- List model(s) and version to be used (see Section 2).

CALPUFF – Version 7.2.1 – Level 150618
CALMET – Version 6.5.0 – Level 150223
CALPOST – Version 7.1.0 – Level 141010

- Specify any non-guideline models or versions (i.e., beta-test versions) planned for use (Section 2.3.1). Provide rationale.

The models and versions proposed are consistent with the Guideline recommendation of using the latest version of the CALPUFF system that is publically available.

- If modifications to any of the models are planned, provide a description and the rationale (Section 2.3.2).

No modifications are planned.

Default Switch Settings

- For AERMOD identify any switch settings that will be different than the recommended defaults (Section 7.7). Provide rationale.

N/A

- For CALMET/CALPUFF identify any key switch settings in CALMET and CALPUFF that will be different from the "black (do not touch)" defaults as per Tables 6.2 and 7.1. Provide rationale.

No changes to the default (do not touch) switch settings are proposed.

- If the CALMET model is used, provide:
  - a CALMET domain map that also shows the locations of surface meteorological stations and upper air stations

  Please see Figure 1

  - anticipated grid resolution:

  250 (m)

  - number of grids in X and Y direction

  NX = 160, NY = 120

  - vertical levels (m):

  0, 20, 40, 80, 160, 320, 600, 1000, 1500, 2000, 3000, and 4000.

AERMOD and Receptors

If the AERMET/AERMOD model is used, provide the following:

- proposed receptor grid spacing (see Section 7.2):
- an AERMET/AERMOD domain map that shows the locations of surface meteorological stations, upper air stations and receptor grid
- anticipated sensitive receptors (see Section 7.4) and also indicate them on the domain map (if applicable)
- receptor (flagpole) height (m) (see Section 7.5):

CALPUFF and Receptors

If the CALPUFF model is used, provide the following:

- proposed receptor grid spacing (see Section 7.2):

See Figure 2

  - 20 m receptor spacing along the plant boundary (fenceline) - while access to the Project area will be limited to project personnel, the Project area is not surrounded by a physical fence. For the purposes of the air quality modelling the fence line is assumed to be a 500 metre buffer around the processing plant area, the TMF and the portal areas. The roadway buffer to the fenceline is 50 metres.

- 50 m spacing within 500 m of the fenceline
- 250 m spacing within 2 km of the fenceline
- 500 m spacing within 5 km of the facility
- 1000 m beyond 5 km of the facility

- a map of the CALPUFF domain and receptor grid:

See Figure 2 for the distribution of the receptor grid described above.

- anticipated sensitive receptors (see Section 7.4)) and also indicate them on the CALPUFF domain map (if applicable)

Sensitive receptors identified from other disciplines (human health risk assessment; fish, wildlife, rare plants) are included in the receptor grid and presented in Figure 2.

- receptor (flagpole) height (m) (see Section 7.5):

Receptors will be at 1.5 metres for the evaluation of human exposure and at 0 metres for the evaluation of deposition.

PLANNED MODEL OUTPUT: AIR QUALITY ASSESSMENT NEEDS

Output Requirements for

What model output is required for decision makers and stakeholders? (i.e. what is the purpose of the assessment?). Circle as appropriate.

- Air Quality: concentrations, depositions, visibility, fogging, icing, other (specify)

Tables and Figures for Level 1 Assessment:

N/A

- maximum concentration of contaminants predicted including location and corresponding meteorological conditions
- printout of AERSCREEN model output

Tables and Figures for Level 2 and 3 Assessments (see detailed list in Section 8.3.2):

- spatial distribution maps of air quality parameters (maximums, exceedance frequencies, annual averages)
- tables of maximum short and long time average air quality parameters (locations and associated meteorological conditions)
- tables of air quality parameters at select receptors of interest (maximums, frequency distributions)
- tables of air quality parameters under certain emission situations (upsets, start-up)

Emissions from construction and operation phases of the mine will be considered for modelling. No upset or start-up scenarios are proposed.

- output spatial scale: near-field (<10 km), local (<50 km), regional (>50 km)
- special output required for vegetation, health risk or visibility assessments

  Predicted air quality concentrations or deposition rates will be provided to other EA disciplines for input to those assessments at receptors identified by each discipline.
- other (specify):

EMISSION SOURCES AND CHARACTERISTICS

Provide a map showing the source locations, buildings, and facility fence line.

Point source information at the processing plant is provided in Figure 5. Other area source locations will be distributed at appropriate locations along the roadways and portal areas.

Model Emission Scenarios

If applicable, describe the different model emission scenarios required for the assessment if multiple options are under consideration. For example, different source characteristics (stack dimensions, emission rates) or source arrangements (locations, types, buildings) may need separate modelling runs to examine the air quality implications of different scenarios.

Model emission scenarios will consider the different emission sources related to two phases of the project, construction and operations. Within these scenarios, emission rates may vary for evaluation against acute or short-term air quality objectives (1-hour and 24-hour) and chronic or annual air quality objectives.

Contaminants Emitted for Each Emission Scenario

Provide the following details of the sources to be modelled:

Source	Type: Point (P), Area (A), Line (L), Volume(V), etc. Indicate type	Contaminants (SO_2, NO_2, $PM_{2.5}$*. . .)	Basis of Emissions (Section 3.3)
Underground mine exhaust at air exchange units	P	CO, NO_x, SO_2, TSP, PM_{10}, $PM_{2.5}$, dustfall	___approved/proposed emission limits ___manufacturer specifications __emission factors ___CEM ___modelled emission rates ___stack sample _X_other (specify): exhaust air will be assumed to meet air limits as specified in the Health, Safety and Reclamation Code for Mines in BC
Equipment exhaust: (surface support, pressure support, ore haulage, temporary infrastructure, earthworks, and construction)	A	CO, NO_x, SO_2, TSP, PM_{10}, $PM_{2.5}$, dustfall	___approved/proposed emission limits ___manufacturer specifications _X_emission factors ___CEM ___modelled emission rates ___stack sample ___other (specify)
Vehicular emissions	Road	CO, NO_x, SO_2, TSP, PM_{10}, $PM_{2.5}$, dustfall	___approved/proposed emission limits ___manufacturer specifications _X_emission factors ___CEM ___modelled emission rates ___stack sample ___other (specify)
Road dust	Road	TSP, PM_{10}, $PM_{2.5}$, dustfall	___approved/proposed emission limits ___manufacturer specifications _X_emission factors ___CEM ___modelled emission rates ___stack sample ___other (specify)

