Environmental and Social Impact Assessment Modelling – Air Dispersion Modelling

James Bay Lithium Pegmatite Project

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Executive Summary

Stantec Consulting Ltd. (Stantec) was contracted by Galaxy Lithium (Canada) Inc. (Galaxy) to conduct an air quality dispersion modelling assessment, as well as a GHG emission estimate to support the James Bay Lithium Pegmatite Project (the Project), located in the region of Nord-Du-Quebec. This report presents the results of the air quality dispersion modelling assessment. In 2018, Galaxy prepared an air dispersion modelling study and GHG assessment (WSP 2018) to support the development of an Environmental and Social Impact Assessment (ESIA). Since the completion of the initial ESIA modelling, there have been several site layout and operational changes that arose in the Value Engineering phase (GMS 2020) of the Project which require revised air dispersion modelling. In addition, there were comments and Information Requests from the regulatory bodies (e.g., the Impact Assessment Agency of Canada, IAAC, and the Comité d'examen des répercussions sur l'environnement et le milieu social, COMEX), which have been incorporated in the dispersion modelling. Where applicable, Stantec remained consistent with the previous methods applied in the initial ESIA air dispersion modelling (WSP 2018), including for the estimation of emissions and the set-up of the modelling parameters.

The GHG assessment involved updating the GHG emission estimates to be representative of the revised site layout and to be compliant with the most recent requirements from Environment and Climate Change Canada (ECCC). Emissions of GHGs were quantified by individual pollutant and expressed in units of kilotonnes of CO_2 equivalent per year (kt CO_2e/y). The GHG species in the emission inventory included carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). The GHG assessment is attached to this air dispersion modelling report.

The objective of the air dispersion modelling study was to verify whether applicable ambient air quality limits will be met for contaminants that are expected to be emitted from two Project phases (i.e., construction and operation). The ambient air quality limits used in this assessment were prescribed by the Quebec Ministry of Environment and Climate Change/Ministère de l'Environnement et de la Lutte contre les changements climatiques (MELCC 2018), the Canadian Council of Ministers of the Environment (CCME 2021), and the World Health Organization (WHO 2005). The CAAQS are reference values for regional air quality management and are applicable to measured ambient concentrations at human receptor locations away from the industrial facility boundaries. The maximum model predicted concentrations from the Project are compared to the CAAQS in this context and do not imply compliance at the application boundary limit.

The air contaminants of interest include carbon monoxide (CO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), volatile organic compounds (VOCs), and particulate matter (total particulate matter, TPM; particulate matter with an average size of 10 µm, PM_{10}; and particulate matter with an average size of 2.5 µm, $PM_{2.5}$), for both the construction and operation phase, and 19 metals for the operation phase.

The emission rates used in the air dispersion modelling were based on a combination of site-specific data and published emission factors. The dispersion modelling was performed using the AERMOD dispersion modelling system (v18181) and hourly meteorological data for a 5-year period, 2011-2015, consistent with the former WSP (2018) ESIA modelling.

The assessment was conducted following the “Guide de la modélisation de la dispersion atmosphérique” (GMDA) (MELCC 2005) and the instruction guide “Préparation et réalisation d’une modélisation de la dispersion des émissions atmosphériques – Projets miniers” (MELCC 2017).

Modelling results are presented at locations at and beyond a defined application boundary as well as at several sensitive receptors that fall into the categories of Cree Camp, traditional activity, valued area, and a local truck stop (km 381). The model predicted concentrations for construction phase were below the applicable ambient air quality limits for all species except for the 1-hour NO_2 (CAAQS). The 1-hour NO_2 concentration exceeded the 2020 CAAQS by 164% and 234% for the 2025 CAAQS. The model predicted maximum 1-hour NO_2 concentrations that were greater than the 2020 and 2025 CAAQS were limited in spatial area and not near the sensitive receptors.

For operation phase, the model predicted concentration for all species/averaging period were below the applicable ambient air quality limits except 24-hour TPM, 1-hour NO_2 (CAAQS), 1-hour crystalline silica and annual crystalline silica concentrations. The 24-hour TPM concentration limit was exceeded by 101% at a single location on the application boundary, for one 24-hour period over the 5-years modelled (~0.05% of the time). The 1-hour NO_2 (CAAQS) concentration exceeded the CAAQS on the application domain and at the traditional activity sensitive receptors. The maximum 1-hour NO_2 (CAAQS) concentration exceeded the 2020 CAAQS by 196% and 280% for 2025 CAAQS. The 1-hour crystalline silica air quality limit was exceeded by 179% in the application domain (outside the defined application boundary), but not exceeded at any of the sensitive receptors. The annual crystalline silica air quality limit was exceeded by 435% in the application domain (outside of the defined application boundary), by 213% at the km 381 truck stop, and by 261% at location of traditional activity.

Abbreviations

Ag	silver
As	arsenic
ANFO	ammonium nitrate/fuel oil
Ba	barium
Be	beryllium
CAAQS	Canadian Ambient Air Quality Standards
CAT	Caterpillar (machinery and equipment brand)
CCME	Canadian Council of Ministers of the Environment
Cd	cadmium
CH_4	methane
CEAA	Canadian Environmental Assessment Agency
CO	carbon monoxide
COMEX	Comité d'examen des répercussions sur l'environnement et le milieu social
Cr (VI)	hexavalent chromium
Co	cobalt
Cu	copper
DEMP	Dust Emissions Management Plan
DMS	dense medium separation
ECCC	Environment and Climate Change Canada
ESIA	Environmental and Social Impact Assessment
EQA	*Environment Quality Act/Loi sur la qualité de l'environnement*
FeSi	ferrosilicon
GHGs	greenhouse gases
GMS	G Mining Services
Hg	mercury
IAAC	Impact Assessment Agency of Canada
JBNQA	James Bay and Northern Quebec Agreement
MELCC	Quebec Ministry of Environment and Climate Change/ Ministère de l'Environnement et de la Lutte contre les changements climatiques

Mn	manganese
NCQQA	*Quebec air quality standards and criteria/Normes et critères Québécois de qualité de l'atmosphère*
NH_3	ammonia
Ni	nickel
NOx	nitrogen oxides
NO_2	nitrogen dioxide
N_2O	nitrous oxide
NPRI	National Pollutant Release Inventory
OLM	Ozone limiting method
O_3	ozone
$PM_{2.5}$	fine particulate matter with an average size of 2.5 µm
PM_{10}	particulate matter with an average size of 10 µm
Pb	lead
ROM	run of mine
SiO_2	silicon dioxide (crystalline silica)
SO_2	sulphur dioxide
Ti	titanium
TI	thallium
TMF	tailings management facility
TPM	total particulate matter
US EPA	United States Environmental Protection Agency
UTM	Universal Transverse Mercator
V	vanadium
VKT	vehicle kilometers traveled
VOCs	volatile organic compounds
WHO	World Health Organization
WRAP	Western Regional Air Partnership
WSP	WSP Global Inc.
Z	zinc

1.0 INTRODUCTION

Stantec Consulting Ltd. (Stantec) was contracted by Galaxy Lithium (Canada) Inc. (Galaxy) to conduct an air quality dispersion modelling assessment and greenhouse gas (GHG) emission estimate to support the James Bay Lithium Project (the Project) in the region of Nord-Du-Quebec. The Project mine site is located approximately 10 km south of the Eastmain River, 100 km east of James Bay, and 1 km North of the 381 kilometer truck stop managed by the Société de Développement de la Baie James. The mine site is located on Cree territory and Category III lands as classified by the James Bay and Northern Quebec agreement.

An atmospheric dispersion modelling study and GHG assessment (WSP 2018) were conducted in 2018 to support an Environmental and Social Impact Assessment (ESIA). The former dispersion modelling assessment will herein be referred to as the initial ESIA modelling (WSP 2018). The Project is subject to the provincial environmental impact assessment and review procedure, as stated in Section 153 of Chapter II of the *Environment Quality Act* (*Loi sur la qualité de l'environnement)* (EQA). Annex A of the EQA lists the projects that require an assessment, and includes "any mining project, including expansion, conversion, or modification of an existing mining operation." In addition, the Project is in territory governed by the James Bay and Northern Quebec Agreement (JBNQA), in which Annex 1 of Chapter 22 of the JBNQA lists mining projects as being required to undergo and environmental impact assessment.

The Project is also subject to a federal environmental assessment under the *Canadian Environmental Assessment Act, 2012* (CEAA 2012). Article 16(b) of the CEA Act lists the *Regulations Designating Physical Activities* and includes the construction and operation of a new mine, other than a rare element mine or gold mine, with a production capacity of 3,000 t/day or more and a metal mill with an input capacity of 4,000 t/day or more will require an environmental assessment.

The Project requires additional modelling due to site layout and operational changes made by a Value Engineering Feasibility Assessment (GMS 2020) conducted since the initial ESIA modelling submission in 2018 (WSP 2018). In addition, there were several information requests/comments provided by the Impact Assessment Agency of Canada (IAAC - formerly known as the Canadian Environmental Assessment Agency, CEAA), and the Comité d'examen des répercussions sur l'environnement et le milieu social (COMEX), which have been addressed by this revised air quality dispersion modelling assessment.

The site layout changes are the relocation of the processing plant, and relocation of the overburden, waste rock, and tailings stockpiles. The site layout changes resulted in a reduction of the proposed developed site area, which reduced road distances and truck travelling distances across the site.

The proposed site layout changes also affect greenhouse gas (GHG) emissions, and as such, Stantec updated the GHG emission estimates that consider the proposed site layout changes and to be compliant with the most recent requirements from Environment and Climate Change Canada (ECCC). Emissions of GHGs were quantified by individual pollutant and as kilotonnes of CO_2 equivalent per year (kt CO_2e/y). The GHG species in the emission inventory included carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). The GHG assessment is attached to this air dispersion modelling report (Appendix D).

This report is divided into the following sections:

- Section 1 provides a general introduction to the dispersion modelling assessment
- Section 2 provides a description of the Facility and operations
- Section 3 describes the air contaminants of interest and applicable ambient air quality limits
- Section 4 provides an overview of the Facility emissions
- Section 5 provides the methods and inputs used to conduct the air dispersion modelling
- Section 6 provides the results of the modelling study
- Section 7 provides a summary and the overall conclusions
- Section 8 provides closing remarks
- Section 9 provides the list of references used in the report

2.0 PROJECT DESCRIPTION AND PROCESS OVERVIEW

The James Bay lithium mine, located in the region of Nord-du-Quebec, will be constructed over an 18-month period. The construction phase includes, but is not limited to, road preparation, concentrator construction, waste rock pile preparation, dike construction, and the operation of the pits for the supply of construction material.

Following construction, the mine will be operated as a conventional open pit mine that will extract approximately 2.0 million tonnes of spodumene pegmatites per year. The extracted ore will be sent to a concentrator mill on-site and processed to the product, spodumene concentrate beneficiated to approximately 6.0% lithium oxide (Li_2O). The mine and associated processing mill are expected to operate for 19 years.

The Project site will have stockpiles (for topsoil, overburden, waste rock, tailings and ore), retention basins, a water treatment unit, administrative buildings, a camp for workers, garages and an explosives storage site.

In the pit, conventional open pit methods using drill and blast technique will be used to access the ore. Ammonium nitrate/fuel oil (ANFO) explosive will be used for the blasting of the ore during the winter months (November to April) and bulk emulsion explosives used during the warmer months (May to October). During construction, blasting will occur approximately 20 times over the peak construction year for a maximum of three blasts per week. For the peak operational year (year 14), blasting will occur approximately 156 times annually, with approximately three blasts per week. The peak operational year was determined from the material movement log provided by Galaxy and presented in Appendix G.

Waste rock will be transported to the designated waste rock stockpiles via truck. The active waste rock pile changes throughout the operation of the mine, as capacity is reached. The east waste rock pile is active during construction, while the east waste rock extension is active during the peak operational year (year 14). Ore will be transported to the run-of-mine (ROM) stockpile at the processing mill storage yard. The processing will include a three-stage crushing/screening circuit, dense media separation, dewatering/filtration and dry stack tailings disposal, and concentrate stockpile and shipping. The three-stage crushing will consist of a primary jaw crusher, a multi-deck sizing screen, a secondary crusher, and a tertiary crusher that conveys the crushed material ranging from 1 to 15 mm to the crushed material stockpile.

The crushed material will then be fed to the Dense Medium Separation (DMS) plant via vibrating pan feeders and a sizing screen feed conveyor which will separate fines (<1 mm) out to be sent directly to tailings. In the DMS plant, the material is first mixed with a ferrosilicon (FeSi) slurry, used to densify the material to enhance gravity separation. The primary DMS cyclone is then fed, the overflow streams will be dewatered by a series of static and vibrating screens and the FeSi will be recovered. The dewatered waste and fines will be sent to the dry tailings and waste rock stockpile. The primary cyclone underflow streams will be dewatered and the FeSi recovered. The dewatered products will be directed to the secondary DMS cyclones to repeat the process. The spodumene concentrate is then stockpiled and ready for shipping.

The process overview information was obtained from several sources, including but not limited to the ESIA Modelling Scope of Work (Galaxy 2020), the Value Engineering Report (GMS 2020), and the former dispersion modelling report (WSP 2018).

2.1 DUST MANAGEMENT PLAN

Since the initial ESIA modelling (WSP 2018) was conducted, Galaxy has developed a Dust Emissions Management Plan (DEMP) that outlies dust control techniques that will be applied during all Project phases, i.e., construction, operations, and closure. The DEMP has been provided in Appendix E. The DEMP includes controls including, but not limited to, the following:

- minimizing uncovered stripped surface areas by restoring and revegetating storage piles
- low loading drop heights limited to a 10 m height
- dust collectors on the drilling machines
- water jets prior to the crushing line (during construction)
- watering of unpaved roads
- chemical dust suppression applied on unpaved roads, when deemed necessary
- low speed limits of 40 km/h on site
- avoiding unnecessary idling
- dust collectors at the concentrator plant (during operations)
- limiting certain operations during particulate meteorological conditions, e.g., to avoid blasting/material handling during times of high winds or when prevailing winds can transport dust to sensitive areas (e.g., truck stop at km 381)

The DEMP also outlines the ambient air quality monitoring program Galaxy will implement for the Project's operations phase.

3.0 AIR CONTAMINANTS OF INTEREST

The air contaminants of interest considered in this study remain consistent with those that were assessed in the initial ESIA modelling (WSP 2018) and include those expected to be released which have a standard or criteria defined by the Quebec Ministry of the Environment and Climate Change/Ministère de l'Environnement et de la Lutte contre les changements climatiques (MELCC 2018), the Canadian Council of Ministers of the Environment (CCME 2021), or whose modelling was required by the CEA Guidelines for the Preparation of an EISA.

The air contaminants of interest include carbon monoxide (CO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), volatile organic compounds (VOCs), particulate matter (total particulate matter, TPM, particulate matter with an average size of 10 µm, PM_{10}, particulate matter with an average size of 2.5 µm ($PM_{2.5}$), and 19 metals and metaloids. The metals include antimony (Sb), silver (Ag), arsenic (As), barium (Ba), beryllium (Be), cadmium (Cd), chromium (Cr (III)), cobalt (Co), copper (Cu), crystalline silica (SiO_2), manganese (Mn), mercury (Hg), nickel (Ni), lead (Pb), thallium (Tl), titanium (Ti), vanadium (V), and zinc (Z).

3.1 AMBIENT AIR QUALITY LIMITS

Ambient air quality (e.g., outdoor air as opposed to workplace air) in Quebec is regulated under the Environment Quality Act. Provincial ambient air quality limits have been established by the Quebec Ministry of the Environment and Climate Change (MELCC) (Ministère de l'Environnement et de la Lutte contre les changements climatiques) and defined under the *Quebec air quality standards and criteria/Normes et critères Québécois de qualité de l'atmosphère, version 6* (NCQQA, v6) (MELCC 2018). In addition, the Canadian Council of Ministers of the Environment (CCME 2021) has established Canadian Ambient Air Quality Standards (CAAQS) which have been considered in this assessment.

Since PM_{10} values are not presented in the NCQQA, guideline values from the World Health Organization (WHO) are used instead.

In accordance with the MELCC modelling guide (MELCC 2005), the predicted modelled concentrations must be added to ambient (background or initial) concentrations representative of the region studied to assess compliance. To determine ambient concentrations, the following approaches can be considered:

- Concentration measurements obtained on-site
- Concentration measurements taken by MELCC air quality monitoring stations, available from MELCC
- Generic initial concentrations defined by MELCC.

The initial concentrations used in this study are sourced mainly from generic initial concentration defined by MELCC. The project is remote and located away from major sources of emissions due to human activity, and as such, the initial concentrations described for Northern Projects in the document - *Preparation and realization of a dispersion modeling Atmospheric emissions - Mining projects/ Guide d'instructions – Préparation et réalisation d'une modélisation de la dispersion des émissions atmosphériques – Projets miniers* (MELCC 2017) were adopted for this assessment. For some species, the initial concentrations for Northern Projects are not defined, in which the concentrations in the NCQQA v5 were considered.

For the annual concentration of $PM_{2.5}$, an initial concentration of 4.5 µg/m^3 was used, established in the initial ESIA modelling (WSP 2018) from the measurements at the Pémonca station which is in a region representative of the modelling domain. For PM_{10}, an initial 24-hour concentration of 21.8 µg/m^3 was estimated in the original ESIA modelling (WSP 2018) from an interpolation between the initial 24-hour concentration for TPM (40 µg/m^3) and $PM_{2.5}$ (15 µg/m^3), whereas the annual PM_{10} value (5.5 µg/m^3) was estimated using the same method from the annual concentration of TPM at the Lac-Édouard station (8 µg/m^3) and $PM_{2.5}$ at the Pémonca station (4.5 µg/m^3),

There is no available initial concentration value for VOCs. As there is no defined VOC limit, the concentration results with or without the addition of the initial concentration is irrelevant, especially since the sources of the project will be the main VOC emission in the modelling domain. An initial concentration of zero was therefore considered appropriate for VOCs.

The initial concentrations applied were consistent with those used in the initial ESIA modelling submission (WSP 2018). The threshold limits for each air contaminant listed in the NCQQA (MELCC 2018), the CAAQS, or WHO, are presented in Table 1 along with their applicable initial concentration. The threshold limits are presented in units of micrograms per cubic meter (µg/m^3).

Table 1 Ambient Air Quality Limits

Air Contaminant	Averaging Period	Statistical	Limit (µg/m^3)	Type of Limit	Authority	Initial Concentration (µg/m^3)	Initial Concentration Reference
Total Suspended Particulate (TPM)	24 hours	1st Maximum	120	Standard	MELCC	40	Northern projects
Particulate Matter < 10 µm (PM_{10})	24 hours	99th Percentile	50	Guidelines	WHO	21.8	TPM / PM 2.5 interpolation
	Annual	1st Maximum	20	Guidelines	WHO	5.5	TPM / PM 2.5 interpolation
Fine particulate matter ($PM_{2.5}$)	24 hours	1st Maximum	30	Standard	MELCC	15	Northern projects
	24 hours	98th Percentile[1]	27	CAAQS	CCME	15	Northern projects
	Annual	1st Maximum[2]	8.8	CAAQS	CCME	4.5	MELCC monitoring[1]
Nitrogen dioxide (NO_2)	1 hour	98th Percentile[4]	113 (2020) / 79 (2025)	CAAQS	CCME	50	Northern projects
	1 hour	1st Maximum	414	Standard	MELCC	50	Northern projects
	24 hours	1st Maximum	207	Standard	MELCC	30	Northern projects
	Annual	1st Maximum	103	Standard	MELCC	10	Northern projects
	Annual	1st Maximum[5]	32 (2020) / 23 (2025)	CAAQS	CCME	10	Northern projects
Sulphur dioxide (SO_2)	4 min	1st Maximum[6]	1,310	Standard	MELCC	40	Northern projects
	4 min	99.5th Percentile[6]	1,050	Standard	MELCC	40	Northern projects
	1 hour	99th percentile[7]	183 (2020) / 170 (2025)	CAAQS	CCME	21	Northern projects[6]
	24 hours	1st Maximum	288	Standard	MELCC	10	Northern projects
	Annual	1st Maximum[8]	52	Standard	MELCC	2	Northern projects
	Annual	1st Maximum	13 (2020) / 10 (2025)	CAAQS	CCME	2	Northern projects
Carbon monoxide (CO)	1 hour	1st Maximum	34,000	Standard	MELCC	600	Northern projects
	8 hours	1st Maximum	12,700	Standard	MELCC	400	Northern projects
Volatile Organic Compounds (VOCs)	Annual	1st Maximum	-	-	ACEA	0	-
Antimony (Sb)	Annual	1st Maximum	0.17	Standard	MELCC	0.001	Northern projects

Table 1 Ambient Air Quality Limits

Air Contaminant	Averaging Period	Statistical	Limit (µg/m^3)	Type of Limit	Authority	Initial Concentration (µg/m^3)	Initial Concentration Reference
Silver (Ag)	Annual	1st Maximum	0.23	Standard	MELCC	0.005	Northern projects
Arsenic (As)	Annual	1st Maximum	0.003	Standard	MELCC	0.002	Northern projects
Barium (Ba)	Annual	1st Maximum	0.05	Standard	MELCC	0.02	Northern projects
Beryllium (Be)	Annual	1st Maximum	0.0004	Standard	MELCC	0	Northern projects
Cadmium (Cd)	Annual	1st Maximum	0.0036	Standard	MELCC	0.0005	Northern projects
Chromium (Cr (III))	Annual	1st Maximum	0.1	Standard	MELCC	0.01	Northern projects
Chromium (Cr (IV))	Annual	1st Maximum	0.004	Standard	MELCC	0.002	Northern projects
Cobalt (Co)	Annual	1st Maximum	0.1	Criterion	MELCC	0	Northern projects
Copper (Cu)	24 hours	1st Maximum	2.5	Standard	MELCC	0.2	Northern projects
Manganese (Mn)	Annual	1st Maximum	0.025	Criterion	MELCC	0.005	Northern projects
Mercury (Hg)	Annual	1st Maximum	0.005	Standard	MELCC	0.002	Northern projects
Nickel (Ni)	24 hours	1st Maximum	0.014	Standard	MELCC	0.002	Northern projects
Lead (Pb)	Annual	1st Maximum	0.1	Standard	MELCC	0.004	Northern projects
Selenium (Se)	Annual	1st Maximum	2	Criterion	MELCC	0.15	NCQQA v5
Crystalline silica (SiO_2)	1 hour	1st Maximum	23	Criterion	MELCC	6	NCQQA v5
	Annual	1st Maximum	0.07	Criterion	MELCC	0.04	NCQQA v5
Thallium (Tl)	Annual	1st Maximum	0.25	Standard	MELCC	0.005	Northern projects
Titanium	24 hours	1st Maximum	2.5	Criterion	MELCC	0	NCQQA v5
Vanadium (V)	Annual	1st Maximum	1	Standard	MELCC	0.01	Northern projects
Zinc (Z)	24 hours	1st Maximum	2.5	Standard	MELCC	0.1	Northern projects

Notes:

1 The 3-year average of the annual 98th percentile of the daily 24-hour average concentrations
2 The 3-year average of the annual average concentrations
3 Value established from measurements at the Pémonca station located in a region representative of the study site, compared to other available stations (WSP 2018)
4 The 3-year average of the annual 98th percentile of the NO_2 daily maximum 1-hour average concentrations
5 The arithmetic average over single calendar year of all 1-hour NO_2 concentrations
6 Based on the initial 4-minute concentration converted for a period of 1 hour using the conversion formula ($C(T) = C_{MAX\text{-}H} \times 0.97\ T^{-0.25}$)
7 The 3-year average of the annual 99th percentile of the SO_2 daily maximum 1-hour average concentrations
8 The arithmetic average over single calendar year of all 1-hour SO_2 concentrations

4.0 EMISSION SOURCES

An emissions inventory was developed for the proposed emission sources at the Project. Emissions were categorized for the construction and operation phases. Emissions were estimated using published emission factors or engineering calculations in combination with operational and compositional data provided by Galaxy. The methodologies, assumptions, and general data used in the emission estimation for each of the Project sources are described in the following sub-sections. When applicable, the sources of data, estimation methodologies, and assumptions were kept consistent with those used in the initial ESIA modelling (WSP 2018). Sample calculations of the source emission estimates are provided in Appendix C.

4.1 CONSTRUCTION PHASE

The location of the emission sources included in the modelling of the construction scenario are presented in Figure B2-1 (Appendix B) while the source description tables are presented in Appendix A. The construction activities generally occur for 10 hours a day, from 7 am to 5 pm, with the peak construction occurring over a 100-day period. As consistent with the initial ESIA modelling (WSP 2018), construction emissions included TPM, PM_{10}, $PM_{2.5}$, CO, NO_x, VOCs, and SO_2. Metals were not considered from the construction phase.

4.1.1 Ore Concentrator and Workers' Camp

The concentrator is not in operation during construction hence concentrator emissions in the construction model scenario were not considered. The workers' camp and some administrative buildings will be operational during the construction phase. The combustion of propane for heating these buildings is a source of particulates and combustion gas emissions (TPM, PM_{10}, $PM_{2.5}$, CO, NOx, VOCs and SO_2) and were considered in the modelling. The administrative buildings with air emissions include the dormitories, kitchens, offices, laundry, and medical room. Eleven stacks were considered active for the construction period. These sources were modelled at their nominal capacity for a period of 24 hours per day, as such, they are conservatively overestimated in the modelling scenario. In addition, the auxiliary heating sources would only be active during the cold season, however, they were conservatively modelled year-round.

The stack characteristics for these sources, such as location, dimensions (height and diameter), temperature, and exit velocity have been compiled using information provided by Galaxy and are presented in Table A.1.1 (Appendix A).

Emission rates from the combustion of propane were estimated using the nominal propane consumption (provided by Galaxy) and emission factors from the US EPA AP-42 Chapter 1.5 - Liquefied Petroleum Gas Combustion (US EPA 2008). For particulates, the emissions included the sum of filterable particles and condensable particles. All particles are less than 1 µm in size, as described in Section 1.5 of AP-42, as such, the ratios of PM_{10}/TPM and $PM_{2.5}$/TPM were 100%. The estimated emission rates are presented in Table A.1.2 (Appendix A).

4.1.2 Unpaved Roads

Traffic on the unpaved roads generates fugitive dust emissions. The generation of emissions is directly proportional to the quantity of material transported, the vehicle type, the road silt content, and the maintenance of road surfaces.

The main roads used during the construction scenario correspond to those required for mining during operations. The usage and physical characteristics of the roads modeled were based of technical data provided by Galaxy. The proposed haul truck fleet is detailed in Table 2 for the construction model scenario. The height, length, and gross weight were obtained from manufacturer specifications for the haul truck model, CAT 777G.

Table 2 Description of the Proposed Transport Truck Fleet - Construction

Vehicle Model	Height (m)	Width (m)	Gross Weight (t)	Number of Vehicles in the Fleet (construction)
Caterpillar 777G	5	4	164.4	3

The routes considered were based on the material hauling log for the construction phase provided by Galaxy, which are provided in Appendix F. There are three routes, center pit phase 1 bench to surface, surface to ore (processing plant), and surface to the east waste rock pile. The haul trucks transport material from the pit to the storage yard where the construction material is crushed, and from the pit to the waste rock pile. These routes are presented in Figure B2-1 (Appendix B). These sources were modeled as adjacent line-volume sources and set up using the haul-roads tool in Lakes Environmental (AERMOD view). The release height and initial vertical dimensions were estimated based on the average height of the trucks, while the width and horizontal dimension were based on the 20 m width of the roads throughout the site. The source parameters of the roads are presented in Table A.1.3 (Appendix A).

The length of road segments and number of cycles were obtained from the material movement log for haul trucks (see Appendix F). The number of cycles considers that the payload is approximately 86 dry tonnes of rock per trip (GMS 2020), the number of construction days during the year is 100, and there is 10 hours of construction per day. The vehicle kilometers traveled (VKT) were determined based on the route length and number of trips.

Particulate emissions were calculated using the method from US EPA, AP-42, Chapter 13.2.2 Unpaved Road, Equation 13.2.2(1a) (US EPA 2006a). A fugitive dust control efficiency of 95% was applied during the winter months (October-May) as there is snow coverage, and a summer (June-September) fugitive dust control efficiency of 80% for the application of dust suppression and consistent road watering. These efficiencies were obtained from Golder Associates. 2012. "Final Report Determination of Natural Winter Mitigation of Road Dust Emissions from Mining Operations in Northern Canada." The silt content of the unpaved road surface material, 2%, was provided by Galaxy. The emission rates for each road segment are presented in Table A.1.4 (Appendix A).

The distance, annual amount of material hauled, and the number of truck trips for each of the assessed routes is presented in Table 3.

Table 3 Construction Phase Haul Road Usage Details

Haul Route	Approximate Length (m)	Annual Material Hauled (kt)	Truck Trips	
			Annual	Daily
Center Pit Phase 1 (CP1) – Bench to Surface	11,34	2,500	29,070	291
CP1 – Surface to Ore	1,827	184	2,135	22
CP1 – Surface to East Waste Rock	1,634	2,316	26,936	270

4.1.3 Material Handling

Material handling (loading and unloading) to haul trucks generates fugitive emissions of particulates and particulate metals. Material loading/unloading were assessed as drop sources, with particulate emissions calculated using US EPA, AP-42 Chapter 13 Aggregate Handling and Storage Piles, Equation 13.2.4.(1) and the quantity of material transferred (US EPA 2006b). The quantity of material transferred was based on the data provided by Galaxy in the material handling log (provided in Appendix F). Hourly emission rates were determined for each hour in the 5-year data set as a function of the corresponding hourly wind speed. The moisture content for ore is 5% (from project engineering data for pit materials, consistent with the initial ESIA modelling by WSP 2018) while the moisture content for sand is 7.4% according to AP-42 Chapter 13.2.4 for Municipal solid waste landfills, sand (US EPA 2006b).

The locations of the material handling source emissions are presented in Figure B2-1 (Appendix B) and the physical source parameters and emission rates are presented in Table A.1.5 (Appendix A). For material loading, the initial horizontal dispersion parameter was estimated from the width of the load excavator (Caterpillar 374), while the release height and initial vertical dispersion parameters were estimated from the dimensions of the haul trucks. For material unloading, these three parameters were estimated based on the dimensions of the haul trucks.

4.1.4 Mobile Crushing/Screening

There are two crushing/screening lines located in the storage yard each consisting of a mobile crusher and a mobile screen. The model specifications are not available, as such, conservative assumptions were made to estimate the emissions. The feed rates of the units were assumed to be consistent with those presented in the initial ESIA modelling (WSP 2018), which are 725 t/h for each line, for a total of 1,450 t/h. This works out to be a daily tonnage of 11,109 t/d crushed rock for 10 hours of construction per day.

Particulate emissions from crushing and screening were estimated using throughput data and emission factors sourced from the US EPA AP-42 Chapter 11.19.2 - Crushed Stone Processing and Pulverized Mineral Processing (US EPA 2004a). It was conservatively assumed that the emission factors for crushing corresponded to controlled tertiary crushing. The controlled emission factors were used as there will be direct water sprays on the material prior to crushing.

The crushing and screening units have been modelled as volume sources, the physical parameters and emission rates are presented in Table A.1.6 (Appendix A). The exhaust gas from these units has also been included in the modelling, modelled as point sources, as described in Section 4.1.8.

4.1.5 Dozing

Bull dozers are used to lay construction material during the construction of the dike, waste areas, and storage yard. The maximum construction year assessed does not correspond to the construction stage of the dikes and waste areas, as such, the three dozers (two track dozers and one wheel dozer) were placed in the storage yard.

The dozer emission rates for particulate were estimated using emission factors presented in AP-42 Section 11.9 Western Surface Coal Mining (US EPA 1998). The emission factors for overburden were used. A control efficiency of 50% was applied to represent the intermittent nature of this type of activity. Rock moisture was assumed to be 5%, consistent with the initial ESIA modelling (WSP 2018) which was based on engineering data for the pit materials. The silt content was 2%, which is the site-specific content for ore provided by Galaxy.

The dozing activities were represented in the model using volume sources, as shown in Figure B2-1 (Appendix B). The physical characteristic and the emission rates of these modeled sources are presented in Table A.1.7 (Appendix A).

4.1.6 Blasting

Blasting occurs during construction to generate the waste rock used in the construction activities and during the preparation of the pit. Blasting parameter data was provided by Galaxy and included, but was not limited to, the quantity of explosives used during the construction phase, the tonnage of rock displaced, the frequency of blasts, drill holes per blast and blast/drill hole dimensions. Construction blasts can occur up to three times per week. Ammonium nitrate (AN) emulsion will be used for blasting in the summer while ANFO will be used for blasting in the winter. It was assumed that winter blasting occurred for six months, from November to April, while summer blasting occurred for the remainder of the year. The relevant construction phase blasting data used in the emission estimates and modelling parameters is presented in the Table 4.

Table 4 Source Parameters used to Estimate Blasting Emissions during Construction

Blasting/Drilling Parameter	Unit	Value
Burden	m	5
Spacing	m	5
Blasting surface by drilling	m²/hole	25
Holes per blast	Hole/blast	185
Total Blasting Surface	m²/blast	4,616
Tonnes Blasted	Kt/period	2,500
Blasts per week	Number	3

Emissions from explosive detonation were estimated using the mass of explosives per blast and emission factors sourced from Australian NPI - "Emission estimation technique manual for explosives detonation and firing ranges Version 3.1" (2016). Emissions from ore blasting were estimated using emission factors sourced from US EPA, AP-42, Fifth Edition, Volume I, Chapter 11.9 Western Surface Coal Mining (US EPA 1998). Galaxy indicated that the duration of the explosive detonation is 3 seconds.

The blasting was assumed to occur at 6 pm on Monday, Wednesday and Friday. The height of the blast was estimated to be 10 m. Blasting emissions were modelled as volume sources, the location is shown in Figure B2-1 (Appendix B) while the source parameters and emission rates are presented in Table A.1.8 (Appendix A).

4.1.7 Drilling

Drilling of the blasting boreholes in the starter pit is a source of fugitive dust emissions. Two drills were considered during construction, one pre-split drill and one production drill. There are 185 holes/blast during construction. There can be up to three blasts per week during the construction phase. The drill penetration rate is 19.6 m/h. Drilling emissions will be controlled with dust collectors.

Particulate emissions from drilling were calculated using the estimated number of holes drilled per hour and the emission factors presented in AP-42 Chapter 11.9 - Western Surface Coal Mining (US EPA 1998). A control efficiency of 99% (for a dust collector) was used following Australian NPI Emission estimation technique manual for mining Version 3.1 (2012). The estimated number of holes drilled each hour was estimated from the number or holes drilled per blast, the blast frequency, and the operational hours per day.

The drilling emissions were modelled using a volume source, the locations are presented in Figure B2-1 (Appendix B), while the source parameters and emission rates are presented in Table A.1.9 (Appendix A). The source characteristics were based on the physical parameters of a Caterpillar MD5125 drill rig.

4.1.8 Combustion Exhaust Gases

The emissions of diesel combustion exhaust gases (TPM, PM_{10}, $PM_{2.5}$, CO, NOx, SO_2, and VOCs) from large mobile equipment and haul-trucks were considered in the construction phase modelling. Smaller mobile sources (smaller equipment and passenger vehicles) were not modelled as the expected air contaminant releases are not likely to contribute substantively to ground-level concentrations outside the Project's defined application boundary.

Exhaust gas emissions from off-road mobile equipment were estimated using the engine power (hp), the load factor, and emission factors (g/hp hr) obtained from the US-EPA (2010a) document "Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling Compression-Ignition". This method was applied for total hydrocarbon emissions, in which the rates of VOCs were speciated from using conversion factors provided by the US EPA (2010b). As the specific vehicle ages is unknown, the emissions were conservatively estimated assuming that the engine degradation was maximized. The list of mobile equipment was provided by Galaxy, where engine power was not provided, it was assumed to be like those in the former assessment performed by WSP (WSP 2018). The diesel sulphur content was

assumed to be 15 ppm, the limit prescribed by the Sulfur in Diesel Fuel Regulations (ECCC 2013) for diesel fuels for off-road engines. The input data used to estimate emissions from mobile equipment exhaust are presented below in Table 5.

As haul trucks exhaust pipes are often horizontal or on the side of the vehicle, the dispersion is impacted by the movement of the vehicle. The haul trucks were categorized using line-volume sources in the model (combined with the unpaved road emissions), which conservatively removes the consideration of buoyancy and vertical exit velocity. The emissions were distributed over the segments based on the average time spent on the segment (e.g., based on the route lengths and number of trips per route).

For the localized mobile equipment, the dispersion is not significantly influenced by vehicle movements as travel is at low speed. As such, exhaust gases from these sources were represented by point sources using physical parameters (e.g., vertical exit velocity, temperature, height, and diameter of released) based on the vehicle specifications. The locations of these sources are presented in Figure B2-1 (Appendix B). The source parameters and emission rates of these sources are presented in Table A.1.10 (Appendix A).

Table 5 Mobile Equipment Source Parameters for Construction

Equipment	Assumed Model	Power Rating (hp)	Engine Tier	Loading Factor	Number in Fleet (Construction Phase)	Modelled Sources
100 t haul truck	Caterpillar 777	916	T4	0.59	3	Roads
Track dozer	Caterpillar D9T	441	T3	0.59	2	Trdoz1x, Trdoz2x
Wheel dozer	Caterpillar 966K	496	T3	0.59	1	Whdz1x
Crushing unit	Kpijci 3055	415	T3	0.43	2	Crush1x, Crush2x
Screening unit	Kpijci FT6203	225	T3	0.43	2	Scrn1x
pre-split drilling machine	Caterpillar MD5125	325	T3	0.43	1	Scrn2x
Production Drilling Machine	Caterpillar MD5125	325	T3	0.43	1	Prodrilx
Grader	Caterpillar 14M	294	T3	0.59	1	Predrlx
Utility Wheel Loader	Caterpillar 966K	250	T4i	0.59	1	Whldr1x

The total emissions from the haul trucks were distributed over the different segments based on the average time spent on each, which are presented in Table 6. These sources were modeled cumulatively with the emissions from the unpaved routes.

Table 6 Percent of Time Spent on Each Road Segment

Road Segment	Time Spend on Each Segment (%)
	Caterpillar 777
Center Pit Phase 1 (CP1) Bench to Surface	50
CP1 Surface to Ore	5
CP1 Surface to East Waste Rock	45

4.1.9 Wind Erosion – Storage Piles

Wind erosion of the storage pile surfaces is a source of fugitive dust. During construction, the piles considered were construction material (rock and sand) in the storage yard, the east waste rock pile, and the stripping required for the south-west waste rock pile. It was assumed that all these piles were exposed.

The equation for estimating storage pile particulate emissions is sourced from Mojave Desert Air Quality Management District (MDAQMD 2000), Mineral Handling and Processing Industries, Table 2 (2000), as presented in the ECCC's (2017) NPRI "Pits and quarries reporting guide." This method is for an annual estimate and was converted to an emission rate in g/s. This equation has a wind speed threshold of 19.3 km/h (i.e., there are no emissions unless the wind speed is equal to or greater than 19.3 km/h). The variable emissions by wind speed class function were used in the AERMOD model such that for hours with a wind speed greater than 5.14 m/s (18.6 km/hour) would result in emissions. This is conservative as it assumed emissions for winds between 18.6 and 19.3 km/hour that would not generate emissions, however, these wind speed categories are pre-programmed into the AERMOD model. To represent the worst-case emissions, the control factor due to precipitation was not taken into consideration.

Only a fraction of the waste rock piles would be "active" at any one time, meaning that unloading/loading and dozing activities would only be carried out in a small fraction of the pile footprint. In addition, once the wind threshold is surpassed and the fine particles are emitted, the emissions from the pile will reduce unless the next modelled hour has a wind speed that is greater than the threshold. Precipitation and humidity will also wash surfaces and cement fine particles, further decreasing particulate emissions. For the construction phase, assuming that the entire waste rock piles are active is conservative. The construction material piles in the storage yard will likely remain active as re-handling occurs consistently.

Silt content of the ore piles was 2%, a value provided by Galaxy. In absence of specific project data, the silt content of the remaining categories was sourced from AP-42 Chapter 13.2.4 (US EPA 2006b), as follows:

- Sand Storage Pile: 2.6% according to the category Municipal solid waste landfills, sand
- Stripped Surface of Waste Rock Piles: 7.5% according to the Western surface coal mining, Overburden category

Storage pile erosion emissions were modelled as area sources using a release height at the height of the piles and the area of the pile, the locations are presented in Figure B2-1 (Appendix B). The source parameters and emission rates are presented in Table A.1.11 (Appendix A) along with the estimated emission rates.

4.1.10 Generators

The generators used during construction will be a source of exhaust gas and particulate emissions. The exact models are unknown, and as such, it was assumed that the assumption applied in the CEAA-QC60 & 104 Information Request responses (WSP 2020) could be applied. This assumes that there are five 100 kW generators and five 500 kW generators used during construction. The emission rates were estimated following the same methodology of off-road mobile equipment, as presented in Section 4.1.8. For conservatism and to simplify the modelling, the generators have been positioned in two specific points in the storage yard, consistent with the approach by WSP (WSP 2020), the locations are presented in Figure B2-1 (Appendix B). The source parameters and emission rates are presented in Table A.1.11 (Appendix A).

4.1.11 Dust Collector

The concrete plant used during construction will have a dust collector to control emissions from the various dust sources such as the cement silo or the loading of concrete trucks. The dust collector considered was assumed to be consistent with that presented in the CEAA-QC60 & 104 Information Request responses (WSP 2020). A flow rate of 13,000 ft^3/minute (368 m^3/minute) was used, and the emissions were set at 30 mg/Rm^3, consistent with the limit presented in Section 10 of the Regulation on Air Purification/*règlement sur l'assainissement de l'atmosphère* (Quebec 2019). Consistent with WSP's (2020) assumption, the filtration efficiency rates used to estimate the ratios of particulate emissions were PM_{10} is 76% of TPM and $PM_{2.5}$ is 35% of TPM. The dust collector was modelled as a point source, the source parameters and emissions are presented in Table A.1.12 (Appendix A).

4.2 OPERATION PHASE

The location of the emission sources included in the modelling of the operation scenario are presented in Figure B3-1 (Appendix B) while the source description tables are presented in Appendix A. Mine operations are generally scheduled for 24-hours per day, 365 days per year, with the exception of blasting and concentrate shipping. Blasting only occurs three times per week, assumed to be at 5 pm. Concentrate shipping occurs during a 12-hour period each day. As consistent with the initial ESIA modelling (WSP 2018), operation emissions included TPM, PM_{10}, $PM_{2.5}$, CO, NO_x, VOCs, SO_2, and metals.

The peak operational year was assessed for the emission rates and dispersion modelling, based on the maximum rates for mining activities, material movement, and milling. This year corresponds to year 14. The material movement log for the life of the mine is presented in Appendix F.

Emissions from the transport of concentrate from the mine site to Matagami, QC, along the James Bay Road, were assessed separately and the results are presented in Appendix H.

4.2.1 Ore Concentrator and Workers' Camp

The ore concentrator is active during operations, which includes emission sources from dust collectors and from propane combustion in the heating and ventilation for the plant and camp.

A total of 33 stationary combustion stacks were considered active for the operation model scenario. These sources were modelled at their nominal capacity for a period of 24 hours per day, as such, they are overestimated in the modelling scenario. In addition, the auxiliary heating sources would only be active during the cold season, however, they were conservatively modelled as continuous sources year-round. The emission estimation methods and the assumptions were the same as those used for the construction scenario (refer to Section 4.1.1). The stack characteristics for these sources are presented in Table A.2.1 (Appendix A) and the emission rates are presented in Table A.2.2 (Appendix A).

Three dust collectors will emit particulate matter. As mentioned in the Information Request response to QC2-35, Galaxy will be committed to using dust collectors which have manufacturer guarantees of particulate emissions less than 20 mg/Nm^3. The output concentration along with the units' flowrates were used to estimate the particulate emissions from the dust collectors. The dust collector filtration efficiency ratios were PM_{10} is 95% of TPM, while $PM_{2.5}$ is 50% of TPM. The flow rates and the output ratio of particulate size were consistent with those used in the WSP dispersion modelling assessment (WSP 2018). The stack characteristics and the emission rates for the dust collector sources are presented in Table A.2.3 (Appendix A).

4.2.2 Unpaved Roads

Traffic on the unpaved roads during operations is a source of fugitive dust emissions. The unpaved roads use crushed waste rock as the aggregate (i.e., road surface material). The main roads traveled on during operations are those required for mining (haul roads) and the road for concentrate shipping. The proposed operational haul truck fleet contains the same make and models as presented in Table 3 for construction, but nine haul trucks are used during operations.

The routes considered were based on the material movement log for the peak operational year (year 14), provided by Galaxy, and are comprised of eight active roads during operations. These eight roads are presented in Table 7 along with the parameters used to estimate the emission rates and modelled lengths. These routes are presented in Figure B3-1 (Appendix B). These sources were modeled as line-volume sources (adjacent) and set up using the haul-roads tool in Lakes Environmental (AERMOD view). The release height and initial vertical dimensions were estimated based on the average height of the trucks (5 m), while the width and horizontal dimension was based on the width of the roads (20 m) throughout the site. The source parameters of the roads are presented in Tale A.2.4.

Particulate emissions were calculated using the method previously presented in Section 4.1.2 and are presented in Table A.2.5 (Appendix A).

The length of the road segments and number of cycles were obtained from the material movement log for haul trucks (Appendix F). The number of cycles considers that the payload is approximately 86 tonnes of rock per trip (GMS 2020), and operations 24 hours per day 365 days per year for all roads except shipping, which occurs during a 12-hour period. The vehicle kilometers traveled (VKT) were determined based on the route length and number of trips. The distance, annual amount of material hauled, and the number of truck trips for each of the assessed routes is presented in Table 7.

Table 7 Operations Phase Haul Road Usage Details

Haul Route	Approximate Length (m)	Annual Material Hauled (kt)	Truck Trips	
			Annual	Daily
Center Pit Phase 4 (CP4) Bench to Surface	3,590	8,969	104,291	286
CP4 Surface to Ore	1,827	1,173	13,642	38
CP4 Surface to East Dump Extension	2,486	7,796	90,649	249
East Pit Phase 1 (EP1) Bench to Surface	827	2,031	23,617	65
EP1 Surface to Ore	2,405	757	8,798	25
EP1 Surface to East Dump Extension	2,405	1,275	14,820	41
Concentrate Shipping – Loadout to Off-Site	450	-	-	53[a]
Tailings to East Dump Extension	2,220	1,691	19,663	54

Notes:
[a] 53 daily deliveries provided directly from Galaxy

4.2.3 Material Handling

Material handling (loading and unloading) to haul trucks generates fugitive emissions of particulates and particulate metals. The same methodology applied in Section 4.1.3 to estimate the construction emission rates and physical parameters of material handling sources were used for operations.

The moisture content for ore was 5% (from project engineering data for pit materials), for tailings the moisture content was 11.4%, and for the concentrate at the moisture content was 10%. The loading of concentrate occurs inside a building, however, it was still conservatively assumed as a source of emissions for the air dispersion model. The production activities were continuous.

The locations of the modelled material handling sources are presented in Figure B3-1 (Appendix B) and the physical source parameters are presented in Table A.2.6 (Appendix A). For material loading, the initial horizontal dispersion parameter was estimated from the width of the load excavator (assumed to be the Caterpillar 6015B), while the release height and initial vertical dispersion parameters were estimated from the dimensions of the haul trucks. For material unloading, these three parameters were estimated based on the dimensions of the haul trucks.

4.2.4 Dozing

Two track dozers are used at the active waste rock pile to dispose of material and one wheel dozer is used in the pit. The same methodology presented in Section 4.1.5 for construction to determine the source parameters and emission rates are used for operations. The moisture content was 5% and the silt content was 2%, as provided by Galaxy. A control efficiency of 50% was applied to represent the intermittent nature of this type of activity.

The dozing operations were represented in the model using volume sources, as shown in Figure B3-1 (Appendix B). The physical characteristic and the emission rates of these modeled sources are presented in Table A.2.7 (Appendix A).

4.2.5 Blasting

The quantity of rock blasted in the peak operations year (year 14) is estimated to be 11,000 kt. Blasts could occur three times per week during the peak operational year. Blasting parameter data was provided by Galaxy and included, but was not limited to, the annual quantity of explosives used, the tonnage of rock displaced, the frequency of blasts, drill holes per blast and blast/drill hole dimensions. Ammonium nitrate (AN) emulsion will be used for blasting in the summer while ANFO will be used for blasting in the winter. It was assumed that winter blasting occurred for six months, from November to April, while summer blasting occurred for the remainder of the year. The relevant blasting data used for estimating blasting emissions during the peak operational year is presented in Table 8.

Table 8 Parameters used to Estimate Blasting Emissions during Peak Operations

Blasting/Drilling Parameter	Unit	Value
Burden	m	5
Spacing	m	5
Blasting surface by drilling	m²/hole	25
Holes per blast	Hole/blast	1,032
Total Blasting Surface	m²/blast	2,539
Tonnes Blasted	Kt/period	11,000
Blasts per week	Number	3

Emissions from the explosive detonation and from the ore blasting were estimated using the same techniques presented in Section 4.1.6 for construction. Physical blast characteristics also followed the same methods presented in Section 4.1.6 for construction. The emissions were modelled as volume sources, with the locations presented in Figure B3-1 (Appendix B) and the source parameters and emissions rates presented in Table A.2.8 (Appendix A).

4.2.6 Drilling

Drilling of boreholes used for blasting of the pit is a source of fugitive dust emissions. Three drills were considered during operations, one pre-split drill and two production drills. There are 1,032 holes/blast. There can be up to three blasts per week during the peak operational year. The drill penetration rate is 19.6 m/h. Particulate emissions from drilling are controlled with dust collectors.

The methodology used to determine the drilling source characteristics and emission rates is consistent with that presented in Section 4.1.7 for construction.

The drilling operations were modelled using a volume source, the locations are presented in Figure B3-1 (Appendix B), while the source parameters and emission rates are presented in Table A.2.9 (Appendix A). The source characteristics were based on the physical parameters of a Caterpillar MD5125 drill rig.

4.2.7 Combustion Exhaust Gases

The emissions of diesel combustion exhaust gases (TPM, PM_{10}, $PM_{2.5}$, CO, NOx, SO_2, VOCs, and various metals) from large mobile equipment and haul-trucks were considered in the modelling. Smaller mobile sources (smaller equipment and passenger vehicles) were not modelled as the expected air contaminant releases are not likely to contribute substantively to ground-level concentrations outside the Project's defined application boundary. The mobile equipment considered was estimated using technical data provided by Galaxy for year 14 of operations.

For off-road vehicles and mobile equipment, the same methodology presented in Section 4.1.8 for construction was applied to estimate physical source parameters and emission rates. The source parameters and emission rates of these sources are presented in Table A.2.10 (Appendix A).

For on-road vehicles (e.g., Kenworth T800 transport truck), the emission rates were estimated using the US emission standards presented in the document "Light-Duty Vehicles and Light-Duty Trucks: Clean Fuel Fleet Exhaust Emission Standards" (US-EPA 2016) with a speed of 30 km/h. Only the road segment on-site was included. The source parameters and emission rates of these sources are presented in Table A.2.10 (Appendix A).

The input data used to estimate emissions from mobile equipment exhaust during operations are presented in Table 9 for off-road equipment and Table 10 for on-road equipment.

Table 9 Off-Road Mobile Equipment Parameters Considered during Operations

Equipment	Assumed Model	Power Rating (hp)	Engine Tier	Loading Factor	Number in Fleet (Operation Phase)	Modelled Sources
100 t haul truck	Caterpillar 777	916	T4	0.59	9	Roads
Track dozer	Caterpillar D9T	441	T3	0.59	2	Trdoz1x, trdoz2x
Wheel dozer	Caterpillar 966K	496	T3	0.59	1	Whdoz1x
Pre-split drilling machine	Caterpillar MD5125	325	T3	0.43	1	Predril1x
production drilling machine	Caterpillar MD5125	325	T3	0.43	2	Prodril1x, prodril2x
Utility Wheel Loader - (250HP)	Caterpillar 966K	250	T4i	0.59	1	Whldr1x

Table 10 On-Road Vehicles Parameters Considered during Operations

Vehicle	Vehicle Type	Emission Category	Useful Life Standard	Gross Weight (tonne)	Maximum Speed (km/h)	Modelled Sources
Kenworth T800	HLDTs	LEV	Full	44	30	Roads

The total emissions from the haul trucks and Kenworth transport trucks were distributed over the different segments based on the average time spend on each road segment as shown in Table 10. These sources were modeled cumulatively with the emissions from the unpaved routes.

Table 11 Percent of Time Spent on Each Road Segment

Road Segment	Time Spend on Each Segment (%)	
	Caterpillar 777[1]	Kenworth T800
Center Pit Phase 4 (CP4) Bench to Surface	34	0
CP4 Surface to Ore	6	0
CP4 Surface to East Dump Extension	31	0
East Pit Phase 1 (EP1) Bench to Surface	9	0
EP1 Surface to Ore	6	0
EP1 Surface to East Dump Extension	6	0
Plant Loadout to Off-Site	0	100
Tailings to East Dump Extension	9	0
Notes: [1]Due to rounding, total time spent on each segment does not add up to 100%		

4.2.8 Wind Erosion – Storage Piles

The operations phase considered wind erosion from several storage piles, such as four waste rock piles, the ROM pad stockpile, the primary ore stockpile and the final product stockpile.

The methodology used to determine the storage pile wind erosion source characteristics and emission rates is consistent with that presented in Section 4.1.9 for construction.