Source	Type: Point (P), Area (A), Line (L), Volume(V), etc. Indicate type	Contaminants (SO_2, NO_2, $PM_{2.5}$*. . .)	Basis of Emissions (Section 3.3)
Explosion emissions	A	CO, NO_x, SO_2, TSP, PM_{10}, $PM_{2.5}$, dustfall	___approved/proposed emission limits ___manufacturer specifications _X_emission factors ___CEM ___modelled emission rates ___stack sample ___other (specify)
Crusher dust collector stack	P	TSP, PM_{10}, $PM_{2.5}$, dustfall	___approved/proposed emission limits ___manufacturer specifications _X_emission factors ___CEM ___modelled emission rates ___stack sample ___other (specify)
Stockpile and reclaim dust collector stack or bin	P	TSP, PM_{10}, $PM_{2.5}$, dustfall	___approved/proposed emission limits _X_manufacturer specifications ___emission factors ___CEM ___modelled emission rates ___stack sample ___other (specify)
Reagent extraction stack	P	TSP, PM_{10}, $PM_{2.5}$, dustfall	___approved/proposed emission limits _X__manufacturer specifications __emission factors ___CEM ___modelled emission rates ___stack sample ___other (specify)

Source	Type: Point (P), Area (A), Line (L), Volume(V), etc. Indicate type	Contaminants (SO_2, NO_2, $PM_{2.5}$*. . .)	Basis of Emissions (Section 3.3)
Smelting furnace baghouse stack	P	CO, NO_x, SO_2, TSP, PM_{10}, $PM_{2.5}$, dustfall	_X__approved/proposed emission limits ___manufacturer specifications __emission factors ___CEM ___modelled emission rates ___stack sample ___other (specify)
Assay lab stack	P	TSP, PM_{10}, $PM_{2.5}$, dustfall	___approved/proposed emission limits ___manufacturer specifications _X_emission factors ___CEM ___modelled emission rates ___stack sample ___other (specify)
Fire water – standby diesel pump	P	CO, NO_x, SO_2, TSP, PM_{10}, $PM_{2.5}$, dustfall	___approved/proposed emission limits ___manufacturer specifications _X_emission factors ___CEM ___modelled emission rates ___stack sample ___other (specify)
Material handling	V	TSP, PM_{10}, $PM_{2.5}$, dustfall	___approved/proposed emission limits ___manufacturer specifications _X_emission factors ___CEM ___modelled emission rates ___stack sample ___other (specify)

***** for PM emissions indicate whether it is filterable, or filterable + condensable, or if unknown (see Section 3.6) –

Given the types of sources considered, PM emissions will be the filterable portion.

Source Emission Rate Variability

Hourly or annual emission rates will be used to model sources for acute or chronic and emissions will not vary substantially. The use of variable emission rates within the model will not be undertaken. Post-processing of model results will consider the proposed 8 month schedule of mining activities.

BASELINE CONCENTRATION

- Indicate method used to determine baseline concentrations for each pollutant (Section 8.1):

  _____monitoring data (Section 8.1.1 and 8.1.2)

  _____establish monitoring program (Section 8.1.3)

  _____modelled sources (Section 8.1.5)

  __X___other method (describe)

The BC MoE has recently compiled a series of air zone reports. The Red Mountain Project sits along the border of the Coastal Air Zone and Central Interior Air Zone. The remote project location is likely more represented by the Coastal Air Zone which is relatively undeveloped outside of Prince Rupert, Terrace and Kitimat (BC MOE 2015a). Air quality measurements and concerns identified in the report are focused on emissions from industrial sources and woodstoves within these communities, concerns that would not be applicable to the Red Mountain project. Despite this, air zone management levels for $PM_{2.5}$ were classified as "green", the classification given for air zones that are the lowest in comparison to ambient air quality objectives, based on monitoring conducted in the major population centres in the zone. It is reasonable to assume that the Red Mountain mine location, a remote area with few anthropogenic sources, would be less impacted by air emissions than these centres.

The method that will be adopted to define the necessary baseline concentrations for the air quality assessment is a method that has been accepted for environmental assessments (EAs) conducted and approved for other mining projects in the region. Most of these assessments have been conducted by Rescan/ERM and rely on historical data collected by Rescan/ERM to define an appropriate baseline for remote areas with few anthropogenic sources.

The approach uses data from monitoring stations that are representative of remote project areas that are typical of mining locations in Northeastern BC, including the Red Mountain project. The Red Mountain project is located in an area that is similar to both recent projects (Brucejack, Rescan, 2014 and Kemess, Rescan, 2016) and historical projects (KSM, Rescan, 2013) that have used this approach to baseline characterization:

- Remote, undeveloped locations.
- Located in complex terrain in steep valleys dominated by forest cover at lower elevations and rock, snow and ice at higher elevations.
- No specific anthropogenic sources of emissions can be identified near the site beyond limited access for recreational or commercial activities along the current access road off of highway 37.
- Located within the same biogeoclimatic zone in BC and subject to similar season climatic regimes.

In order to perform air quality dispersion modelling as part of the environmental assessment, ambient background concentrations of air contaminants must be considered The order of priority of information sources used to establish the background concentration levels is stated in the Guidelines for Air Quality Dispersion Modelling in British Columbia (BC MoE, 2015b):

1. A network of long-term ambient monitoring stations near the source under study;
2. Long-term ambient monitoring at a different location that is adequately representative; and,
3. Modelled background.

In the case of the recent and historical projects that utilized the proposed approach to establishing baseline concentrations, the approach used relies on a combination of ambient background concentrations from stations from different locations that are adequately representative of the background concentrations at the project site.

Monitoring Stations and Information Used in Previous Assessments that are Representative of Project Area (adapted from Kemess Underground Project, Rescan, 2016)

For representative SO_2 concentrations, other regional mining environmental assessments have relied upon the available estimates of remote ambient background concentrations as published by the Canadian Air and Precipitation Monitoring Network (CAPMoN). CAPMoN is a non-urban air quality monitoring network, with siting criteria designed to ensure that the measurement locations are regionally representative (i.e., not affected by local sources of air pollution). There are currently 28 measurement sites in Canada and one in the United States. The closest CAPMoN site to the Project is the Saturna station, off the southern tip of Vancouver Island in the middle of the Strait of Georgia. Although the station is almost 1,000 km southeast of the Project, it provides the best estimate of background concentration available for British Columbia. Daily measurements of SO_2 concentrations are available from the Saturna monitoring station from 1996 to 2002 (1997 is not available). The average annual SO_2 concentration for that period was reported as 2.3 µg/m^3. However, ambient NO_2 concentrations were not measured at the Saturna station.

Since CAPMoN does not provide background concentrations for all pollutants, ambient background concentrations were also determined from other representative locations. A summary of those concentrations as submitted for the previous assessments and the recommended baseline concentrations for the Red Mountain air quality assessment is provided below (Table recreated from ERM, 2014).