The surface area of the piles was based on technical drawings provided by Galaxy and it was conservatively assumed that emissions could occur from the full surface. The active waste rock pile (east waste rock for the peak operations year) had a 5,000 m^2 active area during any one time, while the remaining area was considered inactive. The active area used a silt content of 2%, while the inactive area used a silt content of 0.5%. The inactive area would be covered by materials of larger size, and it would also have been exposed for longer and the fine particles have been blown away, washed away, and/or formed a crust due to precipitation. The ore stockpile surface was assumed to have a silt content of 9.5% according to the AP-42 table 13.2.4-1 for “Iron and steel production, Lump ore” category (US EPA 2006b).

Storage pile erosion emissions were modelled using area sources using a release height at the height of the piles and the area of the pile. The source parameters are presented in Table A.2.11 (Appendix A) along with the estimated emission rates.

4.2.9 Metal Emissions

Metal emissions were estimated for the operation phase from particulate emissions and associated lithologies performed on ore, waste rock and tailings. It was assumed that the metal content in the particulate matter emitted is like the metal content in the associated material in which particulate matter is emitted from. There were six different groups of materials with differing lithologies, described in Table 12.

Table 12 Material Group Descriptions to Estimate Metal Concentrations

Group	Description	Example of Sources Associated
Mineral Ore	Ore handling operations only	Dust collector at the concentration plant. loading / unloading of ore, wind erosion of the ore dump
Waste Rock	Waste rock handling operations only	Loading / unloading of waste rock. crushing. bulking and wind erosion of building material piles
Haul Routes	Haul Route related emissions	Haul routes across the entire site
Handling of Waste Rock	Operations related to the handling of materials in the waste rock piles	Dumping on the waste rock piles and wind erosion of the waste rock piles
Pit Extraction	Operations related to the handling of ore or waste rock in the pit	Dozing. drilling and blasting in the open pit
Diesel Exhaust	Combustion of diesel in mobile equipment	Mobile equipment exhaust, e.g., dozers, drilling machine, haul trucks, etc.
Metal-free	Metal emission-free operations	Exhaust gases from plant combustion sources (propane)

The metal content of the particulates emitted from each of these groups, except diesel exhaust, is estimated from the lithologies associated with these source groups and their respective metal contents. The lithologies applied for the peak operational year were consistent with the former dispersion modelling report (WSP 2018) and are presented in Table 13.

Table 13 Distribution of Lithologies Associated with each Source Group

Source Group	Composition of Lithologies per Source Group (%)		
	Mineral - Pegmatite	Waste Rock - Gneiss	Waste Rock – Banded Gneiss
Mineral Ore	100	0	0
Waste Rock	0	86	14
Routes	0	86	14
Handling of Waste Rock	11	76	13
Pit Extraction	13	75	12
Metal-free	0	86	14

The metal emission rates were obtained by multiplying the determined composition content by the emission rate of particulates. As presented by the MELCC, the metal concentrations are mainly based on TPM, except for manganese, nickel, 1-hour crystalline silica and titanium which uses PM_{10}, and annual crystalline silica where PM_4 is used. However, PM_4 was not assessed in the previous study. To estimate the annual crystalline silica emissions rates from the emission rates for PM_4, the methods prescribed in the US EPA AP-42 Appendix B.2 – Generalized Particle Size Distributions were applied based on the source category (US EPA 1995).

The lithologies were based on geochemical compositional tests carried out by Activation Laboratories Ltd. (Actlabs November 2017) and by SGS Canada Inc. (SGS August 2018). The certificate of analysis is presented in Appendix F. The average of the samples analyzed was used, as consistent with the initial ESIA modelling (WSP 2018). If the value was below the detection limit, half of the detection limit was used. For crystalline silica (SiO_2), the compositions are based on a quantitative mineralogy analysis also presented in Appendix F. Table 14 presents the metal contents for each of these lithologies.

Table 14 Metal Content by Lithology

Metal	Content by lithology (kg/kg)			
	Pegmatite	Gneiss	Gneiss rubane	Diabase
	Mineral	Waste Rock	Waste Rock	Aggregate
Antimony (Sb)	1.00E-06	1.00E-06	1.00E-06	4.00E-07
Silver (Ag)	1.50E-06	1.50E-06	1.50E-06	5.00E-07
Arsenic (As)	3.17E-05	1.12E-04	3.70E-05	8.05E-06
Barium (Ba)	3.66E-05	6.85E-04	7.11E-04	6.95E-04
Beryllium (Be)	1.15E-04	3.50E-06	1.50E-06	9.50E-07
Cadmium (Cd)	1.00E-06	1.00E-06	1.00E-06	3.73E-07
Chromium total (Cr)	2.30E-04	2.70E-04	3.53E-04	7.25E-05
Cobalt (Co)	3.60E-07	2.41E-05	2.05E-05	5.43E-05
Copper (Cu)	1.00E-06	5.30E-05	5.63E-05	3.53E-05
Manganese (Mn)	3.06E-04	6.19E-04	5.31E-04	1.75E-03
Mercury (Hg)	2.50E-09	2.50E-09	2.50E-09	2.50E-08
Nickel (Ni)	5.00E-06	9.30E-05	7.67E-05	4.90E-05
Lead (Pb)	4.30E-06	1.69E-05	1.42E-05	1.07E-05
Selenium (Se)	1.57E-05	1.19E-06	4.00E-07	3.50E-07
Crystalline Silica (SiO_2)	2.64E-01	3.00E-01	3.28E-01	2.30E-02
Thallium (Tl)	4.72E-06	1.87E-06	1.43E-06	4.40E-07
Titanium (Ti)	5.00E-05	3.67E-03	3.17E-03	1.65E-02
Vanadium (V)	2.50E-06	1.25E-04	9.70E-05	3.78E-04
Zinc (Zn)	1.71E-04	9.60E-05	7.00E-05	1.80E-04

Metal emissions from mobile equipment diesel exhaust were estimated using estimated fuel consumption and emission factors (g/gal) obtained from the "US-EPA 2018 document Speciation Profiles and Toxic Emission Factors for Nonroad Engines in MOVES2014b" (US EPA 2018). It was conservatively assumed the equipment had no diesel particulate filters (DPF) or selective catalytic reduction (SCR).

5.0 AIR DISPERSION MODELLING METHODOLOGY

5.1 MODEL SELECTION

The United States Environmental Protection Agency (US EPA) dispersion modelling system referred to as AERMOD was used in this assessment. AERMOD is a regulatory model developed by the American Meteorological Society/Environmental Protection Agency Regulatory Model Improvement Committee (AERMIC) in association with the US EPA. AERMOD is a steady-state plume dispersion model that is designed to estimate near-field (less than 50 km) concentrations from most types of industrial emission sources (US EPA 2004b; 2005). The AERMOD modelling system consists of three separate programs, including the plume dispersion model (AERMOD), a meteorological pre-processor (AERMET), and a terrain pre-processor (AERMAP). This dispersion modelling assessment uses the version of the US EPA AERMOD dispersion model consistent with the previous dispersion modelling assessment (version 18081).

AERMOD makes use of two continuous stability parameters, friction velocity, and Monin-Obukhov length to characterize the atmosphere. The friction velocity is a measure of mechanical effects alone, such as wind shear at ground-level. The Monin-Obukhov length indicates the relative strengths of mechanical and buoyancy effects on atmospheric turbulence. Thus, AERMOD can account for turbulence both from wind shear and from buoyancy effects due to solar heating during the day and radiation cooling at night. To properly account for these effects, AERMOD requires three land use parameters: albedo, Bowen ratio, and surface roughness. Albedo is defined as the fraction of total incident solar radiation reflected by a particular surface without absorption. Bowen ratio is an indicator of surface moisture conditions and can be defined as the ratio of the sensible heat flux to the latent heat flux. Bowen ratio can vary significantly over the course of the day; however, it usually remains fairly constant during mid-day. Surface roughness is a length scale that characterizes the roughness of the earth's surface.

Modern planetary boundary layer theory is used to scale turbulence and other parameters to the height of the plume. The AERMOD system (specifically, the AERMET meteorological pre-processor) derives hourly mixing heights based on the morning upper air sounding and the surface meteorology, including available solar radiation. AERMAP is a terrain pre-processor that is designed to handle the input of receptor terrain elevation data for the AERMOD dispersion model. With the assumption that the effect of terrain on an individual receptor is directly proportional to the difference between the elevation of the receptor and the height of the local terrain features and inversely proportional to the distance between the receptor and terrain features, AERMAP searches for the terrain height and location that has the greatest influence on dispersion for an individual receptor. This height is referred to as the height scale (hc). The height scale, which is uniquely defined for each receptor location, is used to calculate the dividing streamline height along which a plume is assumed to travel under stable atmospheric conditions. Output from AERMAP therefore includes the location and height scale for each receptor, which are used for the computation of air flow around hills.

AERMOD is approved for use in Quebec level 2 studies, a study that is required when one of the following conditions is met (MELCC 2005):

- the project is located in an industrial park
- there are multiple emission sources
- the sum of the modelled and ambient (background) concentrations are equal to or greater than 80% of the applicable standard
- the project is located near a body of water
- the emission sources emit toxic or dangerous air pollutants

5.2 MODELLING APPROACH

Ground level concentrations of the air contaminants of interest (refer to Section 3) were predicted for the operation of the Project. Five-years (2011-2015) of meteorological data was used to predict the maximum ground-level concentrations.

5.3 MODEL DOMAIN

The modelling domain consisted of a 27 km by 27 km area centered at the mine site (Zone 18N, UTM coordinate 356,600 m easting, 5,790,100 m northing). The modelling domain is presented in Figure B1-1 (Appendix B).

5.4 APPLICATION BOUNDARY

For air dispersion modelling, the boundary used to determine compliance with ambient air quality standards and criteria (i.e., limits) is known as the application limit or application boundary. The proposed mine site is located on public land, the MELCC Mining Project Modelling Guide defines the application boundary requirements for projects that are in whole or in part on public land to be generated at 300 m from the “facilities of the project” (MELCC 2017). The application boundary for this assessment is 300 m from project facilities, as shown in Figure B1-1 (Appendix B). Compliance with the applicable ambient air quality limits is assessed at this application boundary and beyond.

5.5 TERRAIN DATA

The terrain elevations used in this modelling study were generated using a combination of technical drawings of the proposed infrastructure, from a LIDAR survey covering the immediate vicinity of the mine site, and from the Canadian Digital Elevation Data (CDED). The CDED data is generated by the Cartographic Information Branch of the Department of Natural Resources Canada and provides terrain elevations at a base resolution of 0.75 arc second in geographic coordinates, corresponding to a resolution of approximately 16 meters over the defined domain.

The construction model scenario terrain was generated using the LIDAR data supplemented with CDED information. For the operations model scenario, data from technical drawings were used to adjust for the elevations of the pit depth and waste rock pile heights.

The terrain data was processed using the AERMAP terrain processor.

5.6 METEOROLOGICAL DATA

The meteorological 5-year (2011-2015) data set was developed by WPS for the 2018 dispersion modelling assessment originally submitted with the ESIA and provided to Stantec for use (WSP 2018). The meteorological data obtained from WSP was preprocessed using AERMET (v18081) and was AERMOD-ready. In the absence of available representative weather station data, prognostic meteorological data using the Weather Research and Forecast (WRF) model (version 3.6) was used in the development of this data set.

The surface data used in the development of the dataset was taken from the WRF prognostic data at grid point 357,183 m, 5,790,573 m UTM18 (52.24˚, -77.09˚). The upper air data was obtained from the MERRA-2 analysis (Modern-Era Retrospective analysis for Research and Applications, Version 2), which has hourly data produced by NASA on a horizontal grid of 50 km. The upper air data was extracted at the grid point 371 286 m, 5 762 698 m UTM18 (52.00˚, -76.87˚).

For details on the meteorological input data and processing, please refer to Section 5.5. of the initial ESIA modelling report (WSP 2018). Wind roses presented by year for the processed data are presented in Figure 2 of the former dispersion modelling report (WSP 2018), while map B.1.3 presented the defined land-use categories used in the processing of the data set (WSP 2018)

Please refer to Figure 2 in the WSP (2018) Atmospheric and dispersion Model Report for wind roses presented by year.

5.7 BUILDINGS

Solid structures may affect the flow of air in the vicinity of a source and cause downwash effects (e.g., eddies on the downwind side), which have the potential to reduce plume rise and affect dispersion. For dispersion modelling purposes, downwash effects were considered using the PRIME downwash routine algorithm in AERMOD (Schulman et al. 1998).

Wind direction dependent building information such as width, length, and height were simulated using the US EPA BPIP (Building Profile Input Program) processor. The building processor requires input data defining the coordinates of the building corners, the tier heights as well as the source locations on each building. The output file from the building processor becomes part of the input file to AERMOD. The BPIP model was developed to incorporate the two fundamental features associated with building downwash: enhanced plume dispersion coefficients due to turbulent wake, and reduced plume rise caused by a combination of descending streamlines in the lee of the building and the increased entrainment in the wake.

The AERMOD model requires direction dependent building information for use in the building wake and building downwash calculations. These data were generated with the BPIP processor based on the site-plans and technical drawings provided by Galaxy. Only buildings that were within the zone of influence from the point sources were included.

5.8 RECEPTORS

Receptors represent specific locations where the air dispersion modelling program (i.e., AERMOD) will compute a ground-level concentration (GLC) value. The receptors have been separated into three categories, the cartesian receptor grid, the application boundary limit, and sensitive receptors, with their positions presented in Figure B1-2 (Appendix B). The receptors were established based on their unique terrain elevations, using the AERMAP preprocessor.

5.8.1 Receptor Grid

The receptor grid used for the dispersion modelling consisted of a 27 km by 27 km grid with receptors spaced as follows:

- 100 m resolution grid in the immediate vicinity of the mining site, spanning 3,000 m in all directions
- 500 m resolution beyond 3,000 m in all directions.

The receptor grid density makes it possible to generate enough modeled values to obtain isopleths for the model predicted GLCs.

5.8.2 Application Boundary Receptors

Receptors were placed every 50 m along the application boundary limit (defined in Section 5.4) for a total of 145 boundary receptors.

5.8.3 Sensitive Receptors

The 52 sensitive receptors that were presented in the previous submission of the EISA modelling report (WSP 2018) were used in this study. The sensitive receptors have been groups into the following categories:

- Road Relay: 1 receptor representing the truck stop station kilometer 381, located approximately 320 m from the application limit.
- Cree camp: 5 receptors representing the Cree camps near the site. The Cree camps considered are located between 4.5 km and 9.5 km from the application limit.
- Valued area: 10 receptors representing valued areas in the domain, such as preservation areas, waterways, and spawning grounds. The closest valued area to the mine site is located approximately 500 m from the application boundary limit.

- Traditional activity: 29 receptors representing areas of practice for traditional activities, such as hunting, trapping, fishing, etc. The closest traditional activity area to the site is within the application boundary limit.
- Not considered: 8 receptors were not considered in the modelling as they either are located within the application boundary limit (e.g., workers camp) or they do not present an issue to air quality

The 53 sensitive receptors are presented in Table 15.

Table 15 Sensitive Receptors

Receptor Description	Identification	X-Coordinate (m)	Y-Coordinate (m)	Elevation (m)	Category
Hunting, Trapping, and fishing area	TRP1	357,154	5,785,844	223.6	Traditional Activity
Hunting, Trapping, and fishing area	CHS1	360,904	5,788,066	202.0	Traditional Activity
Hunting, Trapping, and fishing area	CHS2	358,179	5,783,529	259.2	Traditional Activity
Hunting, Trapping, and fishing area	CHS3	356,472	5,781,385	223.8	Traditional Activity
Hunting, Trapping, and fishing area	CHS4	355,745	5,779,203	248.9	Traditional Activity
Hunting, trapping and fishing area – berry picking	CCT1	348,024	5,779,869	229.1	Traditional Activity
Hunting, Trapping, and fishing area	CHS5	356,913	5,793,331	206.4	Traditional Activity
Hunting, Trapping, and fishing area	PCH1	357,543	5,798,645	142.7	Traditional Activity
Hunting, Trapping, and fishing area	PCH2	356,295	5,798,942	141.7	Traditional Activity
Hunting, Trapping, and fishing area	PCH3	353,946	5,777,245	231.5	Traditional Activity
Hunting, Trapping, and fishing area	PCH4	354,644	5,782,067	225.0	Traditional Activity
Hunting, Trapping, and fishing area	PCH5	351,607	5,781,447	215.2	Traditional Activity
Beaver Preservation Area	AVL1	352,453	5,791,523	185.9	Valued Area
Cree permanent camp	CRI1	357,465	5,797,428	205.8	Cree Camp
Cree permanent camp	CRI2	353,672	5,782,074	225.3	Cree Camp
Cree temporary camp	CRI3	346,167	5,794,496	159.9	Cree Camp
Cree temporary camp	CRI4	353,575	5,797,022	164.1	Cree Camp
Cree temporary camp	CRI5	356,570	5,795,738	198.1	Cree Camp
Worker camp	CPT1	359,071	5,790,376	217.1	Not Considered
Carex Sterilis	PLT1	359,239	5,790,063	209.4	Not Considered
Hunting, Trapping, and fishing area	CHS6	373,148	5,792,945	188.2	Traditional Activity
Valued watercourse	AQU1	354,395	5,788,754	209.9	Valued Area
Valued watercourse	AQU2	355,361	5,788,529	202.5	Valued Area
Valued watercourse	AQU3	356,327	5,788,384	206.4	Valued Area
Valued watercourse	AQU4	357,306	5,788,251	204.0	Valued Area
Spawning ground	AQU5	354,091	5,782,457	225.5	Valued Area
Spawning ground	AQU6	350,083	5,780,989	216.8	Valued Area

Table 15 Sensitive Receptors

Receptor Description	Identification	X-Coordinate (m)	Y-Coordinate (m)	Elevation (m)	Category
Spawning ground	AQU7	351,406	5,777,549	232.4	Valued Area
Hand well	EAU1	359,202	5,788,503	212.1	Not Considered
Secondary Well	EAU2	359,201	5,788,615	213.4	Not Considered
Km 381 road stop	REL1	359,330	5,788,510	211.2	Road Relay
Canoe river	RIV1	350,021	5,781,841	212.76	Traditional Activity
Hunting, trapping, and fishing area	TRP2	357,689	5,795,316	204.55	Traditional Activity
Hunting, trapping, and fishing area	TRP3	358,655	5,792,789	208.19	Traditional Activity
Hunting, trapping, and fishing area	TRP4	354,316	5,783,701	225.9	Traditional Activity
Hunting, trapping, and fishing area	TRP5	356,079	5,792,548	201.5	Traditional Activity
Hunting, trapping, and fishing area	TRP6	355,815	5,794,551	202.47	Traditional Activity
Hunting, trapping, and fishing area	TRC1	359,103	5,790,758	207.37	Traditional Activity
Hunting, trapping, and fishing area	TRC2	358,569	5,788,648	209.08	Traditional Activity
Snowmobile trail	MOT1	358,708	5,788,040	202.65	Traditional Activity
Snowmobile trail	MOT2	356,234	5,786,360	218.65	Traditional Activity
Snowmobile trail	MOT3	355,308	5,786,624	208.6	Traditional Activity
Snowmobile trail	MOT4	352,596	5,783,978	230.94	Traditional Activity
Snowmobile trail	MOT5	350,863	5,785,063	231.2	Traditional Activity
Snowmobile trail	MOT6	349,593	5,783,476	211.72	Traditional Activity
Snowmobile trail	MOT7	351,882	5,782,801	223.88	Traditional Activity
Snowmobile trail	MOT8	347,916	5,778,237	229.31	Traditional Activity
Launch site	AQU8	356,036	5,798,729	145.71	Valued Area
Launch site	AQU9	352,847	5,781,995	215.18	Valued Area
Source of drinking water	EAU3	350,294	5,794,707	165.59	Not Considered
Source of drinking water	EAU4	352,848	5,796,480	163.67	Not Considered
Source of drinking water	EAU5	357,652	5,798,307	205.6	Not Considered
Source of drinking water	EAU6	349,356	5,778,250	237.84	Not Considered

5.9 NO_X TO NO_2 CONVERSION

Nitrogen oxides (NO_x) are composed of nitric oxide (NO) and nitrogen dioxide (NO_2), however only NO_2 concentrations are regulated by provincial and federal agencies in Canada. Therefore, it is important to be able to estimate the proportion of predicted ground-level NO_x that is NO_2. Since most sources emit primarily NO which may transform to NO_2 in the atmosphere because of chemical reactions, a conversion method for determining the amount of NO_2 in the plume must be used. The rate of conversion depends on the oxidizing potential of the atmosphere at the time of release. If sufficient ozone (O_3) is available and given enough time, the NO will be converted by oxidation to NO_2. If the O_3 concentration is low, the conversion of NO to NO_2 will be limited by the amount of O_3 available in the atmosphere.

For this air quality assessment, the ozone limiting method (OLM) was used to estimate the conversion of NO_X to NO_2, (i.e., predict ground-level NO_2 concentrations based on the AERMOD model results for NO_X). The OLM was applied to the predicted NO_X concentrations based on NO2/NOx ratio at the source and the ozone available in the ambient air. The ambient ozone concentrations were taken from MELCC for modelling of northern projects (MELCC 2017), which are 120 µg/m^3 (hourly), 80 µg/m^3 (daily) and 50 µg/m^3 (annual). For the NO_2/NOx ratio, different sources of NOx have different ratios at the source (i.e., in-stack ratio). For diesel engines, 20% is suggested (NL DECC 2012), whereas for blasting, a value around 4% is expected (Attalla 2008). For the 24-hour and 1-year periods, the 20% in-stack ratio was applied as it is representative of the emissions from the mobile equipment exhaust gases, and conservative compared to the emissions during blasting. However, for the 1-hour period in which the contribution of blasting is greater, a ratio of 4.8% was applied, consistent with the method applied by WSP (2018) in the former EISA. This ratio was estimated from a weighted average based on contribution.

5.10 ESTIMATES OF CONCENTRATIONS FOR PERIODS LESS THAN 1 HOUR

The shortest output averaging period available in the AERMOD dispersion model is 1-hour, however, there are ambient air quality limits for some contaminants with shorter averaging periods. For contaminants with averaging periods less than 1-hour, the following equation is used to estimate the concentration over the desired period, following the MELCC Atmospheric Dispersion Model Guide (MELCC 2005):

$$C(T) = C_{1hour} \times 0.97\, T^{-0.25}$$

Where T is the period expressed in hours and C_{1hour} is the model predicted maximum hourly concentration.

6.0 AIR DISPERSION MODELLING RESULTS

The following sections present the results of the dispersion modelling conducted for the construction and operations phases. The model predicted concentrations are added to the initial concentrations for comparison against the respective ambient air quality limits. The applicable limits were presented in Section 3.1 and include standards and criteria set by MELCC (2018) in the Quebec standards and criteria for the quality of the atmosphere/Normes et critères québécois de qualité de l'atmosphère, NAAQS set out by the CCME (2021), and WHO (2005) guidelines. The initial concentrations and their source were also described in Section 3.1.

The results are presented at or outside of the applicable boundary limit, which has been set as 300 m beyond "facilities of the project" as described in Section 5.8.2, as well as at locations of sensitive receptors. The results represent the maximum predicted concentrations over the modelling period spanning five years (2011 – 2015).

6.1 CONSTRUCTION SCENARIO

A summary of the air dispersion modelling maximum concentration results for the construction phase in the modelling domain outside of the application boundary limit are presented in Table 16, and the maximum concentrations at locations of sensitive receptors in Table 17. Particulate deposition results are presented in Table 18 and Table 19, for the maximum in the application domain (outside of the application boundary limit) and the maximum at sensitive receptors, respectively. For contaminants in which the concentration (modelled plus initial) exceeded 50% of the respective ambient air quality limits, isopleth concentration figures are presented in Appendix B.

The model predicted air quality concentrations for all species assessed for the construction phase were lower than their applicable ambient air quality limits except the 1-hour NO_2 (CAAQS). The model predicted 1-hour NO_2 concentrations were greater than the CAAQS at locations near the application boundary limit and at the traditional activity sensitive receptors. The maximum predicted 1-hour NO_2 concentrations occured on the south side of the application boundary limit (maximum concentration of 185 µg/m^3 or 164% of the 2020 CAAQS and 234% of the 2025 CAAQS). The frequency of exceedance is 48 days over a 5-year period for the 2020 CAAQS and 75 days over a 5-year period for the 2025 CAAQS.

Table 16 Model Predicted Air Quality in the Application Domain for Construction

Substance	CAS No.	Averaging Period	Statistical	Limit (µg/m³)	Type of Limit	Authority	Initial Concentration (µg/m³)	Modeled Concentration (µg/m³) Maximum per Meteorological Year						Concentration Total[1] (µg/m³)	Contribution of Project[2] (%)	Percentage of Limit[3] (%)
								Y1	Y2	Y3	Y4	Y5	Max.			
Total Suspended Particulate (TPM)	N/A-1	24 hours	1st Maximum	120	Standard	MELCC	40	37.5	32.7	32.7	25.6	27.9	37.5	77.5	48%	65%
Particulate Matter < 10 µm (PM_{10})	N/A-2	24 hours	99th Percentile	50	Guideline	WHO	21.8	13.7	16.6	15.6	12.7	14.1	16.6	38.4	43%	77%
		Annual	1st Maximum	20	Guideline	WHO	5.5	1.82	1.82	1.77	1.83	1.98	1.98	7.48	26%	37%
Fine particulate matter ($PM_{2.5}$)	N/A-3	24 hours	1st Maximum	30	Standard	MELCC	15	12.7	9.73	11.4	7.34	9.76	12.7	27.7	46%	92%
		24 hours	98th Percentile[4]	27	CAAQS	CCME	15	4.49	4.66	4.21	4.06	4.19	4.66	19.3	24%	71%
		Annual	1st Maximum[5]	8.8	CAAQS	CCME	4.5	0.76	0.753	0.734	0.746	0.816	0.816	5.27	15%	60%
Nitrogen dioxide (NO_2) (from OLM)	10102-44-0	1 hour	98th Percentile[6]	113 (2020) / 79 (2025)	CAAQS	CCME	50	151	139	128	126	135	151	185	82%	**164% (2020) / 234% (2025)**
		1 hour	1st Maximum	414	Standard	MELCC	50	239	264	170	234	350	350	400	88%	97%
		24 hours	1st Maximum	207	Standard	MELCC	30	31.4	32.4	21.1	21.1	21.4	32.4	62.4	52%	30%
		Annual	1st Maximum	103	Standard	MELCC	10	3.81	3.51	3.48	3.31	3.83	3.83	13.8	28%	13%
		Annual	1st Maximum[7]	32 (2020) / 23 (2025)	CAAQS	CCME	10	3.81	3.51	3.48	3.31	3.83	3.83	13.8	28%	43% (2020) / 60% (2025)
Sulphur dioxide (SO_2)	7446-09-5	4 min	1st Maximum[8]	1,310	Standard	MELCC	40	52.1	55.4	23.4	43.9	37	55.4	95.4	58%	7%
		4 min	99.5th Percentile[8]	1,050	Standard	MELCC	40	1.78	1.72	1.68	1.59	1.64	1.78	41.8	4%	4%
		1 hour	99th percentile[9]	183 (2020) / 170 (2025)	CAAQS	CCME	21	12.4	9.12	5.34	7.38	6.68	12.4	28.8	43%	16% (2020) / 17% (2025)
		24 hours	1st Maximum	288	Standard	MELCC	10	1.14	1.21	0.514	1.00	0.818	1.21	11.2	11%	4%
		Annual	1st Maximum	52	Standard	MELCC	2	0.0275	0.0216	0.0166	0.0176	0.0167	0.0275	2.03	1%	4%
		Annual	1st Maximum[10]	13 (2020) / 10 (2025)	CAAQS	CCME	2	0.0275	0.0216	0.0166	0.0176	0.0167	0.0275	2.03	1%	16% (2020) / 20% (2025)
Carbon monoxide (CO)	630-08-0	1 hour	1st Maximum	34,000	Standard	MELCC	600	10,947	13,131	4,872	10,552	10,964	13,131	13,731	96%	40%
		8 hours	1st Maximum	12,700	Standard	MELCC	400	1,370	1,642	610	1,320	1,372	1,642	2,042	80%	16%
Volatile Organic Compounds (VOCs)	N/A-4	Annual	1st Maximum	-	-	ACEA	0	0.353	0.332	0.321	0.307	0.347	0.353	0.353	100%	-

Notes:
[1]The modeled total concentration is the sum of the modeled maximum concentration and the initial concentration.
[2]The project contribution is the maximum modeled concentration divided by the total concentration, as a percentage.
[3]The percentage of the limit value is the total concentration divided by the limit value, as a percentage.
[4]The 3-year average of the annual 98th percentile of the daily 24-hour average concentrations
[5]The 3-year average of the annual average concentrations
[6]The 3-year average of the annual 98th percentile of the NO_2 daily maximum 1-hour average concentrations
[7]The arithmetic average over single calendar year of all 1-hour NO_2 concentrations
[8]Based on the initial 4-minute concentration converted for a period of 1 hour using the conversion formula ($C(T) = C_{MAX\text{-}H} \times 0.97\ T^{-0.25}$)
[9]The 3-year average of the annual 99th percentile of the SO_2 daily maximum 1-hour average concentrations
[10]The arithmetic average over single calendar year of all 1-hour SO_2 concentrations

Table 17 Model Predicted Air Quality at Sensitive Receptors for Construction

Substance	CAS No.	Averaging Period	Statistical	Limit (µg/m³)	Type of Limit	Authority	Initial Concentration (µg/m³)	Model Predicted Concentration (µg/m³) Maximum per Category					Concentration Total[1] (µg/m³)	Contribution of Project[2] (%)	Percentage of Limit[3] (%)
								Road Relay km 381	Cree Camp	Valued Area	Traditional Activity	Max			
Total Suspended Particulate (TPM)	N/A-1	24 hours	1st Maximum	120	Standard	MELCC	40	15.1	0.981	10.7	9.74	15.1	55.1	27%	46%
Particulate Matter < 10 µm (PM_{10})	N/A-2	24 hours	99th Percentile	50	Guideline	WHO	21.8	4.54	0.622	4.12	5.33	5.33	27.1	20%	54%
		Annual	1st Maximum	20	Guideline	WHO	5.5	0.497	0.0586	0.276	0.902	0.902	6.40	14%	32%
Fine particulate matter ($PM_{2.5}$)	N/A-3	24 hours	1st Maximum	30	Standard	MELCC	15	3.49	0.316	3.55	2.51	3.55	18.6	19%	62%
		24 hours	98th Percentile[4]	27	CAAQS	CCME	15	1.16	0.181	0.77	1.38	1.38	16.4	8%	61%
		Annual	1st Maximum[5]	8.8	CAAQS	CCME	4.5	0.165	0.0196	0.0753	0.373	0.373	4.87	8%	55%
Nitrogen dioxide (NO_2) (from OLM)	10102-44-0	1 hour	98th Percentile[6]	113 (2020) / 79 (2025)	CAAQS	CCME	50	59	5.12	40.1	99.8	99.8	**150**	67%	**133% (2020) / 190% (2025)**
		1 hour	1st Maximum	414	Standard	MELCC	50	151	22.1	126	186	186	236	79%	57%
		24 hours	1st Maximum	207	Standard	MELCC	30	15.7	1.35	4.37	17.3	17.3	47.3	37%	23%
		Annual	1st Maximum	103	Standard	MELCC	10	0.849	0.0722	0.368	2.29	2.29	12.3	19%	12%
		Annual	1st Maximum[7]	32 (2020) / 23 (2025)	CAAQS	CCME	10	0.849	0.0722	0.368	2.29	2.29	12.3	19%	38% (2020) / 53% (2025)
Sulphur dioxide (SO_2)	7446-09-5	4 min	1st Maximum[8]	1,310	Standard	MELCC	40	10.6	2.91	3.61	21.1	21.1	61.1	35%	5%
		4 min	99.5th Percentile[8]	1,050	Standard	MELCC	40	0.286	0.0302	0.291	0.580	0.580	40.6	1%	4%
		1 hour	99th percentile[9]	183 (2020) / 170 (2025)	CAAQS	CCME	21	1.01	0.0547	0.563	2.26	2.26	23.3	10%	13% (2020) / 14% (2025)
		24 hours	1st Maximum	288	Standard	MELCC	10	0.238	0.0662	0.0826	0.464	0.464	10.5	4%	4%
		Annual	1st Maximum	52	Standard	MELCC	2	0.00486	0.000309	0.00336	0.00978	0.00978	2.01	0.5%	4%
		Annual	1st Maximum[10]	13 (2020) / 10 (2025)	CAAQS	CCME	2	0.00486	0.000309	0.00336	0.00978	0.00978	2.01	0.5%	15% (2020) / 20% (2025)
Carbon monoxide (CO)	630-08-0	1 hour	1st Maximum	34,000	Standard	MELCC	600	3,134	103	974	6,268	6,268	6,868	91%	20%
		8 hours	1st Maximum	12,700	Standard	MELCC	400	392	12.8	122	784	784	1,184	66%	9%
Volatile Organic Compounds (VOCs)	N/A-4	Annual	1st Maximum	-	-	CEEA	0	0.0643	0.00535	0.0196	0.221	0.221	0.221	100%	-

Notes:
[1]The modeled total concentration is the sum of the modeled maximum concentration and the initial concentration.
[2]The project contribution is the maximum modeled concentration divided by the total concentration, as a percentage.
[3]The percentage of the limit value is the total concentration divided by the limit value, as a percentage.
[4]The 3-year average of the annual 98th percentile of the daily 24-hour average concentrations
[5]The 3-year average of the annual average concentrations
[6]The 3-year average of the annual 98th percentile of the NO_2 daily maximum 1-hour average concentrations
[7]The arithmetic average over single calendar year of all 1-hour NO_2 concentrations
[8]Based on the initial 4-minute concentration converted for a period of 1 hour using the conversion formula ($C(T) = C_{MAX\text{-}H} \times 0.97\ T^{-0.25}$)
[9]The 3-year average of the annual 99th percentile of the SO_2 daily maximum 1-hour average concentrations
[10]The arithmetic average over single calendar year of all 1-hour SO_2 concentrations

Table 18 Model Predicted Particulate Deposition Results in the Application Domain for Construction

Substance	CAS No.	Averaging Period	Statistical	Threshold (g/m^2)	Deposition Initial (g/m^2)	Authorization	Modeled Deposition Results (Domain Application) (g/m^2)						Total Modeled Deposition[1] (g/m^2)	Contribution of Project[2] (%)	Percentage of the Limit[3] (%)
							Maximum per Meteorological Year								
							Y1	Y2	Y3	Y4	Y5	Max			
Total Particulate Deposition	N/A-4	Annual	1st Maximum	-	0	CEAA	15.2	16.4	15.2	16.2	17.2	17.2	17.2	100%	-

Notes:
[1]The modeled total deposition is the sum of the modeled maximum deposition and the initial deposition.
[2]The project contribution is the maximum modeled deposition divided by the total deposition, as a percentage.
[3]The percentage of the limit value is the total deposition divided by the limit value, as a percentage.

Table 19 Model Predicted Particulate Deposition Results at Sensitive Receptors for Construction

Substance	CAS No.	Averaging Period	Statistical	Threshold (g/m^2)	Deposition Initial (g/m^2)	Authorization	Modeled Deposition Results (Sensitive Receptors) (g/m^2)					Total Modeled Deposition[1] (g/m^2)	Contribution of Project[2] (%)	Percentage of the Limit[3] (%)
							Maximum per Category							
							Road Relay km 381	Cree Camp	Valued Area	Traditional Activity	Max.			
Total Particulate Deposition	N/A-4	Annual	1st Maximum	-	0	CEAA	2.69	0.313	1.22	5.55	5.55	5.55	100%	-

Notes:
[1]The modeled total deposition is the sum of the modeled maximum deposition and the initial deposition.
[2]The project contribution is the maximum modeled deposition divided by the total deposition, as a percentage.
[3]The percentage of the limit value is the total deposition divided by the limit value, as a percentage.

Since the dispersion modelling conducted to support the initial ESIA (WSP 2018), there were several Project design changes implemented through the Value Engineering Phase (GMS 2020) and the addition of planned dust control techniques, as presented in Section 2.1 and in the DEMP (Appendix E). These changes were applied to improved efficiency and reduce emissions. The maximum predicted concentration results outside of the application boundary limit for this study compared to those from the initial ESIA modelling study (WSP 2018) are presented in Table 20.

The particulates (TPM, PM_{10}, and $PM_{2.5}$) saw a decrease in predicted total concentrations in this assessment compared to the initial ESIA modelling (WSP 2018). This can be attributed to the changes implemented during the Value Engineering Phase (GMS 2020) and the DEMP (Appendix E), both of which reduced particulate emissions.

Similarly, there is a large difference between predicted total concentrations of CO, NO_2, and SO_2 for averaging periods of 24-hour and lower between the current assessment and the initial ESIA modelling (WSP 2018). The main difference in these predicted concentrations can be attributed to different air dispersion modelling parameters (e.g., release height, sigma-y and sigma-z values) being used for blasting. Although both assessments used the same emission factors from the Australian NPI (2016), this assessment relied on updated blasting parameters recommended during the Value Engineering Phase (GMS 2020).

The sources of VOC emissions and associated emission rates remained relatively consistent between the current assessment and the initial ESIA modelling assessment (WSP 2018), however, the predicted VOC concentration is higher (195%) in the current assessment compared to the former. This change is likely due to the relocation of the accommodations camp. The relocation of the accommodations camp places it closer to the eastern application boundary limit. As the prevailing wind is blowing from the west, this causes a higher concentration at the eastern limit.

Table 20 Dispersion Modelling Construction Results Comparison with Former ESIA Modelling

Substance	CAS No.	Averaging Period	Statistical	Limit (µg/m³)	Initial Concentration (µg/m³)	Current Study		ESIA Modelling (WSP 2018)		Percent Change
						Concentration Total[1] (µg/m³)	Percentage of Limit[2] (%)	Concentration Total[1] (µg/m³)	Percentage of Limit[2] (%)	
Total Suspended Particulate (TPM)	N/A-1	24 hours	1st Maximum	120	40	77.5	65%	208	173%	-63%
Particulate Matter < 10 µm (PM_{10})	N/A-2	24 hours	99th Percentile	50	21.8	38.4	77%	79.3	159%	-52%
		Annual	1st Maximum	20	5.5	7.48	37%	9.30	47%	-20%
Fine particulate matter ($PM_{2.5}$)	N/A-3	24 hours	1st Maximum	30	15	27.7	92%	32.8	109%	-16%
		24 hours	98th Percentile[3]	27	15	19.3	71%	19.9	74%	-3%
		Annual	1st Maximum[4]	8.8	4.5	5.27	60%	5.67	64%	-7%
Nitrogen dioxide (NO_2) (from OLM)	10102-44-0	1 hour	1st Maximum	414	50	400	97%	749	181%	-47%
		24 hours	1st Maximum	207	30	62.4	30%	229	111%	-73%
		Annual	1st Maximum	103	10	13.8	13%	14.0	14%	-1%
Sulphur dioxide (SO_2)	7446-09-5	4 min	1st Maximum	1,310	40	95.4	7%	213	16%	-55%
		4 min	99.5th Percentile[5]	1,050	40	41.8	4%	45.0	4%	-7%
		1 hour	99th percentile[5]	170	21	28.8	17%	44.0	26%	-35%
		24 hours	1st Maximum	288	10	11.2	4%	14.0	5%	-20%
		Annual	1st Maximum	52	2	2.03	4%	2.00	4%	1%
		Annual	1st Maximum[6]	10.5	2	2.03	19%	2.00	19%	1%
Carbon monoxide (CO)	630-08-0	1 hour	1st Maximum	34,000	600	13,731	40%	51,870	153%	-74%
		8 hours	1st Maximum	12,700	400	2,042	16%	7,724	61%	-74%
Volatile Organic Compounds	N/A-4	Annual	1st Maximum	-	0	0.353	-	0.190	-	86%

Notes:
[1]The modeled total concentration is the sum of the modeled maximum concentration and the initial concentration.
[2]The percentage of the limit value is the total concentration divided by the limit value, as a percentage.
[3]The 3-year average of the annual 98th percentile of the daily 24-hour average concentrations
[4]The 3-year average of the annual average of the daily 24-hour average concentrations
[5]1st maximum 4-minute concentration conservatively compared to the limit
61st maximum annual concentration conservatively compared to the limit

6.2 OPERATIONS SCENARIO

A summary of the air dispersion modelling maximum concentration results in the operational phase in the application domain outside of the application boundary limit are presented in Table 21, and the maximum concentrations at locations of sensitive receptors in Table 22. For substances that exceeded the limit, the percent of limit value is bolded. Particulate matter deposition results are presented in Table 23 and Table 24, for the maximum in the application domain outside of the application boundary limit and the maximum at sensitive receptors, respectively. For contaminants in which the concentration (modelled plus initial) exceeded 50% of the respective standard or criteria, isopleth concentration figures are presented in Appendix B. Total chromium was compared to the hexavalent chromium (Cr(VI)) for conservatism.

The model predicted 24-hour TPM concentration was slightly greater than (101%) its applicable 24-hour standard. The model predicted TPM concentrations that were greater than the 24-hour standard occurred at a single location for one 24-hour period over the 5-years modelled, which represents an occurrence of 0.05% of the time at this single location. The location at which the maximum predicted 24-hour TPM standard was greater than the limit is at the south side of the application boundary limit.

The model predicted 1-hour NO_2 (CAAQS) concentration was greater than the CAAQS at locations near the application boundary limit and at traditional activity sensitive receptors. The location at which the maximum predicted 1-hour NO_2 (CAAQS) was greater than the standard is at the east side of the application boundary limit (maximum concentration of 221 µg/m^3 that is 196% of the 2020 CAAQS and 280% of the 2025 CAAQS). The maximum frequency of exceedance is 98 days over a 5-year period for the 2020 CAAQS and 157 days over 5-year period for the 2025 CAAQS.

The model predicted 1-hour and annual crystalline silica concentrations are greater than its applicable ambient air quality standards. The model predicted 1-hour crystalline silica concentrations were greater than the standard at locations outside of the application boundary limit (maximum concentration of 41.2 µg/m^3, 179% of the standard), but not at a location of a sensitive receptor. The model predicted hourly crystalline silica concentration was greater than the standard in a small area along south and south-east of the application boundary limit. The maximum number of hourly crystalline silica exceedances over the 5-year modelled scenario at a single receptor was predicted to occur only 5 times, or 0.011% of the time. The model predicted annual crystalline silica concentration was greater than the standard at locations near the application boundary limit and at sensitive receptors. At the kilometers 381 truck stop, the model predicted maximum annual crystalline silica concentration was greater than its applicable standard by 213%. At a location of traditional activity, the model predicted maximum annual crystalline silica concentration was greater than applicable standard by 261%. The model predicted annual crystalline silica concentration was less than the applicable standard at the Cree Camp and a valued area.

There is no applicable limit for TPM deposition. Formerly, there was a 30-day standard of 7.5 g/m^2 set out in section 6 of the Regulation on Air Purification/*règlement sur l'assainissement de l'atmosphère* (Quebec 2019), which was revoked in 2011. Predicted 30-day deposition in the modelled domain, including at locations of sensitive receptors, met the former standard.

Table 21 Modeled Results in the Application Domain during Operation

Substance	CAS No.	Averaging Period	Statistical	Threshold (µg/m³)	Type of Threshold	Authorization	Initial Conc. (µg/m³)	Model Predicted Concentration (µg/m³) Maximum per Meteorological Year						Concentration Total[1] (µg/m³)	Contribution of Project[2] (%)	Percentage of Limit[3] (%)
								Y1	Y2	Y3	Y4	Y5	Max.			
Total Suspended Particulate (TPM)	N/A-1	24 hours	1st Maximum	120	Standard	MELCC	40	70.3	79.1	65.4	80.9	51.3	80.9	121	67%	**101%**
Particulate Matter < 10 µm (PM_{10})	N/A-2	24 hours	99th Percentile	50	Guideline	WHO	21.8	9.13	10.5	7.9	10.1	8.95	10.5	32.3	33%	65%
		Annual	1st Maximum	20	Guideline	WHO	5.5	2.48	2.41	2.42	2.33	2.68	2.68	8.18	33%	41%
Fine particulate matter ($PM_{2.5}$)	N/A-3	24 hours	1st Maximum	30	Standard	MELCC	15	5.09	5.95	5.69	4.55	4.8	5.95	20.9	28%	70%
		24 hours	98th Percentile[4]	27	CAAQS	CCME	15	3.68	3.12	3.45	2.81	3.05	3.68	18.4	20%	68%
		Annual	1st Maximum[5]	8.8	CAAQS	CCME	4.5	1.04	1.02	1.04	0.932	1.09	1.09	5.54	20%	63%
Nitrogen dioxide (NO_2) (from OLM)	10102-44-0	1 hour	98th Percentile[6]	113 (2020) / 79 (2025)	CAAQS	CCME	50	169	214	159	168	181	214	**221**	97%	**196% (2020) / 280% (2025)**
		1 hour	1st Maximum	414	Standard	MELCC	50	324	351	331	335	342	351	401	88%	97%
		24 hours	1st Maximum	207	Standard	MELCC	30	64.1	71.3	72.9	56.6	64.2	72.9	103	71%	50%
		Annual	1st Maximum	103	Standard	MELCC	10	9.2	9.1	9.52	7.91	9.66	9.66	19.7	49%	19%
		Annual	1st Maximum[7]	32 (2020) / 23 (2025)	CAAQS	CCME	10	9.2	9.1	9.52	7.91	9.66	9.66	19.7	49%	61% (2020) / 85% (2025)
Sulphur dioxide (SO_2)	7446-09-5	4 min	1st Maximum[8]	1,310	Standard	MELCC	40	12.3	10.5	10.7	16.4	9.49	16.4	56.4	29%	4%
		4 min	99.5th Percentile[8]	1,050	Standard	MELCC	40	1.06	1.10	1.09	0.945	1.04	1.10	41.1	3%	4%
		1 hour	99th percentile[9]	183 (2020) / 170 (2025)	CAAQS	CCME	21	3.38	2.91	2.7	1.87	2.19	3.38	23.5	14%	13% (2020) / 14% (2025)
		24 hours	1st Maximum	288	Standard	MELCC	10	0.298	0.326	0.335	0.384	0.297	0.384	10.4	4%	4%
		Annual	1st Maximum	52	Standard	MELCC	2	0.0399	0.0388	0.0411	0.0333	0.0417	0.0417	2.04	2%	4%
		Annual	1st Maximum[10]	13 (2020) / 10 (2025)	CAAQS	CCME	2	0.0399	0.0388	0.0411	0.0333	0.0417	0.0417	2.04	2%	16% (2020) / 20% (2025)
Carbon monoxide (CO)	630-08-0	1 hour	1st Maximum	34,000	Standard	MELCC	600	3,320	3,110	3,170	3,600	2,810	3,600	4,200	86%	12%
		8 hours	1st Maximum	12,700	Standard	MELCC	400	419	446	398	453	352	453	853	53%	7%
Volatile Organic Compounds (VOCs)	N/A-4	Annual	1st Maximum	-	-	ACEA	0	0.855	0.843	0.876	0.742	0.886	0.886	0.886	100%	-
Antimony (Sb)	7440-36-0	Annual	1st Maximum	0.17	Standard	MELCC	0.001	0.00000615	0.00000583	0.00000564	0.00000583	0.00000657	0.00000657	0.00101	1%	1%
Silver (Ag)	7440-22-4	Annual	1st Maximum	0.23	Standard	MELCC	0.005	0.00000922	0.00000874	0.00000847	0.00000875	0.00000986	0.00000986	0.00501	0.2%	2%
Arsenic (As)	7440-38-2	Annual	1st Maximum	0.003	Standard	MELCC	0.002	0.000605	0.000569	0.000557	0.000535	0.000625	0.000625	0.00262	24%	87%
Barium (Ba)	7440-39-3	Annual	1st Maximum	0.05	Standard	MELCC	0.02	0.00406	0.0038	0.00374	0.0036	0.00418	0.00418	0.0242	17%	48%
Beryllium (Be)	7440-41-7	Annual	1st Maximum	0.0004	Standard	MELCC	0	0.000140	0.000130	0.000130	0.000130	0.000150	0.000150	0.00015	100%	38%
Cadmium (Cd)	7440-43-9	Annual	1st Maximum	0.0036	Standard	MELCC	0.0005	0.00000615	0.00000583	0.00000564	0.00000583	0.00000657	0.00000657	0.000507	1%	14%
Total Chromium (hexavalent	18540-29-9	Annual	1st Maximum	0.004	Standard	MELCC	0.002	0.00172	0.00162	0.00158	0.00160	0.00180	0.00180	0.00380	47%	95%

Table 21 Modeled Results in the Application Domain during Operation

Substance	CAS No.	Averaging Period	Statistical	Threshold (µg/m³)	Type of Threshold	Authorization	Initial Conc. (µg/m³)	Model Predicted Concentration (µg/m³) Maximum per Meteorological Year						Concentration Total[1] (µg/m³)	Contribution of Project[2] (%)	Percentage of Limit[3] (%)
								Y1	Y2	Y3	Y4	Y5	Max.			
chromium compounds) (Cr(VI))																
Cobalt (Co)	7440-48-4	Annual	1st Maximum	0.1	Criterion	MELCC	0	0.000139	0.000131	0.000128	0.000123	0.000144	0.000144	0.000144	100%	0.1%
Copper (Cu)	7440-50-8	24 hours	1st Maximum	2.5	Standard	MELCC	0.2	0.00271	0.00286	0.00261	0.00307	0.00241	0.00307	0.203	2%	8%
Manganese (Mn)	7439-96-5	Annual	1st Maximum	0.025	Criterion	MELCC	0.005	0.00101	0.000981	0.000974	0.000985	0.00111	0.00111	0.00611	18%	24%
Mercury (Hg)	7439-97-6	Annual	1st Maximum	0.005	Standard	MELCC	0.002	2.58E-08	2.48E-08	2.48E-08	2.55E-08	2.81E-08	2.81E-08	0.002	0.001%	40%
Nickel (Ni)	7440-02-0	24 hours	1st Maximum	0.014	Standard	MELCC	0.002	0.00101	0.00106	0.000967	0.00113	0.000885	0.00113	0.00313	36%	22%
Lead (Pb)	7439-92-1	Annual	1st Maximum	0.1	Standard	MELCC	0.004	0.0000982	0.0000923	0.0000904	0.0000869	0.000101	0.000101	0.00410	2%	4%
Selenium (Se)	7782-49-2	Annual	1st Maximum	2	Criterion	MELCC	0.15	0.0000217	0.0000211	0.000021	0.0000204	0.0000237	0.0000237	0.150	0.02%	8%
Crystalline silica (SiO_2)	14808–60–7	1 hour	1st Maximum	23	Criterion	MELCC	6	25.9	21.5	21.8	35.2	20.1	35.2	41.20	85%	**179%**
		Annual	1st Maximum	0.07	Criterion	MELCC	0.04	0.241	0.235	0.233	0.231	0.265	0.265	0.305	87%	**436%**
Thallium (Tl)	7440-28-0	Annual	1st Maximum	0.25	Standard	MELCC	0.005	0.00000564	0.00000546	0.00000541	0.00000532	0.00000616	0.00000616	0.00501	0.1%	2%
Titanium	7440-32-6	24 hours	1st Maximum	2.5	Criterion	MELCC	0	0.183	0.193	0.176	0.207	0.162	0.207	0.207	100%	8%
Vanadium (V)	7440-62-2	Annual	1st Maximum	1	Standard	MELCC	0.01	0.000718	0.000676	0.000662	0.000634	0.000743	0.000743	0.0107	7%	1%
Zinc (Z)	7440-66-6	24 hours	1st Maximum	2.5	Standard	MELCC	0.1	0.00477	0.00508	0.00452	0.00541	0.00423	0.00541	0.105	5%	4%

Notes:
Notes:
[1]The modeled total concentration is the sum of the modeled maximum concentration and the initial concentration.
[2]The project contribution is the maximum modeled concentration divided by the total concentration, as a percentage.
[3]The percentage of the limit value is the total concentration divided by the limit value, as a percentage.
[4]The 3-year average of the annual 98th percentile of the daily 24-hour average concentrations
[5]The 3-year average of the annual average concentrations
[6]The 3-year average of the annual 98th percentile of the NO_2 daily maximum 1-hour average concentrations
[7]The arithmetic average over single calendar year of all 1-hour NO_2 concentrations
[8]Based on the initial 4-minute concentration converted for a period of 1 hour using the conversion formula ($C(T) = C_{MAX-H} \times 0.97\ T^{-0.25}$)
[9]The 3-year average of the annual 99th percentile of the SO_2 daily maximum 1-hour average concentrations
[10]The arithmetic average over single calendar year of all 1-hour SO_2 concentrations

Table 22 Results of Modelling at Sensitive Receptors for Operation

Substance	CAS No.	Averaging Period	Statistical	Threshold (µg/m³)	Type of threshold	Authorization	Initial Concentration (µg/m³)	Model Predicted Concentration (µg/m³) Maximum per Category					Concentration Total[1] (µg/m³)	Contribution of Project[2] (%)	Percentage of Limit[3] (%)
								Road Relay km 381	Cree Camp	Valued Area	Traditional Activity	Max			
Total Suspended Particulate (TPM)	N/A-1	24 hours	1st Maximum	120	Standard	MELCC	40	31.7	2.26	12.1	45.8	45.8	85.8	53%	72%
Particulate Matter < 10 µm (PM_{10})	N/A-2	24 hours	99th Percentile	50	Guideline	WHO	21.8	7.17	0.461	2.00	7.45	7.45	29.2	26%	58%
		Annual	1st Maximum	20	Guideline	WHO	5.5	1.1	0.0659	0.293	1.62	1.62	7.12	23%	36%
Fine particulate matter ($PM_{2.5}$)	N/A-3	24 hours	1st Maximum	30	Standard	MELCC	15	2.42	0.221	0.602	4.32	4.32	19.3	22%	64%
		24 hours	98th Percentile[4]	27	CAAQS	CCME	15	1.26	0.094	0.355	2.21	2.21	17.2	13%	64%
		Annual	1st Maximum[5]	8.8	CAAQS	CCME	4.5	0.27	0.0186	0.0729	0.647	0.647	5.15	13%	59%
Nitrogen dioxide (NO_2) (from OLM)	10102-44-0	1 hour	98th Percentile[6]	113 (2020) / 79 (2025)	CAAQS	CCME	50	52.5	9.94	25.4	142	142	**192**	74%	**170% (2020) / 243% (2025)**
		1 hour	1st Maximum	414	Standard	MELCC	50	136	57.9	135	264	264	314	84%	76%
		24 hours	1st Maximum	207	Standard	MELCC	30	19.6	2.76	7.78	57.7	57.7	87.7	66%	42%
		Annual	1st Maximum	103	Standard	MELCC	10	1.94	0.144	0.521	6.87	6.87	16.9	41%	16%
		Annual	1st Maximum[7]	32 (2020) / 23 (2025)	CAAQS	CCME	10	1.94	0.144	0.521	6.87	6.87	16.9	41%	53% (2020) / 73% (2025)
Sulphur dioxide (SO_2)	7446-09-5	4 min	1st Maximum[8]	1,310	Standard	MELCC	40	3.11	0.881	2.72	6.1	6.1	46.1	13%	4%
		4 min	99.5th Percentile[8]	1,050	Standard	MELCC	40	0.283	0.022	0.0742	0.868	0.868	40.9	2%	4%
		1 hour	99th percentile[9]	183 (2020) / 170 (2025)	CAAQS	CCME	21	0.403	0.0656	0.326	0.810	0.810	21.8	4%	12% (2020) / 13% (2025)
		24 hours	1st Maximum	288	Standard	MELCC	10	0.0847	0.0214	0.063	0.257	0.257	10.3	2%	4%
		Annual	1st Maximum	52	Standard	MELCC	2	0.00659	0.00055	0.00204	0.0301	0.0301	2.03	1%	4%
		Annual	1st Maximum[10]	13 (2020) / 10 (2025)	CAAQS	CCME	2	0.00659	0.00055	0.00204	0.0301	0.0301	2.03	1%	16% (2020) / 20% (2025)
Carbon monoxide (CO)	630-08-0	1 hour	1st Maximum	34,000	Standard	MELCC	600	787	258	796	1,800	1,800	2,400	75%	7%
		8 hours	1st Maximum	12,700	Standard	MELCC	400	108	32.2	99.7	226	226	626	36%	5%
Volatile Organic Compounds (VOCs)	N/A-4	Annual	1st Maximum	-	-	ACEA	0	0.214	0.0146	0.0557	0.618	0.618	0.618	100%	-
Antimony (Sb)	7440-36-0	Annual	1st Maximum	0.17	Standard	MELCC	0.001	0.00000384	0.000000207	0.00000099	0.00000422	0.00000422	0.00100	0.4%	1%
Silver (Ag)	7440-22-4	Annual	1st Maximum	0.23	Standard	MELCC	0.005	0.00000576	0.00000031	0.00000149	0.00000633	0.00000633	0.00501	0.1%	2%
Arsenic (As)	7440-38-2	Annual	1st Maximum	0.003	Standard	MELCC	0.002	0.000376	0.00002	0.0000967	0.000416	0.000416	0.00242	17%	81%
Barium (Ba)	7440-39-3	Annual	1st Maximum	0.05	Standard	MELCC	0.02	0.00251	0.000134	0.000646	0.00279	0.00279	0.0228	12%	46%
Beryllium (Be)	7440-41-7	Annual	1st Maximum	0.0004	Standard	MELCC	0	0.0000400	0.0000000	0.0000100	0.0000700	0.0000700	0.00007	100%	18%
Cadmium (Cd)	7440-43-9	Annual	1st Maximum	0.0036	Standard	MELCC	0.0005	0.00000384	0.000000207	0.00000099	0.00000422	0.00000422	0.000504	1%	14%
Total Chromium (hexavalent chromium compounds) (Cr(VI))	18540-29-9	Annual	1st Maximum	0.004	Standard	MELCC	0.002	0.00107	0.0000576	0.000276	0.00118	0.00118	0.00318	37%	80%
Cobalt (Co)	7440-48-4	Annual	1st Maximum	0.1	Criterion	MELCC	0	0.0000865	0.00000459	0.0000222	0.0000959	0.0000959	0.0000959	100%	0.1%
Copper (Cu)	7440-50-8	24 hours	1st Maximum	2.5	Standard	MELCC	0.2	0.00233	0.000182	0.000550	0.00194	0.00233	0.202	1%	8%
Manganese (Mn)	7439-96-5	Annual	1st Maximum	0.025	Criterion	MELCC	0.005	0.000565	0.0000322	0.000148	0.000669	0.000669	0.00567	12%	23%
Mercury (Hg)	7439-97-6	Annual	1st Maximum	0.005	Standard	MELCC	0.002	1.59E-08	8.85E-10	4.09E-09	1.75E-08	1.75E-08	0.00200	0.001%	40%
Nickel (Ni)	7440-02-0	24 hours	1st Maximum	0.014	Standard	MELCC	0.002	0.000864	0.0000679	0.000204	0.000724	0.000864	0.00286	30%	20%
Lead (Pb)	7439-92-1	Annual	1st Maximum	0.1	Standard	MELCC	0.004	0.000061	0.00000325	0.0000157	0.0000676	0.0000676	0.00407	2%	4%
Selenium (Se)	7782-49-2	Annual	1st Maximum	2	Criterion	MELCC	0.15	0.00000728	0.00000044	0.00000192	0.0000124	0.0000124	0.150	0.01%	8%
Crystalline silica (SiO_2)	14808–60–7	1 hour	1st Maximum	23	Criterion	MELCC	6	14.0	2.99	5.05	13.9	14.0	20.00	70%	87%
		Annual	1st Maximum	0.07	Criterion	MELCC	0.04	0.109	0.00623	0.0281	0.143	0.143	0.1830	78%	**261%**

Table 22 Results of Modelling at Sensitive Receptors for Operation

Substance	CAS No.	Averaging Period	Statistical	Threshold (µg/m³)	Type of threshold	Authorization	Initial Concentration (µg/m³)	Model Predicted Concentration (µg/m³) Maximum per Category					Concentration Total[1] (µg/m³)	Contribution of Project[2] (%)	Percentage of Limit[3] (%)
								Road Relay km 381	Cree Camp	Valued Area	Traditional Activity	Max			
Thallium (Tl)	7440-28-0	Annual	1st Maximum	0.25	Standard	MELCC	0.005	0.0000022	0.000000132	0.000000582	0.00000327	0.00000327	0.00500	0.1%	2%
Titanium	7440-32-6	24 hours	1st Maximum	2.5	Criterion	MELCC	0	0.157	0.0123	0.0371	0.131	0.157	0.157	100%	6%
Vanadium (V)	7440-62-2	Annual	1st Maximum	1	Standard	MELCC	0.01	0.000445	0.0000237	0.000114	0.000493	0.000493	0.0105	5%	1%
Zinc (Z)	7440-66-6	24 hours	1st Maximum	2.5	Standard	MELCC	0.1	0.00413	0.000324	0.000977	0.0035	0.00413	0.104	4%	4%

Notes:
[1]The modeled total concentration is the sum of the modeled maximum concentration and the initial concentration.
[2]The project contribution is the maximum modeled concentration divided by the total concentration, as a percentage.
[3]The percentage of the limit value is the total concentration divided by the limit value, as a percentage.
[4]The 3-year average of the annual 98th percentile of the daily 24-hour average concentrations
[5]The 3-year average of the annual average concentrations
[6]The 3-year average of the annual 98th percentile of the NO_2 daily maximum 1-hour average concentrations
[7]The arithmetic average over single calendar year of all 1-hour NO_2 concentrations
[8]Based on the initial 4-minute concentration converted for a period of 1 hour using the conversion formula ($C(T) = C_{MAX-H} \times 0.97\ T^{-0.25}$)
[9]The 3-year average of the annual 99th percentile of the SO_2 daily maximum 1-hour average concentrations
[10]The arithmetic average over single calendar year of all 1-hour SO_2 concentrations

Table 23 Modeled Particulate Deposition Results in the Application Domain during Operation

Substance	CAS No.	Averaging Period	Statistical	Threshold (g/m²)	Deposition Initial (g/m²)	Authorization	Model Predicted Deposition (Domain Application) (g/m²) Maximum per Meteorological Year						Total Modeled Deposition[1] (g/m²)	Contribution of Project[2] (%)	Percentage of the Limit[3] (%)
							Y1	Y2	Y3	Y4	Y5	Max			
Total Particulate Deposition	N/A-4	Annual	1st Maximum	-	0	CEAA	19.8	15.9	17.9	18.2	18.3	19.8	19.8	100%	-
Total Particulate Deposition	N/A-4	Monthly	1st Maximum	-	-	CEEA	4.82	4.61	3.73	4.25	2.99	4.82	4.82	100%	-

Notes:
"-"indicates that the value is not available
[1]The modeled total deposition is the sum of the modeled maximum deposition and the initial deposition.
[2]The project contribution is the maximum modeled deposition divided by the total deposition, as a percentage.
[3]The percentage of the limit value is the total deposition divided by the limit value, as a percentage.

Table 24 Modeled Particulate Deposition Results at Sensitive Receptors during Operation

Substance	CAS No.	Averaging Period	Statistical	Threshold (g/m²)	Deposition Initial (g/m²)	Authorization	Model Predicted Deposition (Sensitive Receptors) (g/m²) Maximum per Category					Total Modeled Deposition[1] (g/m²)	Contribution of Project[2] (%)	Percentage of the Limit[3] (%)
							Road Relay km 381	Cree Camp	Valued Area	Traditional Activity	Max.			
Total Particulate Deposition	N/A-4	Annual	1st Maximum	-	0	CEAA	8.18	0.470	2.94	12.3	12.3	12.3	100%	-
Total Particulate Deposition	N/A-4	Monthly	1st Maximum	-	-	CEEA	1.62	0.0991	0.633	2.49	2.49	2.49	100%	-

Notes:
[1]The modeled total deposition is the sum of the modeled maximum deposition and the initial deposition.
[2]The project contribution is the maximum modeled deposition divided by the total deposition, as a percentage.
[3]The percentage of the limit value is the total deposition divided by the limit value, as a percentage.

Since the completion of the dispersion modelling conducted to support the initial ESIA (WSP 2018), there were several changes to the Project through the Value Engineering Phase (GMS 2020) and the addition of dust control techniques, as presented in Section 2.1 1 and in the DEMP (Appendix E). These changes were applied to improved efficiency and reduce emissions. The following table, Table 25, presents the maximum concentration results outside of the application boundary limit for this study compared to those from the initial ESIA modelling study (WSP 2018).

The particulates (TPM, PM_{10}, and $PM_{2.5}$) saw a decrease in predicted total concentrations in this assessment compared to the initial ESIA modelling (WSP). This can be attributed to the changes implemented during the Value Engineering Phase (GMS 2020) and the DEMP (Appendix E), both of which reduced particulate emissions.

The predicted total concentrations of most metals decreased since the initial ESIA modelling (WSP 2018). Fugitive metal emissions were speciated from particulates (as discussed in Section 4.2.9). As particulate emissions decreased due to increased controls and efficiency, there was a direct decrease in fugitive metal emissions. The metals arsenic and chromium saw an increase in predicted total concentrations since the initial ESIA modelling (WSP 2018). This is due to an increase in emissions due to the inclusion of these species in the mobile exhaust combustion which were not formerly modelled in the initial ESIA modelling (WSP 2018).

Similarly, there is a large difference between predicted total concentrations of CO, NO_2 and SO_2 for averaging periods of 24-hour and lower between the current study and the initial ESIA modelling (WSP 2018). As explained in the construction phase results (Section 6.1), the main difference in these predicted concentrations can be attributed to different air dispersion modelling parameters (e.g., release height, sigma-y and sigma-z values) being used for blasting. Although both assessments used the same emission factors from the Australian NPI (2016), this assessment relied on updated blasting parameters recommended during the Value Engineering Phase (GMS 2020).

The sources of VOC emissions and associated emission rates remained relatively consistent between the current assessment and the initial ESIA modelling assessment (WSP 2018), however, the predicted VOC concentration is higher (195%) in the current assessment compared to the former. This change is likely due to the relocation of the accommodations camp. The relocation of the accommodations camp places it closer to the eastern application boundary limit than previously. As the prevailing wind is blowing from the west, this causes a higher concentration at the eastern limit.

Table 25 Dispersion Modelling Operations Results Comparison with Former ESIA Modelling

Substance	CAS No.	Averaging Period	Statistical	Limit (µg/m³)	Initial Concentration (µg/m³)	Current Study		WSP 2018		Percent Change
						Concentration Total[1] (µg/m³)	Percentage of Limit[2] (%)	Concentration Total[1] (µg/m³)	Percentage of Limit[2] (%)	
Total Suspended Particulate (TPM)	N/A-1	24 hours	1st Maximum	120	40	121	101%	216	180%	-44%
Particulate Matter < 10 µm (PM_{10})	N/A-2	24 hours	99th Percentile	50	21.8	32.3	65%	74.9	150%	-57%
		Annual	1st Maximum	20	5.5	8.18	41%	14.7	74%	-44%
Fine particulate matter ($PM_{2.5}$)	N/A-3	24 hours	1st Maximum	30	15	20.9	70%	30.5	102%	-31%
		24 hours	98th Percentile[3]	27	15	18.4	68%	23.1	86%	-20%
		Annual	1st Maximum[4]	8.8	4.5	5.54	63%	6.41	73%	-14%
Nitrogen dioxide (NO_2) (from OLM)	10102-44-0	1 hour	1st Maximum	414	50	401	97%	409	99%	-2%
		24 hours	1st Maximum	207	30	103	50%	157	76%	-34%
		Annual	1st Maximum	103	10	19.7	19%	16.00	16%	23%
Sulphur dioxide (SO_2)	7446-09-5	4 min	1st Maximum	1,310	40	56.4	4%	111	8%	-49%
		4 min	99.5th Percentile[5]	1,050	40	41.1	4%	46.00	4%	-11%
		1 hour	99th percentile[5]	170.2	21	23.5	14%	32.00	19%	-27%
		24 hours	1st Maximum	288	10	10.4	4%	12.00	4%	-13%
		Annual	1st Maximum	52	2	2.04	4%	2.00	4%	2%
		Annual	1st Maximum[6]	10.5	2	2.04	19%	2.00	19%	2%
Carbon monoxide (CO)	630-08-0	1 hour	1st Maximum	34,000	600	4,200	12%	21,650	64%	-81%
		8 hours	1st Maximum	12,700	400	853	7%	3,409	27%	-75%
Volatile Organic Compounds (VOCs)	N/A-4	Annual	1st Maximum	-	0	0.886	-	0.300	-	195%
Antimony (Sb)	7440-36-0	Annual	1st Maximum	0.17	0.001	0.00101	1%	0.00100	1%	1%
Silver (Ag)	7440-22-4	Annual	1st Maximum	0.23	0.005	0.00501	2%	0.00500	2%	0%
Arsenic (As)	7440-38-2	Annual	1st Maximum	0.003	0.002	0.00262	87%	0.00225	75%	16%
Barium (Ba)	7440-39-3	Annual	1st Maximum	0.05	0.02	0.0242	48%	0.0322	64%	-25%
Beryllium (Be)	7440-41-7	Annual	1st Maximum	0.0004	0	0.000150	38%	0.000158	40%	-5%
Cadmium (Cd)	7440-43-9	Annual	1st Maximum	0.0036	0.0005	0.000507	14%	0.000510	14%	-1%
Total Chromium (hexavalent chromium compounds) (Cr(VI))	18540-29-9	Annual	1st Maximum	0.004	0.002	0.00380	95%	0.00354	89%	7%
Cobalt (Co)	7440-48-4	Annual	1st Maximum	0.1	0	0.000144	0.1%	0.00100	1%	-86%
Copper (Cu)	7440-50-8	24 hours	1st Maximum	2.5	0.2	0.203	8%	0.210	8%	-3%
Manganese (Mn)	7439-96-5	Annual	1st maximum	0.025	0.005	0.00611	24%	0.0190	76%	-68%
Mercury (Hg)	7439-97-6	Annual	1st maximum	0.005	0.002	0.00200	40%	0.00200	40%	0%
Nickel (Ni)	7440-02-0	24 hours	1st maximum	0.014	0.002	0.00313	22%	0.00680	49%	-54%
Lead (Pb)	7439-92-1	Annual	1st maximum	0.1	0.004	0.00410	4%	0.00400	4%	3%
Selenium (Se)	7782-49-2	Annual	1st maximum	2	0.15	0.150	8%	0.170	9%	-12%
Crystalline Silica	14808-60-7	1 hour	1st maximum	23	6	41.20	179%	201	874%	-80%
		Annual	1st maximum	0.07	0.04	0.3050	436%	0.342	489%	-11%
Thallium (Tl)	7440-28-0	Annual	1st maximum	0.25	0.005	0.00501	2%	0.00500	2%	0%
Titanium	7440-32-6	24 hours	1st maximum	2.5	0	0.207	8%	1.46	58%	-86%
Vanadium (V)	7440-62-2	Annual	1st maximum	1	0.01	0.0107	1%	0.0200	2%	-47%
Zinc (Z)	7440-66-6	24 hours	1st maximum	2.5	0.1	0.105	4%	0.130	5%	-19%

Notes:
[1]The modeled total concentration is the sum of the modeled maximum concentration and the initial concentration.
[2]The percentage of the limit value is the total concentration divided by the limit value, as a percentage.
[3]The 3-year average of the annual 98th percentile of the daily 24-hour average concentrations
[4]The 3-year average of the annual average of the daily 24-hour average concentrations
[5]1st maximum 4-minute concentration conservatively compared to the limit
[6]1st maximum annual concentration conservatively compared to the limit

7.0 SUMMARY AND CONCLUSIONS

Stantec conducted dispersion modelling of Galaxy's proposed James Bay lithium mine and processing mill activities to assess the effects on ambient air quality using the US EPA AERMOD dispersion model. This included the assessment of the construction and operation phases. The Project had air dispersion modelling performed as part of their ESIA submitted in 2018 (WSP 2018). However, since the initial ESIA modelling was conducted, several changes to the site layout and operations have been proposed in the Valued Engineering phase of the Project (GMS 2020). This modelling study was performed to incorporate these changes, along with changes that arose from Information Requests received after the 2018 submission of the ESIA. Where applicable, Stantec has applied consistent methodology with the former ESIA modelling (WSP 2018), including for the estimation of emissions and the set-up of modelling parameters.

The assessment was conducted following the "Guide de la modélisation de la dispersion atmosphérique" (GMDA) (MELCC 2005) and the instruction guide "Préparation et réalisation d'une modélisation de la dispersion des émissions atmosphériques – Projets miniers" (MELCC 2017).

The air contaminants of interest include carbon monoxide (CO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), volatile organic compounds (VOCs), particulate matter (total particulate matter, TPM; particulate matter with an average size of 10 µm, PM_{10}; and particulate matter with an average size of 2.5 µm, $PM_{2.5}$), for construction and operation, and 19 metals for operation. The ambient air quality limits used in the 2018 ESIA and this assessment were from the Quebec ministry of environment and climate change (MELCC 2018), the Canadian Council of Ministers of the Environment (CCME 2021), and the World Health Organization (WHO 2005). The CAAQS are reference values for regional air quality management and are applicable to measured ambient concentrations at human receptor locations away from the industrial facility boundary. The maximum predicted concentrations from the Project are compared to the CAAQS in this context and do not imply compliance at the application boundary limit.

Air dispersion modelling results were presented at locations at and beyond a defined application boundary as well as at several sensitive receptors that fall into the categories of Cree Camp, traditional activity, valued area, and a local truck stop (km 381). The model predicted concentrations for construction phase were below the applicable ambient air quality limits/standards for all species except for the 1-hour NO_2 (CAAQS). The model predicted 1-hour NO_2 concentrations were greater than the 2020 CAAQS by 164% and 234% for 2025 CAAQS. The model predicted 1-hour NO_2 concentrations that were greater than the 2020 and 2025 CAAQS were limited in spatial area and not near sensitive receptors.

For operation phase, the model predicted concentration for all species/averaging period were below the applicable ambient air quality limits/standards except 24-hour TPM, 1-hour NO_2 (CAAQS), 1-hour crystalline silica and annual crystalline silica concentrations. The 24-hour TPM concentration limit was exceeded by 101% at a single location on the application boundary, for one 24-hour period over the 5-years modelled (~0.05% of the time). The model predicted 1-hour NO_2 (CAAQS) concentrations were greater than the CAAQS on the application domain and at the traditional activity sensitive receptors. The maximum 1-hour NO_2 (CAAQS) concentration exceeded the 2020 CAAQS by 196% and 280% for 2025

CAAQS. The 1-hour crystalline silica air quality limit was exceeded by 179% in the application domain (outside the defined application boundary), but not exceeded at any of the sensitive receptors. The annual crystalline silica air quality limit was exceeded by 435% in the application domain (outside of the defined application boundary), by 213% at the km 381 truck stop, and by 261% at location of traditional activity. The model predicted annual crystalline silica concentration was not greater than the standard at a location of Cree Camp or valued area.

As presented in the Dust Emissions Management Plan (provided as Appendix E), Galaxy is committed to implementing an ambient air quality monitoring program to assess the impact of mining activities on local air quality. Galaxy will monitor concentrations of TPM, PM_{10}, $PM_{2.5}$, and select metals, including crystalline silica, to determine compliance with applicable ambient air quality limits. The location of the monitoring station will be submitted to MELCC for approval prior to installation. Its positioning will be nearby the truck stop at km 381, a nearby sensitive receptor in which human exposure may occur. After a year of monitoring results are collected, the frequency and number of contaminants monitored may be adjusted if necessary, under approval by MELCC. Results from the monitoring program will be provided to the MELCC and follow-up actions will be implemented as deemed necessary.

8.0 CLOSING

This report has been prepared by Stantec Consulting Ltd. with the input and assistance of Galaxy for the sole benefit of Galaxy. The report may not be relied upon by any other person, entity, other than for its intended purposes, without the express written consent of Stantec Consulting Ltd. And Galaxy.

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APPENDIX A

Emission Source Parameters and Emission Rates

Construction Source Parameters and Emission Rates

Table A.1.1 Source Parameters for Propane Stacks during Construction

Source ID	Description	Source Type	Release Orientation	X-Coordinate (m)	Y-Coordinate (m)	Release Height (m)	Temperature (K)	Exit Velocity (m/s)	Release Diameter (m)	Operational Hours per day
PT34	Construction camp dorm 1	Point	Vertical	359131.7	5790347.1	3.6	303.2	5.1	0.13	24
PT35	Construction camp dorm 2	Point	Vertical	359121.4	5790362.8	3.6	303.2	5.1	0.13	24
PT36	Operations camp dorm 1	Point	Vertical	359109.8	5790378.4	3.6	303.2	5.1	0.15	24
PT37	Operation camp dorm 2	Point	Vertical	359099.3	5790393.8	3.6	303.2	5.1	0.15	24
PT38	Operation camp dorm 3	Point	Vertical	359087.9	5790409.5	3.6	303.2	5.1	0.15	24
PT39	Operation camp dorm 4	Point	Vertical	359078.4	5790426.7	3.6	303.2	5.1	0.15	24
PT40	Operation camp dorm 5	Point	Vertical	359067.7	5790442.0	3.6	303.2	5.1	0.15	24
PT41	Camp cafeteria	Point	Vertical	359032.6	5790451.2	3.6	303.2	5.1	0.26	24
PT42	Construction camp offices	Point	Vertical	358994.2	5790426.0	3.6	303.2	5.1	0.04	24
PT43	Construction camp laundry	Point	Vertical	359062.5	5790389.9	3.6	303.2	5.1	0.15	24
PT44	Construction camp medical	Point	Vertical	359020.0	5790429.9	3.6	303.2	5.1	0.04	24

Table A.1.2 Emission Rates for Propane Stacks during Construction

Source ID	Description	Emission Rate (g/s)						
		TPM	PM_{10}	$PM_{2.5}$	SO_2	NOx	CO	VOCs
PT34	Construction camp dorm 1	1.00E-03	1.00E-03	1.00E-03	7.83E-05	1.86E-02	1.08E-02	1.43E-03
PT35	Construction camp dorm 2	1.00E-03	1.00E-03	1.00E-03	7.83E-05	1.86E-02	1.08E-02	1.43E-03
PT36	Operations camp dorm 1	1.26E-03	1.26E-03	1.26E-03	9.84E-05	2.34E-02	1.35E-02	1.80E-03
PT37	Operation camp dorm 2	1.26E-03	1.26E-03	1.26E-03	9.84E-05	2.34E-02	1.35E-02	1.80E-03
PT38	Operation camp dorm 3	1.26E-03	1.26E-03	1.26E-03	9.84E-05	2.34E-02	1.35E-02	1.80E-03
PT39	Operation camp dorm 4	1.26E-03	1.26E-03	1.26E-03	9.84E-05	2.34E-02	1.35E-02	1.80E-03
PT40	Operation camp dorm 5	1.26E-03	1.26E-03	1.26E-03	9.84E-05	2.34E-02	1.35E-02	1.80E-03
PT41	Camp cafeteria	4.01E-03	4.01E-03	4.01E-03	3.13E-04	7.45E-02	4.30E-02	5.73E-03
PT42	Construction camp offices	1.17E-04	1.17E-04	1.17E-04	9.11E-06	2.17E-03	1.25E-03	1.67E-04
PT43	Construction camp laundry	1.35E-03	1.35E-03	1.35E-03	1.06E-04	2.51E-02	1.45E-02	1.93E-03
PT44	Construction camp medical	9.33E-05	9.33E-05	9.33E-05	7.29E-06	1.73E-03	1.00E-03	1.33E-04

Table A.1.3 Source Parameters for Road Sources during Construction

Source ID	Description	Source Type	Total Length of Route Modelled (m)	X-Coordinate (m)	Y-Coordinate (m)	Release Height (m)	Sigma Y (m)	Sigma Z (m)	Operational Hours per day
CP1B2S	Center Pit Phase 1 (CP1) – Bench to Surface	Line-Volume	1170	Various – Refer to Figure B2-1		4.25	24.2	3.95	10
S2ORE	CP1 – Surface to Ore	Line-Volume	1685	Various – Refer to Figure B2-1		4.25	24.2	3.95	10
CP12EWR	CP1 – Surface to East Waste Rock	Line-Volume	1620	Various – Refer to Figure B2-1		4.25	24.2	3.95	10

Table A.1.4 Emission Rates for Unpaved Road Sources during Construction

Source ID	Description	Emission Rate Total (g/s)[1]					
		Summer[2]			Winter[2]		
		TPM	PM_{10}	$PM_{2.5}$	TPM	PM_{10}	$PM_{2.5}$
CP1B2S	Center Pit Phase 1 (CP1) – Bench to Surface	7.591	1.625	0.161	1.898	0.406	0.040
S2ORE	CP1 – Surface to Ore	0.925	0.198	0.020	0.231	0.049	0.005
CP12EWR	CP1 – Surface to East Waste Rock	10.151	2.173	0.216	2.538	0.543	0.054

Notes:
[1] Total emission rate presented only includes the fugitive road dust emissions. The modelled roads were the sum of fugitive road dust and exhaust particulates (presented in Table A.1.10)
[2] Control efficiency of 80% applied in the summer, control efficiency of 95% applied in the winter

Table A.1.5 Source Parameters and Emission Rates of Material Handling Sources during Construction

Source ID	Description	Source Type	X-Coordinate (m)	Y-Coordinate (m)	Release Height (m)	Sigma Y (m)	Sigma Z (m)	Emission Rate (g/s)[1]			Operational Hours per Day
								TPM	PM_{10}	$PM_{2.5}$	
UNLDROCK	Unloading of rock at ore location	Volume	358553.4	5790082.1	5	1.395	4.651	0.98	0.46	0.07	10
UNLDEWR	Unloading of waste at east dump	Volume	358823.3	5789556.7	5	1.395	4.651	2.95	1.39	0.21	10
UNLDSAND	Unloading of sand at ore location	Volume	358553.4	5790081.7	5	1.395	4.651	0.63	0.30	0.05	10
LDRKCP1B	Loading of rock at the central pit 1 bench	Volume	357809.7	5789557.7	5	1.395	1.395	0.98	0.46	0.07	10
LDSDCP1B	Loading of sand at the central pit 1 bench	Volume	357809.7	5789557.7	5	1.395	1.395	2.95	1.39	0.21	10
LDWRCP1B	Loading of waste rock at the central pit 1 bench	Volume	357809.7	5789557.7	5	1.395	1.395	0.63	0.30	0.05	10
LDCP	Loading at concrete plant	Volume	358562.5	5790139.4	5	1.395	1.395	0.058	0.027	0.004	10

[1] The emission rates presented correspond to the maximum wind speed (13.7 m/s). Material handling sources were modelled using hourly emission rate files corresponding to the hourly wind speeds.

Table A.1.6 Source Parameters and Emission Rates of Mobile Crushing and Screening Operations during Construction

Source ID	Description	Source Type	X-Coordinate (m)	Y-Coordinate (m)	Release Height (m)	Sigma Y (m)	Sigma Z (m)	Emission Rate (g/s)			Operational Hours per Day
								TPM	PM_{10}	$PM_{2.5}$	
CRUSH1	Crushing Unit 1	Volume	358480.7	5789962.0	2.4	1.72	2.23	0.093	0.042	0.008	10
CRUSH2	Crushing Unit 2	Volume	358488.0	5789953.0	2.4	1.72	2.23	0.093	0.042	0.008	10
SCREEN1	Screening Unit 1	Volume	358498.7	5789971.3	2.4	1.84	2.23	0.170	0.057	0.004	10
SCREEN2	Screening Unit 2	Volume	358506.5	5789962.0	2.4	1.84	2.23	0.170	0.057	0.004	10

Table A.1.7 Source Parameters and Emission Rates of Bulldozing during Construction

Source ID	Description	Source Type	X-Coordinate (m)	Y-Coordinate (m)	Release Height (m)	Sigma Y (m)	Sigma Z (m)	Emission Rate (g/s)			Operational Hours per Day
								TPM	PM_{10}	$PM_{2.5}$	
TRDOZ1	Track dozer 1	Volume	358367.1	5789958.1	2	0.814	1.86	0.098	0.014	0.010	10
WHDOZ1	Wheel dozer 1	Volume	358587.3	5790013.0	2	1.16	1.86	0.098	0.014	0.010	10
TRDOZ2	Track dozer 2	Volume	358400.3	5789926.6	2	0.814	1.86	0.098	0.014	0.010	10

Table A.1.8 Source Parameters and Emission Rates for Blasting during Construction

Source ID	Description	Source Type	X-Coordinate (m)	Y-Coordinate (m)	Release Height (m)	Sigma Y (m)	Sigma Z (m)	Hourly Emission Rate (g/s)[1]						Operational Hours per Day[2]
								TPM	PM_{10}	$PM_{2.5}$	CO	NOx	SO_2	
BLSTANFO	ANFO explosive (winter)	Volume	357756.3	5789594.7	5	15.81	4.651	19.16	9.96	0.57	389.7	91.70	0.69	1
BLSTANEM	AN emulsion explosive (summer)	Volume	357756.3	5789594.7	5	15.81	4.651	19.16	9.96	0.575	26.4	2.29	0.69	1

[1] Annual emission rates were scaled from hourly emission rates based on the number of blasts per week as a blast was modelled at 6:00 PM on Monday, Wednesday and Friday
[2] Assumed the blast detonation emissions last one hour

Table A.1.9 Source Parameters and Emission Rates for Drilling during Construction

Source ID	Description	Source Type	X-Coordinate (m)	Y-Coordinate (m)	Release Height (m)	Sigma Y (m)	Sigma Z (m)	Emission Rate (g/s)			Operational Hours per Day
								TPM	PM_{10}	$PM_{2.5}$	
PRDDRIL1	Production drill 1	Volume	357751.9	5789607.2	2.5	1.16279	2.32558	0.013	0.0067	0.0019	10
PREDRILL	Predrill 1	Volume	357737.4	5789592.7	2.5	1.16279	2.32558	0.013	0.0067	0.0019	10

Table A.1.10 Source Parameters and Emission Rates for Equipment Combustion Exhaust during Construction

Source ID	Description	Source Type	Release Orientation	X-Coordinate (m)	Y-Coordinate (m)	Release Height (m)	Temp. (K)	Exit Velocity (m/s)	Release Diameter (m)	Hourly Emission Rate (g/s)							Operational Hours per day
										TPM	PM_{10}	$PM_{2.5}$	CO	NOx	SO_2	VOCs	
Haul Truck[1]	Haul truck exhaust (per unit)	Modelled with Roads								1.53E-02	1.53E-02	1.48E-02	1.32E-01	3.62E-01	7.32E-04	4.57E-02	10
CRUSH1X	Mobile crusher 1 exhaust	Point	Vertical	358480.8	5789962.3	4.2	845.2	25	0.21	1.10E-02	1.10E-02	1.06E-02	4.81E-02	1.25E-01	2.42E-04	8.95E-03	10
CPLDEX	Concrete plant loader exhaust	Point	Vertical	358562.2	5790139.7	3.9	756.5	15.7	0.28	1.83E-02	1.83E-02	1.77E-02	9.95E-02	1.76E-01	3.30E-04	1.27E-02	10
CRUSH2X	Mobile crusher 2 exhaust	Point	Vertical	358487.8	5789953.2	4.2	845.2	25	0.21	1.10E-02	1.10E-02	1.06E-02	4.81E-02	1.25E-01	2.42E-04	8.95E-03	10
SCRN1X	Mobile screen 1 exhaust	Point	Horizontal	358498.7	5789971.5	3.4	716.2	25	0.21	5.94E-03	5.94E-03	5.76E-03	2.31E-02	6.77E-02	1.31E-04	5.34E-03	10
SCRN2X	Mobile screen 2 exhaust	Point	Horizontal	358506.5	5789961.8	3.4	716.2	25	0.21	5.94E-03	5.94E-03	5.76E-03	2.31E-02	6.77E-02	1.31E-04	5.34E-03	10
TRDOZ1X	Track dozer 1 exhaust	Point	Vertical	358367.0	5789958.0	3.4	678.7	25	0.21	2.35E-02	2.35E-02	2.28E-02	1.07E-01	1.89E-01	3.52E-04	1.37E-02	10
TRDOZ2X	Track dozer 2 exhaust	Point	Vertical	358400.2	5789926.5	3.4	678.7	25	0.21	2.35E-02	2.35E-02	2.28E-02	1.07E-01	1.89E-01	3.52E-04	1.37E-02	10
WHDZ1X	Wheel dozer exhaust	Point	Vertical	358587.1	5790013.1	4.8	723.15	25	0.4	2.64E-02	2.64E-02	2.56E-02	1.21E-01	2.13E-01	3.96E-04	1.54E-02	10
PRODRILX	Production drill 1 exhaust	Point	Vertical	357737.6	5789592.7	2.8	755.4	25	0.31	8.58E-03	8.58E-03	8.32E-03	3.76E-02	9.78E-02	1.89E-04	7.01E-03	10
PREDRLX	Predrill 1 exhaust	Point	Vertical	357752.0	5789607.4	2.8	755.4	25	0.31	8.58E-03	8.58E-03	8.32E-03	3.76E-02	9.78E-02	1.89E-04	7.01E-03	10
WHLDR1X	Wheel loader 1 exhaust	Point	Vertical	357809.7	5789557.8	3.5	755.4	11.9	0.2	5.55E-04	5.55E-04	5.39E-04	3.54E-03	1.03E-01	2.00E-04	5.82E-03	10
G100EXH1	Generator 100 kw	Point	Horizontal	358575.2	5790108.8	1.5	755.4	25	0.1	3.44E-02	3.44E-02	3.34E-02	1.26E-01	3.19E-01	6.17E-04	2.51E-02	10
G500EXH	500 kw exhaust	Point	Horizontal	358589.6	5790088.1	1.7	788.2	25	0.2	1.07E-01	1.07E-01	1.04E-01	9.67E-01	1.60E+00	3.09E-03	1.14E-01	10
TRCKEXH	Router truck exhaust	Point	Vertical	358562.2	5790139.7	3	755.4	33.9	0.11	1.05E-03	1.05E-03	1.02E-03	7.53E-03	1.96E-01	2.72E-04	1.11E-02	10
GRDR1X	Mobile grader exhaust	Point	Vertical	358655.5	5790138.9	3.3	723.15	25	0.3	1.56E-02	1.56E-02	1.52E-02	6.34E-02	1.26E-01	2.35E-04	1.00E-02	10

[1] Haul road exhaust emissions have been modelled with the haul road routes

Table A.1.11 Source Parameters and Emission Rates for Storage Piles during Construction

Source ID	Description	Source Type	X-Coordinate (m)	Y-Coordinate (m)	Release Height (m)	Source Surface Area (m^2)	Emission Rate (g/s)[1]			Operational Hours per Day[1]
							TPM	PM_{10}	$PM_{2.5}$	
WESTWR	Stripped surface of the west waste rock pile	Area	Various – Refer to Figure B2-1		10	299,050	8.52E-01	4.26E-01	1.70E-01	Dependent on Windspeed
EASTWR	East waste rock pile (in-use)	Area	Various – Refer to Figure B2-1		40	365,537	5.14E-01	2.57E-01	1.03E-01	Dependent on Windspeed
CRSHROCK	crushed rock	Area	Various – Refer to Figure B2-1		1.4	28,500	3.41E+01	1.71E+01	6.82E+00	Dependent on Windspeed
CRSHSAND	crushed sand stockpile	Area	Various – Refer to Figure B2-1		1.4	13,000	1.11E+01	5.56E+00	2.22E+00	Dependent on Windspeed

[1]The emission rate is zero when the wind speed is less than 19.3 km/h

Table A.1.12 Source Parameters and Emission Rates for Dust Collectors during Construction

Source ID	Description	Source Type	Release Orientation	X-Coordinate (m)	Y-Coordinate (m)	Release Height (m)	Temperature (K)	Exit Velocity (m/s)	Release Diameter (m)	Hourly Emission Rate (g/s)			Operational Hours per day
										TPM	PM_{10}	$PM_{2.5}$	
CPDC	Concrete plant dust collector	Point	Vertical	358484.1	5789991.3	5	Ambient	15	0.7	1.84E-01	1.39E-01	6.39E-02	10

Operation Phase Source Parameters and Emission Rates

Table A.2.1 Source Parameters for Propane Stacks during Operation

Source ID	Description	Source Type	Release Orientation	X-Coordinate (m)	Y-Coordinate (m)	Release Height (m)	Temperature (K)	Exit Velocity (m/s)	Release Diameter (m)	Operational Hours per day
PT20	Auxiliary heating of the crushing building	Point	Vertical	358650.9	5790082.3	16	303.2	5.1	0.23	24
PT21	Crushing building ventilation	Point	Vertical	358619.0	5790135.0	16	293.2	5.1	1.43	24
PT22	Auxiliary heating of the screening building	Point	Vertical	358633.2	5790104.4	14	303.2	5.1	0.17	24
PT23	Screening building ventilation	Point	Vertical	358635.0	5790105.9	14	293.2	5.1	1.43	24
PT24A	Auxiliary heating of the SMD building	Point	Vertical	358840.9	5790258.8	26	303.2	5.1	0.8	24
PT24B	Auxiliary heating of the SMD building	Point	Vertical	358809.7	5790240.7	26	303.2	5.1	0.8	24
PT24C	Auxiliary heating of the SMD building	Point	Vertical	358825.2	5790218.8	26	303.2	5.1	0.8	24
PT24D	Auxiliary heating of the SMD building	Point	Vertical	358853.3	5790240.5	26	303.2	5.1	0.8	24
PT25	SMD building ventilation	Point	Vertical	358805.0	5790246.2	26	293.2	5.1	1.43	24
PT26	Auxiliary heating of the concentrates building	Point	Vertical	358823.9	5790317.7	16	303.2	5.1	0.21	24
PT27	Auxiliary heating of the tailings building	Point	Vertical	358791.6	5790296.3	26	303.2	5.1	0.17	24
PT28	Auxiliary warehouse heating	Point	Vertical	358849.5	5790188.7	16	303.2	5.1	0.23	24
PT29	Warehouse building ventilation	Point	Vertical	358852.8	5790190.9	16	293.2	5.1	1.43	24
PT30	Auxiliary heating of the workshop building	Point	Vertical	358871.5	5790202.8	16	303.2	5.1	0.17	24
PT31	Workshop building ventilation	Point	Vertical	358868.3	5790200.6	16	293.2	5.1	1.43	24
PT32A	Auxiliary heating of the mining services building	Point	Vertical	358775.1	5790260.2	14	303.2	5.1	0.21	24
PT32B	Auxiliary heating of the mining services building	Point	Vertical	358761.1	5790252.1	14	303.2	5.1	0.21	24
PT32C	Auxiliary heating of the mining services building	Point	Vertical	358744.9	5790242.6	14	303.2	5.1	0.21	24
PT32D	Auxiliary heating of the mining services building	Point	Vertical	358723.3	5790228.6	14	303.2	5.1	0.21	24
PT33	Mining services building ventilation	Point	Vertical	358717.4	5790226.1	14	293.2	5.1	1.43	24
PT34	Construction camp dorm 1	Point	Vertical	359131.7	5790347.1	3.6	303.2	5.1	0.13	24
PT35	Construction camp dorm 2	Point	Vertical	359121.4	5790362.8	3.6	303.2	5.1	0.13	24
PT36	Operations camp dorm 1	Point	Vertical	359109.8	5790378.4	3.6	303.2	5.1	0.15	24
PT37	Operation camp dorm 2	Point	Vertical	359099.3	5790393.8	3.6	303.2	5.1	0.15	24
PT38	Operation camp dorm 3	Point	Vertical	359087.9	5790409.5	3.6	303.2	5.1	0.15	24
PT39	Operation camp dorm 4	Point	Vertical	359078.4	5790426.7	3.6	303.2	5.1	0.15	24
PT40	Operation camp dorm 5	Point	Vertical	359067.7	5790442.0	3.6	303.2	5.1	0.15	24
PT41	Camp cafeteria	Point	Vertical	359032.6	5790451.2	3.6	303.2	5.1	0.26	24
PT42	Construction camp offices	Point	Vertical	358994.2	5790426.0	3.6	303.2	5.1	0.04	24
PT43	Construction camp laundry	Point	Vertical	359062.5	5790389.9	3.6	303.2	5.1	0.15	24
PT44	Construction camp medical	Point	Vertical	359020.0	5790429.9	3.6	303.2	5.1	0.04	24
PT45	Admin Building	Point	Vertical	358890.5	5790231.5	3	303.2	5.1	0.09	24
PT46	Lab	Point	Vertical	358904.1	5790216.5	3	303.2	5.1	0.09	24

Table A.2.2 Emission Rates for Propane Sources During Operation

Source ID	Description	Emission Rate (g/s)						
		TPM	PM_{10}	$PM_{2.5}$	SO_2	NOx	CO	VOCs
PT20	Auxiliary heating of the crushing building	3.08E-03	3.08E-03	3.08E-03	2.40E-04	5.72E-02	3.30E-02	4.40E-03
PT21	Crushing building ventilation	1.17E-03	1.17E-03	1.17E-03	9.11E-05	2.17E-02	1.25E-02	1.67E-03
PT22	Auxiliary heating of the screening building	1.73E-03	1.73E-03	1.73E-03	1.35E-04	3.21E-02	1.85E-02	2.47E-03
PT23	Screening building ventilation	4.67E-04	4.67E-04	4.67E-04	3.64E-05	8.67E-03	5.00E-03	6.67E-04
PT24A,B,C,D	Auxiliary heating of the SMD building	3.76E-02	3.76E-02	3.76E-02	2.94E-03	6.99E-01	4.03E-01	5.38E-02
PT25	SMD building ventilation	3.48E-03	3.48E-03	3.48E-03	2.71E-04	6.46E-02	3.73E-02	4.97E-03
PT26	Auxiliary heating of the concentrates building	2.64E-03	2.64E-03	2.64E-03	2.06E-04	4.90E-02	2.83E-02	3.77E-03
PT27	Auxiliary heating of the tailings building	1.73E-03	1.73E-03	1.73E-03	1.35E-04	3.21E-02	1.85E-02	2.47E-03
PT28	Auxiliary warehouse heating	3.08E-03	3.08E-03	3.08E-03	2.40E-04	5.72E-02	3.30E-02	4.40E-03
PT29	Warehouse building ventilation	7.00E-04	7.00E-04	7.00E-04	5.47E-05	1.30E-02	7.50E-03	1.00E-03
PT30	Auxiliary heating of the workshop building	1.73E-03	1.73E-03	1.73E-03	1.35E-04	3.21E-02	1.85E-02	2.47E-03
PT31	Workshop building ventilation	2.33E-04	2.33E-04	2.33E-04	1.82E-05	4.33E-03	2.50E-03	3.33E-04
PT32A,B,C,D	Auxiliary heating of the mining services building	2.64E-03	2.64E-03	2.64E-03	2.06E-04	4.90E-02	2.83E-02	3.77E-03
PT33	Mining services building ventilation	2.54E-03	2.54E-03	2.54E-03	1.99E-04	4.72E-02	2.73E-02	3.63E-03
PT34	Construction camp dorm 1	1.00E-03	1.00E-03	1.00E-03	7.83E-05	1.86E-02	1.08E-02	1.43E-03
PT35	Construction camp dorm 2	1.00E-03	1.00E-03	1.00E-03	7.83E-05	1.86E-02	1.08E-02	1.43E-03
PT36	Operations camp dorm 1	1.26E-03	1.26E-03	1.26E-03	9.84E-05	2.34E-02	1.35E-02	1.80E-03
PT37	Operation camp dorm 2	1.26E-03	1.26E-03	1.26E-03	9.84E-05	2.34E-02	1.35E-02	1.80E-03
PT38	Operation camp dorm 3	1.26E-03	1.26E-03	1.26E-03	9.84E-05	2.34E-02	1.35E-02	1.80E-03
PT39	Operation camp dorm 4	1.26E-03	1.26E-03	1.26E-03	9.84E-05	2.34E-02	1.35E-02	1.80E-03
PT40	Operation camp dorm 5	1.26E-03	1.26E-03	1.26E-03	9.84E-05	2.34E-02	1.35E-02	1.80E-03
PT41	Camp cafeteria	4.01E-03	4.01E-03	4.01E-03	3.13E-04	7.45E-02	4.30E-02	5.73E-03
PT42	Construction camp offices	1.17E-04	1.17E-04	1.17E-04	9.11E-06	2.17E-03	1.25E-03	1.67E-04
PT43	Construction camp laundry	1.35E-03	1.35E-03	1.35E-03	1.06E-04	2.51E-02	1.45E-02	1.93E-03
PT44	Construction camp medical	9.33E-05	9.33E-05	9.33E-05	7.29E-06	1.73E-03	1.00E-03	1.33E-04
PT45	Admin Building	5.13E-04	5.13E-04	5.13E-04	4.01E-05	9.53E-03	5.50E-03	7.33E-04
PT46	Lab	4.43E-04	4.43E-04	4.43E-04	3.46E-05	8.23E-03	4.75E-03	6.33E-04

Table A.2.3 Source Parameters and Emission Rates for Dust Collectors During Operation

Source ID	Description	Source Type	Release Orientation	X-Coordinate (m)	Y-Coordinate (m)	Release Height (m)	Temperature (K)	Exit Velocity (m/s)	Release Diameter (m)	Hourly Emission Rate (g/s)			Operational Hours per day
										TPM	PM_{10}	$PM_{2.5}$	
PT01	Primary crusher dust collector	Point	Vertical	358623.0	5790132.4	6	Ambient	17.8	0.81	1.81E-01	1.71E-01	9.03E-02	24
PT02	Screen dust collector	Point	Vertical	358630.6	5790102.5	6	Point	17.8	0.55	8.60E-02	8.14E-02	4.29E-02	24
PT03	Feed tunnel dust collector	Point	Vertical	358737.9	5790178.7	6	Point	17.8	0.26	1.94E-02	1.84E-02	9.69E-03	24

Table A.2.4 Source Parameters for Routes During Operation

Source ID	Description	Source Type	Total Length of Route Modelled (m)	X-Coordinate (m) / Y-Coordinate (m)	Release Height (m)	Sigma Y (m)	Sigma Z (m)	Operational Hours per day
CP4B2S	Center Pit Phase 4 (CP4) bench to surface	Line-Volume	3027	Various – Refer to Figure B3-1	4.25	24.2	3.95	24
CP4S2ORE	CP4 surface to ore	Line-Volume	939	Various – Refer to Figure B3-1	4.25	24.2	3.95	24
CP4S2EWE	CP4 surface to east dump extension	Line-Volume	2031	Various – Refer to Figure B3-1	4.25	24.2	3.95	24
EP1B2S	East Pit Phase 1 (EP1) bench to surface	Line-Volume	705	Various – Refer to Figure B3-1	4.25	24.2	3.95	24
EP1S2ORE	EP1 surface to ore	Line-Volume	1980	Various – Refer to Figure B3-1	4.25	24.2	3.95	24
EP1S2EWE	EP1 surface to east waste rock extension	Line-Volume	1758	Various – Refer to Figure B3-1	4.25	24.2	3.95	24
TAIL2EWE	Tailings to east waste dump extensions	Line-Volume	2221	Various – Refer to Figure B3-1	4.25	24.2	3.95	24
SHIPPING	On-site shipping route	Line-Volume	436	Various – Refer to Figure B3-1	4.76	14.88	2.21	12

Table A.2.5 Emission Rates for Unpaved Road Sources During Operation

Source ID	Description	Emission Rate Total (g/s)[1]					
		Summer[2]			Winter[2]		
		TPM	PM_{10}	$PM_{2.5}$	TPM	PM_{10}	$PM_{2.5}$
CP4B2S	Center Pit Phase 4 (CP4) bench to surface	9.84	2.11	0.21	2.46	0.53	0.05
CP4S2ORE	CP4 surface to ore	0.67	0.14	0.01	0.17	0.04	0.00
CP4S2EWE	CP4 surface to east dump extension	5.93	1.27	0.13	1.48	0.32	0.03
EP1B2S	East Pit Phase 1 (EP1) bench to surface	0.52	0.11	0.01	0.13	0.03	0.003
EP1S2ORE	EP1 surface to ore	0.58	0.12	0.01	0.14	0.03	0.003
EP1S2EWE	EP1 surface to east waste rock extension	0.95	0.2	0.02	0.24	0.05	0.01
TAIL2EWE	Tailings to east waste dump extensions	1.16	0.25	0.02	0.29	0.06	0.01
SHIPPING	On-site shipping route	0.38	0.081	0.0081	0.095	0.020	0.0020

Notes:
[1] Total emission rate presented only includes the fugitive road dust emissions. The modelled routes were the sum of fugitive road dust and exhaust particulates (presented in Table A.2.10)
[2] Control efficiency applied in the summer of 80%, control efficiency applied in the winter of 95%

Table A.2.6 Source Parameters and Emission Rates for Material Handling Sources During Operation

Source ID	Description	Source Type	X-Coordinate (m)	Y-Coordinate (m)	Release Height (m)	Sigma Y (m)	Sigma Z (m)	Emission Rate (g/s)[1]			Operational Hours per Day
								TPM	PM_{10}	$PM_{2.5}$	
UNLDROCK	Unloading of rock at ore location	Volume	358553.4	5790082.1	5	1.395	4.651	1.97	0.93	0.141	24
UNLDWR	Unloading of waste at east dump	Volume	359149.6	5789403.0	5	1.395	4.651	1.97	0.93	0.14	24
LDRKCP4B	Loading of rock at the central pit 4 bench	Volume	357761.6	5789660.1	5	1.395	1.395	1.97	0.930	0.14	24
LDRES	Loadout of residue (tailings)	Volume	358766.7	5790309.7	2.4	1.395	1.395	0.06	0.0283	0.004	24
LDCONC	Loading of concentrate product	Volume	358808.7	5790329.1	5	1.395	4.651	0.29	1.39E-01	2.11E-02	24
UNLDTAIL	Unloading of tailings residue at east dump	Volume	359149.3	5789404.6	5	1.163	2.326	0.06	2.83E-02	4.29E-03	24

[1] The emission rates presented correspond to the maximum wind speed (13.7 m/s). Material handling sources were modelled using hourly emission rate files corresponding to the hourly wind speeds.