		Concentration (µg/m^3)					
Pollutant	Averaging Period	Brucejack	Saturna	Diavik	Galore	Kitsault	Baseline representing Red Mountain
SO_2	1-hour	-	-	4.0	-	-	4.0
	24-hour	-	-	4.0	-	-	4.0
	30-day	0.13[a]	-	-	-	-	-
	Annual	-	2.3	2.0	-	-	2.0
NO_2	1-hour	-	-	21	-	-	21
	24-hour	-	-	21	-	-	21
	30-day	0.09 to 4.1	-	-	-	-	-
	Annual	-	-	5.0	-	-	5.0
CO	1-hour	-	-	100	-	-	100

	8-hour	-	-	100	-	-	100
TSP	24-hour	-	-	10	-	3.5	10
	Annual	-	-	10	-	-	10
PM_{10}	24-hour	-	-	10	3.4	2.5	3.4
$PM_{2.5}$	24-hour	-	-	-	1.3	2.3	1.3
	Annual	-	-	-	-	-	1.3

The Diavik Diamond Mine (Diavik) is in the Northwest Territories, located about 300 km northeast of Yellowknife. In the Diavik Diamond Mine Environmental Assessment (Cirrus, 1998), ambient background concentrations for NOx, SO_2 and particulates were estimated based on surveys and assumptions. These ambient concentrations have been considered to be typical background concentrations for remote areas with few anthropogenic sources. The Galore Greek Mine Project (Galore) is located approximately 170 km northwest of the Red Mountain Project. The baseline monitoring conducted in 2005 included measurements of ambient PM_{10} and $PM_{2.5}$ concentrations (Rescan, 2006). The Kitsault Mine Project (Kitsault) is located on the northwest coast of British Columbia, approximately 140 km north of Prince Rupert and 130 km south and 60 km south of the Red Mountain project and TSP, PM_{10} and $PM_{2.5}$ were measured on site (AMEC, 2011).

The Brucejack Gold Mine Project EA Application relied on the same baseline air quality representation as presented above and this mine is located approximately 65 km north-northwest of the Red Mountain project. The Kemess Underground project also relied on the same baseline air quality representation and this project is located approximately 225 km northeast of the Red Mountain project. It is recommended, as with the previous assessments referenced, that the baseline concentrations for the Red Mountain air quality assessment adopt ambient concentrations from these representative remote sites.

1-hour and 24-hour SO_2 concentrations of 4.0 $\mu g/m^3$ are from the Diavik Diamond Mine Environmental Assessment. In the Brucejack EA, the passive collection of SO_2 concentrations revealed a 30-day SO_2 concentration of 0.13 $\mu g/m^3$. Comparing this to the annual concentrations of 2.3 and 2.0 $\mu g/m^3$ from Saturna and Diavik, ambient SO_2 concentrations at the Project area were deemed to be much lower. Therefore, the concentrations from Diavik are conservatively assumed to represent the Project area.

As with the Brucejack EA, the 30-day NO_2 concentration of 0.09 $\mu g/m^3$ was collected at the Project's proposed mine site while the concentration of 4.1 $\mu g/m^3$ was collected within 5 km of HWY 37. Comparing with the background concentrations from Diavik, the NO_2 concentrations at the Project area are also much lower. The concentrations from Diavik are conservatively assumed to represent the Project area.

There are currently no CO ambient concentrations available other than from Diavik and therefore the background concentrations of 100 $\mu g/m^3$ from Diavik are assumed to represent the Project area.

For suspended particulates, a wider range of concentration variation was observed between Diavik and Kitsault. Thirty 24-hour samples were collected at Diavik, while for Kitsault, the monitoring durations for TSP, PM_{10} and $PM_{2.5}$ were each approximately 7.5 hours. Data collected from Diavik is deemed to be a more accurate representation of the 24-hour averages and is used to represent the Project area. The Diavik study did not provide clear information on whether the PM_{10} concentration was assumed to be the same as TSP. Since the latter is more likely, PM_{10} concentration from Galore are assumed to be representative of the Project area. Concentration of $PM_{2.5}$ from Galore is also selected to represent the Project area. With the absence of available annual $PM_{2.5}$ concentrations, 24-hour $PM_{2.5}$ concentrations from Galore are conservatively assumed to represent $PM_{2.5}$ annual concentration.

Following the Application, as part of the adaptive management of air quality for the Red Mountain Underground Project, baseline air quality conditions relevant to the adaptive management plan will be characterized prior to construction. These baseline air quality conditions will be used to establish air quality adaptive management criteria or triggers for the construction and operations of the mine. This baseline monitoring, prior to construction, will also serve as a comparative check on the assumptions made in characterizing air quality existing conditions based on available information from other regional EAs and remote monitoring stations.

Dust deposition rates will be modelled to support other valued component assessments. As with the Kemess underground mine assessment (ERM, 2016), dustfall monitoring was not conducted at the Project site; therefore, background dustfall levels from other projects were used. Baseline dustfall data have been collected at the Kerr-Sulphuret-Mitchell (KSM) Project, approximately 75 km north of the Red Mountain Project, the Brucejack, Galore, Kitsault and the Schaft Creek Project, located 180 km northwest of the Red Mountain Project. At KSM, dust deposition rates were monitored from June 2008 to October 2011 at five to ten locations, depending on the year (Rescan, 2012). The deposition rates varied from below-detection limit to 2.75 mg/dm^2/day. Sampling took place during the summer and early fall, which are typically the driest time of the year and therefore dustfall is not mitigated by precipitation. The average dustfall rate for individual stations measured between 2008 and 2011 ranged from 0.12 to 1.22 mg/dm^2/day. At Brucejack, dustfall rates were monitored at six stations in 2012. The average dust deposition rates for each station ranged from 0.18 to 1.53 mg/dm^2/day (ERM, 2014). At Galore dustfall was monitored in 2012. The average for each of the five sites ranged from 0.09 to 0.96 mg/dm^2/day (Rescan, 2013). At Kitsault the air quality baseline monitoring data showed that the highest dustfall rate was 0.46 mg/dm^2/day in July 2009 and the average is 0.21 mg/dm^2/day (AMEC, 2011). At Schaft Creek, dustfall was monitored in 2007 (July, August, and September) and 2008 (June, July, August, and November) at eight stations (Rescan, 2016). Dust deposition ranged from below-detection limit of 0.1 mg/dm^2/day to 2.5 mg/dm^2/day, and the average for each station ranged from 0.18 to 0.93 mg/dm^2/day. Dust deposition rates from various projects are summarized in the table below. The average dust deposition rates from each of the sites were calculated and the average of the five sites is 0.56 mg/dm^2/day. This dustfall deposition rate, representing remote areas, will be used to represent baseline dustfall rates at the Project area.