Table A.2.7 Source Parameters and Emission Rates for Bulldozing During Operation

Source ID	Description	Source Type	X-Coordinate (m)	Y-Coordinate (m)	Release Height (m)	Sigma Y (m)	Sigma Z (m)	Emission Rate (g/s)			Operational Hours per Day
								TPM	PM_{10}	$PM_{2.5}$	
TRDOZ1	Track dozer 1	Volume	359149.6	5789376.2	2	0.814	1.86	0.098	0.014	0.010	24
WHDOZ1	Wheel dozer 1	Volume	357738.1	5789632.5	2	1.16	1.86	0.098	0.014	0.010	24
TRDOZ2	Track dozer 2	Volume	359150.2	5789431.5	2	0.814	1.86	0.098	0.014	0.010	24

Table A.2.8 Source Parameters and Emission Rates for Blasting During Operation

Source ID	Description	Source Type	X-Coordinate (m)	Y-Coordinate (m)	Release Height (m)	Sigma Y (m)	Sigma Z (m)	Hourly Emission Rate (g/s)[1]						Operational Hours per Day[2]
								TPM	PM_{10}	$PM_{2.5}$	CO	NOx	SO_2	
BLSTANFO	ANFO explosive (winter)	Volume	357756.3	5789594.7	5	11.72	4.651	7.82	4.06	0.23	214	50.4	0.38	1
BLSTANEM	AN emulsion explosive (summer)	Volume	357756.3	5789594.7	5	11.72	4.651	7.82	4.06	0.23	14.5	1.26	0.38	1

[1] Annual emission rates were scaled from hourly emission rates based on the number of blasts per week as a blast was modelled daily
[2] Assumed the blast detonation emissions last one hour

Table A.2.9 Source Parameters and Emission Rates for Drilling during Operation

Source ID	Description	Source Type	X-Coordinate (m)	Y-Coordinate (m)	Release Height (m)	Sigma Y (m)	Sigma Z (m)	Emission Rate (g/s)[1]			Operational Hours per Day
								TPM	PM_{10}	$PM_{2.5}$	
PRDDRIL1	Production drill 1	Volume	357640.13	5789657.00	2.5	1.1628	2.326	0.015	0.0079	0.0023	24
PRDDRIL2	Production drill 2	Volume	357653.19	5789643.63	2.5	1.1628	2.326	0.015	0.0079	0.0023	24
PREDRILL	Predrill 1	Volume	357625.60	5789642.47	2.5	1.1628	2.326	0.030	0.0157	0.0045	24

Table A.2.10 Source Parameters and Emission Rates for Equipment Combustion Exhaust During Operation

Source ID	Description	Source Type	Release Orientation	X-Coordinate (m)	Y-Coordinate (m)	Release Height (m)	Temp. (K)	Exit Velocity (m/s)	Release Diameter (m)	Hourly Emission Rate (g/s)							Operational Hours per day
										TPM	PM_{10}	$PM_{2.5}$	CO	NOx	SO_2	VOCs	
Haul Truck[1]	Haul truck exhaust (per unit)	Modelled with Roads								1.53E-02	1.53E-02	1.48E-02	1.32E-01	3.62E-01	7.32E-04	4.57E-02	24
TRDOZ1X	Track dozer 1 exhaust	Point	Vertical	359149.51	5789376.22	3.4	678.7	25	0.21	2.35E-02	2.35E-02	2.28E-02	1.07E-01	1.89E-01	3.52E-04	1.37E-02	24
TRDOZ2X	Track dozer 2 exhaust	Point	Vertical	359150.14	5789431.34	3.4	678.7	25	0.21	2.35E-02	2.35E-02	2.28E-02	1.07E-01	1.89E-01	3.52E-04	1.37E-02	24
WHDZ1X	Wheel dozer exhaust	Point	Vertical	357737.91	5789632.66	4.8	723.15	25	0.4	2.64E-02	2.64E-02	2.56E-02	1.21E-01	2.13E-01	3.96E-04	1.54E-02	24
PRODRIL1X	Production drill 1 exhaust	Point	Vertical	357640.44	5789656.91	2.8	755.4	25	0.31	8.58E-03	8.58E-03	8.32E-03	3.76E-02	9.78E-02	1.89E-04	7.01E-03	24
PRODRIL2X	Production drill 2 exhaust	Point	Vertical	357653.19	5789643.90	2.8	755.4	25	0.31	8.58E-03	8.58E-03	8.32E-03	3.76E-02	9.78E-02	1.89E-04	7.01E-03	24
PREDRLX	Predrill 1 exhaust	Point	Vertical	357625.53	5789642.56	2.8	755.4	25	0.31	8.58E-03	8.58E-03	8.32E-03	3.76E-02	9.78E-02	1.89E-04	7.01E-03	24
WHLDR1X	Wheel loader 1 exhaust	Point	Vertical	357761.66	5789660.20	3.5	755.4	11.9	0.2	5.55E-04	5.55E-04	5.39E-04	3.54E-03	1.03E-01	2.00E-04	5.82E-03	24

[1] Haul road exhaust emissions have been modelled with the haul road routes

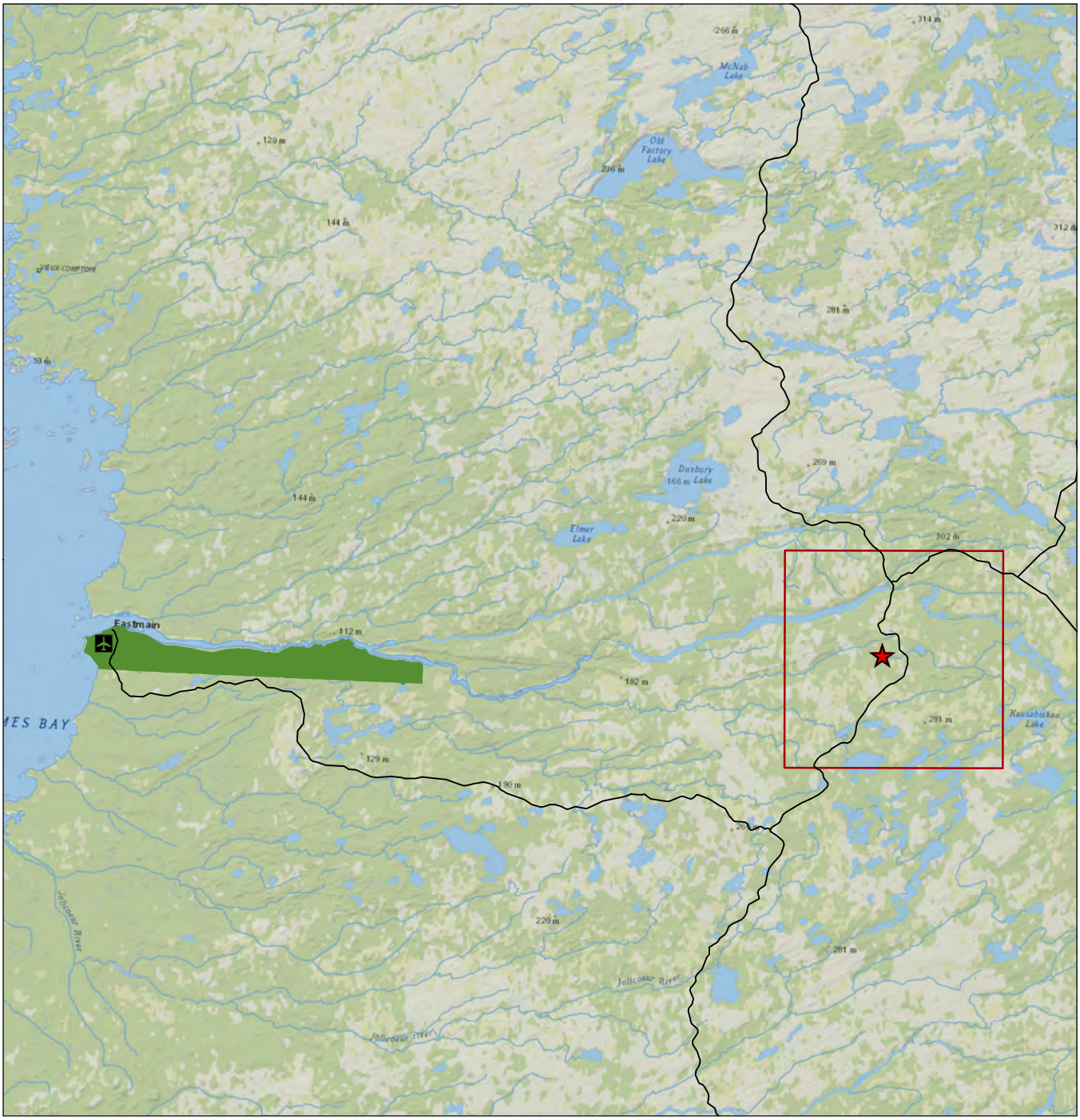
Table A.2.11 Source Parameters and Emission Rates for Storage Piles During Operation

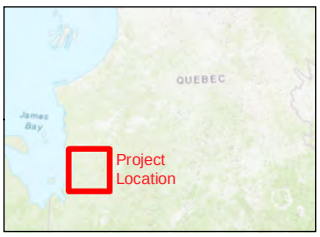
Source ID	Description	Source Type	X-Coordinate (m)	Y-Coordinate (m)	Release Height (m)	Source Surface Area (m^2)	Emission Rate (g/s)[1]			Operational Hours per Day
							TPM	PM_{10}	$PM_{2.5}$	
STHWSTWR	Southwest waste rock (covered)	Area	Various – Refer to Figure B3-1		60	310,314	2.36E+00	1.180E+00	4.72E-01	Dependent on Windspeed
WESTWR	West waste rock (covered)	Area	Various – Refer to Figure B3-1		47	299,050	2.27E+00	1.137E+00	4.55E-01	Dependent on Windspeed
NRTESTWR	North east waste rock dump (covered)	Area	Various – Refer to Figure B3-1		80	568,662	4.33E+00	2.163E+00	8.65E-01	Dependent on Windspeed
EASTWR	East waste rock (covered)	Area	Various – Refer to Figure B3-1		75	365,875	2.74E+00	1.371E+00	5.48E-01	Dependent on Windspeed
WR_ACTIVE	East extension waste rock (active working area)	Area	Various – Refer to Figure B3-1		75	5,041	1.52E-01	7.606E-02	3.04E-02	Dependent on Windspeed
ROMPAD	Rompad stockpile	Area	Various – Refer to Figure B3-1		4.15	1,781	5.42E-02	2.709E-02	1.08E-02	Dependent on Windspeed
PRIMORE	Primary ore stockpile	Area	Various – Refer to Figure B3-1		20.5	1,991	6.06E-02	3.029E-02	1.21E-02	Dependent on Windspeed
CONCSTOCK	Ffinal concentrate stock piles	Area	Various – Refer to Figure B3-1		2	1,536	4.56E-02	2.282E-02	9.13E-03	Dependent on Windspeed

[1]The emission rate is zero when the wind speed is less than 19.3 km/h

APPENDIX B

Figures





- James Bay Lithium Mine
- Modelling Domain
- Cree and Naskapi Category 1A and 1A-N Land
- Airport

0 9,500 19,000 metres

N

Stantec

Project Location

Quebec, Canada

Client/Project 121416913_001

James Bay Lithium Mine
Atmospheric Dispersion Modelling Study

Figure No.

B1-1

Title

Location of Modelling Domain

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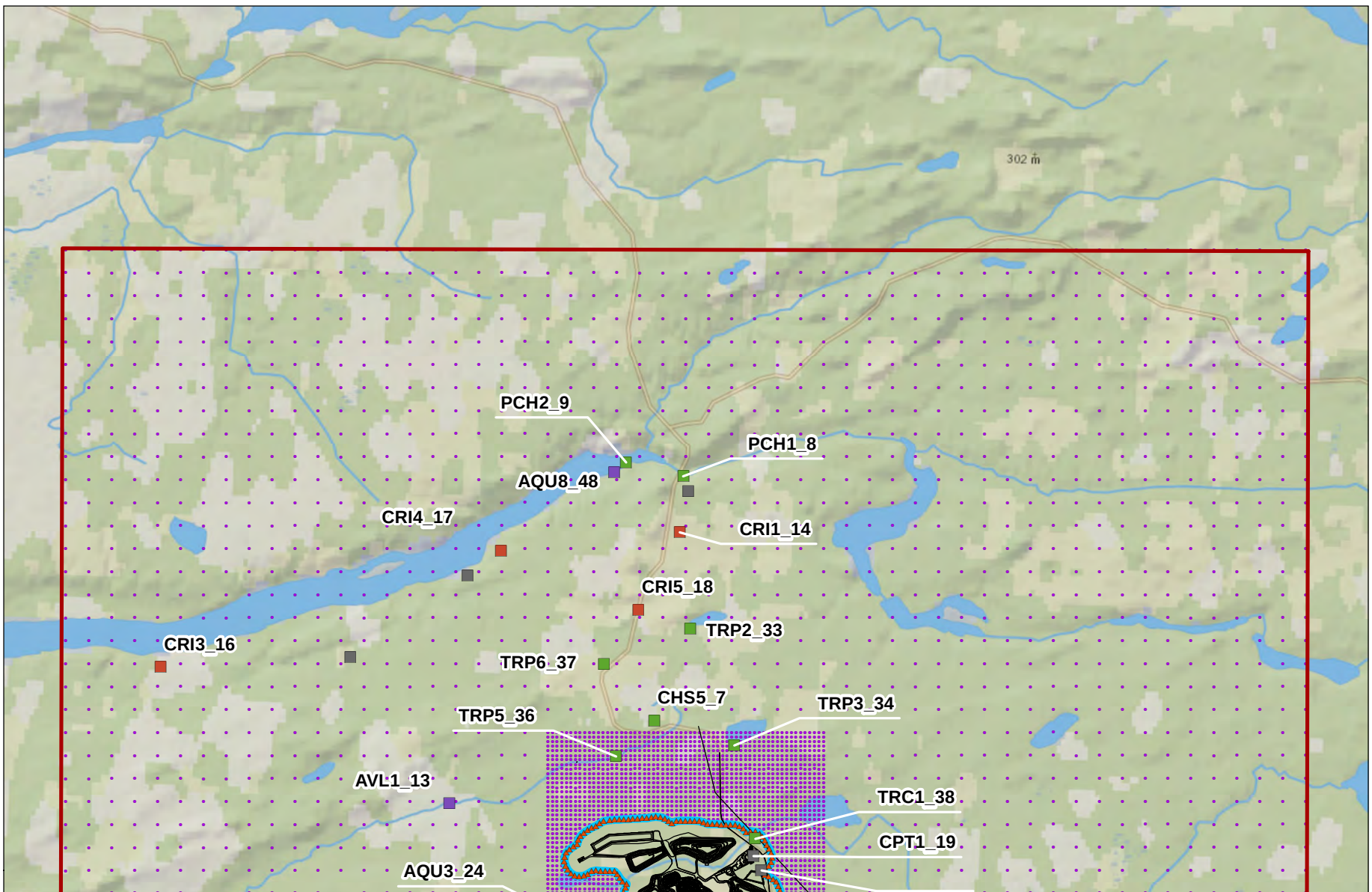

Notes
1. Coordinate System: NAD 1983 UTM Zone 18N
2. Data Sources:
3. Background: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

- Receptors on the Application Limit for Standards and Criteria
- Grid Receptors

Discrete Receptors

- Valued Area
- Traditional Activity
- Cree Camp
- Road Relay
- Not Considered

- Site Plan
- Application Limit for Standards and Criteria
- Modelling Domain

0 2,300 4,600 metres

N

Stantec

Project Location
Quebec, Canada

Client/Project 121416913_002

James Bay Lithium Mine
Atmospheric Dispersion Modelling Study

Figure No.
B1-2

Title
Location of Modeled Receptors

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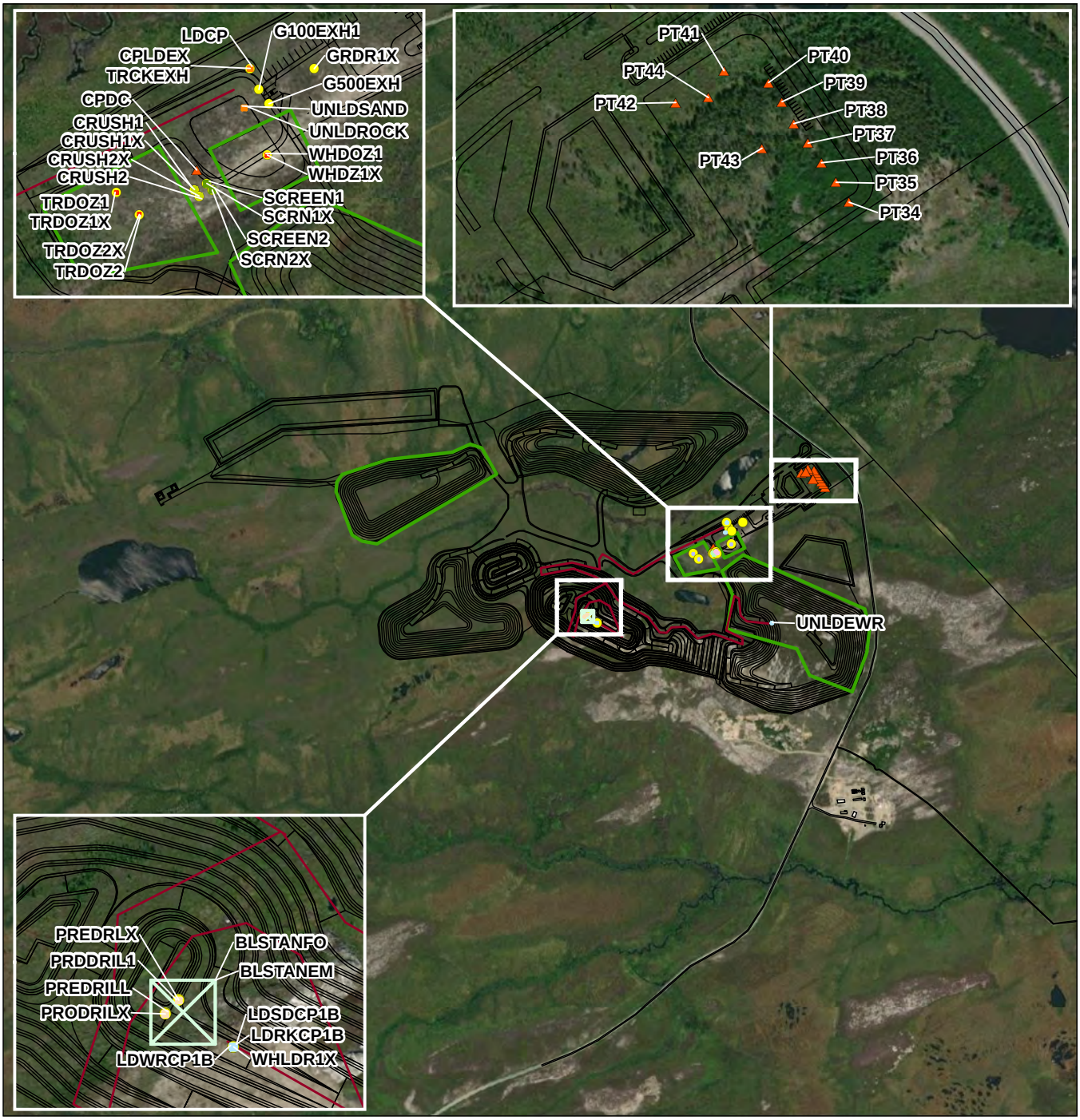

Emission Source

- Exhaust Gas
- Processing Plant
- Blasting
- Dozing
- Drilling
- Material Handling
- Mobile Crusher
- Mobile Screening
- Line Source
- Area Source

Site Plan

0 440 880 metres

N

Stantec

Project Location
Quebec, Canada

Client/Project 121416913_003
James Bay Lithium Mine
Atmospheric Dispersion Modelling Study

Figure No.
B2-1

Title
Modelled Emission Sources
Construction Phase

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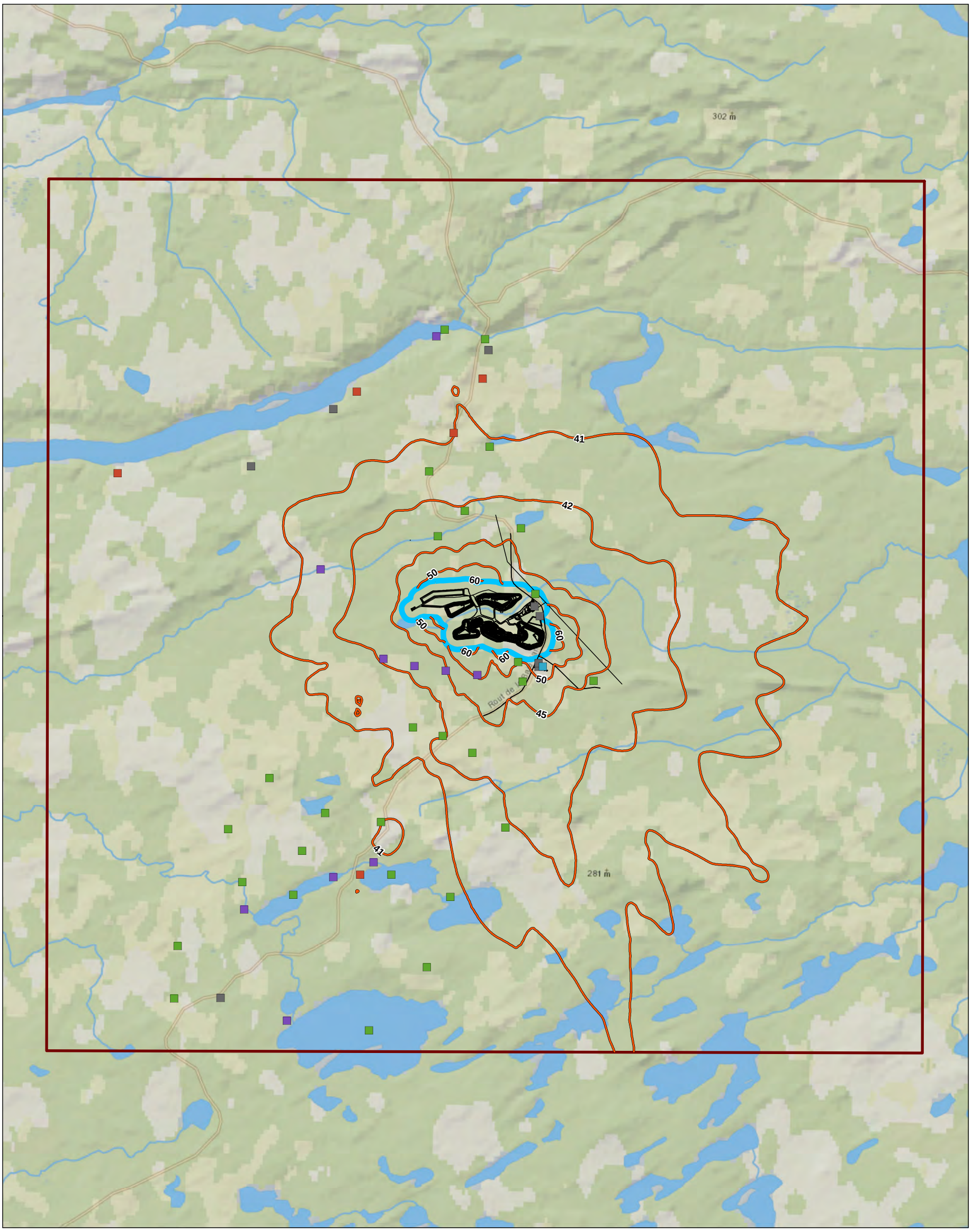

Notes
1. Coordinate System: NAD 1983 UTM Zone 18N
2. Data Sources:
3. Background: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

Maximum Predicted 24-hour TPM Concentration - Construction Phase (Including Initial Concentration)

Discrete Receptors
- Valued Area
- Traditional Activity
- Cree Camp
- Road Relay
- Not Considered

Site Plan
Application Limit for Standards and Criteria
Modelling Domain

0 2,000 4,000 metres

N

Stantec

Project Location
Quebec, Canada

Client/Project 121416913_007f
James Bay Lithium Mine
Atmospheric Dispersion Modelling Study

Figure No.
B2-2

Title
Maximum Predicted 24-hour TPM Concentration - Construction Phase (Including Initial Concentration)
Maximum Value = 77.5 µg/m^3
Limit = 120 µg/m^3
Initial Concentration = 40 µg/m^3

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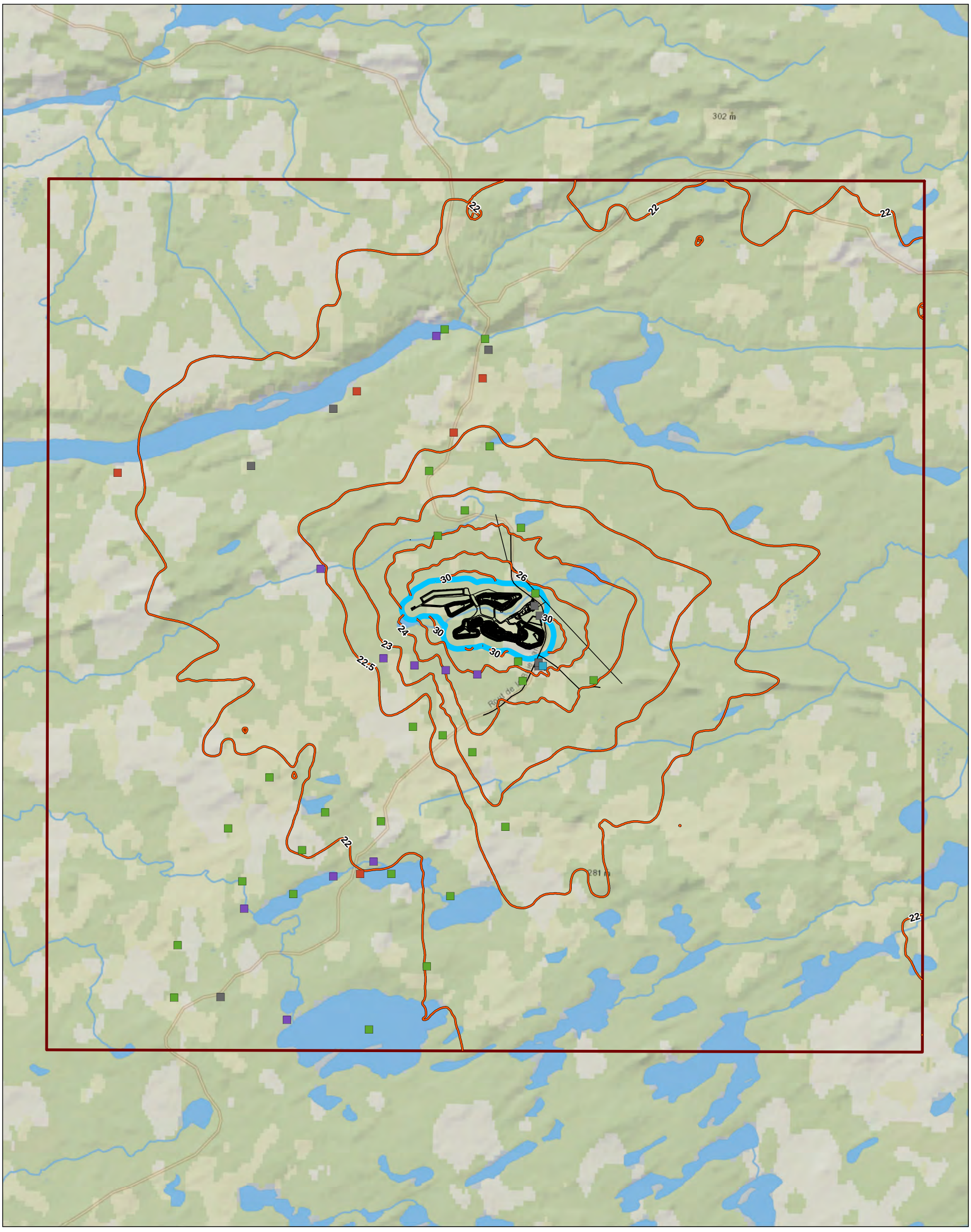

Maximum Predicted 99% 24-hour PM_{10} Concentration - Construction Phase (Including Initial Concentration)

Discrete Receptors

- Valued Area
- Traditional Activity
- Cree Camp
- Road Relay
- Not Considered

- Site Plan
- Application Limit for Standards and Criteria
- Modelling Domain

0 2,000 4,000 metres

N

Stantec

Project Location

Quebec, Canada

Client/Project 121416913_007e

James Bay Lithium Mine
Atmospheric Dispersion Modelling Study

Figure No.

B2-3

Title

Maximum Predicted 99% 24-hour PM_{10} Concentration - Construction Phase (Including Initial Concentration)
Maximum Value = 38.4 µg/m^3
Limit Value = 50 µg/m^3
Initial Concentration = 21.8 µg/m^3

Notes
1. Coordinate System: NAD 1983 UTM Zone 18N
2. Data Sources:
3. Background: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community
National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

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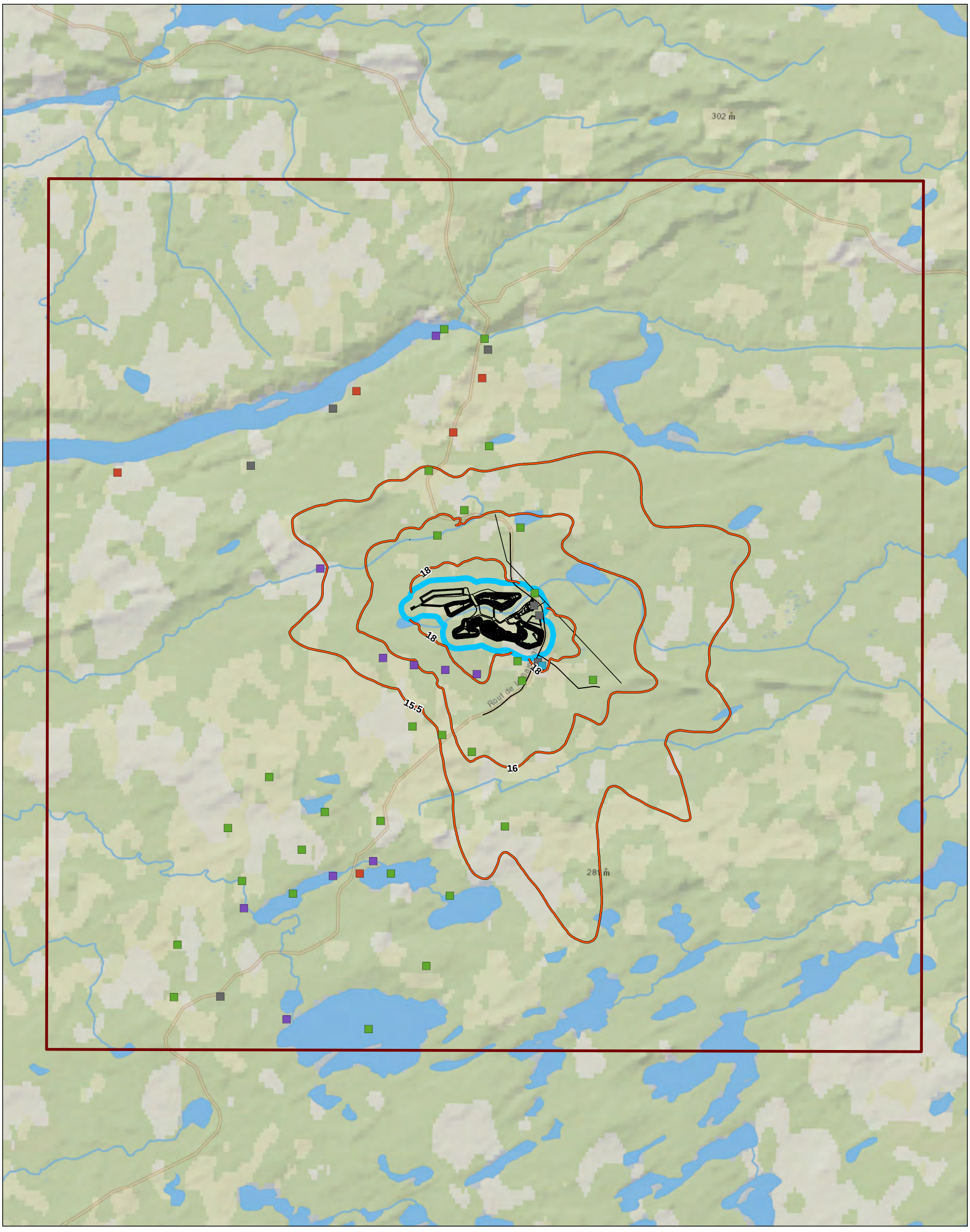

Notes
1. Coordinate System: NAD 1983 UTM Zone 18N
2. Data Sources:
3. Background: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community
National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

- Maximum Predicted 24-hour $PM_{2.5}$ Concentration - Construction Phase (Including Initial Concentration)

Discrete Receptors
- Valued Area
- Traditional Activity
- Cree Camp
- Road Relay
- Not Considered

- Site Plan
- Application Limit for Standards and Criteria
- Modelling Domain

0 2,000 4,000 metres

N

Stantec

Project Location
Quebec, Canada

Client/Project 121416913_007h
James Bay Lithium Mine
Atmospheric Dispersion Modelling Study

Figure No.
B2-4

Title
Maximum Predicted 24-hour $PM_{2.5}$ Concentration - Construction Phase (Including Initial Concentration)
Maximum Value = 27.7 µg/m^3
Limit Value = 30 µg/m^3
Initial Concentration = 15 µg/m^3

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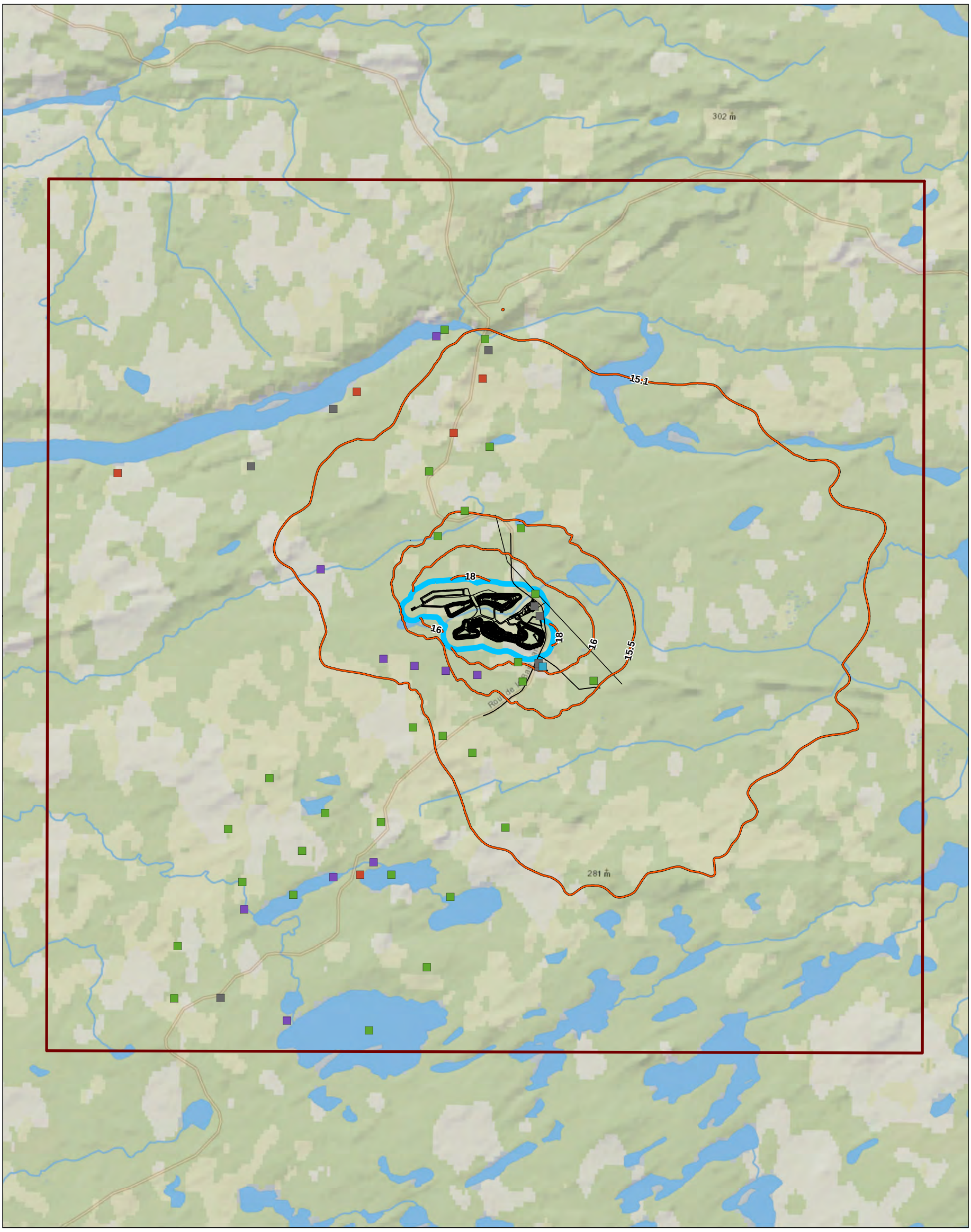

Notes
1. Coordinate System: NAD 1983 UTM Zone 18N
2. Data Sources:
3. Background: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

- Maximum Predicted 24-hour $PM_{2.5}$ Concentration (CAAQS) - Construction Phase (Including Initial Concentration)

Discrete Receptors
- Valued Area
- Traditional
- Cree Camp
- Road Relay
- Not Considered

- Site Plan
- Application Limit for Standards and Criteria
- Modelling Domain

0 2,000 4,000 metres

N

Stantec

Project Location
Quebec, Canada

Client/Project 121416913_007i
James Bay Lithium Mine
Atmospheric Dispersion Modelling Study

Figure No.
B2-5

Title
Maximum Predicted 24-hour $PM_{2.5}$ Concentration (CAAQS) - Construction Phase (Including Initial Concentration)
Maximum Value = 19.3 µg/m^3
CAAQS = 27 µg/m^3
Initial Concentration = 15 µg/m^3

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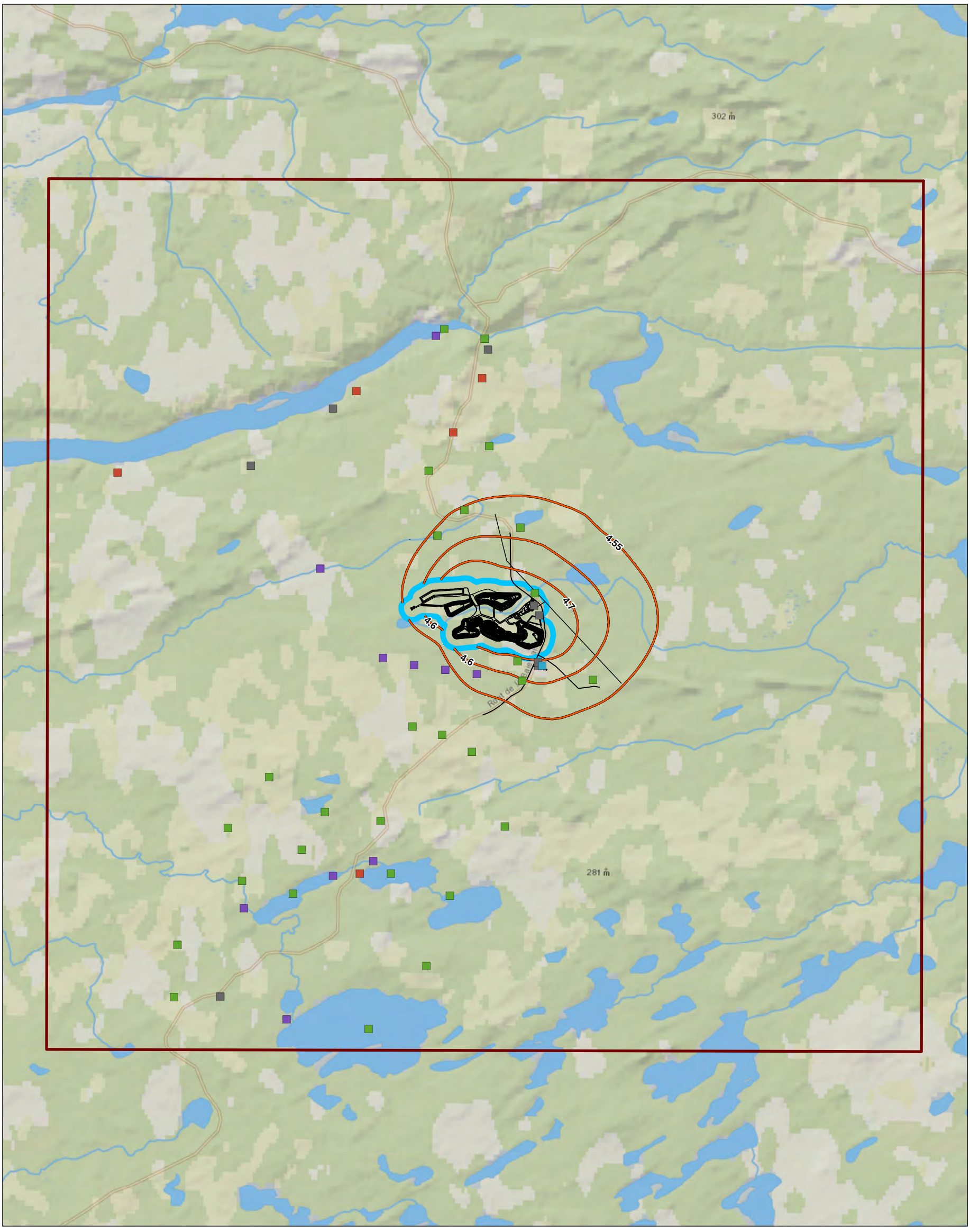

Notes
1. Coordinate System: NAD 1983 UTM Zone 18N
2. Data Sources:
3. Background: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

Maximum Predicted Annual $PM_{2.5}$ Concentration (CAAQS) - Construction Phase (Including Initial Concentration)

Discrete Receptors
- Valued Area
- Traditional Activity
- Cree Camp
- Road Relay
- Not Considered

Site Plan
Application Limit for Standards and Criteria
Modelling Domain

0 2,000 4,000 metres

N

Stantec

Project Location
Quebec, Canada

Client/Project 121416913_007j
James Bay Lithium Mine
Atmospheric Dispersion Modelling Study

Figure No.
B2-6

Title
Maximum Predicted Annual $PM_{2.5}$ Concentration (CAAQS) - Construction Phase (Including Initial Concentration)
Maximum Value = 5.27 µg/m^3
CAAQS = 8.8 µg/m^3
Initial Concentration = 4.5 µg/m^3

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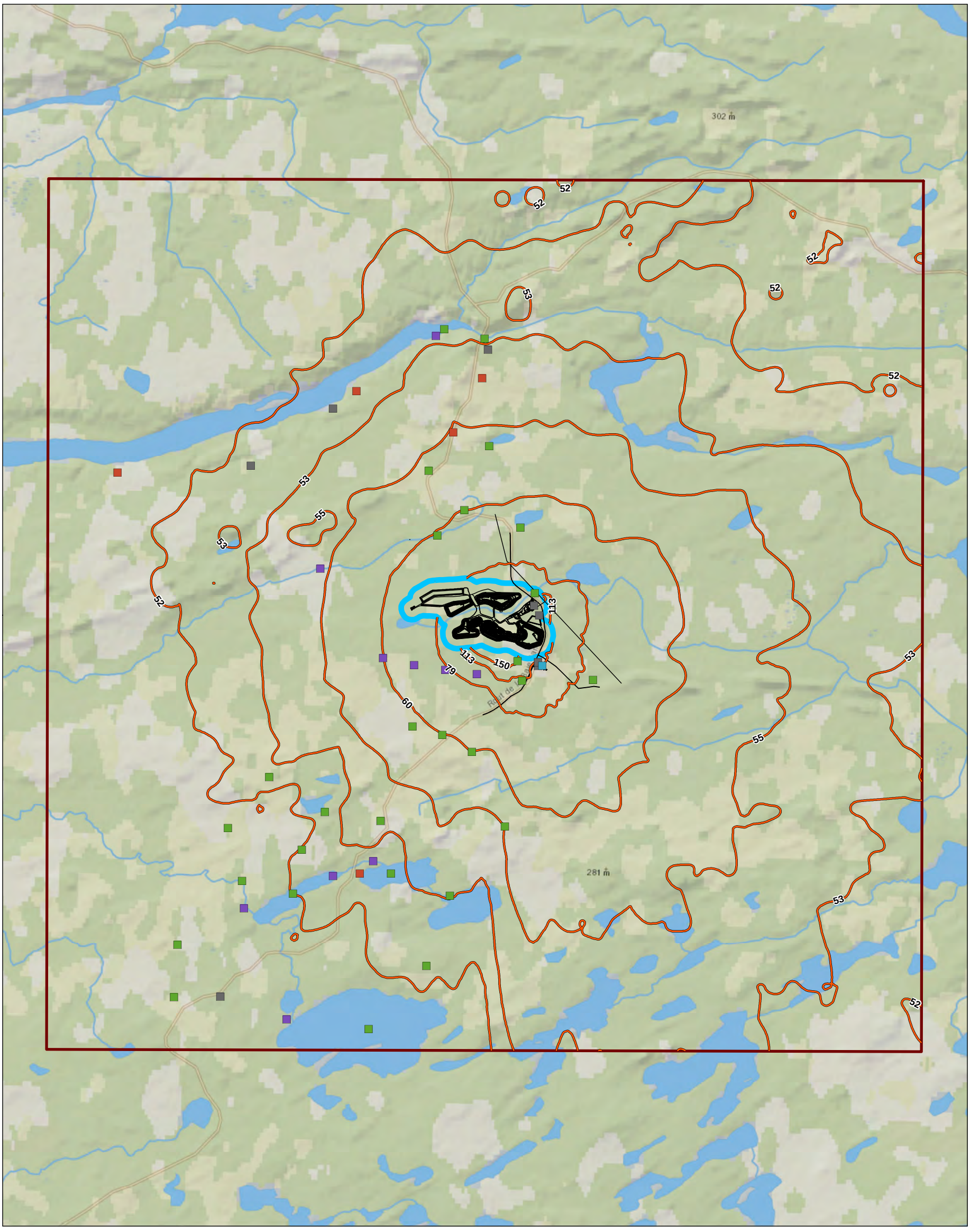

Notes
1. Coordinate System: NAD 1983 UTM Zone 18N
2. Data Sources:
3. Background: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

- Maximum Predicted 98% Daily 1-hour NO_2 Concentration - Construction Phase (Including Initial Concentration)

Discrete Receptors
- Valued Area
- Traditional Activity
- Cree Camp
- Road Relay
- Not Considered

- Site Plan
- Application Limit for Standards and Criteria
- Modelling Domain

0 2,000 4,000 metres

N

Stantec

Project Location
Quebec, Canada

Client/Project 121416913_007e
James Bay Lithium Mine
Atmospheric Dispersion Modelling Study

Figure No.
B2-7

Title
Maximum Predicted 98% Daily 1-hour NO_2 Concentration - Construction Phase (Including Initial Concentration)
Maximum Value = 185 µg/m^3
CAAQS = 113 µg/m^3 (2020) and 79 µg/m^3 (2025)
Initial Concentration = 50 µg/m^3

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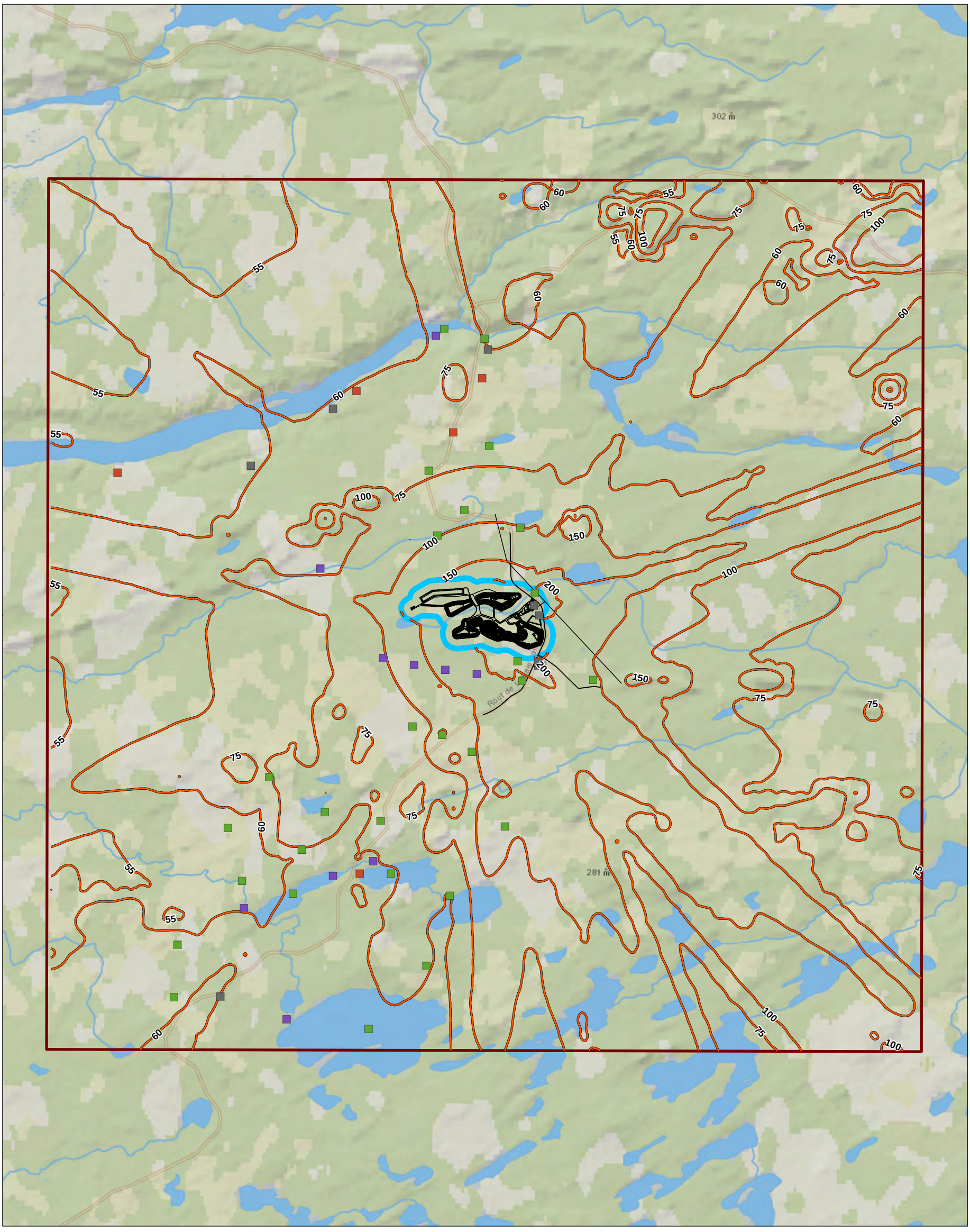

Notes
1. Coordinate System: NAD 1983 UTM Zone 18N
2. Data Sources:
3. Background: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

Maximum Predicted 1-hour NO_2 Concentration - Construction Phase (Including Initial Concentration)

Discrete Receptors
- Valued Area
- Traditional Activity
- Cree Camp
- Road Relay
- Not Considered

Site Plan
Application Limit for Standards and Criteria
Modelling Domain

0 2,000 4,000 metres

N

Stantec

Project Location
Quebec, Canada

Client/Project 121416913_007e
James Bay Lithium Mine
Atmospheric Dispersion Modelling Study

Figure No.
B2-8

Title
Maximum Predicted 1-hour NO_2 Concentration - Construction Phase (Including Initial Concentration)
Maximum Value = 400 µg/m^3
Limit Value = 414 µg/m^3
Initial Concentration = 50 µg/m^3

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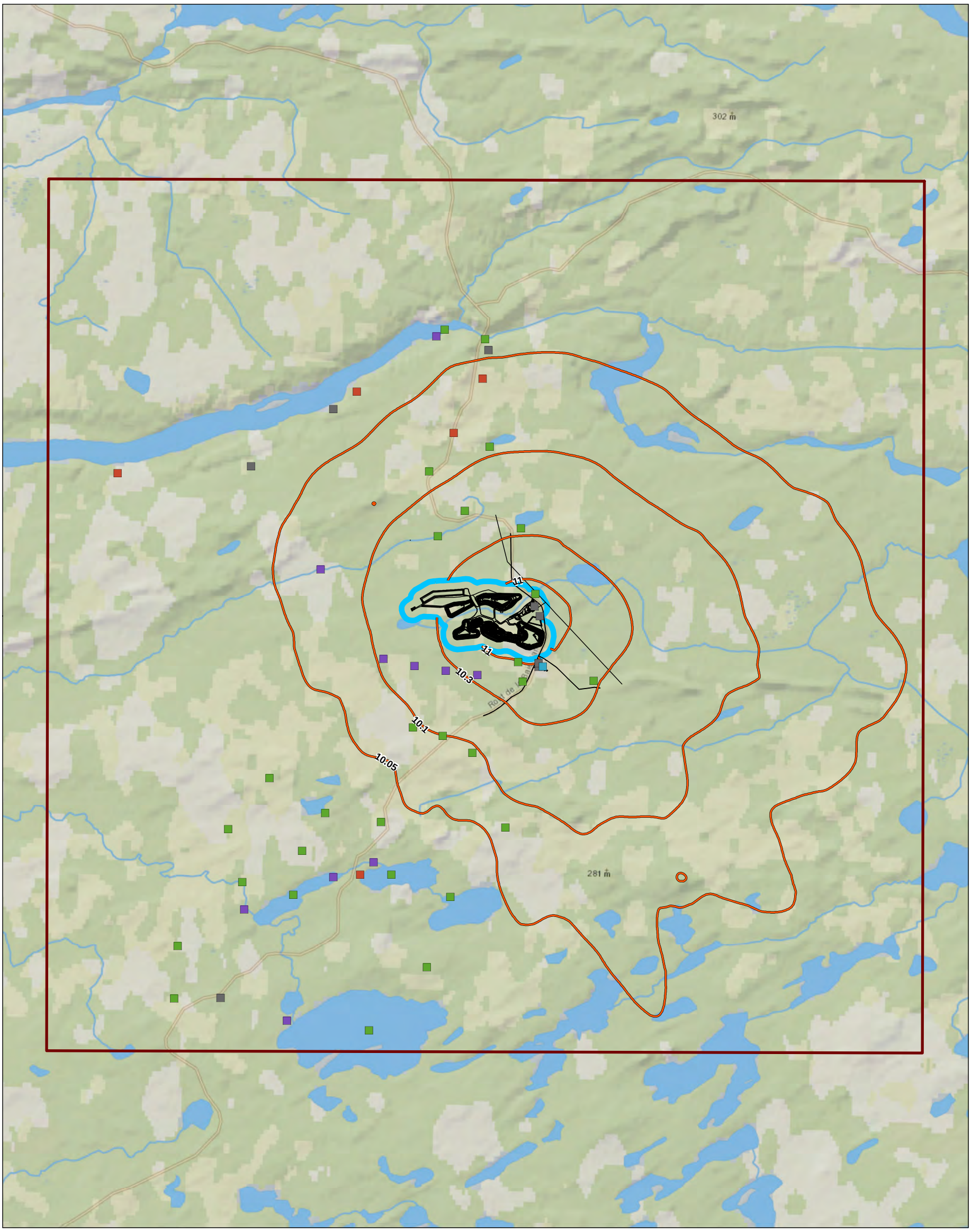

Notes
1. Coordinate System: NAD 1983 UTM Zone 18N
2. Data Sources:
3. Background: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

- Maximum Predicted Annual NO_2 Concentration (CAAQS) - Construction Phase (Including Initial Concentration)

Discrete Receptors

- Valued Area
- Traditional
- Cree Camp
- Road Relay
- Not Considered

- Site Plan
- Application Limit for Standards and Criteria
- Modelling Domain

0 2,000 4,000 metres

N

Stantec

Project Location
Quebec, Canada

Client/Project 121416913_007e
James Bay Lithium Mine
Atmospheric Dispersion Modelling Study

Figure No.
B2-9

Title
Maximum Predicted Annual NO_2 Concentration (CAAQS) - Construction Phase (Including Initial Concentration)
Maximum Value = 13.8 µg/m^3
CAAQS = 32 µg/m^3 (2020) and 23 µg/m^3 (2025)
Initial Concentration = 10 µg/m^3

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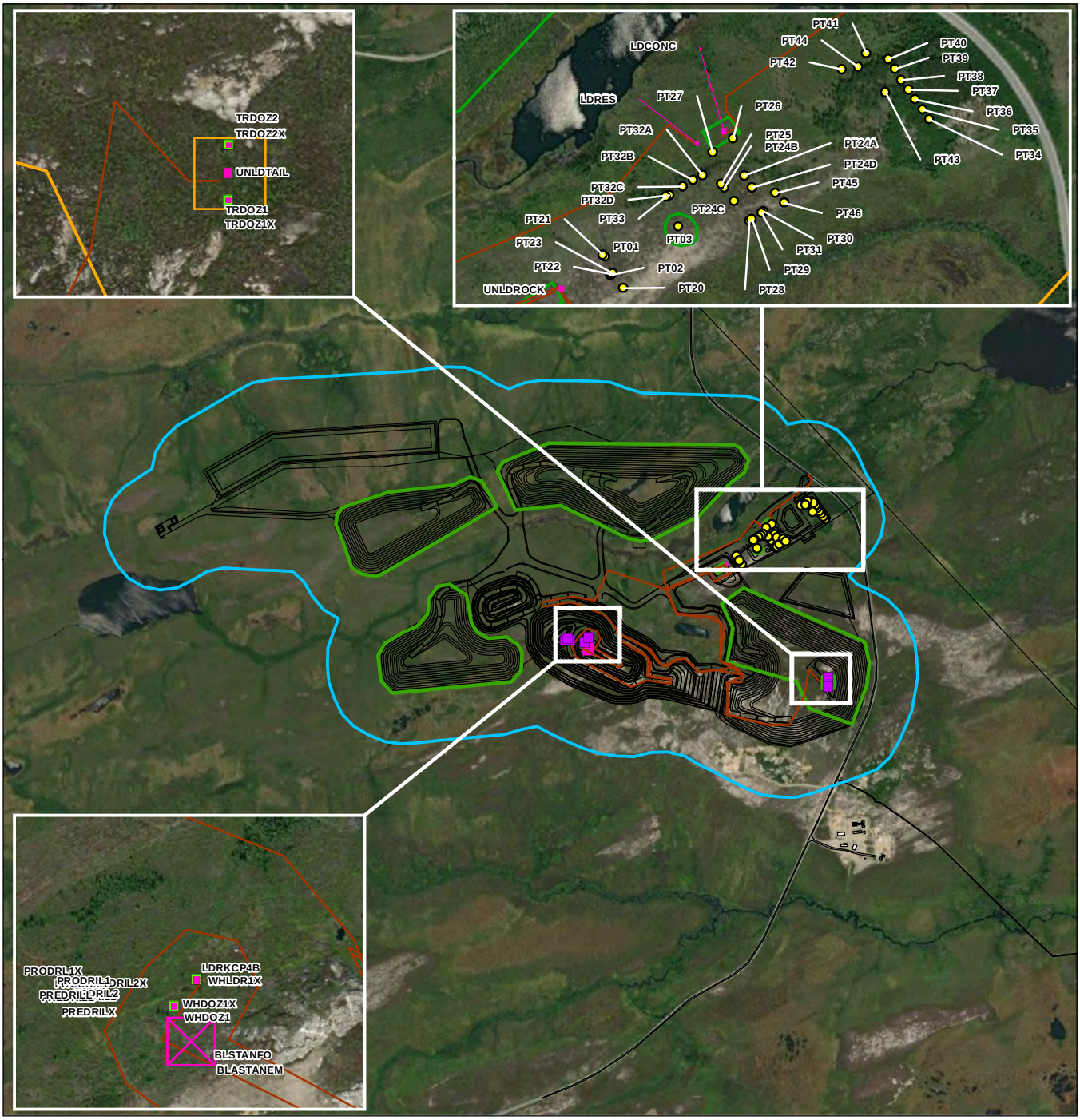

Emission Source

Point Source

- Exhaust Gas
- Processing Plant

Line Source (Road)

Area Source

VolumeSources

Application Limit for Standards and Criteria

Site Plan

0 440 880 metres

N

Stantec

Project Location

Quebec, Canada

Client/Project 121416913_004

James Bay Lithium Mine
Atmospheric Dispersion Modelling Study

Figure No.

B3-1

Title

Modelled Emission Sources
Operational Phase

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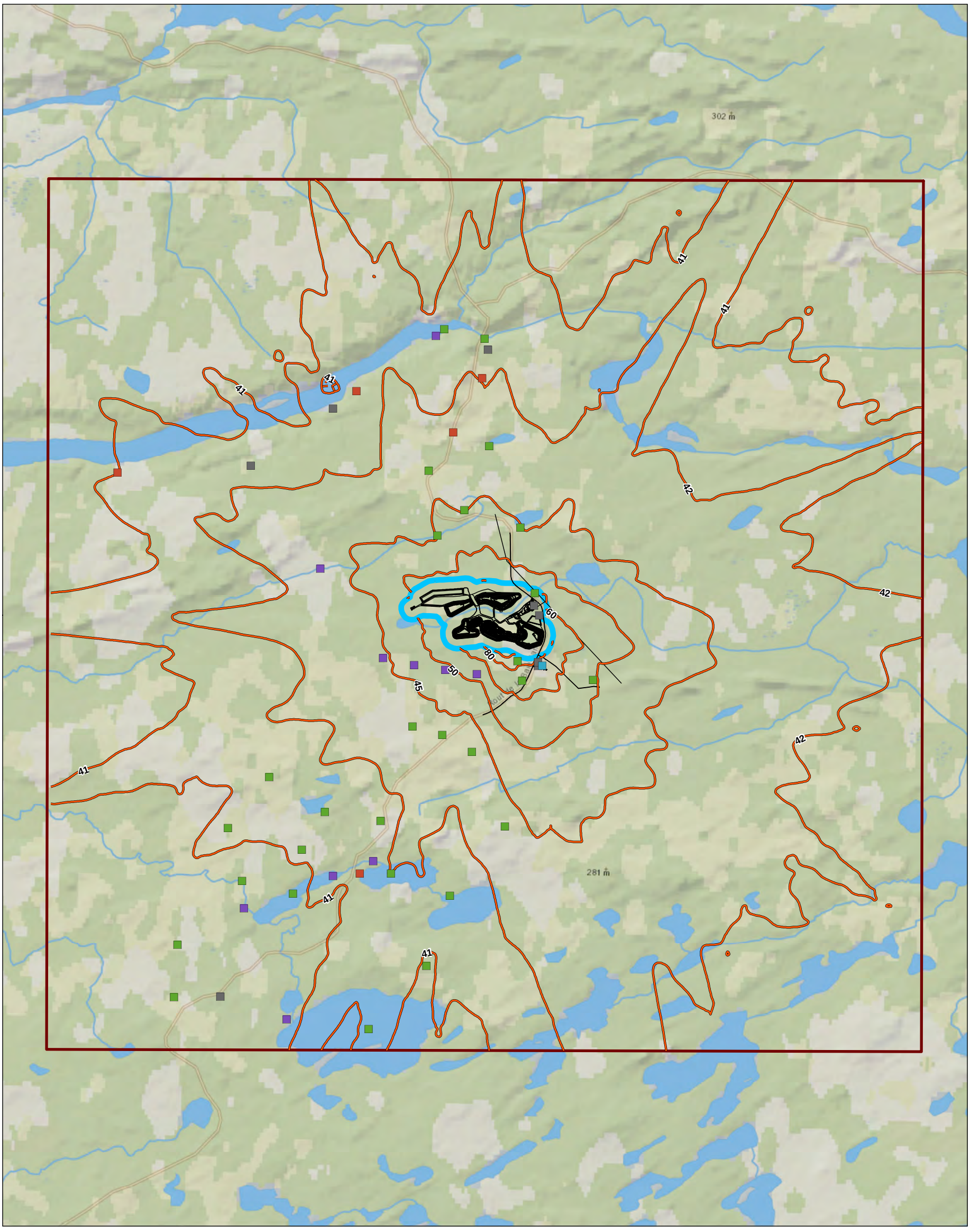

Notes
1. Coordinate System: NAD 1983 UTM Zone 18N
2. Data Sources:
3. Background: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

- Maximum Predicted 24-hour TPM Concentration - Operation Phase (Including Initial Concentration)
- Site Plan
- Application Limit for Standards and Criteria
- Modelling Domain

Discrete Receptors
- Valued Area
- Traditional Activity
- Cree Camp
- Road Relay
- Not Considered

0 2,000 4,000 metres

N

Stantec

Project Location
Quebec, Canada

Client/Project 121416913_007f
James Bay Lithium Mine
Atmospheric Dispersion Modelling Study

Figure No.
B3-2

Title
Maximum Predicted 24-hour TPM Concentration - Operation Phase (Including Initial Concentration)
Maximum Value = 40 µg/m^3
Limit Value = 120 µg/m^3
Initial Concentration = 40 µg/m^3

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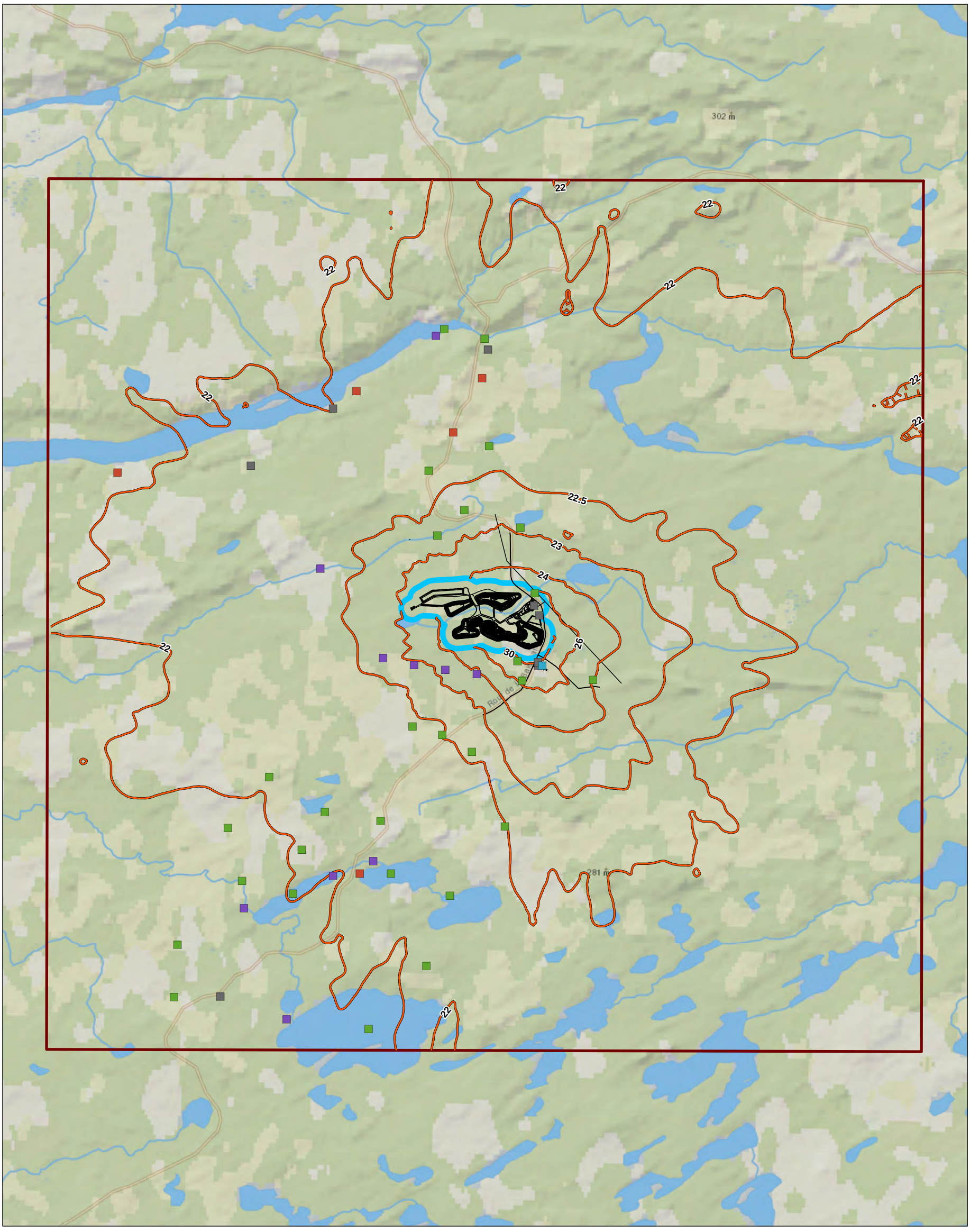

Maximum Predicted 24-hour PM_{10} Concentration - Operation Phase (Including Initial Concentration)

Site Plan

Application Limit for Standards and Criteria

Modelling Domain

Discrete Receptors

- Valued Area
- Traditional Activity
- Cree Camp
- Road Relay
- Not Considered

0 2,000 4,000 metres

N

Stantec

Project Location

Quebec, Canada

Client/Project 121416913_007e

James Bay Lithium Mine
Atmospheric Dispersion Modelling Study

Figure No.

B3-3

Title

Maximum Predicted 24-hour PM_{10} Concentration - Operation Phase (Including Initial Concentration)
Maximum Value = 32.3 µg/m^3
Limit Value = 50 µg/m^3
Initial Concentration = 21.8 µg/m^3

Notes
1. Coordinate System: NAD 1983 UTM Zone 18N
2. Data Sources:
3. Background: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community
National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

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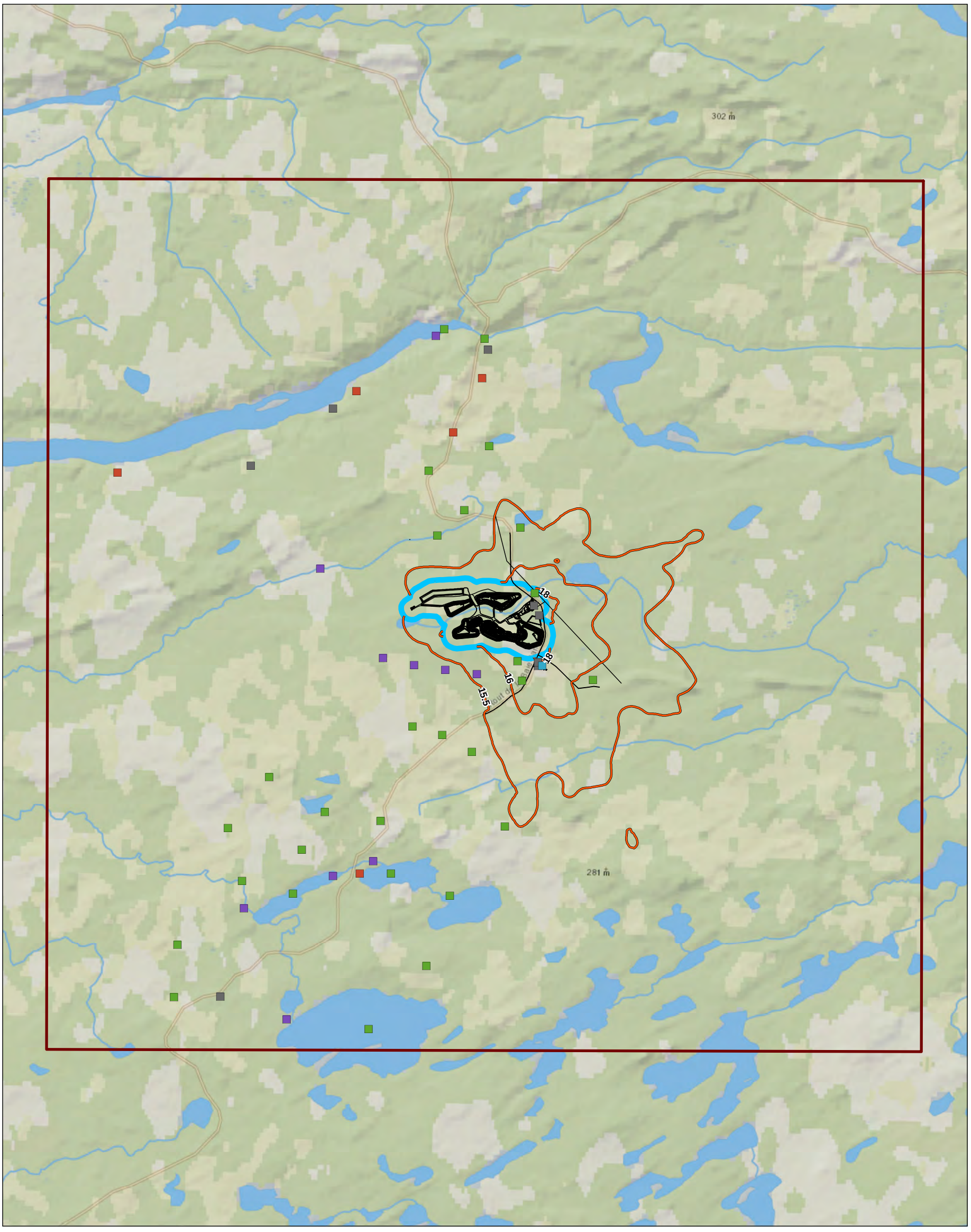

Notes
1. Coordinate System: NAD 1983 UTM Zone 18N
2. Data Sources:
3. Background: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

- Maximum Predicted 24-hour $PM_{2.5}$ Concentration - Operation Phase (Including Initial Concentration)
- Site Plan
- Application Limit for Standards and Criteria
- Modelling Domain

Discrete Receptors
- Valued
- Traditional
- Cree Camp
- Road Relay
- Not Considered

0 2,000 4,000 metres

N

Stantec

Project Location
Quebec, Canada

Client/Project 121416913_007h
James Bay Lithium Mine
Atmospheric Dispersion Modelling Study

Figure No.
B3-4

Title
Maximum Predicted 24-hour $PM_{2.5}$ Concentration - Operation Phase (Including Initial Concentration)
Maximum Value = 20.9 µg/m^3
Limit Value = 30 µg/m^3
Initial Concentration = 15 µg/m^3

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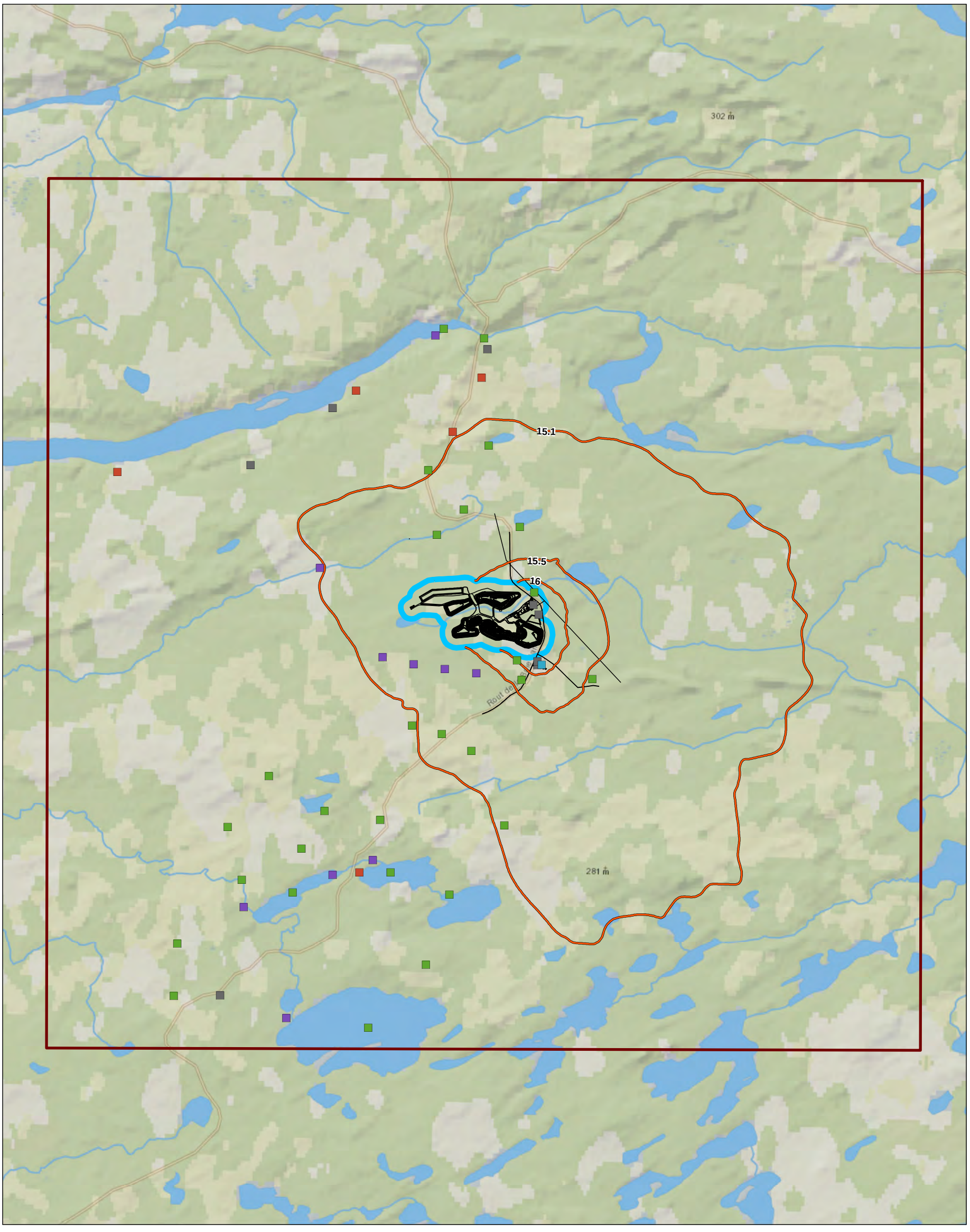

Notes
1. Coordinate System: NAD 1983 UTM Zone 18N
2. Data Sources:
3. Background: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

Maximum Predicted 24-hour $PM_{2.5}$ Concentration (CAAQS) - Operation Phase (Including Initial Concentration)

Discrete Receptors
- Valued Area
- Traditional Activity
- Cree Camp
- Road Relay
- Not Considered

- Site Plan
- Application Limit for Standards and Criteria
- Modelling Domain

0 2,000 4,000 metres

N

Stantec

Project Location
Quebec, Canada

Client/Project 121416913_007i
James Bay Lithium Mine
Atmospheric Dispersion Modelling Study

Figure No.
B3-5

Title
Maximum Predicted 24-hour $PM_{2.5}$ Concentration (CAAQS) - Operation Phase (Including Initial Concentration)
Maximum Value = 18.4 µg/m^3
CAAQS = 27 µg/m^3
Initial Concentration = 15 µg/m^3

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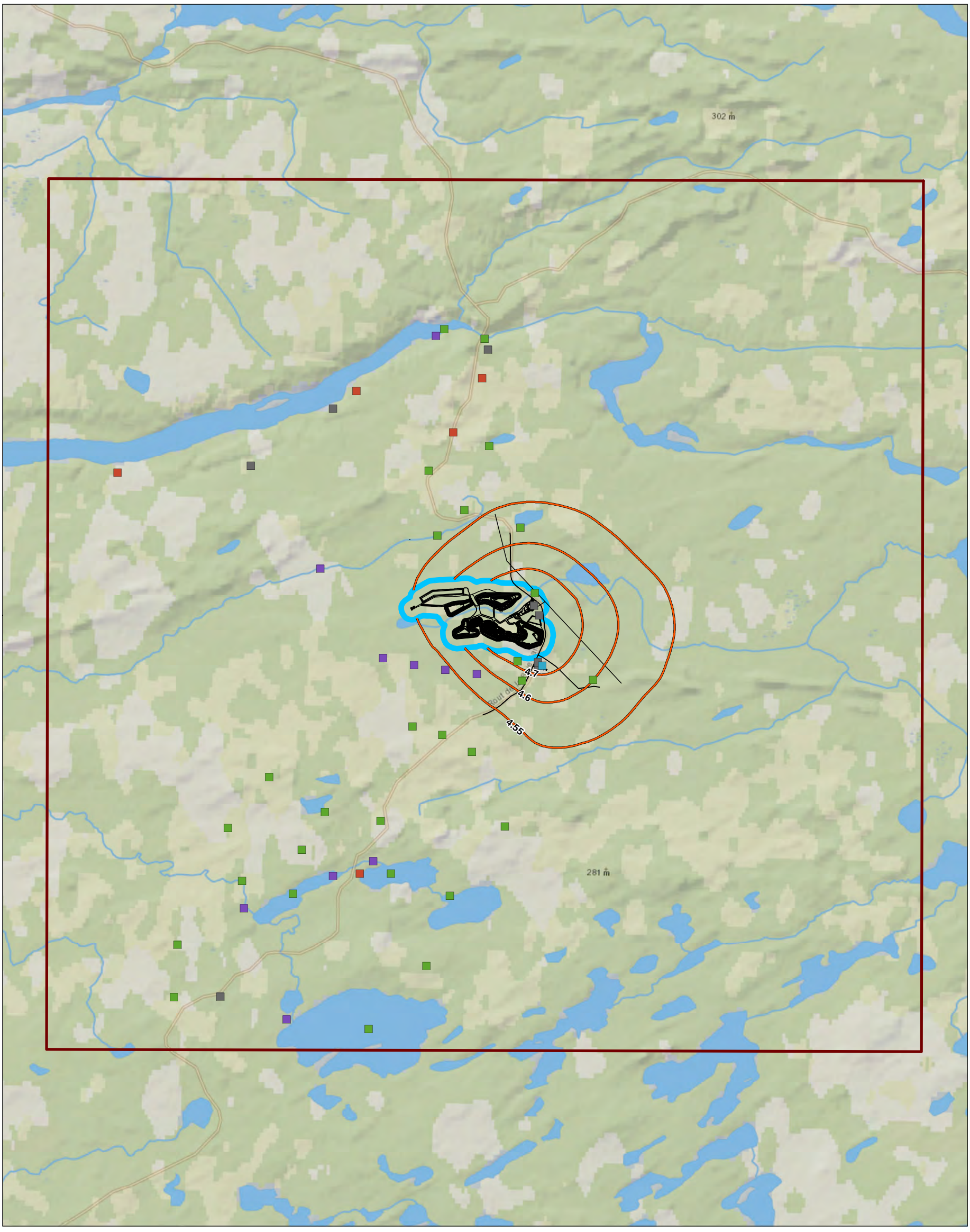

Notes
1. Coordinate System: NAD 1983 UTM Zone 18N
2. Data Sources:
3. Background: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

- Maximum Predicted Annual $PM_{2.5}$ Concentration (CAAQS) - Operation Phase (Including Initial Concentration)

Discrete Receptors
- Valued Area
- Traditional Activity
- Cree Camp
- Road Relay
- Not Considered

- Site Plan
- Application Limit for Standards and Criteria
- Modelling Domain

0 2,000 4,000 metres

N

Stantec

Project Location
Quebec, Canada

Client/Project 121416913_007j
James Bay Lithium Mine
Atmospheric Dispersion Modelling Study

Figure No.
B3-6

Title
Maximum Predicted Annual $PM_{2.5}$ Concentration (CAAQS) - Operation Phase (Including Initial Concentration))
Maximum Value = 5.54 µg/m^3
CAAQS = 8.8 µg/m^3
Initial Concentration = 4.5 µg/m^3

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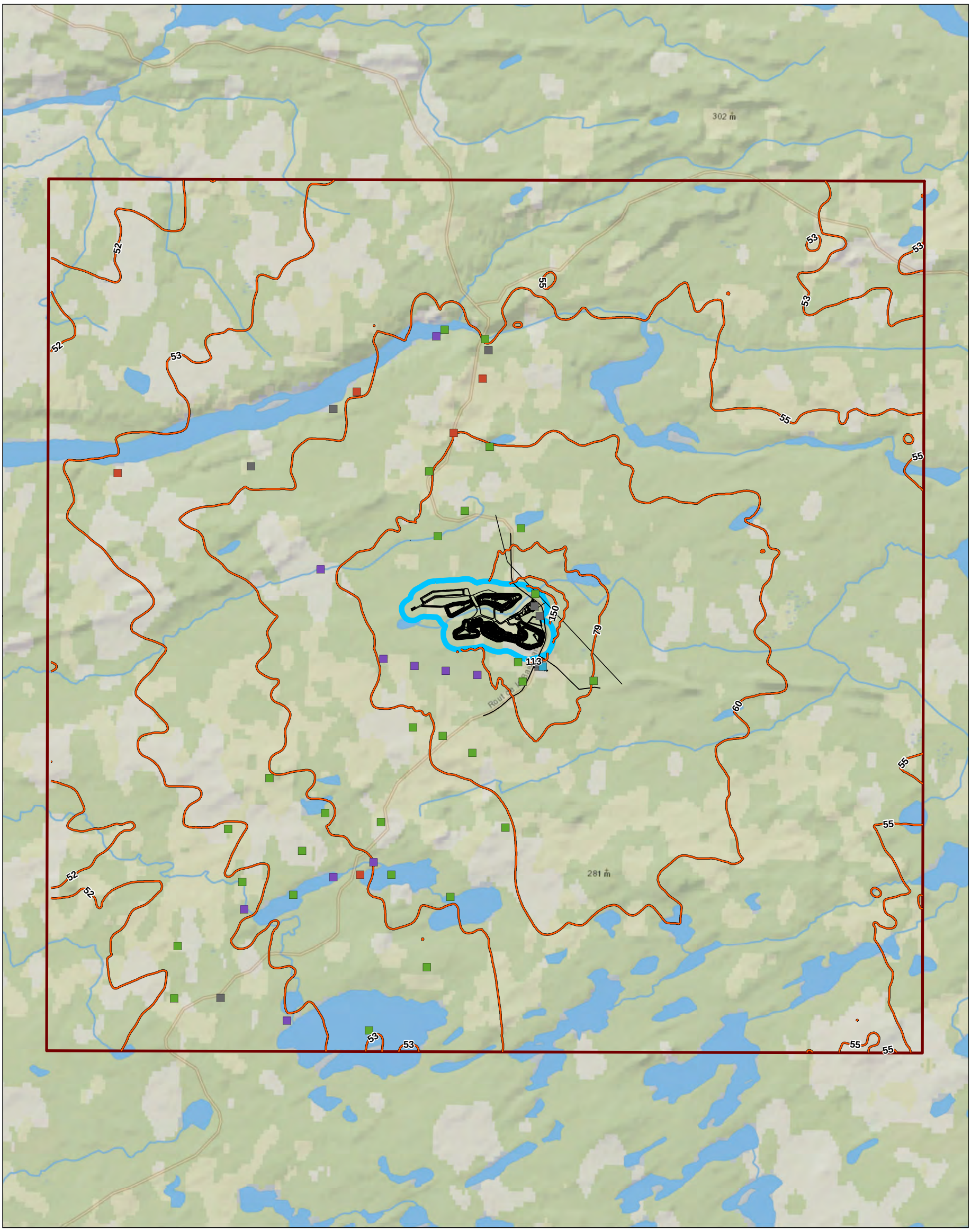

Maximum Predicted 98% Daily 1-hour NO_2 Concentration - Operation Phase (Including Initial Concentration)

Discrete Receptors

- Valued Area
- Traditional Activity
- Cree Camp
- Road Relay
- Not Considered

- Site Plan
- Application Limit for Standards and Criteria
- Modelling Domain

0 2,000 4,000 metres

N

Stantec

Project Location

Quebec, Canada

Client/Project 121416913_007a

James Bay Lithium Mine
Atmospheric Dispersion Modelling Study

Figure No.

B3-7

Title

Maximum Predicted 98% Daily 1-hour NO_2 Concentration - Operation Phase (Including Initial Concentration)
Maximum = 221 µg/m^3
CAAQS = 113 µg/m^3 (2020) and 79 µg/m^3 (2025)
Initial Concentration = 50 µg/m^3

Notes

1. Coordinate System: NAD 1983 UTM Zone 18N
2. Data Sources:
3. Background: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

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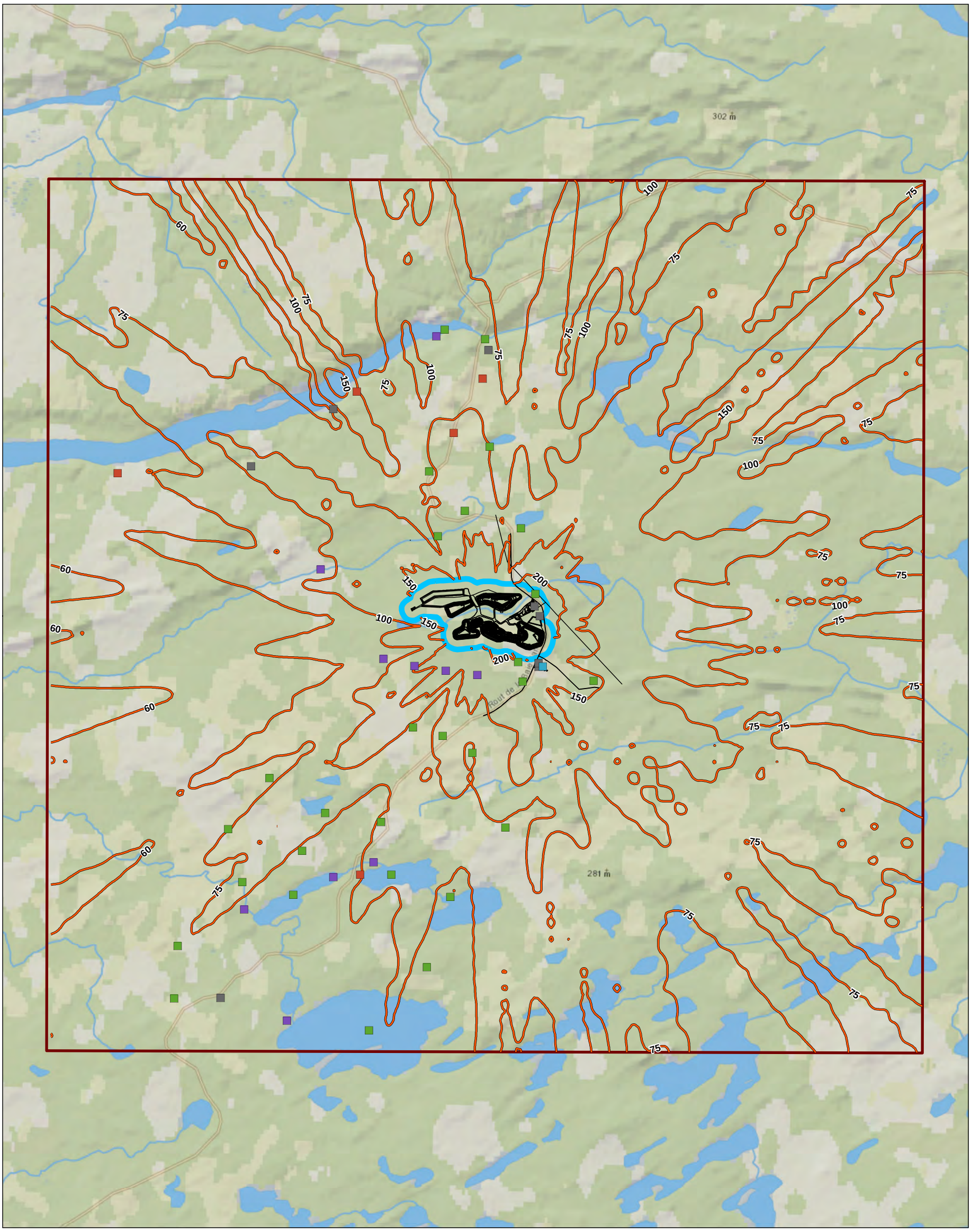

Notes
1. Coordinate System: NAD 1983 UTM Zone 18N
2. Data Sources:
3. Background: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community
National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

Maximum Predicted 1-hour NO_2 Concentration - Operation Phase (Including Initial Concentration)

Discrete Receptors
- Valued Area
- Traditional Activity
- Cree Camp
- Road Relay
- Not Considered

Site Plan
Application Limit for Standards and Criteria
Modelling Domain

0 2,000 4,000 metres

N

Stantec

Project Location
Quebec, Canada

Client/Project 121416913_007b
James Bay Lithium Mine
Atmospheric Dispersion Modelling Study

Figure No.
B3-8

Title
Maximum Predicted 1-hour NO_2 Concentration - Operation Phase (Including Initial Concentration)
Maximum Value = 401 µg/m^3
Limit Value = 414 µg/m^3
Initial Concentration = 50 µg/m^3

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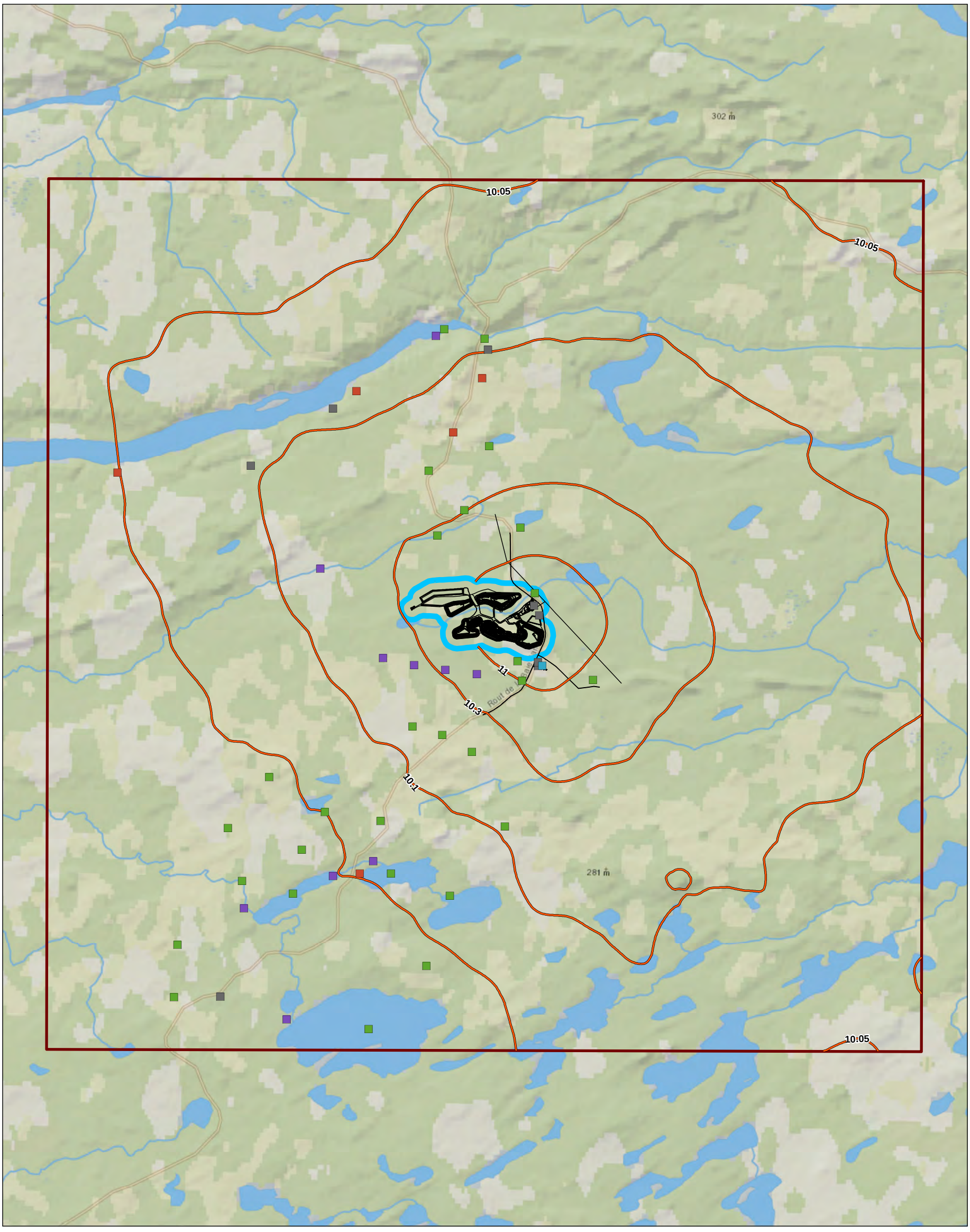

Notes
1. Coordinate System: NAD 1983 UTM Zone 18N
2. Data Sources:
3. Background: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

Maximum Predicted Annual NO_2 Concentration (CAAQS) - Operation Phase (Including Initial Concentration)

Discrete Receptors
- Valued Area
- Traditional Activity
- Cree Camp
- Road Relay
- Not Considered

- Site Plan
- Application Limit for Standards and Criteria
- Modelling Domain

0 2,000 4,000 metres

N

Stantec

Project Location
Quebec, Canada

Client/Project 121416913_007e
James Bay Lithium Mine
Atmospheric Dispersion Modelling Study

Figure No.
B3-9

Title
Maximum Predicted Annual NO_2 Concentration (CAAQS) - Operation Phase (Including Initial Concentration)
Maximum Value = 19.7 µg/m^3
CAAQS = 32 µg/m^3 (2020) and 23 µg/m^3 (2025)
Initial Concentration = 10 µg/m^3

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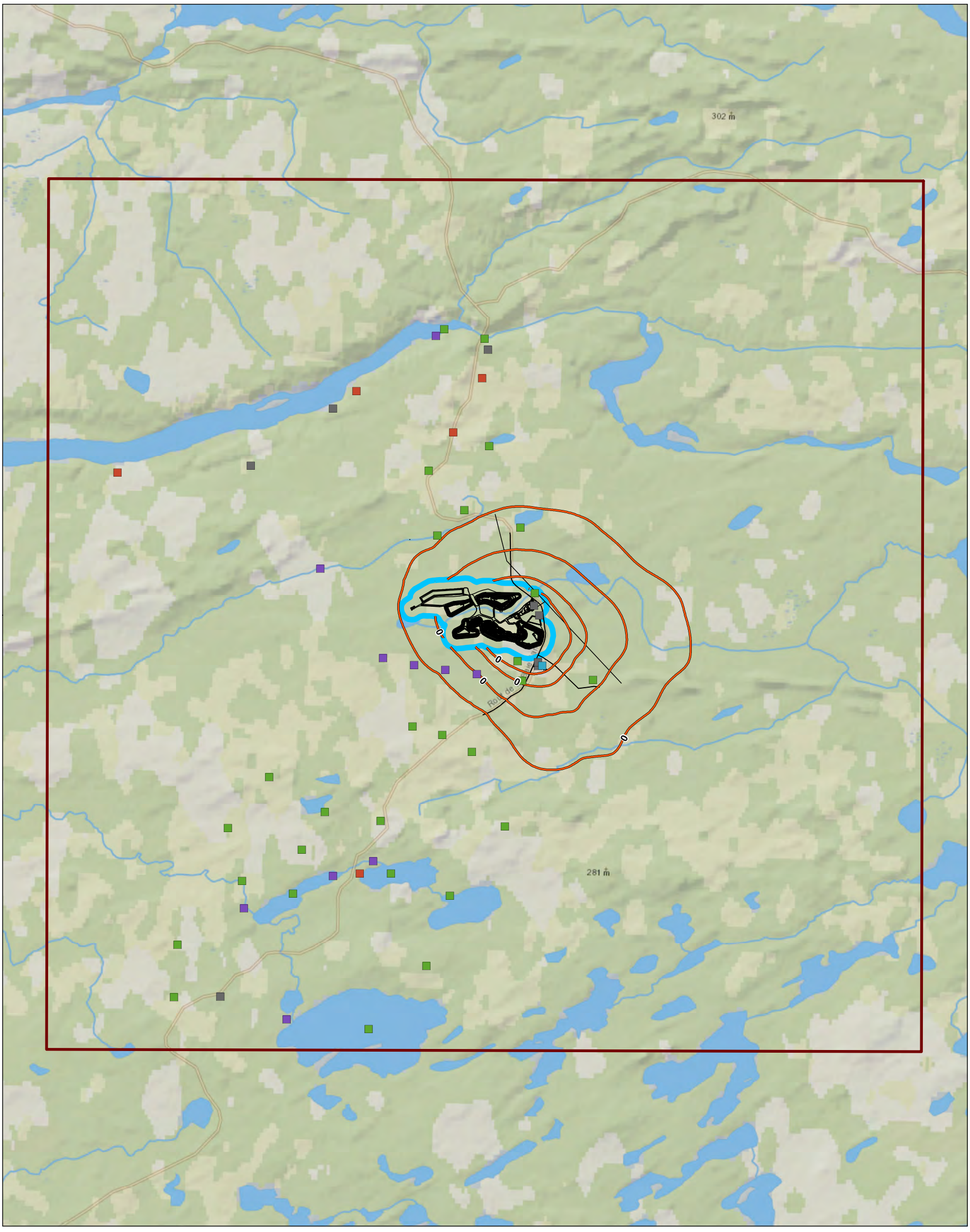

Notes
1. Coordinate System: NAD 1983 UTM Zone 18N
2. Data Sources:
3. Background: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

- Maximum Predicted Annual Arsenic Concentration - Operation Phase (Including Initial Concentration)

Discrete Receptors
- Valued Area
- Traditional Activity
- Cree Camp
- Road Relay
- Not Considered

- Site Plan
- Application Limit for Standards and Criteria
- Modelling Domain

0 2,000 4,000 metres

N

Stantec

Project Location
Quebec, Canada

Client/Project 121416913_007k
James Bay Lithium Mine
Atmospheric Dispersion Modelling Study

Figure No.
B3-10

Title
Maximum Predicted Annual Arsenic Concentration - Operation Phase (Including Initial Concentration)
Maximum Value = 0.00262 µg/m^3
Limit Value = 0.003 µg/m^3
Initial Concentration = 0.002 µg/m^3

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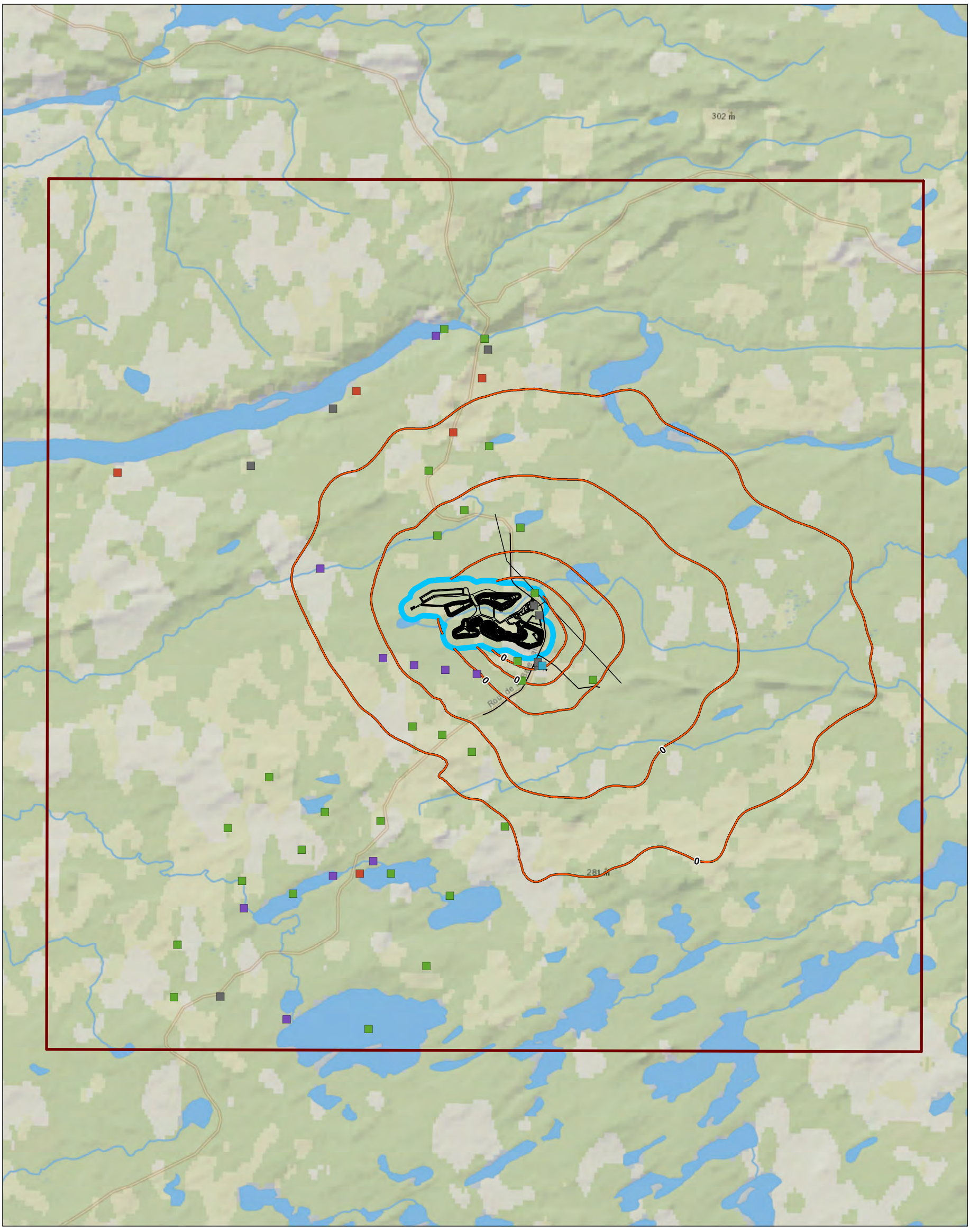

Notes
1. Coordinate System: NAD 1983 UTM Zone 18N
2. Data Sources:
3. Background: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

- Maximum Predicted Annual Total Chromium Concentration - Operation Phase (Including Initial Concentration)

Discrete Receptors
- Valued Area
- Traditional Activity
- Cree Camp
- Road Relay
- Not Considered

- Site Plan
- Application Limit for Standards and Criteria
- Modelling Domain

0 2,000 4,000 metres

N

Stantec

Project Location
Quebec, Canada

Client/Project 121416913_007I
James Bay Lithium Mine
Atmospheric Dispersion Modelling Study

Figure No.
B3-11

Title
Maximum Predicted Annual Total Chromium Concentration - Operation Phase (Including Initial Concentration)
Maximum Value = 0.00380 µg/m^3
Limit Value (hexavalent chromium compounds) (Cr(VI)) = 0.004 µg/m^3
Initial Concentration = 0.002 µg/m^3

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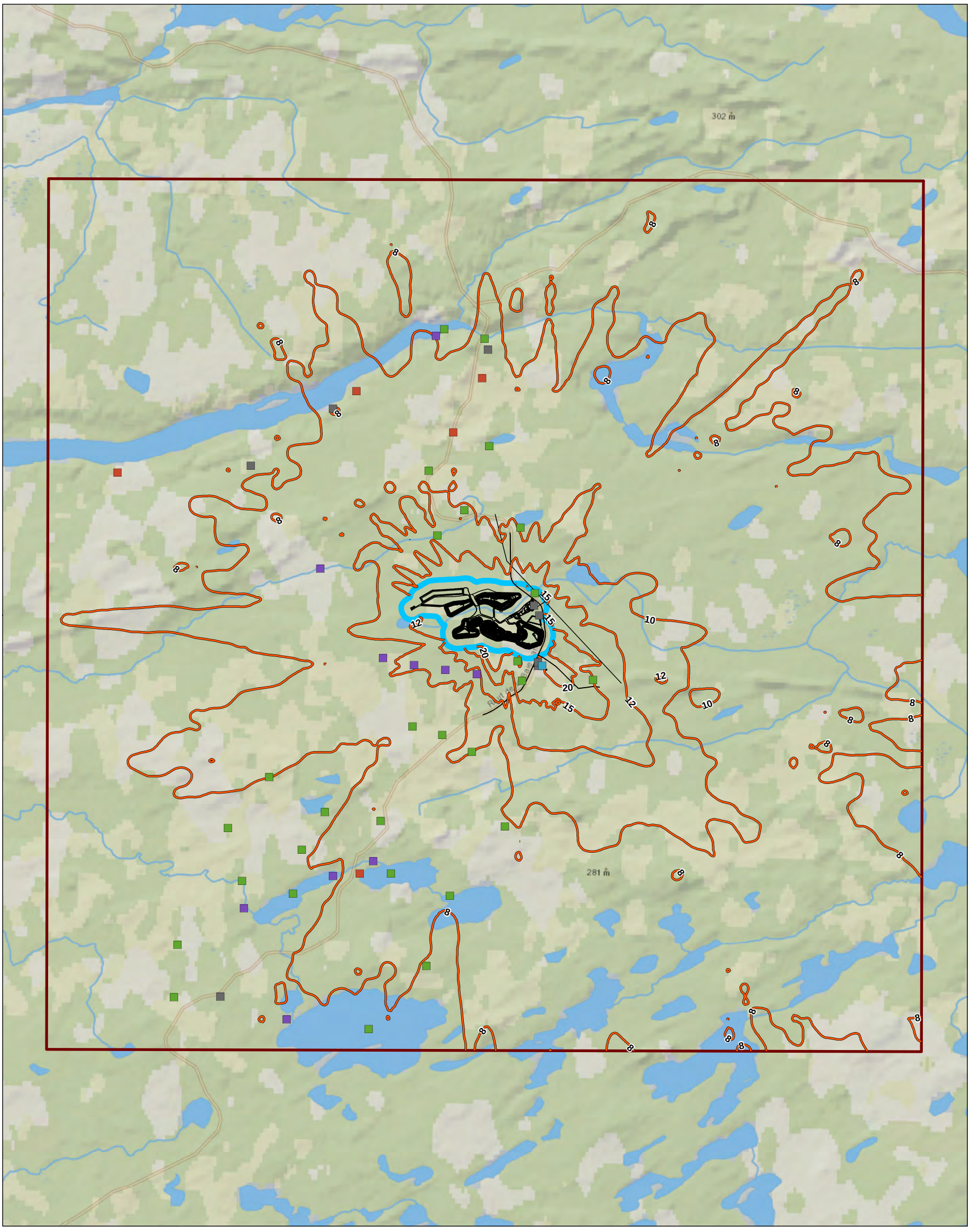

Notes
1. Coordinate System: NAD 1983 UTM Zone 18N
2. Data Sources:
3. Background: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

- Maximum Predicted 1-hour Crystalline Silica Concentration - Operation Phase (Including Initial Concentration)

Discrete Receptors
- Valued Area
- Traditional Activity
- Cree Camp
- Road Relay
- Not Considered

- Site Plan
- Application Limit for Standards and Criteria
- Modelling Domain

0 2,000 4,000 metres

N

Stantec

Project Location
Quebec, Canada

Client/Project 121416913_007m
James Bay Lithium Mine
Atmospheric Dispersion Modelling Study

Figure No.
B3-12

Title
Maximum Predicted 1-hour Crystalline Silica Concentration - Operation Phase (Including Initial Concentration)
Maximum Value = 41.2 µg/m^3
Limit Value = 23 µg/m^3
Initial Concentration = 6 µg/m^3

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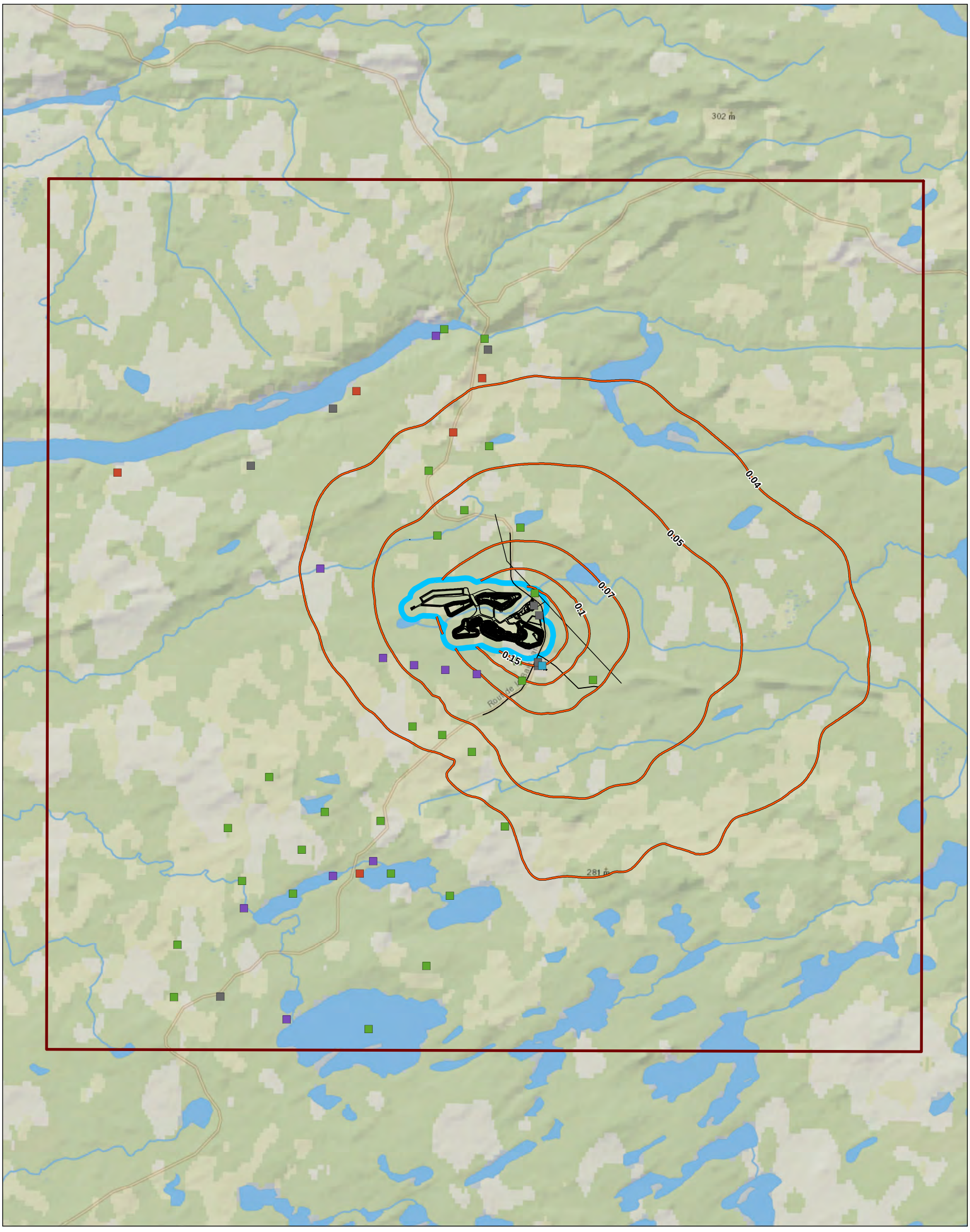

Notes
1. Coordinate System: NAD 1983 UTM Zone 18N
2. Data Sources:
3. Background: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

Maximum Predicted Annual Crystalline Silica Concentration - Operation Phase (Including Initial Concentration)

Discrete Receptors

- Valued
- Traditional Activity
- Cree Camp
- Road Relay
- Not Considered

- Site Plan
- Application Limit for Standards and Criteria
- Modelling Domain

0 2,000 4,000 metres

N

Stantec

Project Location
Quebec, Canada

Client/Project 121416913_007n
James Bay Lithium Mine
Atmospheric Dispersion Modelling Study

Figure No.
B3-13

Title
Maximum Predicted Annual Crystalline Silica Concentration - Operation Phase (Including Initial Concentration)
Maximum Value = 0.305 µg/m^3
Limit Value = 0.07 µg/m^3
Initial Concentration = 0.04 µg/m^3

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APPENDIX C

Sample Calculations

Pit Blasting

Source Description

Blasting occurs from the open pit. ANFO explosive will be used in the winter while an ammonium nitrate emulsion will be used in the summer. Emissions source from the explosive detonation and from the dust generated by blasting of the ore.