Pollutant	Dustfall Deposition Rate (mg/dm^2/day)					
	KSM	Brucejack	Galore	Kitsault	Schaft Creek	Baseline representing Red Mountain
Dust deposition	0.12 - 1.22	0.18 - 1.53	0.09 - 0.96	0.21	0.13 - 0.93	0.56

BUILDING DOWNWASH

- Potential for building downwash. Please provide rational if building downwash is not modelled.

There is a potential for building downwash affecting the sources at the process plant, so the buildings associated with the processing plant will be processed by BPIP-PRIME for modelling of building downwash for these sources. Please refer to Figure 5 for the locations of point sources to be modelled relative to the buildings on site.

- If building downwash included, provide a site map to indicate buildings to be processed by BPIP-PRIME, and also complete the following Table:

Source Height (m)	Distance from the Source to the Nearest Building (m)	Building Length (m)	Building Height (m)	Building Width (m)
• 1.3 (Fresh/Fire Water Tank Diesel Pump) • 24.9 (Smelting Furnace Stack) • 22.2 (Reagent Mixing Stack)	On top of the Reagent Building	42.1	19.2	33.7
5 (Assay Lab Stack)	On top of the Grinding Building	31.9	21.9	33.7
6.95 (Stockpile and Reclaim Dust Collector Stack)	29.4 to the Grinding Building	31.9	22	33.7
6.95 (Crusher Dust Collector Stack)	113.6 to the Grinding Building	31.9	22	33.7

GEOPHYSICAL DATA INPUT

Topography and Land Use Data

- Terrain data (specify source of data) and an elevation map for the model domain:

Canadian data was obtained from GeoGratis (http://geogratis.gc.ca) Canadian Digital Elevation Data (CDED) at 1:50,000 scale.

American data was obtained from the ASTER Global Digital Elevation Model V002 (http://gdex.cr.usgs.gov/gdex/) having a vertical root-mean-squared error (RMSE) accuracies between 10 – 25 m.

See Figure 3 for terrain map.

- Land use data (specify source of data) and a land use map for the model domain:

Canadian data was obtained from DataBC (http://www.data.gov.bc.ca) Baseline Thematic Mapping Present Land User Version 1 Spatial Layer at 1:250,000 scale.

American data was obtained from the NLDC 2011 Land Cover for Alaska. (http://www.mrlc.gov/nlcd11_data.php) at a spatial resolution of about 30 metres.

See Figure 4 for land use map.

Surface Characteristics

For AERSCREEN, provide seasonal values of surface characteristics (surface roughness, albedo and Bowen ratio) for input to MAKEMET.

For Level 2 and 3 Assessments, Indicate if recommended seasonally varied surface characteristics (surface roughness, albedo, Bowen ratio, etc.) (see Section 4.3 and 4.4) are used for the dispersion modelling study. If not, provide the proposed surface characteristics and the rationales.

Table 4.8 Season 1(Mid-Summer) Geophysical Parameters, Table 4.9 Season 2 (Autumn) Geophysical Parameters, 4.10 Season 3 (Winter 1) Geophysical Parameters, and 4.12 Season 5 (Transitional Spring) Geophysical Parameters from the British Columbia Air Quality Dispersion Modelling Guideline (BC MOE, December 2015) were used as per the by month and latitude recommendations in Table 4.5.

METEOROLOGICAL DATA INPUT (FOR LEVEL 2 AND 3 ASSESSMENTS ONLY)

Surface Meteorological Data

If surface observation data are used, provide a map with the location of each surface meteorological station identified and also provide the following:

A surface meteorological station was installed at the Red Mountain Underground Project site on July 30, 2014 at the site of the "Upper Tram Station" from a previous environmental assessment conducted at the Red Mountain site (Rescan, 1994). See Figure 1 for the location of the surface meteorological station at Red Mountain. The table below provides station details.

Surface Met Data and Location (lat/long or indicate on map)	Data Source MOE, MV, MSC, Site Specific, other (specify) [1]	Period of Record (start/end data) [2]	% of Wind Speeds = 0.0 [3]	Anemometer Height (m)	Parameters
Red Mountain Surface Station	Site-Specific	January 2015 – December 2015 *Please note the data	0.2%	10	• Wind speed • Wind direction • Temperature /

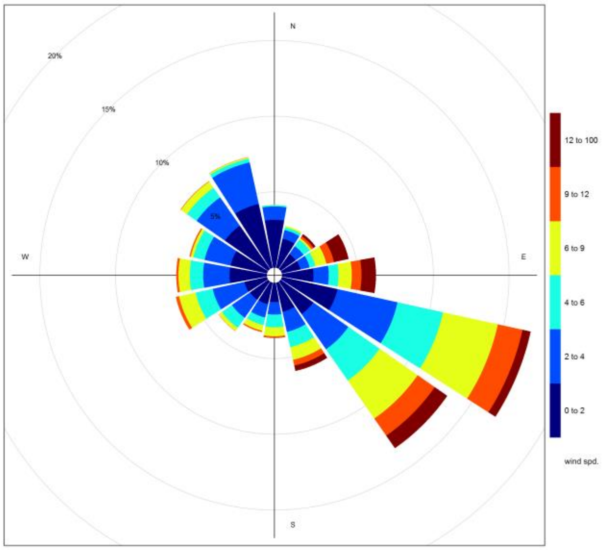
(Figure 1)		completeness for wind and temperature are 62% and 48%, respectively.			Relative Humidity • Pressure • Precipitation • Solar radiation

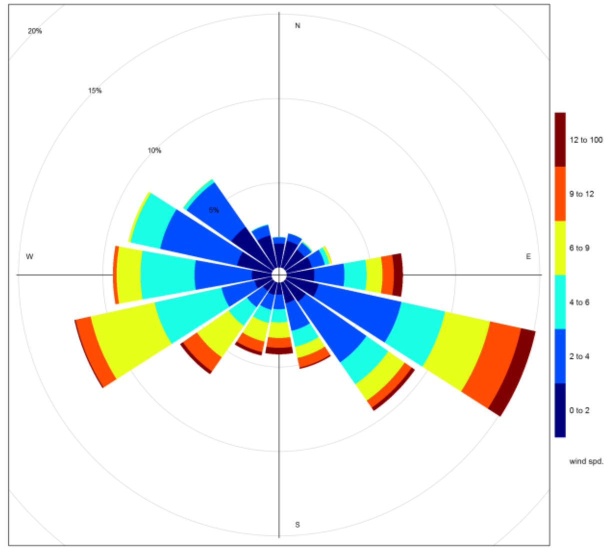
1. If data from a non - Ministry, MV or MSC station are planned to be used, follow guidance in Section 5.2.3
2. For data completeness and data filling, follow guidance in Section 5.5
3. For light and no wind conditions, follow guidance in Section 5.6

Despite regular inspection and maintenance, the surface meteorological data collected onsite contains significant data gaps, related to instrument and datalogger errors and the harsh monitoring environment for meteorological parameters. As such, it is recommended for the air quality assessment to use the province-wide WRF output as direct input to the CALMET model. The available surface station data will be used where appropriate in the Application, but will not form part of the model input data.