Methodology

-Emissions from explosive detonation were estimated using weight of explosive and emission factors sourced from Australian NPI - "Emission estimation technique manual for Explosives detonation and firing ranges Version 3.1" 2016. It was assumed that one blast occurs over a 3 second period, as indicated by Galaxy.
-Emissions from ore blasting estimated using emission factors sourced from US EPA, AP-42, Fifth Edition, Volume I, Chapter 11.9 Western Surface Coal Mining.
*Due to the unavailability of emission factors for the blasting process for lithium mining, emission factors for blasting of overburden from coal mines was used. This approach is consistent with the NPRI document "Pits and Quarries Reporting Guide"

Emission Release Summary

			Emissions [g/s]			
Substance	**CAS-No**	**Weight % TPM**	**Construction - ANFO (Winter)**	**Construction - AN Emulsion (Summer)**	**Operations - ANFO (Winter)**	**Operations - AN Emulsion (Summer)**
Carbon Monoxide	630-08-0	—	389.7	26.4	214.3	14.5
Nitrogen Oxides	11104-93-1	—	91.70	2.29	50.43	1.26
Sulphur Dioxide	7446-09-5	—	6.88E-01	6.88E-01	0.378	0.378
Total Particulate Matter	NA	—	19.16	19.16	7.817	7.82
Particulate matter less than or equal to 10 micrometers (µm) (PM10)	NA - M09	—	9.965	9.965	4.0646	4.0646
Particulate matter less than or equal to 2.5 µm (PM2.5)	NA - M10	—	0.57	0.575	0.2345	0.2345

Calculation Inputs

Explosive Type	**ANFO (Winter)[1]**	**AN Emulsion (Summer)[1]**
Explosive Used - Construction (y -1) [t/blast]:	41.26	41.26
Explosive Used - Operations (y 14) [t/blast]:	22.70	22.70
Average Area per Blast - Construction [m^2]:	4615.66	4615.66
Average Area per Blast - Peak Operations (y 14) [m^2]:	2538.61	2538.61
Assumed Blast Duration (all scenarios)	0.05	min

[1]It was assumed that 50% of blasts are in the summer and 50% are in the winter

Emission Calculations

Explosive Detonation

				Construction	Operations
Substance	**CAS-No**	**Explosive**	**Emission Factor [kg/Mg]**	**Hourly Emissions [g/s]**	**Hourly Emissions [g/s]**
Carbon Monoxide	630-08-0	ANFO	34	389.7	214.3
		AN Emulsion[1]	2.3	26.4	14.5
Nitrogen Oxides	11104-93-1	ANFO	8	91.7	50.4
		AN Emulsion	0.2	2.29	1.26
Sulphur Dioxide	7446-09-5	ANFO	0.06	0.688	0.378
		AN Emulsion[2]	0.06	0.688	0.378

[1]CO emission factor for AN Emulsion for > 150mm diameter holes
[2]SO_2 emission factor for AN emulsion assumed the same as ANFO

					Hourly		Annual	
Substance	**CAS-No**	**Emission Factor Construction[1] [kg/blast]**	**Emission Factor Operations[1] [kg/blast]**	**Scaling Factor to TPM**	**Emissions - Construction [g/s]**	**Emissions - Operations [g/s]**	**Emissions - Construction [g/s]**	**Emissions - Operations [g/s]**
Total Particulate Matter	N/A -1	68.99	28.1	—	19.16	7.82	3.42E-01	1.40E-01
Particulate matter less than or equal to 10 micrometers (µm) (PM10)	N/A -2	—	—	0.52	9.96	4.06	1.78E-01	7.26E-02
Particulate matter less than or equal to 2.5 µm (PM2.5)	N/A -3	—	—	0.03	0.57	0.23	1.03E-02	4.19E-03

[1]The dust emissions are independent of explosive type

Sample Calculations

Explosive Detonation

CO Emissions, Construction = Emission Factor [kg/Mg] x Explosive Used [kg/blast] x Number of Blasts [#/hour] x conversion

$$\text{CO Emissions, Construction} = \frac{34\ \text{kg CO}}{\text{Mg ANFO}} \times 41.265\ \frac{\text{t ANFO}}{\text{blast}} \times 1\ \frac{\text{blasts}}{\text{hour}} \times \frac{1000\ \text{g CO}}{1\ \text{kg CO}} \times \frac{1\ \text{hour}}{3600\ \text{seconds}}$$

$$\text{CO Emissions, Construction} = 389.7\ \frac{\text{g}}{\text{s}}$$

Blasting of Ore

TPM Emission Factor [kg/blast] = 0.00022 x A^1.5

Where A = horizontal area (m^2) when blasting depth <21 m.

$$\text{TPM Emission Factor, Construction} = 0.00022 \times (4615.66\ m^2\ \text{/ blast})^{1.5}$$

$$\text{TPM Emission Factor, Construction} = 68.99\ \frac{\text{kg}}{\text{blast}}$$

$$\text{TPM Emission Factor, Construction} = \frac{\text{EF} \times \text{Blasts}}{\text{hour}} \times \text{Conversion}$$

$$\text{TPM Emissions} = \frac{68.99\ \text{kg}}{\text{blast}} \times \frac{1\ \text{Blasts}}{\text{hour}} \times \frac{1000\ \text{g}}{1\ \text{kg}} \times \frac{1\ \text{hour}}{3600\ \text{seconds}}$$

TPM Emissions = $\frac{19.2\ g}{s}$

TPM Emission Factor, Operations = $\frac{0.00022 \times (2538.61\ m^2)^{\wedge 1.5}}{blast}$

TPM Emission Factor, Operations = $\frac{28.1\ kg}{blast}$

Drilling Operations

Source Description

Drilling of boreholes used for blasting of the pit. There is one pre-split drill and one production drill during construction, and one pre-split and two production drills during operations. There are 185 holes/blast during construction and 1,032 holes/blast during peak operational year (y14). There can be up to 3 blasts per week during both construction and operation phases. The drill penetration rate is 19.6 m/h. Drilling is controlled with dust collectors.

Methodology

Particulate emissions from drilling were estimated using the estimated number of holes drilled per hour and the emission factors presented in AP-42 Chapter 11.9 - Western Surface Coal Mining. Emissions of PM10, PM2.5, and PM4 were estimated from TPM based on factors from the US EPA AP-42 Appendix B.2 Generalized Particle Size Distribution Document (1995), available at: https://www3.epa.gov/ttnchie1/ap42/appendix/appb-2.pdf
A control efficiency of 99% (for a dust collector) was used following Australian NPI Emission estimation technique manual for mining Version 3.1. January 2012. The estimated number of holes drilled hourly was estimated from the number or holes drilled per blast, the blast frequency, and the operational hours per day.

Emission Release Summary

Phase	Source	Description	Number of Drills/hour	Emission Rates (g/s)		
				TPM	PM_{10}	$PM_{2.5}$
Construction	ProdDrill1	Production Drill (4-8")	7.9	0.013	0.0067	0.0019
	Predrill	Auxiliary Pre-split Drill (4.5-8")	7.9	0.013	0.0067	0.0019
Operations	ProdDrill1	Production Drill (4-8")	9.2	0.015	0.0079	0.0023
	ProdDrill2	Production Drill (4-8")	9.2	0.015	0.0079	0.0023
	PreDrill	Auxiliary Pre-split Drill (4.5-8")	18.4	0.030	0.0157	0.0045

Calculation Inputs

Phase	Number of Days	Operational Hours per Day	Blasts per week	Holes/blast	Number of drill holes per day
Construction	100	10	3	185	79.13
Operations	365	24	3	1032	442.27

Mitigation	Dust collector
Control efficiency	99%
Drill penetration rate (m/h)	19.6

Contaminant	Efs (kg/borehole)	Scale factor	Source
TPM	0.59	-	AP-42; Table 11.9-4
PM10	-	0.52	AP-42 Appendix B.2; Table B.2.2
PM2.5	-	0.15	AP-42 Appendix B.2; Table B.2.2

Sample Calculations

TPM Emissions, Construction ProdDrill1 (g/s) = drilling rate [holes/hour] x Emission Factor [kg TPM/hole] x Conversion x (1-CE)

$$\text{TPM Emissions, Construction ProdDrill1 (g/s)} = \frac{7.9 \text{ holes}}{\text{hour}} \times \frac{0.59 \text{ kg}}{\text{borehole}} \times \frac{1 \text{ hr}}{3600 \text{ sec}} \times \frac{1000 \text{ g}}{1 \text{ kg}} \times (1-0.99)$$

$$\text{TPM Emissions, Construction ProdDrill1} = \frac{0.013 \text{ g}}{\text{s}}$$

Storage Pile Erosion - Fugitive Emissions of Particulate Matter

Source Description There are numerous materials (different grade ores, till, waste rock) that are stockpiled outside at the facility. Emissions result from wind erosion of stockpile surfaces. Of the active waste rock pile, only 5000 m2 is exposed at any one time, the remainder is covered with material with a lower silt content. During construction, it was assumed that the piles are exposed. ROM pad, ore, and final product were also assumed to be exposed.

Methodology -The equation for estimating storage pile particulate emissions is sourced from Mojave Desert Air Quality Management District (MDAQMD), Mineral Handling and Processing Industries, Table 2, 2000, as presented in the ECCC NPRI "Pits and quarries reporting guide." This method is for an annual estimate and was converted to an emission rate in g/s. To represent the worst case day of emissions (dry and windy), it was assumed that 100% of time was >19.3 km/hour wind and that there were zero days with rain or snow cover.

Calculation Inputs

Silt Content (Exposed Rock) [%]	2.0
Silt Content (Covered Wasterock)[1]	0.5
Active Wasterock area exposed [m2]	5000.0
Silt Content (Sand and till) [%][2]	2.6
Silt Content (overburden) [%][2]	7.5
Days with rain >0.252mm or with snow cover[3]	0

[1]Silt content of rock/wasterock provided by Galaxy. Exposed/active rock 2% silt, covered rock 0.5% silt.

[2]Silt contents of sand/overburden obtained from AP-42 13.2.4 table 13.2.4-1 as follows:

-Sand according to municipal solid waste landfills, sand

-Overburden according to the Western surface coal mining, overburden

[3]Assumed to be 0 for worst case days in which there is no precipitation

Emission Calculations

$EF = 1.12 * 10^{-4} * J * 1.7 * (s/1.5) * 365 * ((365-P)/235) * (I/15)$

Where,

EF: Emission factor in (kg/m^2)

J: Particulate aerodynamic factor

s: Average silt loading of storage pile in percent (%)

P: Average number of days during the year with at least 0.254 mm of precipitation

I: Percentage of time in the year with unobstructed wind speed >19.3 km/h in percent (%)

The particle aerodynamic factor for TPM, PM_{10} and $PM_{2.5}$ are:

$J_{(TPM)}$ =	1
$J_{(PM10)}$ =	0.5
$J_{(PM2.5)}$ =	0.2

Substance	NPRI CAS-No	Emission Factor Rock - Active [kg/m^2]	Emission Factor Rock - Covered [kg/m^2]	Emission Factor Sand [kg/m^2]	Emission Factor Overburden [kg/m^2]
Total Particulate Matter	NA - M08	9.59E-01	2.40E-01	1.25	3.60
Particulate matter less than or equal to 10 micrometers (µm) (PM10)	NA - M09	4.80E-01	1.20E-01	0.62	1.80
Particulate matter less than or equal to 2.5 µm (PM2.5)	NA - M10	1.92E-01	4.80E-02	0.25	0.72

				Max. Emission Rate [g/s]			Max. Emission Rate [g/s m^2]		
Phase	Stockpile	Material	Surface Area (m^2)	TPM	PM10	PM2.5	TPM	PM10	PM2.5
Construction[1]	Storage Yard - Mobile Crusher Rock	Rock	28,000	8.52E-01	4.26E-01	1.70E-01	3.04E-05	1.52E-05	6.08E-06
	Storage Yard - Mobile Crusher Sand	Sand and till	13,000	5.14E-01	2.57E-01	1.03E-01	3.96E-05	1.98E-05	7.91E-06
	Stripped waste rock - W	Overburden	299,050	3.41E+01	1.71E+01	6.82E+00	1.14E-04	5.70E-05	2.28E-05
	Stripped waste rock - E	Rock	365,537	1.11E+01	5.56E+00	2.22E+00	3.04E-05	1.52E-05	6.08E-06
Operations - Year 14 (2035)	South-West Waste Rock - Covered	Rock	310,314	2.36E+00	1.180E+00	4.72E-01	7.61E-06	3.80E-06	1.52E-06
	West Waste Rock - Covered	Rock	299,050	2.27E+00	1.137E+00	4.55E-01	7.61E-06	3.80E-06	1.52E-06
	North East Waste Rock - Covered	Rock	568,662	4.33E+00	2.163E+00	8.65E-01	7.61E-06	3.80E-06	1.52E-06
	East Waste Rock (pre extension) - Covered	Rock	360,537	2.74E+00	1.371E+00	5.48E-01	7.61E-06	3.80E-06	1.52E-06
	East Waste Rock (pre extension) - Active	Rock	5,000	1.52E-01	7.606E-02	3.04E-02	3.04E-05	1.52E-05	6.08E-06
	Rom Pad Stockpile	Rock	1,781	5.42E-02	2.709E-02	1.08E-02	3.04E-05	1.52E-05	6.08E-06
	Primary Ore Stockpile	Rock	1,991	6.06E-02	3.029E-02	1.21E-02	3.04E-05	1.52E-05	6.08E-06
	Final Product Stockpile	Rock	1,500	4.56E-02	2.282E-02	9.13E-03	3.04E-05	1.52E-05	6.08E-06
	Total		**143,259**	4.36E+00	2.18E+00	8.72E-01	3.04E-05	1.52E-05	6.08E-06

[1]Assumes that all four waste rock piles are stripped during construction

Sample Calculations

TPM Emissions = Emission Factor × Surface Area of Stockpiles × Conversion

Emission Factor TPM Rock = 1.12 * 10-4 * J * 1.7 * (s/1.5) * 365 * ((365-P)/235) * (l/15)

**Parameters defined above*

$$\text{Emission Factor TPM Rock} = \frac{1.12 \times 0.0001 \times 1 \times 1.7 \times \frac{2.0}{1.5} \times 365 \times \left(\frac{365 - 0}{235}\right) \times \frac{100}{15}}{}$$

$$\text{Emission Factor TPM Rock} = 0.959 \ \frac{kg}{m^2 \ year}$$

$$\text{TPM Emissions} = \frac{0.959 \ \frac{kg}{m^2 \ year} \times 28000 \ m^2 \times \frac{1000 \ g}{1 \ kg} \times \frac{1 \ year}{365 \ days} \times \frac{1 \ day}{24 \ hours} \times \frac{1 \ hour}{3600 \ seconds}}{}$$

$$\text{TPM Emissions} = 0.9 \ \frac{g}{s}$$

Haul Truck Fugitives

Source Description: Fugitive dust from movement of haul trucks along haul routes and shipping trucks from loadout to off-site are estimated which include releases of TSP, PM10 and PM2.5. That roads will be watered regularly. Releases of combustion gases and particulate from fuel combustion in haul trucks are estimated in the " *Mobile Equipment Exhaust*" worksheet.

Methodology: Emissions calculated using method from US EPA, AP-42, Chapter 13.2.2 Unpaved Roads (US EPA 1995), Equation 13.2.2(1a). The length of road segments and number of cycles were obtained from the material movement log for haul trucks, and were based on the length from load-out to off-site and by the number of deliveries for the transport trucks. A control efficiency of 95% was applied during the winter months (October-May) as there is snow coverage, and a summer (June-September) control efficiency of 80% for the application of dust supression and consitent road watering, efficiencies obtained from Golder Associates. 2012. "Final Report Determination of Natural Winter Mitigation of Road Dust Emissions from Mining Operations in Northern Canada."

Calculation Inputs

Silt Content (%)[1]	2.00
Winter Control Efficiency (%)	95%
Summer Control Efficiency (%)	80%

[1]Silt content corresponding to the average value from US EPA AP-42 Chapter 13 Table 13.2.2-1, for "Stone Quarrying and Processing" for "Haul Road to/from Pit"

Vehicle	Vehicle weight (t)[2]	Cycles per Day
Haul Truck (CAT 777)[3]	119.8	Dependent on Route - See Material Movement Log
Kenworth T800 [4]	78.99	53

[3]From CAT 777G Specs, unloaded CAT 777 gross weight is 164.6 metric tonnes (loaded), with the payload of 89.4 metric tonnes. Average of loaded and unloaded is 119.8 metric tonnes. (https://www.cat.com/en_US/products/new/equipment/off-highway-trucks/off-highway-trucks/18265926.html)
[2]Assume the CAT 777 haul trucks are the average of the empty and loaded weight.
[4] As per "21010803 POLARIS CONFIG3.pdf", unloaded truck tare weight is 28.931 tonnes and the loaded truck weight is 114.431 tonnes. Average of loaded and unloaded truck is 78.99 metric tonnes.

Haul Truck Capacity

	Rock	Waste	Overburden
	Mining Haul Truck (100 t) CAT 777	Mining Haul Truck (100 t) CAT 777	Mining Haul Truck (100 t) CAT 777
Rated Truck Payload (t)	90	90	90
Actual Truck Payload - Wet (t)	88	88	88
Actual Truck Payload - Dry (t)	86	85	86

Phase	Daily Operating Hours	Operating Days per Phase
Construction	10	100
Operations - hauling	24	365
Operations - shipping	12	365
Operations - expansion	10	365

Compound	Particle Size (µm)	k [kg/VKT]	a	b	Emission Factor (Haul Trucks) [kg/VKT]	Emission Factor (Kenworth) [kg/VKT]
Total Particulate Matter[5]	30	1.381	0.7	0.45	2.071	1.717
Particulate matter less than or equal to 10 micrometers (µm) (PM10)	10	0.423	0.9	0.45	0.443	0.367
Particulate matter less than or equal to 2.5 µm (PM2.5)	2.5	0.042	0.9	0.45	0.044	0.036
Particulate matter less than or equal to 4 µm (PM4)	4	0.1219	0.9	0.45	0.1	0.1

[5]Parameters for PM-30 assumed to be equal to TPM as stated in US EPA CHIEF, AP-42, Chapter 13, Table 13.2.2-2

Haul Route Information

		Construction													Operation - Year 14												
								Summer (June-Sept)				Winter (Oct-May)										Summer (June-Sept)				Winter (Oct - May)			
Phase	Haul Route	Approx. Length (m)	Material Hauled (ktonnes)	Truck trips (cycles)			VKT (per day)	TPM Emission (haul trucks)[5] [g/s]	PM10 Emission (haul trucks) [g/s]	PM4 (annual rate)	PM2.5 Emission (haul trucks) [g/s]	TPM Emission (haul trucks)[2] [g/s]	PM10 Emission (haul trucks) [g/s]	PM4 (annual rate)	PM2.5 Emission (haul trucks) [g/s]	Approx. Length (m)	Material Hauled (ktonnes for year 14)	Truck trips (cycles)			VKT (per day)	TPM Emission[5] [g/s]	PM10 Emissions [g/s]	PM2.5 Emissions [g/s]	PM4 (annual rate)	TPM Emission[5] [g/s]	PM10 Emissions [g/s]	PM2.5 Emissions [g/s]	PM4 (annual rate)
				Annual (Y -1)	Daily	Hourly												Annual (Y14)	Daily	Hourly								
JB2-1 (Center Pit Phase 1). CP1	Bench to Surface	1133.9	2500	29070	291	30	659.9	7.591	1.625	0.4683	0.161	1.898	0.406	0.117	0.040	0	0	0	0	0	0	0	0	0	0	0	0	0
	Surface to Ore	1826.8	183.6	2135	22	3	80.4	0.925	0.198	0.0570	0.020	0.231	0.049	0.014	0.005	0	0	0	0	0	0	0	0	0	0	0	0	0
	Surface to North Dump	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Surface to JB1 Dump	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Surface to East Dump	1634.1	2316.4	26936	270	27	882.4	10.151	2.173	0.6261	0.216	2.538	0.543	0.157	0.054	0	0	0	0	0	0	0	0	0	0	0	0	0
	Surface to East Dump Ext.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
JB2-4 (Center Pit Phase 4) - CP4	Bench to Surface	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3590.119378	8968.9	104291	286	12	2054	9.84	2.11	0.21	0.61	2.46	0.53	0.05	0.152
	Surface to Ore	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1826.848333	1173.2	13642	38	2	139	0.67	0.14	0.01	0.04	0.17	0.04	0.00	0.010
	Surface to North Dump	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0
	Surface to JB1 Dump	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0
	Surface to East Dump	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0
	Surface to East Dump Ext.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2486	7795.8	90649	249	11	1238	5.93	1.27	0.13	0.366	1.48	0.32	0.03	0.092
JB3-1 (East Pit Phase 1)	Bench to Surface	0	0	0	0	0	0	0	0	0	0	0	0	0	0	826.89	2031.1	23617	65	3	107	0.52	0.11	0.01	0.032	0.13	0.03	0.00	0.008
	Surface to Ore	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2404.71	756.6	8798	25	2	120	0.58	0.12	0.01	0.036	0.14	0.03	0.00	0.009
	Surface to North Dump	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0
	Surface to JB1 Dump	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0
	Surface to East Dump	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0
	Surface to East Dump Ext.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2404.71	1274.5	14820	41	2	197	0.95	0.2	0.02	0.058	0.24	0.05	0.01	0.0146
Concentrate Shipping[2]	Plant Loadout to Off-site	0	0	0	0	0	0	0	0	0	0	0	0	0	0	450	-	-	53	5	48	0.38	0.081	0.0081	0.023	0.095	0.020	0.0020	0.0058
Tailings to East ER Extension[1]	Tails to East Dump Ext.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2220	0	-	-	3	242	1.16	0.25	0.02	0.072	0.29	0.06	0.01	0.0179

[5]Parameters for PM-30 assumed to be equal to TPM as stated in US EPA CHIEF, AP-42, Chapter 13, Table 13.2.2-2
[2]Distance estimated from final product loadout area to off-site
[1]Distance estimated from tailings loadout to east waste rock extension location

Sample Calculation

EF = k x (s/12)^a x (W/3)^b]

Where
EF = Emission Factor (kg/VKT)
VKT/day = km/day (total unpaved road travelled)
s = % (surface material silt content)
W = metric tonnes (mean vehicle weight)

EF TPM (haul trucks) = [1.381 kg/VKT] x (2.00 / 12)^0.7 x (119.80 tonnes / 3)^0.45]

EF TPM (haul trucks) = 2.0706 kg/VKT

TPM Emission Rate = EF x VKT x (1- Control Efficiency) x (Natural Adjustment) x Conversion

TPM Emission Rate Summer (Construction JB2-1, surface to ore) = 2.0706 kg/VKT x 80.3813 km/day x (1-0.8) x 1000 g/kg x 1 day/10 hour x 1 hour/3600 seconds

TPM Emission Rate = 0.92 g/second

Off-Road Mobile Equipment Exhaust

Source Description

Exhaust from the combustion of diesel fuel in large off-road mobile equipment and haul trucks on-site. Smaller mobile sources (smaller equipment and passenger vehicles) were not modelled as the expected air contaminant releases are not likely to contribute substantively to ground-level concentrations outside Project area.

Methodology

Exhaust gas emissions from off-road mobile equipment were estimated using the engine power (hp), the load factor, and emission factors (g/hp hr) obtained from the US-EPA July 2010 document "Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling Compression-Ignition". Metal emissions from exhaust were estimated using estimated fuel consumption (from hp and BSFC) and emission factors (g/gal) obtained from the "US-EPA 2018 document Speciation Profles and Toxic Emission Factors for Nonroad Engines in MOVES2014b." It was conservatively assumed all of the equipment had no DPF or SCR. Equipment list was provided by Galaxy, where engine power was not provided, it was assumed to be similar to those in the former assessment.

Calculation Inputs

Transient Adjustment Factors (TAF) by Equipment Type for Nonroad CI Equipment

Non-Road Equipment	HC	CO	NOx		PM		BSFC	
	Base-T3	Base-T3	Base, T0-T2	Tier 3	Base, T0-T2	Tier 3	Base-T3	Tier 4
Dozer	1.05	1.53	0.95	1.04	1.23	1.47	1.01	1
Bore/Drill	1	1	1	1	1	1	1	1
Excavators	1.05	1.53	0.95	1.04	1.23	1.47	1.01	1
Graders	1.05	1.53	0.95	1.04	1.23	1.47	1.01	1
Off-highway Trucks	1.05	1.53	0.95	1.04	1.23	1.47	1.01	1
Loader	1.05	1.53	0.95	1.04	1.23	1.47	1.01	1
Rollers	1.05	1.53	0.95	1.04	1.23	1.47	1.01	1
Construction Equipment Crushing/Pro	1	1	1	1	1	1	1	1

Engine Power (hp)	Technology Type	Emission Factors Steady-State (g/hp-hr)				BSFC (lb/hp-hr)
		HC	CO	NOx	PM	
>175 to 300	Tier 2	0.3085	0.7475	4	0.1316	0.367
	Tier 3	0.1836	0.7475	2.5	0.15	
	Tier 4	0.1314	0.075	2.5	0.0092	
	Tier 4N	0.1314	0.075	0.276	0.0092	
>300 to 600	Tier 2	0.1669	0.8425	4.3351	0.1316	0.367
	Tier 3	0.1669	0.8425	2.5	0.15	
	Tier 4	0.1314	0.084	2.5	0.0092	
	Tier 4N	0.1314	0.084	0.276	0.0092	
>600 to 750	Tier 2	0.1669	1.3272	4.1	0.1316	0.367
	Tier 3	0.1669	1.3272	2.5	0.15	
	Tier 4	0.1314	0.133	2.5	0.0092	
	Tier 4N	0.1314	0.133	0.276	0.0092	
>750 except generator sets	Tier 2	0.1669	0.7642	4.1	0.1316	0.367
	Tier 4	0.2815	0.7642	2.392	0.069	
	Tier 4N	0.1314	0.076	2.392	0.0276	

Diesel Density	7.1	lb/gal

Deterioration Factors

Species	A (%increase/% useful life)			
	Base/Tier 0	Tier 1	Tier 2	Tier 3+
HC	0.047	0.036	0.034	0.027
CO	0.185	0.101	0.101	0.151
Nox	0.024	0.024	0.009	0.008
PM	0.473	0.473	0.473	0.473

Metal Emission Factors

Engine Tier & Power	Pollutant	Emission Factor (g/gal)
Tier 0 – Tier 3, Tier 4: no DPF	Chromium 6	7.78E-08
	Manganese	3.46E-05
	Nickel	6.05E-05
	Elemental Gas-Phase Hg	1.20E-07
	Reactive Gas-Phase Hg	6.20E-08
	Particulate Hg	3.20E-08
	Total Hg	2.14E-07
	Arsenic	1.61E-05
Tier 4: DPF, no SCR	Chromium 6	3.19E-08
	Manganese	4.09E-06
	Nickel	4.15E-06
	Elemental Gas-Phase Hg	1.20E-07
	Reactive Gas-Phase Hg	6.20E-08
	Particulate Hg	3.20E-08
	Total Hg	2.14E-07
	Arsenic	1.61E-05
Tier 4: DPF+SCR	Chromium 6	1.16E-08
	Manganese	1.20E-06
	Nickel	1.58E-06
	Elemental Gas-Phase Hg	1.20E-07
	Reactive Gas-Phase Hg	6.20E-08
	Particulate Hg	3.20E-08
	Total Hg	2.14E-07
	Arsenic	1.61E-05

Emission Release Summary

Non-Road Equipment	HP	Tier	Loading Factor	Estimated Fuel Usage (lbs/hour)	Number of Units		Emission Factors (g/hp-hr)				TAF				Deterioration Factor				Adjusted EF				
					Construction	Operations	HC	CO	NOx	PM	HC	CO	Nox	PM	HC	CO	Nox	PM	HC	CO	NOx	PM	SO_2
Haul Truck - 100t CAT777	916	T4	0.59	336.2	3	9	0.28	0.76	2.39	0.07	1	1	1	1	1.027	1.151	1.008	1.473	0.289	0.880	2.411	0.102	0.005
Excavator (7m3)	476	T3	0.59	174.7	2	2	0.1669	0.8425	2.5	0.15	1.05	1.53	1.04	1.47	1.027	1.151	1.008	1.473	0.180	1.484	2.621	0.325	0.005
Excavator (49 t)	476	T3	0.59	174.7	1	1	0.1669	0.8425	2.5	0.15	1.05	1.53	1.04	1.47	1.027	1.151	1.008	1.473	0.180	1.484	2.621	0.325	0.005
Track dozer	441	T3	0.59	161.8	2	2	0.1669	0.8425	2.5	0.15	1.05	1.53	1.04	1.47	1.027	1.151	1.008	1.473	0.180	1.484	2.621	0.325	0.005
Wheel dozer	496	T3	0.59	182.0	1	1	0.1669	0.8425	2.5	0.15	1.05	1.53	1.04	1.47	1.027	1.151	1.008	1.473	0.180	1.484	2.621	0.325	0.005
Crushing/screening unit	415	T3	0.43	152.3	2	1	0.1669	0.8425	2.5	0.15	1	1	1	1	1.027	1.151	1.008	1.473	0.171	0.970	2.520	0.221	0.005
Crushing/screening unit	225	T3	0.43	82.6	2	1	0.1836	0.7475	2.5	0.15	1	1	1	1	1.027	1.151	1.008	1.473	0.189	0.860	2.520	0.221	0.005
pre-split drilling machine	325	T3	0.43	119.3	1	1	0.1669	0.8425	2.5	0.15	1	1	1	1	1.027	1.151	1.008	1.473	0.171	0.970	2.520	0.221	0.005
production drilling machine	325	T3	0.43	119.3	1	2	0.1669	0.8425	2.5	0.15	1	1	1	1	1.027	1.151	1.008	1.473	0.171	0.970	2.520	0.221	0.005
Grader	294	T3	0.59	107.9	1	1	0.1836	0.7475	2.5	0.15	1.05	1.53	1.04	1.47	1.027	1.151	1.008	1.473	0.198	1.316	2.621	0.325	0.005
Wheel loader	814	T2	0.59	298.7	0	1	0.1669	0.7642	4.1	0.1316	1.05	1.53	0.95	1.23	1.034	1.101	1.009	1.473	0.181	1.287	3.930	0.238	0.005
Utility Wheel Loader - (250HP)	250	T4i	0.59	91.8	1	2	0.1314	0.075	2.5	0.0092	1	1	1	1	1.027	1.151	1.008	1.473	0.135	0.086	2.520	0.014	0.005
Stemming Loader	386	T4	0.59	141.7	0	1	0.1314	0.084	2.5	0.0092	1	1	1	1	1.027	1.151	1.008	1.473	0.135	0.097	2.520	0.014	0.005
Articulated Dump Truck (34kL tank)	791	T2	0.59	290.3	1	1	0.1669	0.7642	4.1	0.1316	1.05	1.53	0.95	1.23	1.034	1.101	1.009	1.473	0.181	1.287	3.930	0.238	0.005
Articulated Dump Truck 45t	791	T2	0.59	290.3	2	2	0.1669	0.7642	4.1	0.1316	1.05	1.53	0.95	1.23	1.034	1.101	1.009	1.473	0.181	1.287	3.930	0.238	0.005

	Emissions per unit (g/s)																
Non-Road Equipment	**HC**	**CO**	**NOx**	**PM**	**$PM_{2.5}$[1]**	**PM_{10}[2]**	**VOCs[3]**	**SO_2**	**Cr6**	**Cr3[4]**	**Total Cr**	**Mn**	**Ni**	**Gaseous Hg**	**Particulate Hg**	**Total Hg**	**As**
Haul Truck - 100t CAT777	4.34E-02	1.32E-01	3.62E-01	1.53E-02	1.48E-02	1.53E-02	4.57E-02	7.32E-04	6.04E-10	2.75E-09	3.35E-09	2.68E-07	4.69E-07	1.41E-09	2.48E-10	1.66E-09	1.25E-07
Excavator (7m3)	1.40E-02	1.16E-01	2.04E-01	2.53E-02	2.46E-02	2.53E-02	1.48E-02	3.80E-04	3.14E-10	1.43E-09	1.74E-09	1.40E-07	2.44E-07	7.34E-10	1.29E-10	8.63E-10	6.49E-08
Excavator (49 t)	1.40E-02	1.16E-01	2.04E-01	2.53E-02	2.46E-02	2.53E-02	1.48E-02	3.80E-04	3.14E-10	1.43E-09	1.74E-09	1.40E-07	2.44E-07	7.34E-10	1.29E-10	8.63E-10	6.49E-08
Track dozer	1.30E-02	1.07E-01	1.89E-01	2.35E-02	2.28E-02	2.35E-02	1.37E-02	3.52E-04	2.91E-10	1.32E-09	1.61E-09	1.29E-07	2.26E-07	6.80E-10	1.20E-10	7.99E-10	6.01E-08
Wheel dozer	1.46E-02	1.21E-01	2.13E-01	2.64E-02	2.56E-02	2.64E-02	1.54E-02	3.96E-04	3.27E-10	1.49E-09	1.82E-09	1.45E-07	2.54E-07	7.65E-10	1.34E-10	8.99E-10	6.76E-08
Crushing/screening unit	8.50E-03	4.81E-02	1.25E-01	1.10E-02	1.06E-02	1.10E-02	8.95E-03	2.42E-04	1.99E-10	9.08E-10	1.11E-09	8.87E-08	1.55E-07	4.66E-10	8.20E-11	5.48E-10	4.13E-08
Crushing/screening unit	5.07E-03	2.31E-02	6.77E-02	5.94E-03	5.76E-03	5.94E-03	5.34E-03	1.31E-04	1.08E-10	4.92E-10	6.00E-10	4.81E-08	8.40E-08	2.53E-10	4.45E-11	2.97E-10	2.24E-08
pre-split drilling machine	6.65E-03	3.76E-02	9.78E-02	8.58E-03	8.32E-03	8.58E-03	7.01E-03	1.89E-04	1.56E-10	7.11E-10	8.67E-10	6.94E-08	1.21E-07	3.65E-10	6.42E-11	4.29E-10	3.23E-08
production drilling machine	6.65E-03	3.76E-02	9.78E-02	8.58E-03	8.32E-03	8.58E-03	7.01E-03	1.89E-04	1.56E-10	7.11E-10	8.67E-10	6.94E-08	1.21E-07	3.65E-10	6.42E-11	4.29E-10	3.23E-08
Grader	9.54E-03	6.34E-02	1.26E-01	1.56E-02	1.52E-02	1.56E-02	1.00E-02	2.35E-04	1.94E-10	8.83E-10	1.08E-09	8.62E-08	1.51E-07	4.53E-10	7.97E-11	5.33E-10	4.01E-08
Wheel loader	2.42E-02	1.72E-01	5.24E-01	3.18E-02	3.09E-02	3.18E-02	2.55E-02	6.51E-04	5.36E-10	2.44E-09	2.98E-09	2.39E-07	4.17E-07	1.26E-09	2.21E-10	1.48E-09	1.11E-07
Utility Wheel Loader - (250HP)	5.53E-03	3.54E-03	1.03E-01	5.55E-04	5.39E-04	5.55E-04	5.82E-03	2.00E-04	1.65E-10	7.51E-10	9.15E-10	7.33E-08	1.28E-07	3.85E-10	6.78E-11	4.53E-10	3.41E-08
Stemming Loader	8.54E-03	6.12E-03	1.59E-01	8.57E-04	8.32E-04	8.57E-04	8.99E-03	3.09E-04	2.54E-10	1.16E-09	1.41E-09	1.13E-07	1.98E-07	5.95E-10	1.05E-10	7.00E-10	5.26E-08
Articulated Dump Truck (34kL tank)	2.35E-02	1.67E-01	5.09E-01	3.09E-02	3.00E-02	3.09E-02	2.47E-02	6.32E-04	5.21E-10	2.37E-09	2.90E-09	2.32E-07	4.05E-07	1.22E-09	2.14E-10	1.43E-09	1.08E-07
Articulated Dump Truck 45t	2.35E-02	1.67E-01	5.09E-01	3.09E-02	3.00E-02	3.09E-02	2.47E-02	6.32E-04	5.21E-10	2.37E-09	2.90E-09	2.32E-07	4.05E-07	1.22E-09	2.14E-10	1.43E-09	1.08E-07

[1]PM2.5 scaling factor is equal to 0.97 TPM, from US EPA (2010)

[2]PM10 = TPM as per US EPA (2010)

[3]VOC = HC*1.053 as per Conversion factors for hydrocarbon emission components, US-EPA 2010.

[4]Chromium III emissions assume that Chromium VI emissions are 18% of total Chromium emissions based on:

US EPA 2016. Air Toxic Emissions from On-road Vehicles in MOVES2014

Taylor, M. 2003. Memorandum: Revised HAP Emission Factors for Stationary Combustion Turbines, Prepared by Alpha-Gamma Technologies, Inc for Sims Roy, EPA OAQPS ESD Combustion Group. August, 2003.Docket ID: OAR-2002-0060-0649. Access via http://www.regulations.g

Sample Calculations

Example below for emissions of carbon monoxide from a track dozer (441 HP, Tier 3, 0.59 loading factor

Deterioration Factor CO = 1 + A x age factor

Deterioration Factor CO = 1 + 0.151 x 1

Deterioration Factor CO = 1.151

Adjusted Emission Factor CO = $Ef_{ss,CO}$ x TAF_{CO} x DF_{CO}

Adjusted Emission Factor CO = 0.8425 g/hp-hr x 1.53 x 1.151

Adjusted Emission Factor CO = 1.484 g/hp-hr

CO Emissions (g/s)= $EF_{adj,CO}$ x veh_{HP} x load factor x conversion

CO Emissions (g/s)= 1.484 g/hp-hr x 441 hp x 0.59 x 1/3600 h/sec

CO Emissions (g/s)= 0.1072 g/s

Emission Factors of SO_2 estimated using US-EPA July 2010 document "Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling Compression-Ignition" as presented below:

$$SO_2 = (BSFC * 453.6 * (1 - soxcnv) - HC) * 0.01 * soxdsl * 2 \quad \text{[Equation 7]}$$

Where *BSFC the in-use adjusted fuel consumption in lb/hp-hr*
453.6 is the conversion factor from pounds to grams
soxcnv is the fraction of fuel sulfur converted to direct PM
HC is the in-use adjusted hydrocarbon emissions in g/hp-hr
0.01 is the conversion factor from weight percent to weight fraction
soxdsl is the episodic weight percent of sulfur in nonroad diesel fue
2 is the grams of SO2 formed from a gram of sulfu

Parameter	Value	Units	Source
soxcnv	0.02247	g PM sulphur/ g fuel S consumed (Base to T3)	US-EPA (2010)
	0.3	Tier 4	
soxdsl	0.0015	episodic fuel sulphur weight percent	Sulfur in Diesel Fuel Regulations (Environment Canada, 2013) for diesel fuels for off-road engines
EF *ss-BSFC*	0.367	lb / hp-hr	US PEA (2010) Table A4

SO_2 Emission Factor(g/hp-hr) = (BSFC x 453.6 g/lb x (1 - soxCNV) - HC) x 0.01 x soxdsl x 2

SO_2 Emission Factor(g/hp-hr) = (0.367 lb/hp-hr x 453.6 g/lb x (1 - 0.02247) x 0.01 x 0.0015 x 2

SO_2 Emission Factor(g/hp-hr) = 0.0048819 g/hp-hr

Loading and Unloading - Fugitive Emissions of Particulate Matter

Source Description There are numerous materials (ore, waste rock, concentrate, residue) that are handled on-site. Emissions source from the loading and unloading of material (drop sources).

Methodology Material loading/unloading were assessed as drop sources, particulate emissions were calculated using *US EPA TTN CHIEF, AP-42, Fifth Edition, Volume I, Chapter 13, Equation 13.2.4.(1)* and the quantity of material transferred.

Emission Release Summary

				Maximum Emission Rate [g/s][1]		
Phase	**Source ID**	**Description**	**Tonnage material [kt/hour]**	**TPM**	**PM10**	**PM2.5**
Construction	ldrockCP1Ben	Loading of rock at the Central Pit Phase 1 bench	1.00	0.98	0.46	0.07
	ldwrCP1Ben	Loading of waste rock at the Central Pit Phase 1	3.00	2.95	1.39	0.21
	ldsandCP1Ben	Loading of sand at the Central Pit Phase 1 bench	1.11	0.63	0.30	0.05
	unlrock	Unloading of rock at ore location	1.00	0.98	0.46	0.07
	unlwstED	Unloading of waste rock at East Dump	3.00	2.95	1.39	0.21
	unlsandORE	Unloading of sand at ore location	1.11	0.63	0.30	0.05
Operations (Maximum year - Year 14)	ldrkCP4B	Loading of rock at the Central Pit Phase 4 bench	2.00	1.97	0.930	0.14
	lders	Loading of plant residue	0.19	0.06	0.0283	0.004
	loadconc	Loading of concentrate at plant	0.79	0.29	1.39E-01	2.11E-02
	unlrock	Unloading of rock at ore location	2.00	1.97	0.93	0.141
	unlwstEDEx	Unloading of waste rock at East Dump Extension	2.00	1.97	0.93	0.14
	unldtail	Unloading plant residue at east dump extention[2]	0.19	0.06	2.83E-02	4.29E-03

[1] Emission rate corresponding to the maximum windspeed of 13.7 m/s

[2] Unloading of residue in the peak operational year (Y14) assumed to be at the east dump extension as this is the dump active during this phase

Calculation Inputs

Phase	Number of Days	Operational Hours per Day
Construction	100	10
Operations	365	24

Haul Route Information

		Construction			Operation - Year 14		
		Material Moved (Ktonnes)			Material Moved (Ktonnes)		
Phase	**Haul Route**	**Hourly**	**Daily**	**Annual (Y -1)**	**Hourly**	**Daily**	**Annual (Y14)**
JB2-1 (Center Pit Phase 1). CP1	Bench to Surface	3.0	25.0	2500	0.0	0.0	0
	Surface to Ore	1.0	2	184	0.0	0.0	0
	Surface to North Waste Rock	0.0	0	0	0.0	0.0	0
	Surface to JB1 Waste Rock	0.0	0	0	0.0	0.0	0
	Surface to East Waste Rock	3.0	24.0	2316	0.0	0.0	0
	Surface to East Waste Rock Ext.	0.0	0	0	0.0	0.0	0
JB2-4 (Center Pit Phase 4) - CP4	Bench to Surface	0.0	0	0	2.0	25.0	8969
	Surface to Ore	0.0	0	0	1.0	4.0	1173
	Surface to North Waste Rock	0.0	0	0	0.0	0.0	0
	Surface to JB1 Waste Rock	0.0	0	0	0.0	0.0	0
	Surface to East Waste Rock	0.0	0	0	0.0	0.0	0
	Surface to East Waste Rock Ext.	0.0	0	0	1.0	22.0	7796
JB3-1 (East Pit Phase 1)	Bench to Surface	0.0	0	0	1.0	6.0	2031
	Surface to Ore	0.0	0	0	1.0	3.0	757
	Surface to North Waste Rock	0.0	0	0	0.0	0.0	0
	Surface to JB1 Waste Rock	0.0	0	0	0.0	0.0	0
	Surface to East Waste Rock	0.0	0	0	0.0	0.0	0
	Surface to East Waste Rock Ext.	0.0	0	0	1.0	4.0	1274

				Sand		Ore/Waste Rock		Plant Residue		Concentrate	
Substance	**NPRI CAS**	**Particle Size**	**k**	**Moisture Content [%]**	**Drop Emission Factor [kg/ Mg]**	**Moisture Content [%]**	**Drop Emission Factor [kg/ Mg]**	**Moisture Content [%]**	**Drop Emission Factor [kg/ Mg]**	**Moisture Content [%]**	**Drop Emission Factor [kg/ Mg]**
Total Particulate Matter	NA - M08	< 30 um	0.74	7.4	0.0020	5	0.0035	11.4	0.0011	10	0.0013
Particulate matter less than or equal to 10 micrometers (μm) (PM10)	NA - M09	< 10 um	0.35		0.0010		0.0017		0.0005		0.0006
Particulate matter less than or equal to 2.5 μm (PM2.5)	NA - M10	< 2.5 um	0.053		0.0001		0.0003		0.0001		0.0001

Emission Calculations

US EPA AP-42, Chapter 13, Equation 13.2.4.(1):

E = k x 0.0016 x (U/2.2)^1.3 / (M/2)^1.4

Where:

E =		Emission Factor (kg/Mg)
U =	*13.700*	Max Wind Speed (m/s)
M =	*See above*	Material Moisture Content (%)
k =	*See above*	Particle Size Multiplier (dimensionless)

Sample Calculations

Drop E TPM Rock, uncontrolled = $0.74 \times 0.0016 \times \left(\frac{13.700 \text{ m/s}}{2.2}\right)^{1.3} \times \left(\frac{\text{See above \%}}{2}\right)^{1.4}$

Drop E TPM Rock, uncontrolled = 3.54E-03 kg/Mg

Drop Emission Rate Rock TPM, uncontrolled = E [kg/Mg] x Material Transferred [Mg/Year] x Conversion

WRDS Drop ER Rock TPM, uncontrolled = $3.54\text{E-}03 \frac{\text{kg}}{\text{Mg}} \times \frac{1 \text{ kt}}{\text{hour}} \times \frac{1000 \text{ tonne}}{1 \text{ kt}} \times \frac{1 \text{ hour}}{3600 \text{ seconds}} \times \frac{1000 \text{ g}}{1 \text{ kg}}$

WRDS Drop ER Rock TPM, uncontrolled = 0.98 g/s

Emissions from Mobile Crushing/Screening (during construction)

Source Description Emissions from the two mobile crushers and two mobile screens used during construction phase activities. The mobile crushers and screens are located at the storage yard.

Methodology Particulate emissions from crushing and screening were estimated using throughput data and emission factors sourced from the US EPA AP-42 Chapter 11.19.2 - Crushed Stone Processing and Pulverized Mineral Processing. It was conservatively assumed that the emission factor for crushing be that of tertiary crushing, controlled, as there is a waterjet prior to the crushing circuit.