NWP (numerical weather predictions) from WRF will be input as an Initial Guess field for CALMET, which also takes advantage of CALMET's ability to apply the finer scale terrain effects (kinematic, slope, and blocking) to create a more realistic flow field. Given the complex terrain in the area, even if the surface station provided a more complete data record, the surface station influence would have to be limited by a small R1 area to restrict the influence of the station at inappropriate elevations. Thus, most of the mine footprint would likely fall outside of the station influence. In addition, running in "hybrid" mode with an incomplete data record is likely to cause convergence and divergence zones (sometimes referred to as "donut holes") in the wind field at the edge of R1 which would fall on the mine site and could impact predicted concentrations. It is recommended that a NO-OBS CALMET run using the provincial WRF dataset be used for the assessment.

The available surface station (left) is compared with an extracted wind rose from the WRF model data (right) in the figure below. The dominant wind direction from the southeast directions are captured well by the WRF data and it is anticipated that CALMET will apply finer scale terrain effects that will capture a representative wind flow in the NO-OBS CALMET run using the provincial WRF dataset in the absence of a complete surface station dataset. The surface station data collected will be used, where appropriate, for comparison as part of the quality management program and presented as part of the EA Application.





Upper-Air Meteorological Data

If upper air meteorological data are used provide the following:

Station Name	Period of Record (start/end date) [1]	Distance between the Upper Air Station and Project (km)
	Not Applicable	

[1.] For data completeness and data filling, follow guidance in Section 5.5.

NWP Model Output

If NWP output (different than the province-wide WRF output) used provide the following:

WRF data from the province-wide WRF output, produced by Exponent, will be used in this assessment from the 2015 calendar year.

- Mesoscale Meteorological Model (Name\Version\Model Configuration):
- Model Output Provider:
- Domain (attach a map showing the horizontal extent):
- Horizontal and Vertical Grid Resolution and Height of Each Vertical Level:

- Data Period (start/end date):
- Four Dimensional Data Assimilation is applied (Yes or No):

NWP model output use (circle one below for the selected dispersion model):

- AERMET/AERMOD:
  - Extract pseudo surface station and pseudo upper air sounding (as input to AERMET), or
  - Create .SFC and .PFL files (AERMOD-ready files, skip AERMET)

- CALMET:
  - NWP only, or
  - Surface station and NWP, or -

Both of these options for CALMET have been tested; however, given the data gaps in the surface station data record discussed above, the relatively small influence the surface station would have on wind fields near the TMF/processing area or portal areas (parameter R1 in CALMET would be restricted due to steep valley and elevation changes). It is proposed that the final CALMET run will utilize NWP only.

  - Surface station, upper air sounding, and NWP, or
  - Other (specify):

TREATMENTS

<u>NO to NO_2 Conversion:</u>

Identify the method to be used (Section 8.2).

_____Ambient Ratio Method

- indicate monitoring station(s)

___ X __OLM:

- specify O_3 concentration and how it was selected,

A technical document about background concentration of ozone in BC (McKendry, 2006) indicated background ozone concentration to be in the range of 40 to 80 µg/m^3 (20 to 40 parts per billion) in the province. Ozone background of 60 µg/m^3 will be used in this assessment.

- if non default in-stack ratios are used, specify and provide rationale.

_____PVMRM (for AERSCREEN and AERMOD only):

- specify O_3 concentration and how it was selected,
- if non default equilibrium ratios and/or in- stack ratios are used, specify and provide rationale.

Chemical Transformation:

- Specify transformation method and provide details on inputs if Secondary $PM_{2.5}$, Acid Deposition or Visibility effects are to be estimated. Depending on the transformation method, this could include ammonia, ozone, hydrogen peroxide concentrations, nighttime loss and formation rates for nitrates and sulphates.

Chemical transformation methods will not be employed as secondary $PM_{2.5}$, acid deposition and visibility effects will not be considered in the assessment.

Particle Deposition:

- If non-recommended particle size distributions (see Section 3.6) are used, provide Table of particle emission (including heavy meals if modelled) size/density distribution and indicate the basis for the Table.

Stagnation:

- Provide an estimate of the frequency of stagnation based local meteorological data if available. If AERMOD is proposed, provide methodology on how stagnation periods will be treated (see Section 10.2).

The CALPUFF model is being used and can handle stagnation periods appropriately.

Shore/Coastal Effects:

- If included, indicate whether sub-grid-scale Thermal Internal Boundary Layer option is selected along with the required input coastline coordinate data (see Section 10.3).

The project area is not near any bodies of water that would require specific handling of shore or coastal effects in the meteorological model.

Plume Condensation (Fogging) and Icing:

- Indicate if this will be included (Section 10.6).

Fogging and icing will not be evaluated in the model.

QUALITY MANAGEMENT PROGRAM

The EA Application appendix for the air quality assessment will include quality management checks of model input data as recommended below by the BC Ministry of Environment.

Model Input Data

Indicate the tests that will be undertaken to assure the quality of the inputs.

For the geophysical input data:

- contour plot of topography
- plots of land use and land cover

For the meteorological data:

- wind rose (annual and/or seasonal)
- frequency distribution of surface wind speeds
- average hourly temperature plot (annual and/or seasonal)

If NWP output is used, describe the tests undertaken to assure the quality of the output (Section 6.1)

- wind rose at selected locations and heights (annual and/or seasonal)
- average hourly temperature plot at selected locations and heights (annual and/or seasonal)
- wind field plots for selected periods that indicate topographic influences such as channeling and thermally generated flows

Model Output Data

The EA Application appendix for the air quality assessment will include model output data checks as recommended below by the BC Ministry of Environment and the referenced sections of the British Columbia Air Quality Dispersion Modelling Guideline.

For CALMET/CALPUFF applications, provide a list of the tests conducted to confirm the quality of the model output (intermediate pre-processing files and concentration/deposition predictions).

With respect to the pre-processed files that are prepared for CALPUFF input, there are several tests listed in Section 9.1.1 and 9.1.2 to check the output from the pre-processing utility programs to confirm that they have been properly processed. These are related to checking:

- terrain, land use
- sources (locations and elevation) and emission characteristics
- meteorological data (locations) and tests in confirm proper processing of the raw meteorological data (units, parameters)
- receptor locations and elevations

For CALMET output there are several tests listed in Section 9.1.3 to test the quality of the generated meteorological fields. These are related to reviewing the following:

- wind field maps (surface and different elevations) for select periods where topographic influences (channeling, thermally driven flows) would be evident
- wind roses and selected locations and elevations (annual, seasonal)
- frequency distributions of various meteorological parameters (annual, seasonal) such as PG-stability class, mixing heights
- plots of hourly average parameters such as temperature, mixing height, precipitation at key locations (seasonal and annual)

Note: The Ministry may require all computer files associated with the modelling to be submitted upon request.

MINISTRY REVIEW OF PLAN AND REVISIONS

A modelling plan can change over the course of developing the air quality assessment so acceptance of the initial submission of the plan is on the basis of the best information provided to date. Changes to the plan (additions, modifications) should be noted and agreed to with the Ministry as necessary. An updated Dispersion Modelling Plan may be necessary.

Ministry Acceptance of Original Plan (Name):_________________________

Date:____________________

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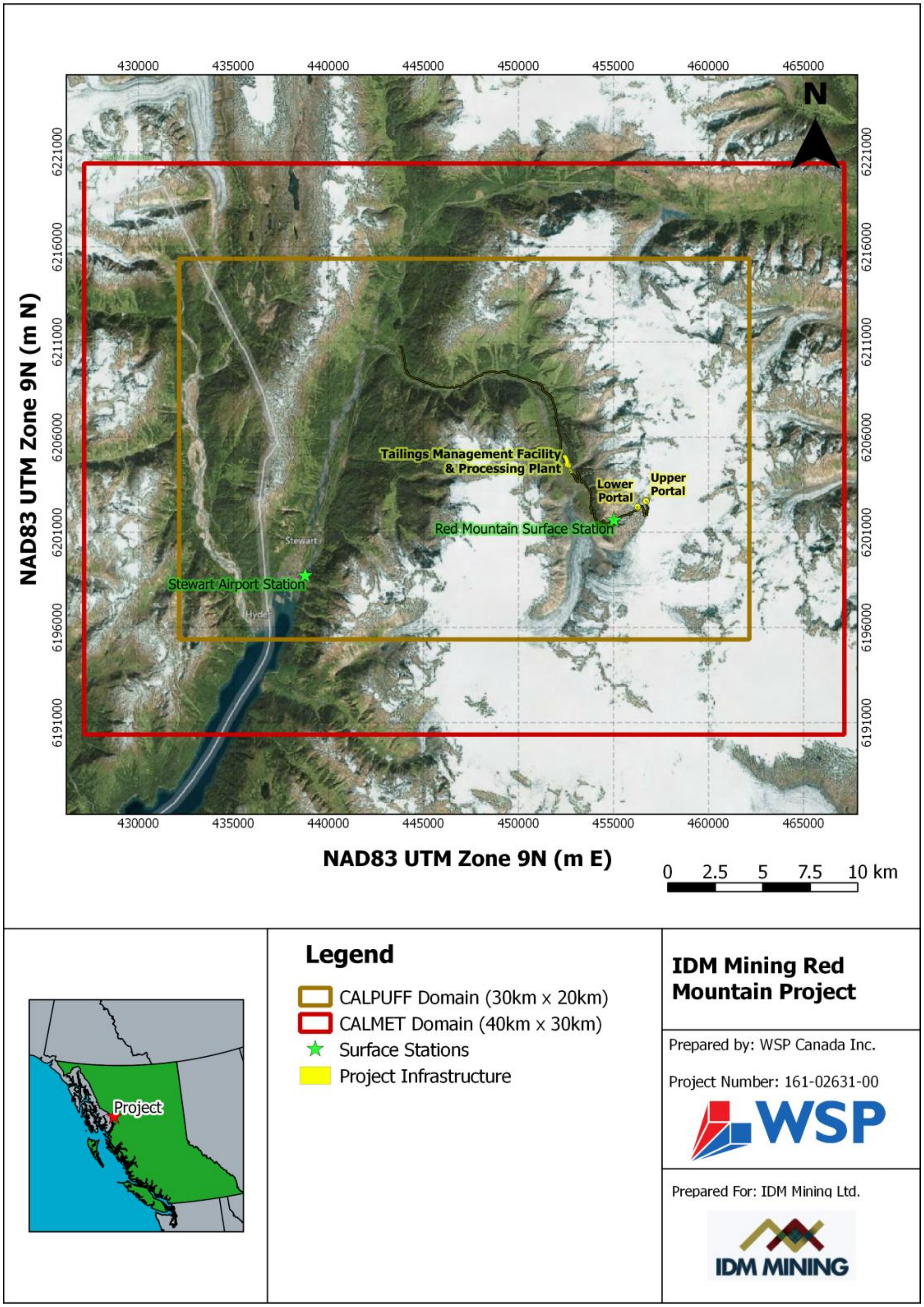