Emissions Summary

		Construction Emission Rates (g/s)		
Source	**Process Description**	**TPM**	**PM_{10}**	**$PM_{2.5}$**
CRUSH1	Tertiary Crushing	0.093	0.042	0.008
CRUSH2	Tertiary Crushing	0.093	0.042	0.008
SCREEN1	Screening	0.170	0.057	0.004
SCREEN2	Screening	0.170	0.057	0.004

Particulate Matter Emission Calculations

	Construction
Througput [tonne/day]	11109.0
Operational Hours/day	10.00
Efficiency Factor	1.00
Throughput hourly [tonnes/hour]	1110.9
Throughput hourly per unit [tonnes/hour]	555.5

						Construction Emission Rates (g/s)		
Source	**Process Description**	**TPM EF [g/kg]**	**PM10 EF [g/kg]**	**PM2.5 EF [g/kg]**	**Mass throughput [kg/hour]**	**TPM**	**PM_{10}**	**$PM_{2.5}$**
CRUSH1	Tertiary Crushing	0.0006	0.00027	0.00005	555.45	0.09	0.04	0.008
CRUSH2	Tertiary Crushing	0.0006	0.00027	0.00005	555.45	0.09	0.04	0.008
SCREEN1	Screening	0.0011	0.00037	0.000025	555.45	0.17	0.06	0.004
SCREEN2	Screening	0.0011	0.00037	0.000025	555.45	0.17	0.06	0.004

Sample Calculations

Tertiary Crushing TPM Emissions = Annual Throughput × Emission Factor × Conversion x (1 - Control Efficiency)

$$\text{Tertiary Crushing TPM Emissions} = \frac{555\ \text{tonnes}}{\text{hour}} \times \frac{1000\ \text{kg}}{1\ \text{tonne}} \times \frac{0.0006\ \text{g}}{\text{kg}} \times \frac{1\ \text{hour}}{3600\ \text{seconds}}$$

$$\text{Tertiary Crushing TPM Emissions} = \frac{0.09\ \text{g}}{\text{s}}$$

Bull Dozing

Source Description Bull dozers are used to lay construction material and are used during the construction of the dike and waste areas

Methodology The dozer emission rates for particulate were estimated using hourly emission factors presented in AP-42 Section 11.9 Western Surface Coal Mining. It was assumed the emission factor for overburden could be used. A control efficiency of 50% was applied to represent the intermittent nature of this type of operation.

Emission Release Summary

Source ID	Source Description	Silt Content (%)[1]	Moisture %	Control Efficiency	Emission Rates (g/s) TPM	PM_{10}	$PM_{2.5}$
TrDoz1	Track Dozer (436 HP)	2	5	50%	0.098	0.014	0.010
TrDoz2	Track Dozer (436 HP)	2	5	50%	0.098	0.014	0.010
WhDoz1	Wheel Dozer (496 HP)	2	5	50%	0.098	0.014	0.010

[1]Silt content was provided by client for the ore and wasterock

Emission Calculations

Scaling Factors	
PM_{10} (of PM_{15})	$PM_{2.5}$ (of TPM)
0.75	0.105

TPM Emission Factor [kg/hour]= $\frac{2.6(s)^{1.2}}{(M)^{1.3}}$

Where: s = silt content (%)
M = Moisture content (%)

TPM Emission Factor [kg/hour]= $2.5 \times \frac{2.0}{5.0}^{\wedge 1.2 \,/\, \wedge 1.3}$

TPM Emission Factor [kg/hour]= $0.71 \frac{kg}{hr}$

TPM Emission Rate [g/s] = Emission Factor × Conversion x (1 - Control Efficiency)

TPM Emission Rate [g/s] = $0.71 \frac{kg}{hr} \times (1\text{-}0.5) \times \frac{1\ hr}{3600\ seconds} \times \frac{1000\ g}{1\ kg}$

TPM Emission Rate [g/s] = $0.098 \frac{g}{s}$

PM15 Emission Factor [kg/hour]= $\frac{0.45(s)^{1.5}}{(M)^{1.4}}$

PM15 Emission Factor [kg/hour]= $0.13 \frac{kg}{hr}$

Propane Combustion - Building Heating

Source Description The combustion of propane on-site for the heating of buildings.

Methodology Emissions from propane combustion were estimated using emission factors sourced from US EPA AP-42 Chapter 1.5 - Liquefied Petroleum Gas Combustion, July 2008.

Calculation Inputs

Sulphur Fuel Content[1]	239.6	mg/kg
Density propane	522	kg/m^3
Sulphur Fuel Content	125071.2	mg/m^3
Conversion mg/m^3 to gr/ft^3	0.00044	gr/ft^3
	0.54656	$gr/100\ ft^3$

[1]Sulphur fuel content of 239.6 mg/kg is based on the maximum Canadian sulphur standard in propane fuel - CAN / CGSB-3.14-2013

Substance	CAS No.	Emission Factor [kg/1000 L]
Total Particulate Matter	NA - 1	0.084
Particulate matter less than or equal to 10 micrometers (µm) (PM_{10})	NA - 2	0.084
Particulate matter less than or equal to 2.5 µm ($PM_{2.5}$)	NA - 3	0.084
Sulphur Dioxide[3]	7446-09-5	0.0066
Nitrogen Oxides	11104-93-1	1.56
Carbon Monoxide	630-08-0	0.9
Volatile Organic Compounds	NA - 4	0.12

Emission Release Summary

				Emissions [g/s]						
Source ID	Source Description	Phase	Max Propane usage [L/h]	Total Particulate Matter	Particulate matter less than or equal to 10 micrometers (µm) (PM_{10})	Particulate matter less than or equal to 2.5 µm ($PM_{2.5}$)	Sulphur Dioxide	Nitrogen Oxides	Carbon Monoxide	Volatile Organic Compounds
pt20	Auxiliary heating of the crushing building	Operations	132	3.08E-03	3.08E-03	3.08E-03	2.40E-04	5.72E-02	3.30E-02	4.40E-03
pt21	Crushing building ventilation	Operations	50	1.17E-03	1.17E-03	1.17E-03	9.11E-05	2.17E-02	1.25E-02	1.67E-03
pt22	Auxiliary heating of the screening building	Operations	74	1.73E-03	1.73E-03	1.73E-03	1.35E-04	3.21E-02	1.85E-02	2.47E-03
pt23	Screening building ventilation	Operations	20	4.67E-04	4.67E-04	4.67E-04	3.64E-05	8.67E-03	5.00E-03	6.67E-04
pt24a, b, c, d	Auxiliary heating of the SMD building	Operations	1613	3.76E-02	3.76E-02	3.76E-02	2.94E-03	6.99E-01	4.03E-01	5.38E-02
pt25	SMD building ventilation	Operations	149	3.48E-03	3.48E-03	3.48E-03	2.71E-04	6.46E-02	3.73E-02	4.97E-03
pt26	Auxiliary heating of the concentrates building	Operations	113	2.64E-03	2.64E-03	2.64E-03	2.06E-04	4.90E-02	2.83E-02	3.77E-03
pt27	Auxiliary heating of the tailings building	Operations	74	1.73E-03	1.73E-03	1.73E-03	1.35E-04	3.21E-02	1.85E-02	2.47E-03
pt28	Auxiliary warehouse heating	Operations	132	3.08E-03	3.08E-03	3.08E-03	2.40E-04	5.72E-02	3.30E-02	4.40E-03
pt29	Warehouse building ventilation	Operations	30	7.00E-04	7.00E-04	7.00E-04	5.47E-05	1.30E-02	7.50E-03	1.00E-03
pt30	Auxiliary heating of the workshop building	Operations	74	1.73E-03	1.73E-03	1.73E-03	1.35E-04	3.21E-02	1.85E-02	2.47E-03
pt31	Workshop building ventilation	Operations	10	2.33E-04	2.33E-04	2.33E-04	1.82E-05	4.33E-03	2.50E-03	3.33E-04
pt32a, b, c, d	Auxiliary heating of the mining services building	Operations	113	2.64E-03	2.64E-03	2.64E-03	2.06E-04	4.90E-02	2.83E-02	3.77E-03
pt33	Mining services building ventilation	Operations	109	2.54E-03	2.54E-03	2.54E-03	1.99E-04	4.72E-02	2.73E-02	3.63E-03
pt34	Construction camp - dorms 1	Construction & Operations	43	1.00E-03	1.00E-03	1.00E-03	7.83E-05	1.86E-02	1.08E-02	1.43E-03
pt35	Construction camp - dorms 2	Construction & Operations	43	1.00E-03	1.00E-03	1.00E-03	7.83E-05	1.86E-02	1.08E-02	1.43E-03
pt36	Operations camp - dorms 1	Construction & Operations	54	1.26E-03	1.26E-03	1.26E-03	9.84E-05	2.34E-02	1.35E-02	1.80E-03
pt37	Operations camp - dorms 2	Construction & Operations	54	1.26E-03	1.26E-03	1.26E-03	9.84E-05	2.34E-02	1.35E-02	1.80E-03
pt38	Operations camp - dorms 3	Construction & Operations	54	1.26E-03	1.26E-03	1.26E-03	9.84E-05	2.34E-02	1.35E-02	1.80E-03
pt39	Operations camp - dorms 4	Construction & Operations	54	1.26E-03	1.26E-03	1.26E-03	9.84E-05	2.34E-02	1.35E-02	1.80E-03
pt40	Operations camp - dorms 5	Construction & Operations	54	1.26E-03	1.26E-03	1.26E-03	9.84E-05	2.34E-02	1.35E-02	1.80E-03
pt41	Operations camp - kitchen/café	Construction & Operations	172	4.01E-03	4.01E-03	4.01E-03	3.13E-04	7.45E-02	4.30E-02	5.73E-03
pt42	Operations camp - offices	Construction & Operations	5	1.17E-04	1.17E-04	1.17E-04	9.11E-06	2.17E-03	1.25E-03	1.67E-04
pt43	Operations camp - laundry	Construction & Operations	58	1.35E-03	1.35E-03	1.35E-03	1.06E-04	2.51E-02	1.45E-02	1.93E-03
pt44	Operations camp - infirmary (medical room)	Construction & Operations	4	9.33E-05	9.33E-05	9.33E-05	7.29E-06	1.73E-03	1.00E-03	1.33E-04
pt45	Admin Building	Operations	22	5.13E-04	5.13E-04	5.13E-04	4.01E-05	9.53E-03	5.50E-03	7.33E-04
pt46	Lab	Operations	19	4.43E-04	4.43E-04	4.43E-04	3.46E-05	8.23E-03	4.75E-03	6.33E-04

Sample Calculation

Particulate Matter Emissions Propane (Aux heating of crushing)=

$$\frac{132}{1}\ \frac{L}{hour} \times 0.0840000\ \frac{kg}{L} \times \frac{1000\ g}{1\ kg} \times \frac{1\ hour}{3600\ sec}$$

Particulate Matter Emissions Propane (Aux heating of crushing)= $0.0031\ \frac{g}{s}$

APPENDIX D

Greenhouse Gas Assessment

Greenhouse Gas Assessment

June 15, 2021

Prepared for:

Galaxy Lithium (Canada) Inc.

Prepared by:

Stantec Consulting Ltd.

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LIST OF TABLES

1.0 INTRODUCTION

Stantec was retained by Galaxy to update the air dispersion modelling and greenhouse gas (GHG) emissions estimate for the James Bay Lithium Pegmatite Project (the Project) Environmental and Social Impact Assessment (ESIA) due to recent Project design changes since the original GHG assessment (WSP 2018).

GHGs were selected as a subcomponent of the atmospheric environment because the change in GHGs is of scientific and regulatory concern. The revisions made to the Project since the original ESIA submissions (WSP 2018) is expected to influence the GHGs emitted throughout construction and operation. The objective of this assessment is to identify direct and indirect GHG emission sources from the Project, estimate the GHG emissions from the Project activities, and compare the total emissions to provincial and national emission totals and reduction targets.

2.0 BACKGROUND

In the atmosphere, GHGs absorb and re-emit infrared radiation from the planetary surface, thereby introducing the potential effect of warming the lower levels of the atmosphere and acting as a thermal blanket for the planet. Globally, GHGs are emitted from numerous natural and anthropogenic sources and the increased atmospheric concentrations have been associated with climate change (Intergovernmental Panel on Climate Change [IPCC] 2014). Although the science of climate change has not been advanced to the point where a clear cause-and-effect relationship can be established between project-specific activities and subtle changes to global climate, GHG assessments are conducted to assess the effects on facility-level and jurisdictional inventories.

In the GHG assessment for the Project, the emissions of GHGs, expressed in units of tonnes of carbon dioxide equivalent (CO_{2e}), were estimated and compared to provincial and national emission totals and reduction targets. The GHG assessment includes the following known GHG substances that will be emitted by the Project:

- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrous oxide (N_2O)

Greenhouse gases also include perfluorocarbons (PFC), hydrofluorocarbons (HFC), sulfur hexafluoride (SF_6) and nitrogen trifluoride (NF_3). These gases are expected to be released in insubstantial amounts, or not at all, and are therefore not considered further in the GHG assessment.

The management of GHG emissions takes place at provincial, national and international scales. The existing acts and accords are primarily related to operational emissions above specified thresholds or are related to emission reductions on provincial and federal scales.

The Government of Quebec has set the following emission reduction targets in the provincial Climate Change Action Plan (Government of Quebec 2020):

- a 37.5% reduction in regional GHG emissions below 1990 levels by 2030
- carbon neutrality (net zero emissions) by 2050

The Government of Canada has committed to these GHG emission reduction targets (ECCC 2019a):

- a 17% reduction of national GHG emissions below 2005 levels by 2020 (under the 2009 Copenhagen Accord)
- a 40% to 45% reduction of national GHG emissions below 2005 levels by 2030 (2021 Earth Day Summit, ECCC 2021a) replacing the former target of a 30% reduction of national GHG emissions below 2005 levels by 2030 (2015 submission to the United Nations Framework Convention on Climate Change, under the Paris Agreement)
- Net zero emissions by 2050 (Strategic Assessment of Climate Change [ECCC 2020])

To support the initiatives and facilitate achieving the GHG reduction targets, the federal government developed the Pan-Canadian Approach to Pricing Carbon Pollution, providing flexibility to provinces and territories to develop carbon pollution pricing systems of their own, and outlining the required criteria for these systems (ECCC 2019b). For provinces and territories that have not implemented jurisdictional carbon pollution pricing systems that would meet the federal benchmark requirements, they are required to comply with the federal carbon pollution pricing system. Quebec has its own established carbon tax in place, through a cap-and-trade system which sets caps (limits) on GHG emissions by industry.

In addition to the GHG reduction targets and carbon pricing, there are GHG emission reporting requirements both federally and provincially. Federally, under the authority of the *Canadian Environmental Protection Act*, *1999* (CEPA), the GHG Emission Reporting Program requires operators of facilities to report their annual GHG emissions to ECCC if their emissions are above 10,000 t CO_{2e} per year (ECCC 2019a). There is provincial GHG emission reporting requirements under the authority of Quebec's *Environment Quality Act* (2017) and the *Regulation Respecting Mandatory Reporting of Certain Emissions of Contaminants into the Atmosphere* (Q-2 r.15). There are three provincial levels of GHG reporting:

- Facilities emitting 10,000 tonnes of CO_{2e} or more annually must report their emissions to the Minister
- Facilities emitting more than 25,000 tonnes of CO_{2e} are subject to the provincial cap-and-trade regulation for GHG emission allowances and require third-party verification of emission quantifications in compliance with ISO 14064-3 and ISO 14065

Depending on the annual quantity of GHG emissions released to the atmosphere, the Project may be required to report annual GHG emissions to the provincial and federal governments.

3.0 QUANTIFICATION METHODS AND SOURCE ESTIMATES

The methods used to estimate GHG emissions from the construction, operation of the Project were guided by the principles of the GHG Protocol (WRI 2013). The GHG Protocol is an internationally accepted accounting standard and provides guidance on preparing a GHG emissions inventory. Relevance, completeness, consistency, transparency, and accuracy are the five principles that are the foundation of GHG accounting and, therefore, those five principles guided this assessment. The GHG emission inventories are an estimate based on best available information at the time of the assessment. Specific emission factor data are presented in Section 3.1.

Emissions from each of these specific GHGs have been estimated and multiplied by their 100-year global warming potential (GWP) so they can be reported in units referred to as carbon dioxide equivalents or CO_{2e}. The CO_{2e} based in the GWPs is the standardized way to report GHG emissions.

The GWP from the National Inventory Report (NIR) from Environment and Climate Change Canada (ECCC) (2021b) applied in this assessment are:

- Carbon Dioxide (CO_2) = 1
- Methane (CH_4) = 25
- Nitrous Oxide (N_2O) = 298

On this basis, the CO_{2e} for the Project are calculated as:

$$CO_{2e} = (mass\ CO_2 \times 1) + (mass\ CH_4 \times 25) + (mass\ N_2O\ \times 298)$$

For example, for stationary combustion from operation, including propane and diesel combustion, the following sample calculation shows the conversion of the each GHG species emissions to CO_{2e}:

$$CO_{2e} = \left(15{,}759\frac{\text{tonnes}}{\text{year}}\ CO_2 \times 1.0\right) + \left(0.3\frac{\text{tonnes}}{\text{year}}\ CH_4 \times 25\right) + (1.3\frac{\text{tonnes}}{\text{year}}N_2O\ \times 298)$$

$$CO_{2e} = 16{,}153\frac{tonnes}{year}$$

3.1 EMISSION SOURCES

The substantive sources of direct GHG emissions during construction and operation are the mobile and stationary equipment exhausts, and blasting using an ammonium nitrate / fuel oil (ANFO) emulsion. As land clearing is expected to occur prior to the peak construction year, its emissions were not included. These GHG emissions consist primarily of CO_2, with smaller amounts of CH_4 and N_2O.

As per the Strategic Assessment of Climate Change guidance (ECCC 2020), the GHG emissions inventory includes indirect emissions associated with the consumption of purchased electricity, shipping of products and delivery of supplies from outside the Project boundary, and employee transportation to site. Other indirect GHG emissions associated with upstream sources, such as production of purchased materials and associated upstream transportation and distribution, are not included in this assessment.

3.1.1 Blasting

The GHG emissions from explosives detonation during construction and operation were estimated using an emission factor (0.189 t CO_2/tonnes explosives) recommended by the Mining Association of Canada (MAC 2014) and based on the predicted annual explosive quantities. It was assumed that the ammonium nitrate (AN) emulsion would have a similar emission factor as ANFO, consistent with the assumption in the initial ESIA submission (WSP 2018).

The GHG emissions from blasting were calculated using the following equation:

$$Emissions\ [\frac{tonnes}{year}] = Emission\ Factor\ \left[\frac{kg}{tonne\ ANFO}\right] \times\ Explosive\ Usage\ \left[\frac{tonne\ ANFO}{year}\right]$$

Where:

Emissions =	Annual Emission Rate [tonne/year]
Emission Factor =	Mining Association of Canada (MAC 2014) emission factor [0.189 kg CO_2/kg of ammonium nitrate/fuel oil (ANFO)]
Explosive Usage =	Total amount of ANFO explosive used per year provided by Galaxy (807 tonnes/year during construction; 3,550 tonnes/year during peak operational year, year 14)

The following sample calculation presents the CO_2 emissions from blasting during operations peak year (year 14):

$$Emissions\ CO_2 = 0.189\ \frac{kg\ CO_2}{tonne\ ANFO} \times\ 3{,}550\ \frac{tonnes\ ANFO}{year}$$

$$Emissions\ CO_2 = 671.0\ \frac{tonnes}{year}$$

There are no CH4 or N2O emissions from ANFO blasting.

Table D.1 summarizes the explosives used for each year over the life of mine and the associated GHG emissions.

Table D.1 Annual Explosive Usage and Associated GHG Emissions

Source	Year	Annual Explosive Usage [tonne/year]	Emissions [tonnes/year]			
			CO_2	CH_4	N_2O	CO_{2e}
Blasting	Construction (Y -1)	807	152.5	-	-	152.5
	Y1	2,582	488.0	-	-	488.0
	Y2	2,597	490.8	-	-	490.8
	Y3	2,582	488.0	-	-	488.0
	Y4	2,582	488.0	-	-	488.0
	Y5	2,582	488.0	-	-	488.0
	Y6	2,582	488.0	-	-	488.0
	Y7	2,582	488.0	-	-	488.0
	Y8	3,501	661.8	-	-	661.8
	Y9	3,433	648.8	-	-	648.8
	Y10	3,550	671.0	-	-	671.0
	Y11	3,550	671.0	-	-	671.0
	Y12	3,550	671.0	-	-	671.0
	Y13	3,550	671.0	-	-	671.0
	Y14	3,550	671.0	-	-	671.0
	Y15	2,905	549.0	-	-	549.0
	Y16	2,996	566.2	-	-	566.2
	Y17	2,582	488.0	-	-	488.0
	Y18	2,934	554.6	-	-	554.6
	Y19 - Restoration	711	134.3	-	-	134.3
	Total	**55,709**	**10,529**	**-**	**-**	**10,529**

3.1.2 On-Site Transportation and Mobile Equipment

Emissions from off-road mobile equipment during construction and operation were estimated using diesel combustion emission factors from the ECCC NIR (ECCC 2021b) paired with fuel consumptions rates. Similarly, emissions from on-site haul trucks were estimated using combustion emission factors from the ECCC 2020 NIR, based on fuel type and vehicle size (heavy-duty diesel vehicle), and fuel consumption provided by Galaxy. The GHG emission factors used for the transportation and off-road equipment are presented in Table D2.

Table D.2 Transportation and Mobile Equipment Emission Factors

Vehicle Class	CO_2 Emission Factor [g/L]	CH_4 Emission Factor [g/L]	N_2O Emission Factor [g/L]
Light-Duty Diesel Trucks (LDDTs)[A]	2,680.5	0.068	0.21
Heavy-Duty Diesel Vehicles (HDDVs)[A]	2,680.5	0.14	0.082
Off-Road Diesel Equipment [B]	2,680.5	0.073	0.022

Source: 2020 NIR (ECCC 2021b)
Notes:
[A] Emission factors used for on-road diesel vehicles with "Moderate Control"
[B] Emission factors used for off-road diesel >19 kW, Tier 1-3

The GHG emissions from on-site transportation were calculated using the following equation:

$$Emissions\left[\frac{tonnes}{year}\right] = Emission\ Factor\left[\frac{g}{L}\right] \times\ Fuel\ Usage\left[\frac{L}{year}\right] \times Unit\ Conversion\left[\frac{1\ tonne}{10^6\ g}\right]$$

Where:

Emissions = Annual Emission Rate [tonnes CO_{2e} /year]
Emission Factor = Emission factor, specific to GHG species and vehicle class and presented in Table D2 (NIR, ECCC 2021b)
Fuel Usage = Total annual amount of fuel used provided by Galaxy, presented per year in Table D3.

The total estimated diesel fuel usage, the total haul truck estimated fuel usage, and the stationary diesel fuel usage were provided by Galaxy. From these usages, the off-road mobile equipment diesel fuel usage was estimated by removing the quantities used by haul trucks and by stationary from the total. This method lumps employee trucks, vans, ambulances, etc. in with the off-road diesel usage category, but since this usage from these vehicles is minor and the emission factors are similar, it does not make a substantial difference in emissions estimated (<1%).

Table D.3 On-Site Annual Diesel Fuel Usage

Year	Total Estimated Annual Diesel Usage [kL]	Haul Truck Annual Diesel Usage [kL]	Stationary Diesel Usage [kL]	Off-Road Annual Diesel Usage [kL][A]
Y-1	1,801	358	526.7	916
Y1	5,529	1,144	790	3,596
Y2	5,775	1,329	790	3,655
Y3	5,916	1,467	790	3,660
Y4	6,014	1,565	790	3,659
Y5	5,783	1,352	790	3,641
Y6	5,617	1,259	790	3,568
Y7	5,682	1,325	790	3,566
Y8	7,029	1,889	790	4,350
Y9	6,806	1,995	790	4,021

Table D.3 On-Site Annual Diesel Fuel Usage

Year	Total Estimated Annual Diesel Usage [kL]	Haul Truck Annual Diesel Usage [kL]	Stationary Diesel Usage [kL]	Off-Road Annual Diesel Usage [kL][A]
Y10	7,201	2,163	790	4,249
Y11	6,920	2,016	790	4,114
Y12	7,130	2,103	790	4,237
Y13	7,502	2,370	790	4,342
Y14	7,734	2,583	790	4,361
Y15	7,117	2,505	790	3,822
Y16	7,368	2,683	790	3,895
Y17	6,452	2,068	790	3,594
Y18	6,738	2,174	790	3,773
Y19 - Restoration	2,147	494	790	863
Total	**122,260**	**34,841**	**15,537**	**71,882**

Notes:
[A] Off-road annual diesel usage was assumed to be the quantity of total diesel remaining that is not used by haul trucks or stationary. Employee trucks/vans/ambulance, etc. is lumped in with off-road but as the Emission Factors are similar, it will not make a substantial difference (<1% change).

The following sample calculation is for the CO_2 emissions from all off-road diesel equipment during operation year 14:

$$Emissions\ CO_2 = 2{,}680.5\frac{g}{L} \times\ 4{,}361{,}000\frac{L}{year} \times \frac{1\ tonne}{10^6 g}$$

$$Emissions\ CO_2 = 11{,}690\frac{tonnes}{year}$$

Similar to the above example for CO_2, CH_4 and N_2O would be estimated using their respective emission factors (EFs). Emissions for the other vehicle types were estimated following the same method but with their respective fuel usages and emission factors. Table D.4 summarizes the associated GHG emissions for haul trucks and off-road mobile equipment.

The following table, Table D4, presents the GHG emissions from the haul trucks and the off-road mobile equipment over the life of the mine.

Table D.4 Annual GHG Emissions from Haul Trucks and Off-Road Mobile Equipment

Year	Emissions [tonnes/year]							
	Haul Truck (On-Road Transportation)				Off-Road Mobile			
	CO_2	CH_4	N_2O	CO_{2e}	CO_2	CH_4	N_2O	CO_{2e}
Y-1	960	0.13	1.10E-05	963	2,456	0.07	0.02	2,515
Y1	3,065	0.43	3.52E-05	3,076	9,639	0.26	0.08	9,870
Y2	3,564	0.50	4.09E-05	3,576	9,798	0.27	0.08	10,033
Y3	3,931	0.55	4.51E-05	3,945	9,809	0.27	0.08	10,045
Y4	4,194	0.59	4.82E-05	4,208	9,809	0.27	0.08	10,044
Y5	3,625	0.51	4.16E-05	3,638	9,759	0.27	0.08	9,993
Y6	3,374	0.47	3.87E-05	3,385	9,564	0.26	0.08	9,794
Y7	3,552	0.50	4.08E-05	3,565	9,560	0.26	0.08	9,789
Y8	5,063	0.71	5.81E-05	5,081	11,659	0.32	0.10	11,939
Y9	5,348	0.75	6.14E-05	5,367	10,778	0.29	0.09	11,037
Y10	5,797	0.81	6.66E-05	5,817	11,389	0.31	0.09	11,662
Y11	5,405	0.76	6.21E-05	5,424	11,027	0.30	0.09	11,292
Y12	5,637	0.79	6.47E-05	5,657	11,356	0.31	0.09	11,629
Y13	6,351	0.89	7.29E-05	6,374	11,639	0.32	0.10	11,918
Y14	6,923	0.97	7.95E-05	6,947	11,690	0.32	0.10	11,971
Y15	6,715	0.94	7.71E-05	6,738	10,246	0.28	0.08	10,492
Y16	7,191	1.01	8.26E-05	7,216	10,442	0.28	0.09	10,692
Y17	5,544	0.78	6.37E-05	5,563	9,633	0.26	0.08	9,864
Y18	5,828	0.82	6.69E-05	5,848	10,115	0.28	0.08	10,358
Y19 - Restoration	1,324	0.19	1.52E-05	1,329	2,314	0.06	0.02	2,370
Total	**93,391**	**13.1**	**1.07E-03**	**93,718**	**192,680**	**5.2**	**1.58**	**197,309**

3.1.3 Stationary Combustion

Emissions from stationary combustion during construction and operation were estimated using the estimated fuel usages (propane and diesel), provided by Galaxy, and emission factors from ECCC's *Canada's Greenhouse Gas Quantification Requirements* (ECCC 2019c). The GHG emission factors used for stationary combustion are presented in Table D.5.

Table D.5 Stationary Equipment Combustion Emission Factors

Fuel Type	CO_2 EF [kg/kL]	CH_4 EF [kg/kL]	N_2O EF [kg/kL]
Diesel	2,681	0.133	0.4
Propane	1,515	0.024	0.108
Source: 2019 Canada's Greenhouse Gas Quantification Requirements (ECCC 2019c)			

The GHG emissions from stationary combustion were calculated using the following equation:

$$Emissions\left[\frac{tonnes}{year}\right] = Emission\ Factor\left[\frac{kg}{kL}\right] \times\ Fuel\ Usage\left[\frac{L}{year}\right] \times Unit\ Convesion\left[\frac{1\ kL}{1{,}000\ L} \times \frac{1\ tonne}{1{,}000\ kg}\right]$$

Where:

Emissions =	Annual Emission Rate [tonne/year]
Emission Factor =	Emission factor, specific to GHG species and fuel type and presented in Table D5 [kg/kL]
Fuel Usage =	Total amount of fuel (diesel or propane) used for stationary combustion provided by Galaxy and presented in Table D6 *[L/year]*

The following sample calculation presents the CO_2 emissions from diesel stationary combustion during operation:

$$Emissions\ CO_2 = 2{,}681\frac{kg}{kL} \times\ 790{,}000\frac{L}{year} \times \frac{1\ kL}{1{,}000\ L} \times \frac{1\ tonne}{1{,}000\ kg}$$

$$Emissions\ CO_2 = 2{,}118\frac{tonnes}{year}$$

Similar to the above example for CO_2, CH_4 and N_2O would be estimated using their respective EFs.

Table D.6, summarizes the fuel quantities for stationary combustion during construction, operation and restoration and the associated GHG emissions.

Table D.6 Stationary Combustion Annual Fuel Consumption and Associated Emissions

Fuel Type	Phase	Fuel Consumption [L/year]	Emissions [tonnes/year]			
			CO_2	CH_4	N_2O	CO_{2e}
Propane	**Construction (peak 1-year)**	6,022,563	9,094	0.2	0.7	9,292
	Operation (per operational year, Y1-Y18)	9,033,845	13,641	0.2	1.0	13,938
	Restoration (Y19)	9,033,845	13,641	0.2	1.0	13,938
Diesel	**Construction (peak 1-year)**	526,667	1,412	0.07	0.2	1,477
	Operation (per operational year)	790,000	2,118	0.11	0.3	2,215
	Restoration	790,000	2,118	0.11	0.3	2,215
Total Stationary Combustion GHG Emissions	**Construction (peak 1-year)**	-	10,506	0.2	0.9	10,769
	Operation (per operational year, Y1-Y19)	-	15,759	0.3	1.3	16,153
	Restoration (Y19)	-	15,759	0.3	1.3	16,153

3.1.4 Electricity Consumption (Indirect)

The indirect GHG emissions from electricity consumption during operation were calculated using the electricity consumption emission factor for Quebec (1.5 g CO_{2e}/kWh) from the ECCC NIR (ECCC 2021b) and the estimated annual electricity usage.

The GHG emissions from electricity consumption (grid power) were calculated using the following equation:

$$Emissions \left[\frac{tonnes}{year}\right] = Emission\ Factor \left[\frac{g\ CO_{2e}}{kWh}\right] \times Annual\ Consumption \left[\frac{kWh}{year}\right] \times Unit\ Convesion \left[\frac{tonnes}{10^6\ g}\right]$$

Where:

Emissions =	Annual Emission Rate [tonnes/year]
Emission Factor =	the electricity consumption emission factor for Quebec [1.5 g CO_{2e}/kWh] from the 2020 NIR (ECCC 2021b)
Annual Consumption =	annual estimated electricity consumption from the grid, provided by Galaxy [kWh/year]

The following sample calculation presents the CO_{2e} emissions from electricity consumption during operations (representative of any year of operation):

$$Emissions\ CO_{2e} = 1.5\ \frac{g\ CO_{2e}}{kWh} \times\ 48{,}678 \frac{kWh}{year} \times \frac{1\ tonne}{10^6 g}$$

$$Emissions\ CO_{2e} = 73 \frac{tonnes}{year}$$

There is no expected electricity usage (from grid power) during construction.

3.1.5 Off-Site Transportation (Shipping and Employee Travel)

The indirect GHG emissions from the shipping of delivered supplies assumed that the supplies originated in Montreal and were delivered to Matagami (200 km one way distance). The land transportation of workers was assessed from Eastman to the Project site. The number of land transport trips associated with shipping, deliveries, and employee travel, the distance, and the fuel used were assumed to remain consistent with the former assessment conducted by WSP (WSP 2018), as confirmed by Galaxy. The GHG emissions from indirect on-land transportation were based on estimated fuel usage and emission factors for HDDVs obtained from the ECCC NIR (ECCC 2021b), previously presented in Table D2.

Employee travel by air was also assessed, assuming flights from Montreal to Eastman. Air-transport emissions were estimated based on estimated fuel usage and the NIR aviation turbodiesel emissions factors (ECCC 2021b), presented in Table D.7. The fuel usage, number of trips, and flight distances were assumed to remain consistent with the former assessment conducted by WSP (WSP 2018), as confirmed by Galaxy.

Table D.7 Aviation Turbo Diesel Emission Factors

Fuel Type	CO_2 EF [g/L]	CH_4 EF [g/L]	N_2O EF [g/L]
Aviation Turbo diesel	2,559.7	0.029	0.0711

The GHG emissions from off-site transportation were calculated using the following equation:

$$Emissions\left[\frac{tonnes}{year}\right] = Emission\ Factor\left[\frac{g}{L}\right] \times\ Fuel\ Usage\left[\frac{L}{year}\right] \times Unit\ Convesion\left[\frac{1\ tonne}{10^6\ g}\right]$$

Where:

Emissions = Annual Emission Rate [tonnes/year]
Emission Factor = Emission factor, specific to the mode of transportation and for the specific GHG species, presented in Table D2 [g/L] for HDDV trucks and in Table D7 [g/L] for aviation
Fuel Usage = Total amount of fuel used in transportation, specific to the mode of transportation, estimated based on distance traveled and fuel consumption rates, presented in Table D8.

Table D.8 summarizes the fuel usage and associated GHG emissions from land transport of supplies, product, and employee travel, and air transport of employees for construction, operation and restoration.

Table D.8 Off-Site Transportation Fuel Usages and Associated GHG Emissions

Period	Source	Number of Trips	Distance (return) [km]	Fuel Usage [L/period]	Emissions [tonnes/period]		
					CO_2	CH_4	N_2O
Construction (12 months)	Construction supplies (Montreal - Project site)	825	1,100	725,445	1,945	0.080	0.110
	Land Transportation of Workers (Eastmain - Project site)	182	130	9,464	25.4	0.001	0.001
	Air Transportation of Workers (Montreal - Eastman)	182	803	843,519	2,159	6.26E-05	4.45E-12
Operation (for each Years 1 to 18)	Supplied to Project Site (Montreal – Project site)	1,460	1,100	1,284,800	3,444	0.141	0.194
	Product Shipping (Project site to Matagami)	8.03	400	2,569,600	6,888	0.283	0.388
	Land Transportation of Workers (Eastmain - Project site)	156	130	7,828	21.0	0.001	0.001
	Air Transportation of Workers (Montreal - Eastman)	156	830	723,017	1,851	5.37E-05	3.82E-12
Restoration (Year 19)	Land Transportation of Workers (Eastmain - Project site)	156	130	8,112	21.7	0.001	0.001
	Air Transportation of Workers (Montreal - Eastman)	156	830	723,017	1,938	0.080	0.109

4.0 GHG EMISSIONS SUMMARY

Direct and indirect emissions of GHG were estimated for construction and operation using site-specific activity data and published emission factors and standard emission estimation methods. Sample calculations of the GHG emission estimates are provided in Section 3. The following sections summarize the total maximum emissions from each Project phase.

4.1 CONSTRUCTION

The maximum estimated annual GHG emissions (direct and indirect) from Project construction activities are presented in Table D.9. The site construction direct GHG emissions include emissions from heavy off-road equipment, on-road trucks and vehicles, stationary generators, and blasting. Indirect GHG emissions from construction include the shipping of supplies to site and employee travel. Approximately 18.6 kt CO_{2e} are estimated to be released (including both direct and indirect) during the construction year with the highest GHG emissions. By conservatively assuming continuous release of the maximum year GHG emissions over the construction period (18 months), the total GHG emissions during construction, assuming a duration of 18-months, are 27.9 kt CO_{2e}.

Table D.9 Summary of Estimated Maximum Annual Construction GHG Emissions

Activity	Units	CO_2	CH_4	N_2O	Total (expressed as CO_{2e})
Blasting[A]	t/y	152.5	-	-	152.5
Stationary Combustion[B]	t/y	10,506	023	0.86	10,768
On-Road Transportation[C]	t/y	960	0.13	1.10E-05	963
Off-Road Mobile Equipment [c]	t/y	2,456	0.07	0.02	2,464
Shipping of Delivered Supplies (indirect) [c]	t/y	1,945	0.08	0.11	1,979
Employee Travel (indirect)	t/y	2,185	0.001	0.001	2,185
Total Direct Emissions	*t/y*	14,075	0.43	0.88	14,348
Total Indirect Emissions	*t/y*	4,129	0.08	0.11	4,164
Total (direct + indirect)	*t/y*	18,204	0.51	0.99	18,512

Notes:
[A] Based on MAC emission factors (MAC 2014)
[B] Based on ECCC's 2019 Canada's Greenhouse Gas Quantification Requirements (ECCC 2019c)
[c] Based on ECCC emission factors provided in Table A6-14 of the NIR (ECCC 2021b)

The contribution of the Project construction GHG emissions (direct and indirect) to provincial and federal totals are summarized in Table D.10. On an annual basis, the Project construction contributes approximately 0.02% and 0.003% to provincial and national GHG emission totals, respectively. The Project construction contributes approximately 0.2% to the National Mineral Product GHG emissions.

Table D.10 Estimated Contribution of Construction GHG Emissions to Federal and Provincial Totals

Parameter	Units	CO_2	CH_4	N_2O	Total (expressed as CO_{2e})
Construction GHG Emissions (direct & indirect)	t/y	18,204	0.51	0.99	18,512
Quebec 2019 GHG Emissions	kt/y	64,300	11,000	5,000	83,700
National 2019 GHG Emissions	kt/y	582,000	98,000	37,000	730,000
National 2019 Mineral Product GHG Emissions	kt/y	-	-	-	8,800
Project Construction Contribution to Quebec GHG Emissions	%	0.03%	0.000005%	0.000023%	0.02%
Project Construction Contribution to National GHG Emissions	%	0.003%	0.000001%	0.000003%	0.003%
Project Construction Contribution to National Mineral Product GHG Emissions	%	-	-	-	0.211%

Notes:
[a] Provincial and national GHG emission totals from ECCC NIR (ECCC 2021b)
[b] Provincial and national GHG emission totals include other fluorinated GHGs

4.2 OPERATION

The maximum estimated annual GHG emissions from Project operation are summarized in Table D.11. The direct GHG emissions for operation includes emissions from heavy off-road equipment, on-road trucks and vehicles, stationary combustion, and blasting. The operations indirect GHG emissions include electricity consumption and transportation (on-road, air) related to supplies and product deliveries and employee travel. Approximately 48.0 kt CO_{2eq} direct emissions are estimated to be released during the year of operation with maximum GHG emissions (Year 14). The estimated total indirect GHG emissions during operations is 12.5 kt CO_{2eq}/year, which is approximately 26% of the total direct annual GHG emissions (48.0 kt CO_{2eq}/year).

Table D.11 Summary of Maximum Estimated Annual GHG Emissions During Project Operation

Activity	Units	CO_2	CH_4	N_2O	Total (expressed as CO_{2eq})
Blasting [A]	t/y	671	-	-	671
Stationary Combustion [B]	t/y	15,759	0.35	1.29	16,153
On-Road Transportation [C]	t/y	6,923	0.97	0.0001	6,947
Off-Road Mobile Equipment [C]	t/y	11,690	0.32	0.10	11,726
Electricity Consumption (indirect) [D]	t/y	73	-	-	73
Shipping of Delivered Supplies & Product (indirect) [C]	t/y	10,332	0.42	0.58	10,516
Employee Travel (indirect) [C,D]	t/y	1,872	0.001	0.001	1,872

Table D.11 Summary of Maximum Estimated Annual GHG Emissions During Project Operation

Activity	Units	CO_2	CH_4	N_2O	Total (expressed as CO_{2eq})
Direct Emissions	t/y	35,043	1.64	1.39	35,497
Indirect Emissions	t/y	12,276	0.42	0.58	12,461
Total (direct + indirect)	t/y	47,319	2.06	1.97	47,958

Notes:
[A] Based on MAC emission factors (MAC 2014)
[B] Based on ECCC's 2019 Canada's Greenhouse Gas Quantification Requirements (ECCC 2019c)
[C] Based on ECCC emission factors provided in Table A6-14 of the NIR (ECCC 2021b)
[D] Based on electricity consumption emission factor for Quebec (1.5 g CO_{2eq}/kWh) from Table A13-6 of the ECCC NIR (ECCC 2021b)

The contribution of the maximum estimated annual GHG emissions from Project operation (direct and indirect) to provincial and federal totals are summarized in Table D12. On an annual basis, Project operation contributes a maximum of 0.06% and 0.007% to provincial and national GHG emission totals, respectively, and 0.54% to the national Mineral Product GHG emission totals.

Table D.12 Estimated Contribution of Operation GHG Emissions to Federal and Provincial Totals

Parameter	Units	CO_2	CH_4	N_2O	Total (expressed as CO_{2eq})
Operations GHG Emissions (direct & indirect)	kt/y	47,319	2.06	1.97	47,958
Quebec 2019 GHG Emissions [A,B]	kt/y	64,300	11,000	5,000	83,700
National 2019 GHG Emissions [A,B]	kt/y	582,000	98,000	37,000	730,000
National 2019 Mineral Product GHG Emissions [A,B]	kt/y	-	-	-	8,800
Project Operations Contribution to Quebec GHG Emissions	%	0.07%	0.00002%	0.00004%	0.06%
Project Operations Contribution to National GHG Emissions	%	0.008%	0.000002%	0.00001%	0.007%
Project Operations Contribution to National Mineral Product GHG Emissions	%	-	-	-	0.54%

Notes:
[a] Provincial and national GHG emission totals from ECCC NIR (ECCC 2021b)
[b] Provincial and national GHG emission totals include other fluorinated GHGs

The GHG emissions from the expected lifetime of Project (including construction, operation and restoration) were estimated using annual activity data over the life of the mine. The estimated Project lifetime GHG emissions are summarized in Table D13. The total emissions over the lifetime of the Project (including construction, operation, and restoration) are 845,800 tonnes CO_{2eq}. The annual GHG emissions from Project operation range from 41,847 to 47,958 tonnes CO_{2eq}. On an annual basis, the Project operation contribution to provincial and national GHG emissions totals range from 0.05% to 0.06% and 0.006% to 0.007%, respectively.

Table D.13 Estimated GHG Emissions Over the Lifetime of the Project

Year	CO_{2e} Emissions [Tonnes/year]								
	Direct Emissions					Indirect Emissions			Total
	Explosives	On-Road Transportation (On-Site)	Off-Road Mobile	Stationary Combustion	Total Direct	Electricity	Off-Site Transportation	Total Indirect	Total Direct + Indirect
Y-1[A]	152.5	963.1	2,464	10,768	14,348	73.0	4,164	4,237	18,585
Y1	488.0	3,076	9,669	16,153	29,386	73.0	12,388	12,461	41,847
Y2	490.8	3,576	9,829	16,153	30,048	73.0	12,388	12,461	42,509
Y3	488.0	3,945	9,840	16,153	30,426	73.0	12,388	12,461	42,886
Y4	488.0	4,208	9,839	16,153	30,688	73.0	12,388	12,461	43,149
Y5	488.0	3,638	9,789	16,153	30,068	73.0	12,388	12,461	42,528
Y6	488.0	3,385	9,594	16,153	29,620	73.0	12,388	12,461	42,081
Y7	488.0	3,565	9,590	16,153	29,795	73.0	12,388	12,461	42,256
Y8	661.8	5,081	11,695	16,153	33,591	73.0	12,388	12,461	46,052
Y9	648.8	5,367	10,812	16,153	32,980	73.0	12,388	12,461	45,441
Y10	671.0	5,817	11,424	16,153	34,065	73.0	12,388	12,461	46,526
Y11	671.0	5,424	11,061	16,153	33,309	73.0	12,388	12,461	45,770
Y12	671.0	5,657	11,392	16,153	33,873	73.0	12,388	12,461	46,334
Y13	671.0	6,374	11,675	16,153	34,873	73.0	12,388	12,461	47,334
Y14	671.0	6,947	11,726	16,153	35,497	73.0	12,388	12,461	47,958
Y15	549.0	6,738	10,278	16,153	33,718	73.0	12,388	12,461	46,179
Y16	566.2	7,216	10,474	16,153	34,409	73.0	12,388	12,461	46,870
Y17	488.0	5,563	9,663	16,153	31,866	73.0	12,388	12,461	44,327
Y18	554.6	5,848	10,146	16,153	32,702	73.0	12,388	12,461	45,163
Y19[B]	134.3	1,329	2,321	16,153	19,937	73.0	1,995	2,068	22,005
LOM	10,529	93,718	193,282	317,670	615,200	1460	229,140	230,600	845,800

Notes:
[a]Construction phase
[b]Restoration Phase

During operation the Project will be regulated under the Quebec *Environment Quality Act* (2017) and the *Regulation Respecting Mandatory Reporting of Certain Emissions of Contaminants into the Atmosphere* (Q-2 r.15). As the operation GHG emissions are expected to be >25,000 tonnes CO_{2e}/year, the Project will be subject to participating in the provincial cap and trade GHG program under the Quebec *Regulation respecting a cap-and-trade system for greenhouse gas emission allowances (*Q-2, r. 46.1).

5.0 MITIGATION PRACTICES TO REDUCE GHG EMISSIONS

Galaxy will take several mitigation actions to reduce the GHG emissions from the Project, such as:

- The use of electricity as a source of energy for most site activities. In Quebec, electricity is mainly generated from hydro and has a low carbon footprint relative to electricity sources from fossil fuels.
- During the valued engineering phase of the project, the site plan was optimized to reduce haul route lengths and reduce the quantity of fuel combusted by haul trucks.
- Equipment and vehicles will be maintained proactively to improve/maintain fuel efficiency.
- Equipment and vehicle idling times will be reduced to the fullest extent possible.
- Cold starts will be limited to the extent possible.

6.0 CONCLUSION

The Project's GHG emissions were quantified for construction and operation and compared to provincial and national totals. Based on the estimated GHG emissions for Project operation, Galaxy will be subject to reporting GHG emissions both federally and provincially, require third-party verification of the annual GHG emissions, and participate in the provincial cap and trade program. A variety of mitigation measures will be used to reduce the GHG emissions over the life of the Project.

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APPENDIX E

Dust Management Plan

James Bay Lithium Mine

Dust Emissions Management Plan

Preliminary Version - June 2021

Table of Contents

1 INTRODUCTION

1.1 Context and Objectives

Galaxy Lithium (Canada) Inc. (Galaxy) is a subsidiary of Galaxy Resources Limited, one of the largest mining companies in the lithium market. Galaxy is currently mining deposits and several other world-class projects are currently under development, including that of James Bay.

Galaxy is acting as the initiator of the current James Bay lithium mine project, located in the administrative region of Nord-du-Québec. The study site is located approximately 10 km south of the Eastmain River, approximately 100 km east of James Bay, at the same latitude as the village of Eastmain.

Galaxy plans to operate a conventional pit mine from which approximately 2 million tonnes per year of spodumene pegmatites will be extracted and sent to a concentrator. In addition to these facilities, the site will include accumulation areas (overburden, topsoil, waste rock / tailings, ore, concentrate), retention basins, administrative and operations buildings, a camp for workers, garages and an explosives storage site. The expected operating period is 16 years.

Galaxy is committed to implementing a "**Dust Emissions Management Plan**" including source emissions testing and a detailed air quality monitoring program.

The management plan is presented in the following sections and it will be maintained and updated during all phases of the project, including construction, operation and closure.

1.2 Responsibility and Enforcement

A Galaxy staff member will be responsible for the “Dust Emissions Management Plan”. Although the application of the measures in this plan is the responsibility of the managers of each department, the overall plan manager will be responsible for communicating to each department the measures presented in this plan. In addition, they will have to ensure that the plan is updated according to the progress of the Project and the findings made during the operation. The program will be integrated into the site management system.

Galaxy staff and its subcontractors will be informed and made aware of the contents of this plan in order to apply best practices to reduce fugitive dust emissions on the James Bay lithium mine site. Training on the different procedures used will be given to the staff and subcontractors concerned.

1.3 Legislation and External Requirements

The main provincial requirements for the quality of the atmosphere are defined by the *Environment Quality Act/Loi de la qualité de l’environnement* (LRQ, chapter Q-2) and, in particular, in the *Regulation on Air Purification*/*Règlement sur*

l'assainissement de l'atmosphère (RAA) (chapter Q-2., R. 4.1). More specifically, the RAA defines quality standards for the atmosphere (R.R.Q., chapter Q-2., R. 4.1 a. 196). These standards are reference thresholds to be respected at the limit of application.

The Ministry of the Environment and the Fight against Climate Change (MELCC) has also published a document entitled *Standards and Quebec Atmosphere Quality Criteria/Normes et critères québécois de qualité de l'atmosphère* (MELCC 2018). In addition to the atmosphere quality standards of the RAA, this document presents a set of criteria established in order to evaluate the results of air quality measurements and also during the assessment of projects generating atmospheric emissions. These criteria represent reference thresholds to be interpreted at the limit of application of the standards and criteria. It is important to note that these criteria are not found, for the moment, in any law or regulation.

The main provincial requirements for the quality of the atmosphere are therefore defined in the following documents:

- *Environment Quality Act/ Loi de la qualité de l'environnement (R.S.Q., chapter Q-2);*
- *Regulation on Air Purification/règlement sur l'assainissement de l'atmosphère (RAA) (R.R.Q., chapter Q-2., R. 4.1);*
- *Quebec Standards and Criteria for the Quality of the Atmosphere/Normes et critères québécois de qualité de l'atmosphère, version 6. MELCC, 2018. Quebec, Department for monitoring the state of the environment, ISBN 978-2-550-82698-9.*

2 ATMOSPHERIC EMISSION SOURCES

The first phase of the James Bay Lithium Project will be the construction phase which includes the construction of infrastructure, site preparation and overburden extraction. During this phase, the main sources of air emissions will result from the following activities:

- Stripping (topsoil and overburden);
- Drilling operation;
- Blasting;
- Loading and unloading of materials;
- Dozing on the dumps;
- Crushing of sterile rock for site development (mobile unit);
- Transport of different materials to the mining site (routing).

Subsequently, during the operation phase of the mine, ore and waste rock extraction and ore processing will be added to the activities mentioned to occur during the construction phase. The expansion activities at the waste rock pile will also be added

to the mining activities. The main sources of air emissions during operations, in addition to those also occurring during construction, are:

- Blasting in the pit;
- Point sources at the concentration plant;
- Shipping of the spodumene concentrate;
- Crushing of sterile rock for expansion activities (mobile unit);
- Wind erosion of storage areas.

3 COMMON MITIGATION MEASURES

Galaxy's dust management strategy is to continually apply routine mitigation measures to the air emissions-generating mining activities, in order to meet the following requirements:

- Limit the individual and cumulative effects of atmospheric emissions on the air quality around the site;
- Control and contain emissions on the site;
- Minimize the negative effects on the surrounding ecosystems;
- Respect air quality standards.

3.1 Construction Phase

3.1.1 *Stripping (topsoil and overburden)*

Stripping will be kept to a minimum in order to avoid wind erosion on the stripped surfaces. The stripping operations will be planned according to the needs of the operating plan.

Where possible, topsoil will be removed while it is wet or covered shortly after stripping. Watering of work areas can be done as needed.

3.1.2 *Drilling Operations*

The drills will be equipped with a wet or dry dust removal device. The dust collected by these devices will be removed in order to minimize its volatility.

Mechanical maintenance of the equipment will be carried out regularly in order to reduce vibrations which can increase emissions. The dust collector system will also be checked regularly.

3.1.3 *Blasting*

The loads and the blasted area will be adapted to reduce the generation of dust. Appropriate materials will be used for packing explosives. The height of the final packing must then be adequate, in all circumstances, to avoid the phenomenon of jamming.

Blasting operations will be carried out according to techniques deemed appropriate by blasting specialists.

3.1.4 *Material Handling*

The height at which material is transferred and the drop height will be kept to a minimum. In addition, since particulate matter generally accumulates near machinery, regular cleaning and watering, if necessary, of work areas will be carried out to prevent the resuspension of these particulates.

As much as possible, the dumping of overburden and waste rock at the dumps will be limited to a height of 10 meters to minimize particulate matter emissions.

3.1.5 *Bulldozing*

Bulldozing operations of unloaded material will be managed to prevent the spread of dust.

3.1.6 *Crushing of Waste Rock for Site Development*

The mobile crusher will be positioned so that it is not exposed to high winds. Crusher emissions will be controlled by the use of water jets.

3.1.7 *Material Transport (Unpaved Roads)*

The transportation of materials on unpaved roads is the largest source of particulate matter emissions from the Project.

The use of non-friable materials with good resistance to road abrasion will be prioritized for road construction and maintenance. Regular road maintenance will be prioritized in order to maintain a good rolling surface and a low silt rate. No clay material will be used for road construction and materials with low silica content will be favored.

Traffic dust emissions are dependent on vehicle speed. In order to mitigate emissions, Galaxy plans to limit the speed of mining transport equipment on the site to 40 km / h.