Figure 1 CALMET and CALPUFF Modelling Domains and Location of Surface Stations

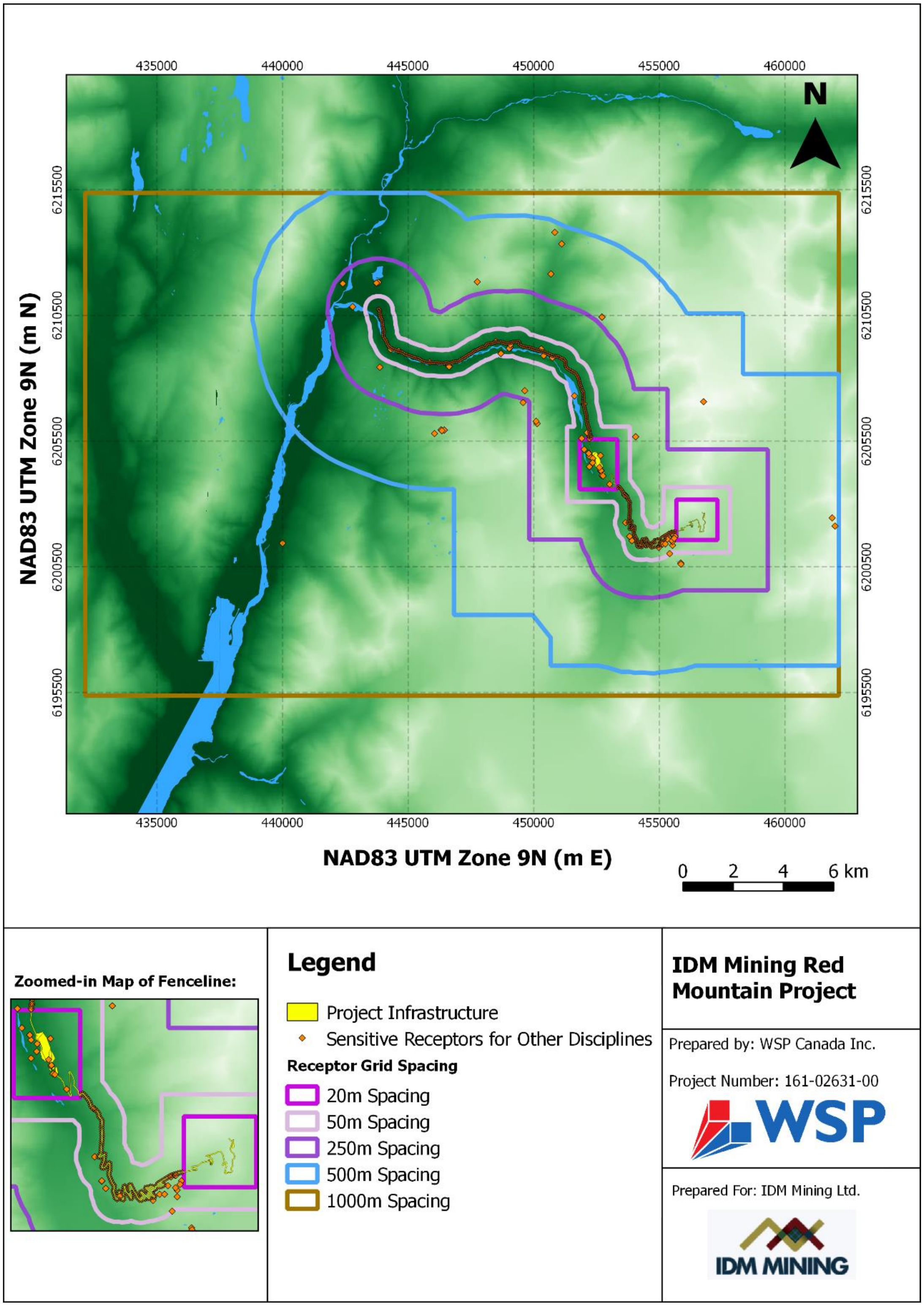

Figure 2 Receptor Map

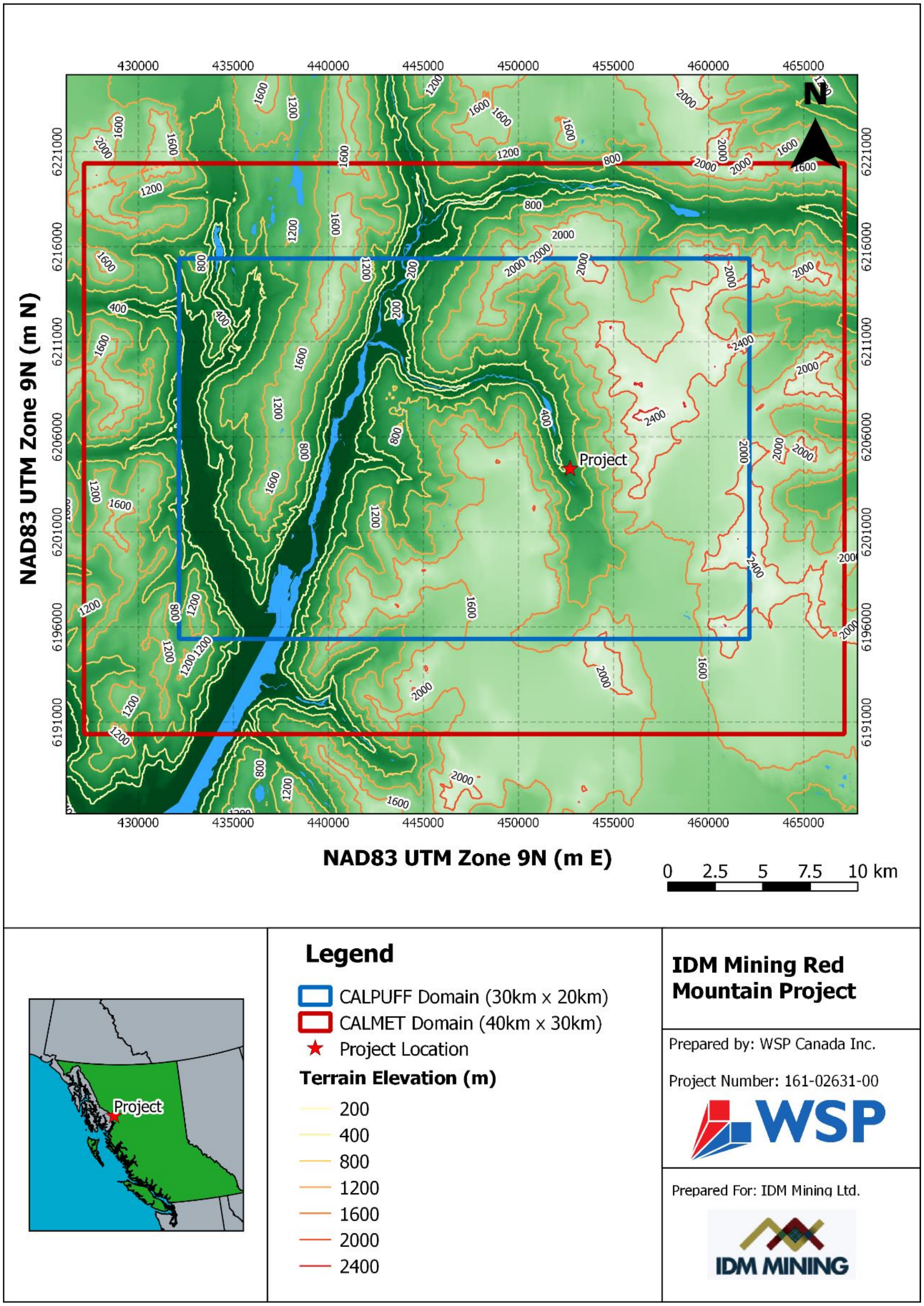

Figure 3 Terrain Data Used in CALMET

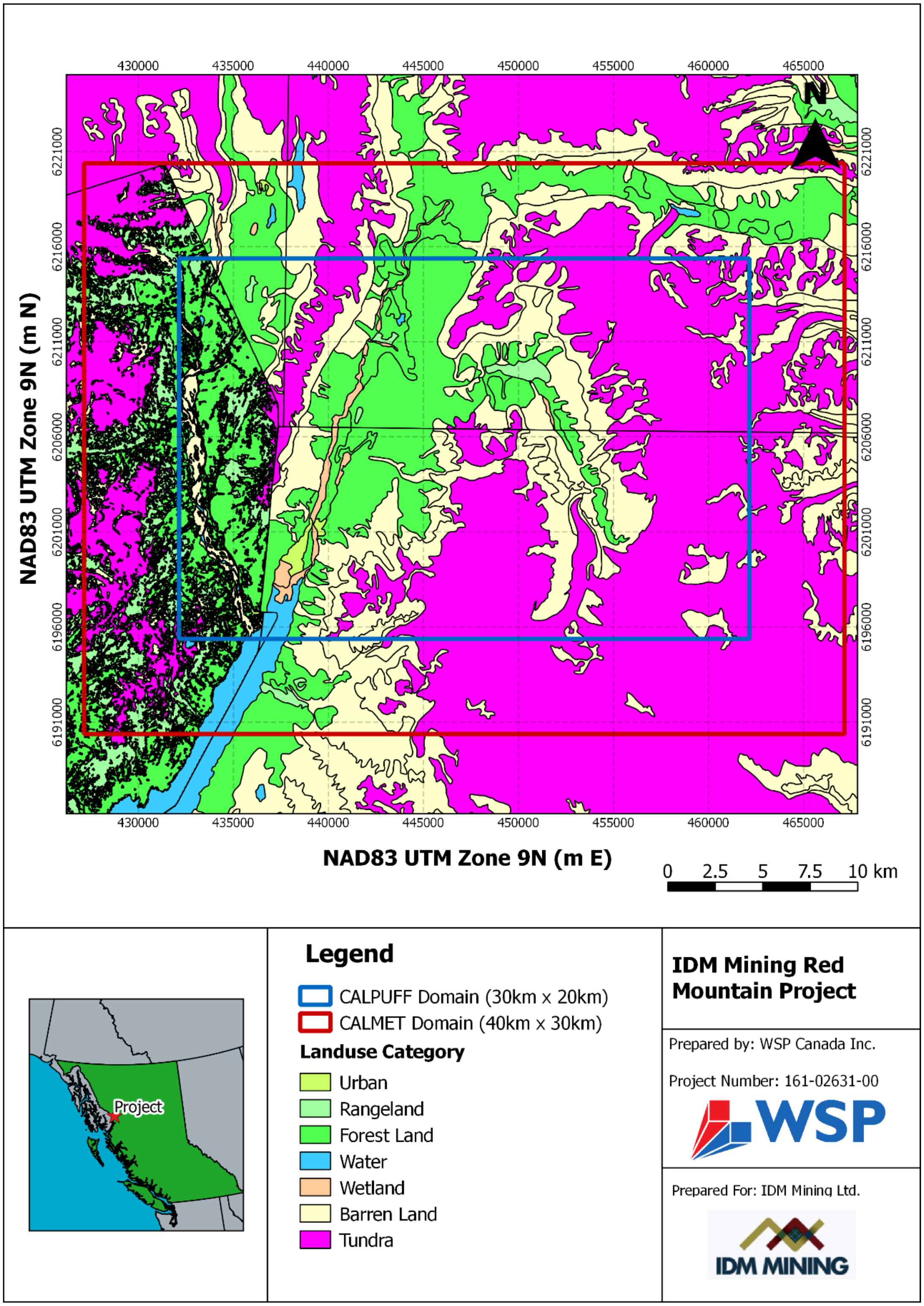

Figure 4 Land Use Data Used in CALMET

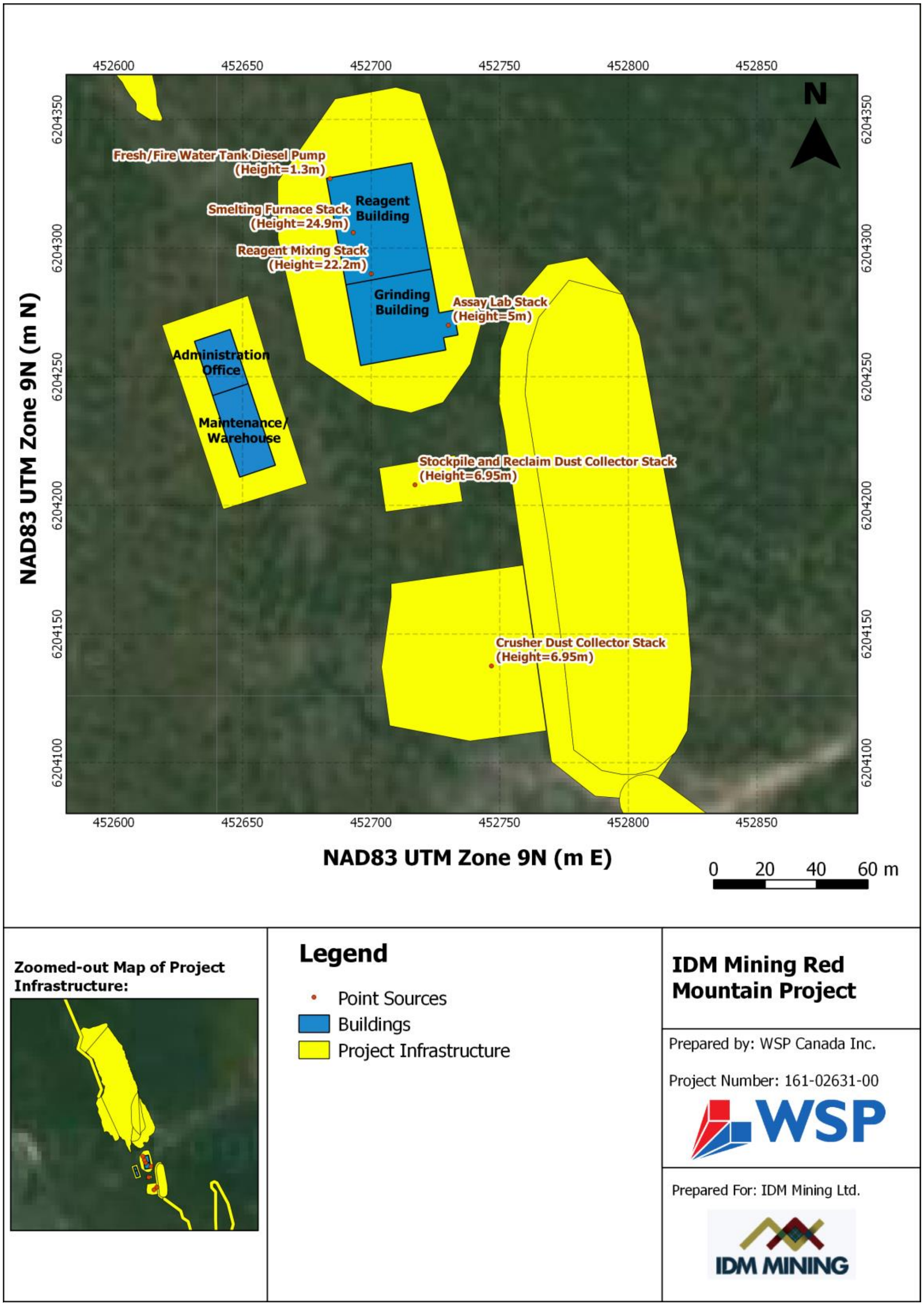

Figure 5 Building Downwash