Finally, emissions will be controlled by regular watering of road surfaces. In the event that dust episodes continue after watering, the use of chemical dust suppressants will be considered. The hygroscopic chemicals used will be certified by the Quebec Standardization Office/Bureau de Normalization du Québec (BNQ) to comply with the BNQ 2410-300 standard (BNQ 2009). A road watering management program will implemented, as presented in Section 4.

3.1.8 *Machinery*

Combustion of fuel in machinery is a source of emissions of particulates and combustion gases. To limit these emissions, unnecessary idling of engines will be avoided.

3.2 Operation Phase

The air emissions management for the operations phase includes the mitigation measures previously identified for the construction phase activities that will be continued during operation. These include drilling operations, loading and unloading of materials, dozing on dumps, transporting various materials to the mining site (routing) and use of machinery. Only the mitigation measures specific to the operation of the mine are therefore described in the following sections.

3.2.1 *Blasting in the Pit*

The loads and the blasted area will be adapted to reduce fugitive emissions. Appropriate materials will be used for packing explosives. The height of the final packing must then be adequate, in all circumstances, to avoid the phenomenon of jamming.

To avoid the dispersion of dust (especially crystalline silica) outside the mine site, if necessary, blasting will be restricted during periods of high winds or when the prevailing winds can transport dust to sensitive areas (I.e., truck stop at km 381). The blasted areas will be humidified so that the dispersion of dry and fine material deposited on the surface by drilling activities is avoided.

3.2.2 *Concentration Plant Point Sources*

The ore will be transported from the pit surface to the three-stage crushing circuit comprising of a primary crusher, a secondary cone crusher and a closed tertiary cone crusher with a sieve screen to produce the target product size.

The crushed ore will be stored in a dome before being sent to the dense media separation (DMS) circuit of the concentration plant. Dust collector systems will be installed at the crushing circuit.

The dust collectors will be checked daily (visual inspection) and cleaned regularly. The dust collected by these devices will be disposed of in such a way as to prevent its dispersion.

3.2.3 *Shipping of the Spodumene Concentrate*

To limit emissions from shipping spodumene concentrate, unpaved roads at the site that are used by trucks will be watered regularly. In the event that dust episodes are observed, the use of chemical dust suppressants will be considered. The hygroscopic chemicals used as the dust suppressant will be certified by the Quebec Standardization Office/Bureau de Normalization du Québec (BNQ) to comply with the BNQ 2410-300 standard (BNQ 2009).

3.2.4 *Crushing of Waste Rock for Expansion Activities*

Crushing and screening operations will be carried out at the storage yard to obtain the aggregates needed for the expansion activities. The crusher will be positioned so that it is not exposed to high winds. Emissions will be controlled by the use of water jets.

3.2.5 *Wind Erosion of Storage Piles*

The piles of waste rock, organic matter and unconsolidated deposits are planned to be revegetated. Throughout the various phases of the Project, gradual restoration, particularly of the outer slopes of these dumps, will be encouraged when possible in order to minimize particulate matter emissions generated by wind erosion.

On the other hand, it is important to remember that precipitation and humidity contribute to the washing of surfaces and the cementing of fine particles, especially when the piles are mainly made of coarse materials, such as the James Bay storage piles.

Road traffic and physical disturbances to storage areas will be controlled and minimized.

4 ROAD WATERING MANAGEMENT PROGRAM

Travel on the unpaved roads at the mine site has been identified by the atmospheric dispersion modelling as the largest contributor to particulate matter emissions. Galaxy plans to control these emissions through regular watering of the unpaved roads.

A road watering management program will be implemented to outline the planned control measures and to monitor the effectiveness. The frequency and intensity of watering the roads will be dependent on weather conditions.

The control of emissions from watering depends on several factors; the amount of water applied to the road per unit area, the time between waterings, the amount of traffic, and the weather conditions during that time. However, the effectiveness of watering as a method of mitigating emissions can be estimated according to the rule of thumb described in the document “Control of Open Fugitive Dust Sources”

(Cowherd et al., 1988) and using the average evaporation rate specific to the James Bay lithium mine site (ATLAS-1978 and EPA-2007).

Depending on the planned operations, this theoretical model predicts that the daily watering needs may reach a volume of 500 m^3 in summer conditions, on dry days, in order to achieve the target control efficiency of 80%. This quantity of water is estimated under maximum operating conditions, which is the year 14 operating scenario at 60.3 kilotons mined per day. For the busiest road segments, the maximum watering intensity required is 0.13 l / m^2 / h.

For watering the roads at the mine site, treated water from the main basin will be used. As shown in the water balance, the flow from the pit will at all times provide sufficient water for irrigation needs.

5 PRELIMINARY AMBIENT AIR QUALITY MONITORING PROGRAM

The objective of the ambient air quality monitoring program will be to measure the impact of mining activities on local and regional air quality and to determine the compliance and acceptability of mining activities with respect to the applicable standards and criteria presented in the document “Quebec Standards and Criteria for the Quality of the Atmosphere/Normes et critères québécois de qualité de l’atmosphère“, version 6, MELCC (2018). This program will consist of two components, the acquisition of meteorological data and the sampling of ambient air quality.

5.1 Meteorological Station

A weather station will be installed temporarily at a representative location in order to acquire sufficient data to determine the positioning of the ambient air quality monitoring station at the start of the project. This station will also allow proper identification of local conditions to support the interpretation of air quality measurements obtained at the air quality monitoring station.

The equipment used, the installation methods, the compilation of meteorological data including the measurement frequency, the calculation of hourly values as well as the data labels will comply with the standards set out in the document “Standards for the Management and Operation of the Networks of the Quebec Cooperative Meteorological Network/Normes de gestion et d’exploitation des réseaux du Réseau météorologique coopératif du Québec”.

The location of the weather station and the planned equipment will be presented to the MELCC for approval, prior to installation.

The meteorological data will also be sent to MELCC on a regular basis via an FTP site or in another format defined by the Cooperative Meteorological Network of Quebec.

5.2 Ambient Air Quality Monitoring

The ambient air quality monitoring program relies primarily on ambient air quality sampling. Galaxy proposes to monitor total particulate matter (TPM), particulate matter with an average size of 10 µm, (PM_{10}), fine particles with an average size of 2.5 µm ($PM_{2.5}$), metals including arsenic and total chromium, and crystalline silica during the operations phase of the Project. The proposed monitoring program will be adjusted based on monitoring results.

5.2.1 *Location of Monitoring Stations*

The position of the monitoring station will be determined as to represent an adequate portrait of the air quality towards the truck stop at km 381. The exact positioning will be defined from the directions of the prevailing winds specific to the site, which will be obtained from the meteorological data collected by the weather station to be installed at the site. The proposed location will be submitted to MELCC for approval, prior to installation.

An audit will be carried out to ensure that the location criteria of Environment and Climate Change Canada (ECCC) and the MELCC are met, namely:

- located at least 100 m from a watercourse or body of water;
- located at least twice the height of windbreak obstacles;
- located such that the collection points or sampling nozzles are located at least 2 m from the ground;
- located such that the measurements taken can be considered representative of the area under study.

5.2.2 *Methods and Frequency of Analysis*

For the analysis of particulate matter, an apparatus recommended by the United States Environmental Protection Agency (US EPA) ("List of Designated Reference and Equivalent Method". US EPA 2019) will be necessary, namely:

- A high-volume sampler (Hi-Vol) (US-EPA reference: 40 CFR Part 50, Appendix B); model TE-5170 MFC from Tisch-Environmental or equivalent;
- A PQ-100PM10 type sampler or equivalent, equipped with a selective head / SCCA cyclone or equivalent
- A continuous measurement nephelometer (US EPA reference automated method EQPM–0516–240); model Teledyne Model T640 or equivalent

For TPM, sampling using Hi-Vol will last 24 hours, from midnight to midnight the following day, and carried out once every six days. Monitoring of exposure to certain metals is also planned from the analysis of these samples. Metals whose standards are on smaller particle size distributions, such as nickel, will first be measured on total particles. In the event that exceedances are observed, the measurement of these particle sizes will be considered.

The monitoring of respirable (PM_{10}) and fine ($PM_{2.5}$) particles will be done using a Teledyne Model T640 type instrument or equivalent. This device is a nephelometer allowing continuous measurement of PM_{10} and $PM_{2.5}$ particles. It is listed in the US EPA List of Designated Reference Methods or Equivalents[1].

Crystalline silica will be monitored from filtered PM_4 particulates sampled using a PQ100 type sampler. The PM_4 fraction will be collected using a sampling flow and a selective head fitted with an appropriate cyclone (SCCA; 11.1 LPM). In order to obtain an adequate detection limit, the sampling will be carried out over a period of 5 days (7200 minutes). Laboratory analyzes of silica will be carried out following the National Institute for Occupational Safety & Health (NIOSH) 7500 protocol.

All analyzes will be carried out in a laboratory approved by the MELCC. The methods used will be in accordance with those of reference, developed by the Quebec Center of Expertise in Environmental Analysis/Centre d'expertise en analyse environnementale du Québec (CEAEQ), if available. Several quality assurance and quality control (QA/QC) measures will be implemented as part of the sampling campaign to ensure the representativeness and accuracy of the results.

The sampling frequencies are presented in Table 1 while the sampling and analysis methods are summarized in Table 2. The frequencies will be adjusted according to the results collected from the first year of operation. The results of the measurements will be sent to the MELCC and the frequency of the follow-ups will be adjusted according to the results obtained and submitted to the MELCC for approval.

Table 1: Sampling Frequency

Parameter	Frequency
Total Particulate Matter TPM	Once every 6 days (adjusted depending on the results)
Metals[1] in TPM	
Respirable (PM_{10}) and fine particulates ($PM_{2.5}$)	Continuous
Crystalline Silica	Once every 15 days (flexible depending on the results)

[1]Metals: according to the "Quebec Standards and Criteria for the Quality of the Atmosphere" (MELCC 2018)

[1] https://www3.epa.gov/ttnamti1/files/ambient/criteria/AMTIC%20List%20Dec%202016-2.pdf.

Table 2 : Sampling and Analysis Methods

Parameter	Method	Analysis
Total Particulate Matter (TPM)	US EPA - Division AMTIC - Compendium of Methods for the Determination of Inorganic Compounds in Ambient Air - Compendium Method IO-2.1 –SAMPLING OF AMBIENT AIR FOR TOTAL SUSPENDED PARTICULATE MATTER (SPM) CENTER OF EXPERTISE IN ENVIRONMENTAL ANALYSIS OF QUEBEC. Determination of particles: gravimetric method, MA. 100 - Part. 1.0, Rev. 3, Quebec Ministry of Sustainable Development, Environment and Parks, 2010, 9 p.	Gravimetric - difference in weight of filters before and after sampling
Metals in TPM According to the MELCC Standards and Quebec Atmosphere Quality Criteria (2018).	US EPA – Division AMTIC - Compendium of Methods for the Determination of Inorganic Compounds in Ambient Air - Compendium Method IO-3.5 - DETERMINATION OF METALS IN AMBIENT PARTICULATE MATTER USING INDUCTIVELY COUPLED PLASMA/ MASS SPECTROMETRY (ICP/MS)	Metal extraction with a solution of nitric acid and hydrochloric acid and analysis by ICP-MS
Respirable (PM_{10}) and fine particulate ($PM_{2.5}$)	US EPA – Automated Equivalent Method - EQPM–0516–240 Continuous analyzer	Scattered light spectrometry measurement
Crystalline Silica	Protocol established with the MELCC with PM_4 sampling head and flow rate of 11.1 LPM, Duration of 120 h, analysis with NIOSH 7500 method.	Filtration, particle size selective head, X-ray analysis.

6 SOURCE EMISSIONS TESTING

In addition to the ambient air quality monitoring program, stationary emission sources will be subject to source emission testing. The sources subject to source emissions testing will be those identified in the Facility's Environmental Approval (l'attestation d'assainissement).

This source emissions monitoring program will meet the MELCC requirements specified in its "Ambient Air Characterization and Monitoring Guide/Guide de caractérisation et de suivi de l'air ambiant" (Couture 2005). Testing will be carried out according to the terms and reference methods prescribed in the "Sampling Guide for the Purposes of Environmental Analyzes - Booklet 4 - Sampling of Atmospheric Emissions from Stationary Sources/Guide d'échantillonnage aux fins d'analyses environnementales – Cahier 4 – Échantillonnage des émissions atmosphériques en provenance de sources fixes » (MELCC 2016).

Testing reports will be periodically produced and sent to the MELCC. If the analysis reveals that a limit value or an emission standard has been exceeded, the event will be reported along with the corrective measures applied.

7 MONITORING OF NO_2 EMISSIONS DURING BLASTING

Monitoring of the potential emission of NO_2 during blasting will be carried out mainly by observing blast events. NO_2 emissions occur primarily when detonation conditions are sub-optimal. The presence of larger rocks and weaker than projected front movements will be used as indicators to qualify the effectiveness of the explosives detonation. In the event that sub-optimal detonation conditions are observed or forecasted, the following measures may be taken, if necessary, as defined in the blasting plans:

- Use of double detonator;
- Use of electronic detonator;
- Explosive formulation adapted to the conditions and site of the blasting;
- Adapted firing procedure;
- Use of a suitable type of explosive such as water-repellent explosives.

The use of one or more of these measures, if necessary, can promote the best possible management of NO_2 emissions and their reduction.

8 MAINTENANCE AND SERVICING

Mining equipment will be inspected regularly and defects will be repaired as quickly as possible to maximize their efficiency.

The particulate matter recovered by the dust collectors will be managed in such a way as to minimize their dispersion, in compliance with article 12 of the RAA which

mentions that the emissions of particles resulting from the transfer, the fall or the handling of materials must not be visible more than 2 m from the point of emission.

Spare parts for the main mitigation equipment will be kept on site (water pumps, filter bags, etc.).

9 ADAPTIVE MITIGATION MEASURES MANAGEMENT PROGRAM

Galaxy's first management strategy is to continually apply routine control and mitigation measures to dust generating activities. However, some alterations in activities (activities that have been identified as occasionally problematic based on the results of the atmospheric dispersion modelling) could be carried out as part of the alert procedure to avoid exceeding the standard.

Galaxy will implement an ambient air quality monitoring program as described above. A system will be installed at the monitoring station that transmits the ambient air quality results to the control room which will generate alarms under certain conditions. Thus, a specific investigation will be carried out in cases where the result obtained (“rolling average”) reaches more than 80% of the standard. In the event that the result is related to an event not connected to the site's activities (e.g., forest fire or others), a note will be placed in the file and the MELCC will be notified. In the event that Galaxy's activities are investigated instead, those causing the high particulate matter will be identified and Galaxy will proceed to apply additional mitigation measures and modify or discontinue them.

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- UNITED STATES ENVIRONMENTAL PROTECTION AGENCY. Code of Federal Regulations, Title 40, Appendix B to Part 50 - Reference Method for the Determination of Suspended Particulate Matter in the Atmosphere. 2011.
- UNITED STATES ENVIRONMENTAL PROTECTION AGENCY. List of Designated Reference and Equivalent Method. June 15, 2019*:*

APPENDIX F

Geochemical Analysis Results

Quality Analysis ... *Innovative Technologies*

Date Submitted: 20-Nov-17
Invoice No.: A17-13205 (i)
Invoice Date: 15-Jan-18
Your Reference: SG17-1479 101854 171-02562-00

Techni-Lab Abitibi Inc.(Actlabs)
245 Rue Roy
Ste-Germaine QC
Canada

ATTN: MATHIEU RANCOURT

CERTIFICATE OF ANALYSIS

18 Pulp samples were submitted for analysis.

The following analytical package(s) were requested:

Code 1G-Hg CV Hg-Cold Vapour (Hg Analyzer)
Code 8-AR Ag Code 8-Assays
Code 9-XRD X-Ray Diffraction
Code UT-7 Sodium Peroxide Fusion (ICP & ICPMS)

REPORT **A17-13205 (i)**

Notes:

Values which exceed the upper limit should be assayed for accurate numbers.

CERTIFIED BY:

<Original signé par>

Emmanuel Eseme , Ph.D.
Quality Control

ACTIVATION LABORATORIES LTD.
41 Bittern Street, Ancaster, Ontario, Canada, L9G 4V5
TELEPHONE +905 648-9611 or +1.888.228.5227 FAX +1.905.648.9613
E-MAIL Ancaster@actlabs.com ACTLABS GROUP WEBSITE www.actlabs.com

Analyte Symbol	Hg	Ag	Al	As	B	Ba	Be	Bi	Ca	Cd	Ce	Co	Cr	Cs	Cu	Dy	Er	Eu	Fe	Ga	Gd	Ge	Ho
Unit Symbol	ppb	ppm	%	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm
Lower Limit	5	3	0.01	5	10	3	3	2	0.01	2	0.8	0.2	30	0.1	2	0.3	0.1	0.1	0.05	0.2	0.1	0.7	0.2
Method Code	1G	ICP-OES	FUS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2
W170493	< 5	< 3	8.42	62	10	8	182	< 2	0.16	< 2	2.7	0.3	230	34.8	< 2	< 0.3	< 0.1	0.1	0.38	45.8	< 0.1	4.6	< 0.2
W170498	< 5	< 3	8.71	< 5	< 10	24	157	< 2	0.20	< 2	< 0.8	0.2	200	52.5	< 2	< 0.3	< 0.1	< 0.1	0.27	40.6	< 0.1	3.7	< 0.2
W170505	< 5	< 3	7.84	45	< 10	101	261	< 2	0.18	< 2	< 0.8	0.5	330	30.5	< 2	< 0.3	< 0.1	< 0.1	0.51	45.3	< 0.1	2.6	< 0.2
W170508	< 5	< 3	8.89	22	20	8	275	< 2	0.36	< 2	3.2	0.2	200	39.2	< 2	< 0.3	< 0.1	0.1	0.23	37.0	0.1	6.1	< 0.2
W170513	< 5	< 3	8.41	27	120	42	179	3	0.21	< 2	2.2	0.6	190	89.8	< 2	< 0.3	< 0.1	0.1	0.32	41.0	0.1	4.7	< 0.2
W170524	< 5	< 3	8.54	45	400	1080	< 3	< 2	1.25	< 2	66.0	22.7	280	50.2	34	2.9	1.6	1.0	5.50	23.4	3.8	0.7	0.6
W170532	< 5	< 3	8.07	39	80	567	< 3	< 2	2.01	< 2	59.0	22.4	320	200	50	2.9	1.6	1.1	5.13	20.6	3.4	0.9	0.6
W170537	< 5	< 3	8.63	< 5	250	809	< 3	< 2	1.24	< 2	74.1	28.7	250	48.7	62	3.4	1.8	1.2	5.87	23.7	4.3	< 0.7	0.6
W170538	< 5	< 3	8.70	417	3380	559	9	< 2	1.12	< 2	66.1	26.2	280	1080	58	2.9	1.6	1.1	5.68	23.2	3.8	1.0	0.6
W170539	< 5	< 3	8.42	230	1110	559	11	< 2	1.15	< 2	68.3	27.3	280	1020	54	3.1	1.6	1.1	5.75	22.2	3.8	0.8	0.6
W170552	< 5	< 3	8.09	150	2060	412	3	< 2	1.83	< 2	44.7	20.1	220	66.5	63	2.3	1.3	1.1	4.28	18.7	2.7	< 0.7	0.4
W170564	< 5	< 3	8.27	< 5	270	599	< 3	< 2	1.17	< 2	58.6	23.4	520	1210	58	2.6	1.4	1.0	4.68	21.0	3.1	0.9	0.5
W170569	< 5	< 3	8.48	< 5	280	978	< 3	< 2	1.27	< 2	58.5	24.1	350	88.8	81	2.8	1.4	1.1	5.36	22.7	3.6	< 0.7	0.6
W170573	< 5	< 3	8.04	106	160	555	< 3	< 2	2.12	< 2	46.8	14.0	190	126	30	1.9	1.1	1.0	2.57	18.5	2.5	0.8	0.4
W170574	< 5	< 3	7.12	243	170	458	8	< 2	5.29	< 2	45.5	38.8	850	375	99	2.5	1.4	1.2	5.76	17.7	3.6	1.0	0.5
W170578	< 5	< 3	5.45	647	2220	541	9	< 2	5.04	< 2	54.9	58.8	1780	535	75	2.2	1.1	1.2	6.58	13.2	3.4	1.8	0.4
W170580	< 5	< 3	7.37	803	2980	1050	7	< 2	3.51	< 2	37.8	47.5	1340	981	27	2.9	1.6	1.1	7.09	19.4	3.5	2.6	0.5
W170581	< 5	< 3	6.99	1590	5610	879	8	< 2	3.80	< 2	34.5	59.3	1750	1130	20	2.8	1.5	0.9	7.62	21.3	3.3	4.5	0.6

Analyte Symbol	Hf	In	K	La	Li	Mg	Mn	Mo	Nb	Nd	Ni	Pb	Pr	Rb	S	Sb	Se	Si	Sm	Sn	Sr	Ta	Tb
Unit Symbol	ppm	ppm	%	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm
Lower Limit	10	0.2	0.1	0.4	3	0.01	3	1	2.4	0.4	10	0.8	0.1	0.4	0.01	2	0.8	0.01	0.1	0.5	3	0.2	0.1
Method Code	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2
W170493	< 10	< 0.2	1.9	1.5	9140	0.04	458	15	87.0	0.9	< 10	1.1	0.3	465	< 0.01	< 2	16.1	> 30.0	0.2	65.5	35	27.6	< 0.1
W170498	< 10	< 0.2	2.3	0.4	1070	0.01	265	10	133.8	< 0.4	< 10	6.1	0.1	879	< 0.01	< 2	12.0	> 30.0	0.1	30.7	58	84.6	< 0.1
W170505	< 10	< 0.2	2.8	< 0.4	> 10000	0.04	446	22	17.8	< 0.4	< 10	1.2	0.1	465	< 0.01	< 2	19.8	> 30.0	< 0.1	19.2	93	2.7	< 0.1
W170508	< 10	< 0.2	2.2	2.5	4010	0.03	140	10	168.5	1.2	< 10	6.0	0.4	792	< 0.01	< 2	17.3	> 30.0	0.2	49.4	39	77.8	< 0.1
W170513	< 10	< 0.2	2.4	1.2	2990	0.06	222	11	147.6	1.0	< 10	7.1	0.3	1030	0.04	< 2	13.4	> 30.0	0.2	79.6	40	101	< 0.1
W170524	< 10	< 0.2	3.0	33.1	435	1.99	595	5	8.1	26.5	100	18.2	7.7	121	0.17	< 2	< 0.8	29.1	4.6	3.6	278	0.8	0.6
W170532	< 10	< 0.2	2.5	29.6	890	1.62	710	7	7.6	24.6	90	20.6	7.0	165	0.31	< 2	< 0.8	> 30.0	4.0	9.3	285	1.9	0.5
W170537	< 10	< 0.2	3.1	37.8	361	2.34	536	3	9.2	30.8	120	17.1	8.7	128	0.17	< 2	< 0.8	28.2	5.3	2.0	231	0.8	0.7
W170538	< 10	< 0.2	2.6	32.9	1660	1.92	615	5	11.6	28.1	100	20.8	7.9	735	0.23	< 2	8.3	29.1	4.7	45.5	243	4.3	0.6
W170539	< 10	< 0.2	2.8	33.9	1870	1.94	663	5	9.1	27.8	110	21.7	8.0	989	0.21	< 2	< 0.8	28.8	4.6	54.0	243	0.8	0.6
W170552	< 10	< 0.2	1.5	21.6	557	1.33	615	6	5.3	19.7	50	7.2	5.6	64.1	0.62	< 2	< 0.8	> 30.0	3.3	8.4	381	0.4	0.4
W170564	< 10	< 0.2	2.8	31.0	788	1.60	558	28	7.8	23.4	100	18.3	6.8	321	0.19	< 2	< 0.8	> 30.0	3.9	7.4	220	1.2	0.5
W170569	< 10	< 0.2	2.8	29.3	791	1.72	570	10	8.0	25.2	100	17.3	7.0	149	0.46	< 2	< 0.8	> 30.0	4.5	4.5	352	0.8	0.5
W170573	< 10	< 0.2	1.8	23.2	885	0.82	465	9	4.7	20.5	30	7.0	5.6	212	0.19	< 2	< 0.8	> 30.0	3.6	25.9	432	0.4	0.4
W170574	< 10	< 0.2	1.1	20.3	1900	6.46	1090	2	5.3	24.3	280	2.9	6.2	136	0.02	< 2	< 0.8	25.8	4.6	16.0	1010	2.2	0.5
W170578	< 10	< 0.2	2.1	29.3	3040	9.66	1210	4	2.4	28.6	520	2.2	7.2	284	0.07	< 2	5.6	23.8	4.6	39.5	1070	0.3	0.5
W170580	< 10	< 0.2	3.5	16.9	1020	8.64	1310	2	3.9	20.6	400	3.0	5.3	302	0.05	< 2	< 0.8	21.7	4.2	62.3	630	0.2	0.5
W170581	< 10	< 0.2	3.4	15.1	993	10.1	1260	5	3.9	18.6	530	< 0.8	4.8	282	0.10	< 2	< 0.8	20.6	3.9	84.2	284	0.3	0.5

Analyte Symbol	Te	Th	Ti	Tl	Tm	U	V	W	Y	Yb	Zn
Unit Symbol	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Lower Limit	6	0.1	0.01	0.1	0.1	0.1	5	0.7	0.1	0.1	30
Method Code	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2
W170493	< 6	0.8	< 0.01	2.8	< 0.1	7.4	< 5	2.5	0.2	< 0.1	40
W170498	< 6	0.9	< 0.01	5.8	< 0.1	7.6	< 5	1.1	0.1	< 0.1	50
W170505	< 6	0.1	< 0.01	2.8	< 0.1	0.8	< 5	2.4	0.2	< 0.1	< 30
W170508	< 6	0.4	< 0.01	5.1	< 0.1	9.4	< 5	1.7	0.3	< 0.1	30
W170513	< 6	1.1	< 0.01	7.1	< 0.1	8.5	< 5	2.7	0.5	< 0.1	720
W170524	< 6	11.4	0.35	0.7	0.2	3.3	133	5.0	15.6	1.6	80
W170532	< 6	10.8	0.35	0.9	0.2	3.9	104	3.1	15.4	1.6	120
W170537	< 6	12.2	0.41	0.8	0.3	3.6	158	4.0	17.6	1.8	100
W170538	< 6	11.5	0.39	5.3	0.2	4.0	128	2.3	15.9	1.6	100
W170539	< 6	11.7	0.38	7.8	0.2	4.4	131	88.9	15.3	1.6	120
W170552	< 6	4.4	0.34	0.4	0.2	1.3	99	1.2	12.3	1.2	70
W170564	< 6	9.8	0.33	1.8	0.2	3.0	105	9.8	14.2	1.5	70
W170569	< 6	9.7	0.37	0.8	0.2	3.0	121	5.7	14.8	1.5	70
W170573	< 6	4.9	0.25	1.7	0.2	1.4	65	7.6	10.5	1.0	70
W170574	< 6	2.9	0.39	1.0	0.2	0.8	156	< 0.7	13.2	1.2	80
W170578	< 6	1.6	0.32	2.1	0.2	0.6	141	7.5	11.0	0.9	90
W170580	< 6	2.9	0.43	1.8	0.2	0.7	189	2.1	14.9	1.4	80
W170581	< 6	2.6	0.41	1.6	0.2	0.8	197	4.4	14.1	1.4	100

Analyte Symbol	Hg	Ag	Al	As	B	Ba	Be	Bi	Ca	Cd	Ce	Co	Cr	Cs	Cu	Dy	Er	Eu	Fe	Ga	Gd	Ge	Ho
Unit Symbol	ppb	ppm	%	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm
Lower Limit	5	3	0.01	5	10	3	3	2	0.01	2	0.8	0.2	30	0.1	2	0.3	0.1	0.1	0.05	0.2	0.1	0.7	0.2
Method Code	1G	ICP-OES	FUS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2
GXR-1 Meas	3960		3.80	400	< 10	708	< 3		0.92	2	14.5	8.1	< 30	4.1	1140	4.9		0.6	25.3	15.1	4.2		
GXR-1 Cert	3900		3.52	427	15.0	750	1.22		0.960	3.30	17.0	8.20	12.0	3.00	1110	4.30		0.690	23.6	13.8	4.20		
GXR-4 Meas	106																						
GXR-4 Cert	110																						
PTM-1a Meas		132																					
PTM-1a Cert		135																					
SDC-1 Meas	22																						
SDC-1 Cert	200.00																						
GXR-6 Meas	73																						
GXR-6 Cert	68.0																						
NIST 696 Meas													310										
NIST 696 Cert													321.0										
GBW 07239 (NCS DC 70007) Meas				< 5				< 2			60.0	13.9			45					24.7		13.4	
GBW 07239 (NCS DC 70007) Cert				1				1			60.3	13.5			49					23.1		12.4	
OREAS 134b (Fusion) Meas				230		1440				534		107			1310				12.4				
OREAS 134b (Fusion) Cert				224		1360				569		104			1340				12.69				
MP-1b Meas		49		> 10000				938	2.56	605					> 10000				8.13				
MP-1b Cert		47.0		23000.00				954.0000	2.47	527.0000					30700				8.19				
OREAS 101b (Fusion) Meas											1270	46.2			411	32.0	18.3	8.0	10.9		36.7		6.5
OREAS 101b (Fusion) Cert											1331	47.0			416	32.1	18.7	7.77	10.8		41		6.34
OREAS 13b (fusion) Meas			8.40			700			5.79				> 10000						8.55				
OREAS 13b (fusion) Cert			8.41			694			5.57				10800.00						8.41				
NCS DC86303 Meas														341									
NCS DC86303 Cert														350									
NCS DC86304 Meas														1660									
NCS DC86304 Cert														1680									
CPB-2 Meas			0.07																6.88				
CPB-2 Cert			0.074																7.065				
CZN-4 Meas		51	0.08	370						2550		98.8			4090								
CZN-4 Cert		51.4	0.0715	356.0000						2604.0000		93.5			4030.000								

Analyte Symbol	Hg	Ag	Al	As	B	Ba	Be	Bi	Ca	Cd	Ce	Co	Cr	Cs	Cu	Dy	Er	Eu	Fe	Ga	Gd	Ge	Ho
Unit Symbol	ppb	ppm	%	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm
Lower Limit	5	3	0.01	5	10	3	3	2	0.01	2	0.8	0.2	30	0.1	2	0.3	0.1	0.1	0.05	0.2	0.1	0.7	0.2
Method Code	1G	ICP-OES	FUS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2
PTC-1b Meas		51																	> 30.0				
PTC-1b Cert		53.1																	36.78				
SdAR-M2 (U.S.G.S.) Meas	1440																						
SdAR-M2 (U.S.G.S.) Cert	1440.00																						
NCS DC35015 Meas																			4.00				
NCS DC35015 Cert																			3.97				
OREAS 922 (Peroxide Fusion) Meas			7.41			474		12	0.49		89.9	20.3	80	7.2	2250	5.9	3.3	1.5	5.72	20.9	6.4		1.2
OREAS 922 (Peroxide Fusion) Cert			7.59			481		11	0.49		88.0	20.9	90	7.5	2220	5.75	3.38	1.52	5.71	21.2	6.94		1.20
OREAS 621 (Peroxide Fusion) Meas			6.50	90		2520	< 3	4	2.03	264	52.1	30.4	40	4.1	3610				3.79	25.4			
OREAS 621 (Peroxide Fusion) Cert			6.63	85		2610	2	4	2.00	295	52.0	31.4	50	3.6	3680				3.71	26.5			
OREAS 621 (Peroxide Fusion) Meas			6.55						1.99										3.80				
OREAS 621 (Peroxide Fusion) Cert			6.63						2.00										3.71				
CCU-1e Meas		199	0.14	1060					0.14	70		305			> 10000				> 30.0				
CCU-1e Cert		205	0.139	1010					0.129	74.2		301			229000				30.7				
W170493 Orig	< 5																						
W170493 Dup	< 5																						
W170581 Orig	< 5	< 3	6.94	1600	5620	885	8	< 2	3.78	< 2	34.4	60.4	1770	1140	20	2.8	1.4	0.9	7.62	21.2	3.3	4.0	0.6
W170581 Dup	< 5	< 3	7.05	1580	5600	872	8	< 2	3.81	< 2	34.6	58.1	1720	1110	20	2.7	1.5	0.9	7.62	21.3	3.3	5.0	0.5
Method Blank		< 3																					
Method Blank			< 0.01	< 5	< 10	< 3	< 3	< 2	< 0.01	< 2	< 0.8	< 0.2	< 30	< 0.1	< 2	< 0.3	< 0.1	< 0.1	< 0.05	< 0.2	< 0.1	< 0.7	< 0.2
Method Blank			< 0.01	< 5	< 10	< 3	< 3	< 2	< 0.01	< 2	< 0.8	< 0.2	< 30	0.1	< 2	< 0.3	< 0.1	< 0.1	< 0.05	< 0.2	< 0.1	< 0.7	< 0.2
Method Blank			< 0.01	< 5	< 10	< 3	< 3	< 2	< 0.01	< 2	< 0.8	< 0.2	< 30	0.3	< 2	< 0.3	< 0.1	< 0.1	< 0.05	< 0.2	< 0.1	< 0.7	< 0.2
Method Blank	< 5																						
Method Blank	< 5																						

Analyte Symbol	Hf	In	K	La	Li	Mg	Mn	Mo	Nb	Nd	Ni	Pb	Pr	Rb	S	Sb	Se	Si	Sm	Sn	Sr	Ta	Tb
Unit Symbol	ppm	ppm	%	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm
Lower Limit	10	0.2	0.1	0.4	3	0.01	3	1	2.4	0.4	10	0.8	0.1	0.4	0.01	2	0.8	0.01	0.1	0.5	3	0.2	0.1
Method Code	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2
GXR-1 Meas	< 10	0.9	< 0.1	7.3	8	0.23	815	19	< 2.4	8.5	50	745		5.2	0.27	123	15.9		2.9	51.6	280	< 0.2	0.8
GXR-1 Cert	0.960	0.770	0.050	7.50	8.20	0.217	852	18.0	0.800	18.0	41.0	730		14.0	0.257	122	16.6		2.70	54.0	275	0.175	0.830
GXR-4 Meas																							
GXR-4 Cert																							
PTM-1a Meas															22.9								
PTM-1a Cert															22.4								
SDC-1 Meas																							
SDC-1 Cert																							
GXR-6 Meas																							
GXR-6 Cert																							
NIST 696 Meas																							
NIST 696 Cert																							
GBW 07239 (NCS DC 70007) Meas				36.9			> 10000	1180		30.5	20	21.6	8.4							30.2			
GBW 07239 (NCS DC 70007) Cert				37.4			11500	1100		29.8	20.9	26.1	7.40							33.2			
OREAS 134b (Fusion) Meas												> 5000			20.2	115							
OREAS 134b (Fusion) Cert												132000.00			20.74	111							
MP-1b Meas		559				0.02		300				> 5000			13.4			16.7		> 10000			
MP-1b Cert		565.000				0.024		285				20900			13.79			16.79		16100			
OREAS 101b (Fusion) Meas			2.4	750		1.28	901	19		363	< 10		127						45.9				5.9
OREAS 101b (Fusion) Cert			2.42	789		1.23	931	21		378	9		127						48				5.37
OREAS 13b (fusion) Meas			2.3			3.11	1230								1.19			23.2			538		
OREAS 13b (fusion) Cert			2.30			3.01	1300.000								1.19			22.9			537		
NCS DC86303 Meas					2130									1380									
NCS DC86303 Cert					2100									1330									
NCS DC86304 Meas					> 10000									> 5000						100			
NCS DC86304 Cert					10600.00									6730						97.1			
CPB-2 Meas						0.06																	
CPB-2 Cert						0.0683																	
CZN-4 Meas												1840			> 25.0		143	0.31					
CZN-4 Cert												1861.000			33.07		86.7	0.295					

Analyte Symbol	Hf	In	K	La	Li	Mg	Mn	Mo	Nb	Nd	Ni	Pb	Pr	Rb	S	Sb	Se	Si	Sm	Sn	Sr	Ta	Tb
Unit Symbol	ppm	ppm	%	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm
Lower Limit	10	0.2	0.1	0.4	3	0.01	3	1	2.4	0.4	10	0.8	0.1	0.4	0.01	2	0.8	0.01	0.1	0.5	3	0.2	0.1
Method Code	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2
PTC-1b Meas															> 25.0			2.55					
PTC-1b Cert															29.95			2.468					
SdAR-M2 (U.S.G.S.) Meas																							
SdAR-M2 (U.S.G.S.) Cert																							
NCS DC35015 Meas																							
NCS DC35015 Cert																							
OREAS 922 (Peroxide Fusion) Meas	< 10	0.3	2.7	44.1	31	1.67	849		18.9	38.6	40	63.6	11.1	172	0.38			> 30.0	7.3	9.8	59	1.6	1.0
OREAS 922 (Peroxide Fusion) Cert	5.93	0.3	2.60	45.6	29	1.61	880		15.2	38.9	40	64.0	10.6	167	0.389			30.51	7.31	10	58.0	1.3	1.02
OREAS 621 (Peroxide Fusion) Meas		1.8	2.2	26.7		0.51	529	13	11.7	22.0		> 5000	6.3	84.9	4.47	144		28.0			98		
OREAS 621 (Peroxide Fusion) Cert		1.9	2.23	26.1		0.516	554	14	10.4	24.2		13300	6.64	89.0	4.51	146		28.1			101		
OREAS 621 (Peroxide Fusion) Meas			2.2			0.51									4.44			28.1					
OREAS 621 (Peroxide Fusion) Cert			2.23			0.516									4.51			28.1					
CCU-1e Meas						0.73	90					> 5000			> 25.0	109							
CCU-1e Cert						0.706	96.0					7030			35.3	104							
W170493 Orig																							
W170493 Dup																							
W170581 Orig	< 10	< 0.2	3.4	14.8	1010	10.0	1290	6	3.9	18.5	530	< 0.8	4.8	283	0.11	< 2	< 0.8	20.8	3.8	82.8	279	0.3	0.5
W170581 Dup	< 10	< 0.2	3.4	15.5	979	10.2	1230	4	3.9	18.8	530	< 0.8	4.8	282	0.10	< 2	< 0.8	20.5	4.0	85.5	289	0.3	0.5
Method Blank																							
Method Blank	< 10	< 0.2	< 0.1	< 0.4	< 3	< 0.01	< 3	< 1	< 2.4	< 0.4	< 10	< 0.8	< 0.1	< 0.4	< 0.01	< 2	< 0.8	< 0.01	< 0.1	< 0.5	< 3	< 0.2	< 0.1
Method Blank	< 10	< 0.2	< 0.1	< 0.4	< 3	< 0.01	< 3	< 1	< 2.4	< 0.4	< 10	< 0.8	< 0.1	< 0.4	< 0.01	< 2	0.8	< 0.01	< 0.1	< 0.5	< 3	< 0.2	< 0.1
Method Blank	< 10	< 0.2	< 0.1	< 0.4	< 3	< 0.01	< 3	2	< 2.4	< 0.4	< 10	< 0.8	< 0.1	< 0.4	< 0.01	< 2	< 0.8	< 0.01	< 0.1	< 0.5	< 3	< 0.2	< 0.1
Method Blank																							
Method Blank																							

Analyte Symbol	Te	Th	Ti	Tl	Tm	U	V	W	Y	Yb	Zn
Unit Symbol	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Lower Limit	6	0.1	0.01	0.1	0.1	0.1	5	0.7	0.1	0.1	30
Method Code	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2
GXR-1 Meas	12	2.5	0.03	0.4	0.4	34.7	91	173	30.4	2.2	820
GXR-1 Cert	13.0	2.44	0.036	0.390	0.430	34.9	80.0	164	32.0	1.90	760
GXR-4 Meas											
GXR-4 Cert											
PTM-1a Meas											
PTM-1a Cert											
SDC-1 Meas											
SDC-1 Cert											
GXR-6 Meas											
GXR-6 Cert											
NIST 696 Meas							405				
NIST 696 Cert							403.0000				
GBW 07239 (NCS DC 70007) Meas								1040	36.6		120
GBW 07239 (NCS DC 70007) Cert								1000.00	34.2		120
OREAS 134b (Fusion) Meas											> 10000
OREAS 134b (Fusion) Cert											181200.00
MP-1b Meas								1100			> 10000
MP-1b Cert								1100.000			167000
OREAS 101b (Fusion) Meas		34.4	0.39		2.8	399	84		143	18.2	
OREAS 101b (Fusion) Cert		37.1	0.386		2.66	396	80		178	17.6	
OREAS 13b (fusion) Meas			0.69				304				
OREAS 13b (fusion) Cert			0.711				330				
NCS DC86303 Meas								8.7			
NCS DC86303 Cert								8.9			
NCS DC86304 Meas								45.6			
NCS DC86304 Cert								43.7			
CPB-2 Meas											
CPB-2 Cert											
CZN-4 Meas											> 10000
CZN-4 Cert											550700

Analyte Symbol	Te	Th	Ti	Tl	Tm	U	V	W	Y	Yb	Zn
Unit Symbol	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Lower Limit	6	0.1	0.01	0.1	0.1	0.1	5	0.7	0.1	0.1	30
Method Code	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2	FUS-MS-Na2O2
											.00
PTC-1b Meas											
PTC-1b Cert											
SdAR-M2 (U.S.G.S.) Meas											
SdAR-M2 (U.S.G.S.) Cert											
NCS DC35015 Meas											
NCS DC35015 Cert											
OREAS 922 (Peroxide Fusion) Meas		17.0	0.44	0.8	0.5	3.5	103		31.2	3.2	280
OREAS 922 (Peroxide Fusion) Cert		17.7	0.439	0.9	0.510	3.6	92.0		31.1	3.17	280
OREAS 621 (Peroxide Fusion) Meas		8.1	0.18	2.0		2.9	32	2.5	13.2	1.1	> 10000
OREAS 621 (Peroxide Fusion) Cert		8.6	0.181	2.0		3.0	36.3	2.6	13.9	1.03	52200
OREAS 621 (Peroxide Fusion) Meas			0.18								
OREAS 621 (Peroxide Fusion) Cert			0.181								
CCU-1e Meas				2.6							> 10000
CCU-1e Cert				2.69							30200
W170493 Orig											
W170493 Dup											
W170581 Orig	< 6	2.6	0.41	1.6	0.2	0.7	204	4.2	14.2	1.4	100
W170581 Dup	< 6	2.6	0.42	1.6	0.2	0.8	191	4.7	14.1	1.4	90
Method Blank											
Method Blank	< 6	< 0.1	< 0.01	< 0.1	< 0.1	0.1	< 5	< 0.7	< 0.1	< 0.1	< 30
Method Blank	< 6	< 0.1	< 0.01	< 0.1	< 0.1	< 0.1	< 5	< 0.7	< 0.1	< 0.1	< 30
Method Blank	< 6	< 0.1	< 0.01	< 0.1	< 0.1	0.1	< 5	0.7	< 0.1	< 0.1	< 30
Method Blank											
Method Blank											

X-ray Diffraction Analysis of Thirteen Samples

W.O. # A17-13205
Invoice # A17-13205

Client: TECHNI_LAB

Attn: Mathieu Rancourt

Date Reported: December 4, 2017

Method

Thirteen samples were submitted for quantitative X-ray diffraction analysis. A portion of each powder sample was mixed with corundum and packed into a standard holder. Corundum was added as an internal standard, to estimate the X-ray amorphous content. The X-ray diffraction analysis was performed on a Panalytical X'Pert Pro diffractometer, equipped with a Cu X-ray source and an X'Celerator detector, operating at the following conditions: voltage: 40 kV; current: 40 mA; range: 5 - 70 deg 2θ; step size: 0.017 deg 2θ; time per step: 50.165 sec; divergence slit: fixed; angle 0.5°; sample rotation: 1 rev/sec. The quantities of the crystalline mineral phases were determined using the Rietveld method. The Rietveld method is based on the calculation of the full diffraction pattern from crystal structure information. The X'Pert HighScore Plus software along with the PDF-4/Minerals ICDD database were used for mineral identification and quantification.

Results

The minerals identified in the samples and their abundances are in Table 1 and the diffraction patterns are in Appendix 1.

Table 1. Mineral abundances (wt %)

Client ID	W170498	W170508	W170513	W170524	W170537	W170552	W170564
Actlabs ID	A17-13205-2	A17-13205-4	A17-13205-5	A17-13205-6	A17-13205-8	A17-13205-11	A17-13205-12
Quartz	25.2	28.4	25.7	26.4	31.1	32.4	29.5
Plagioclase	60.3	55.3	52.2	24	25.6	44.5	31.2
K feldspar	8.3	6.2	8.3	n.d.	n.d.	n.d.	n.d.
Muscovite	6.3	8.0	9.0	5	4.4	trace	5.3
Biotite	n.d.	n.d.	n.d.	15.3	17.3	10.5	18.3
Chlorite	n.d.	n.d.	n.d.	4	1.8	n.d.	1.3
Spodumene	n.d.	2.1	4.8	n.d.	n.d.	n.d.	n.d.
Amphibole	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Holmquisite	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Tourmaline	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Amorphous	n.d.	n.d.	n.d.	25.3	19.8	12.6	14.4

Table 1. Mineral abundances (wt %)

Client ID	W170569	W170573	W170574	W170578	W170580	W170581
Actlabs ID	A17-13205-13	A17-13205-14	A17-13205-15	A17-13205-16	A17-13205-17	A17-13205-18
Quartz	28.9	39.9	4.2	0.8	1.9	2.3
Plagioclase	29.6	47.5	29.2	3.7	12.0	n.d.
K feldspar	n.d.	2.6	n.d.	n.d.	n.d.	n.d.
Muscovite	5.0	n.d.	n.d.	n.d.	n.d.	n.d.
Biotite	20.3	9.0	10.3	24.4	42.9	37.2
Chlorite	n.d.	1.0	2.0	1.0	2.7	3.6
Spodumene	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Amphibole	n.d.	n.d.	44.0	51.6	36.1	41.6
Holmquisite	n.d.	n.d.	10.3	18.5	n.d.	n.d.
Tourmaline	n.d.	n.d.	n.d.	n.d.	4.3	9.3
Amorphous	16.2	n.d.	n.d.	n.d.	n.d.	6.0

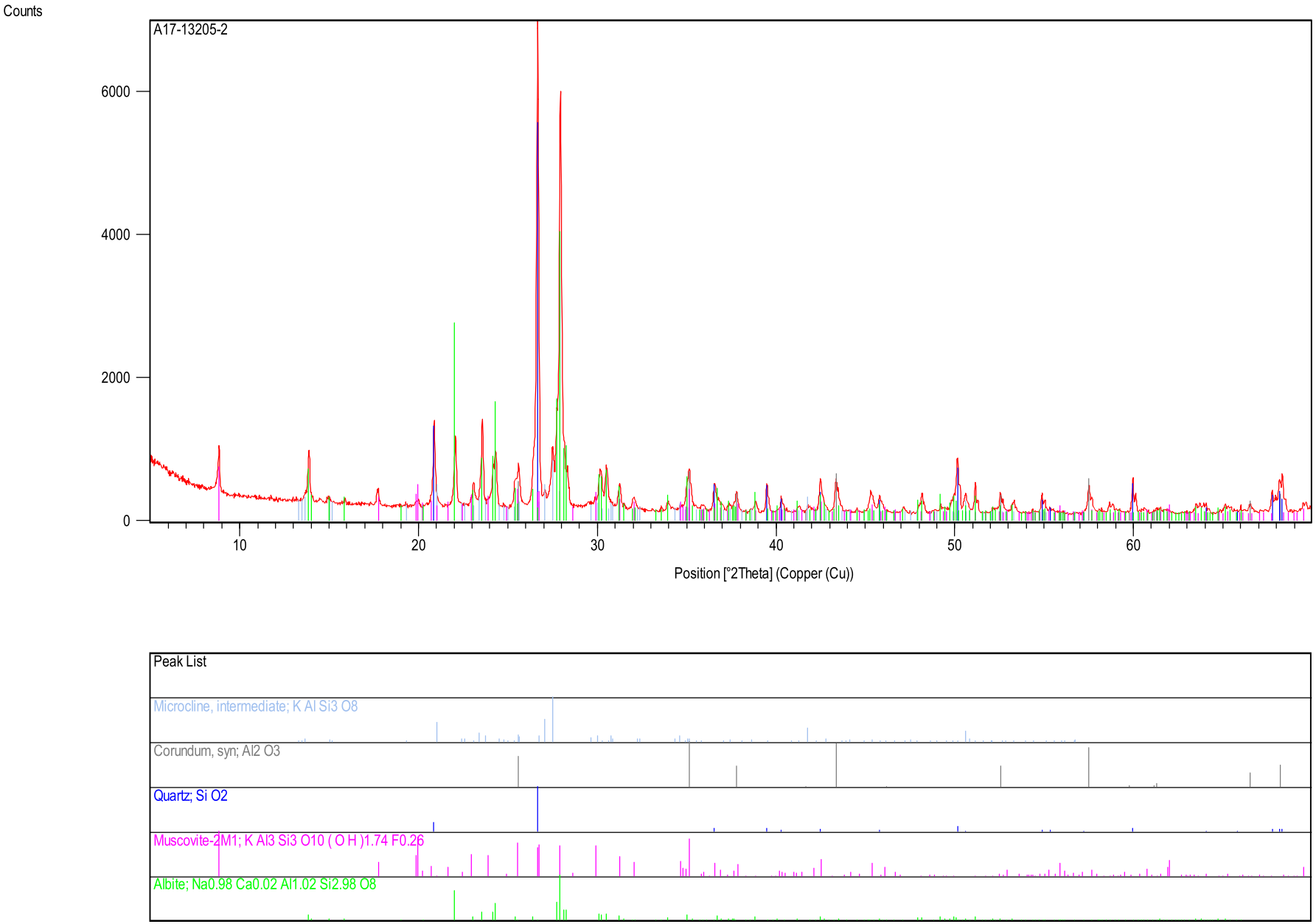
Note: n.d. = not detected; amorphous refers to X-ray amorphous material

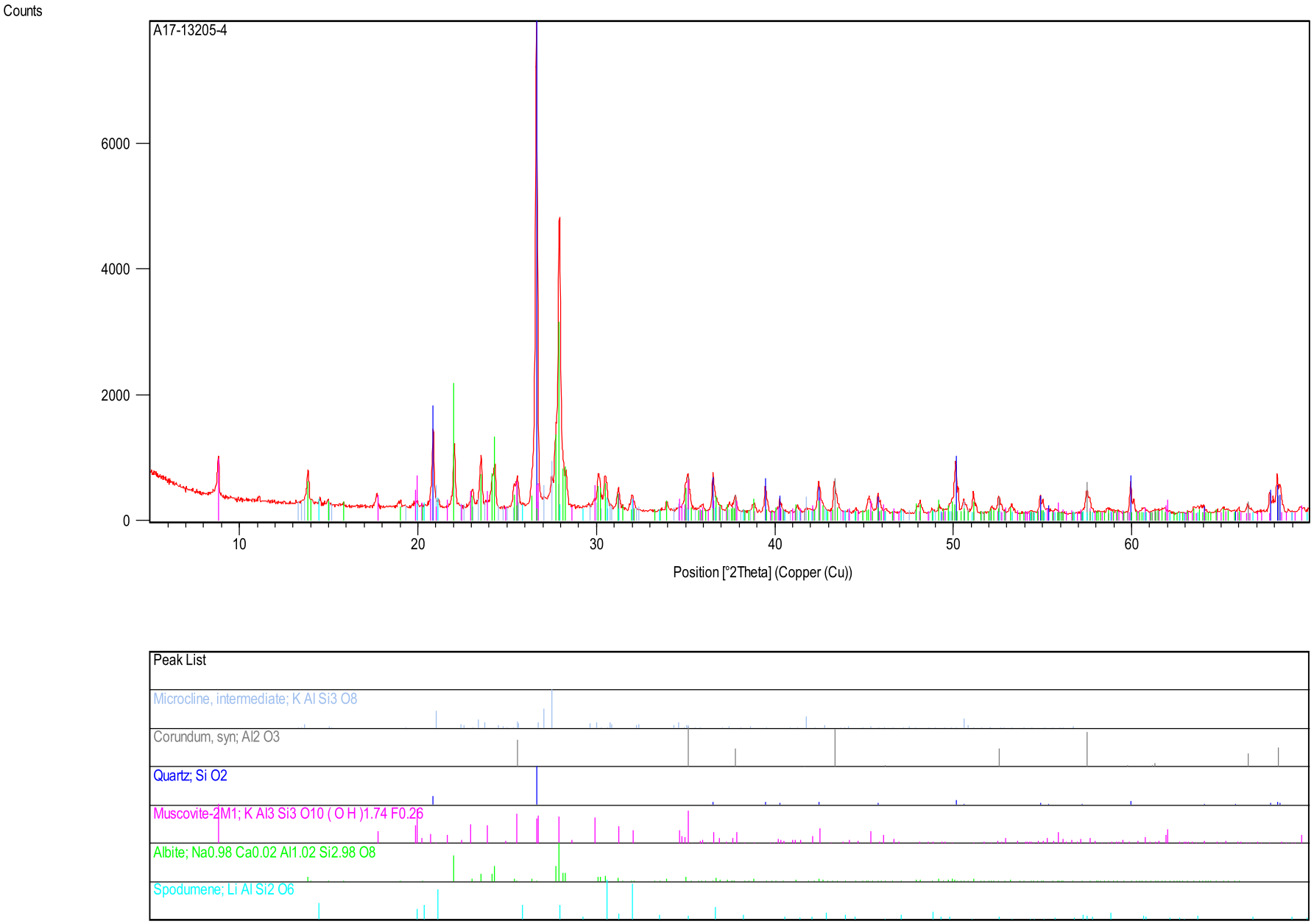
<Original signé par>

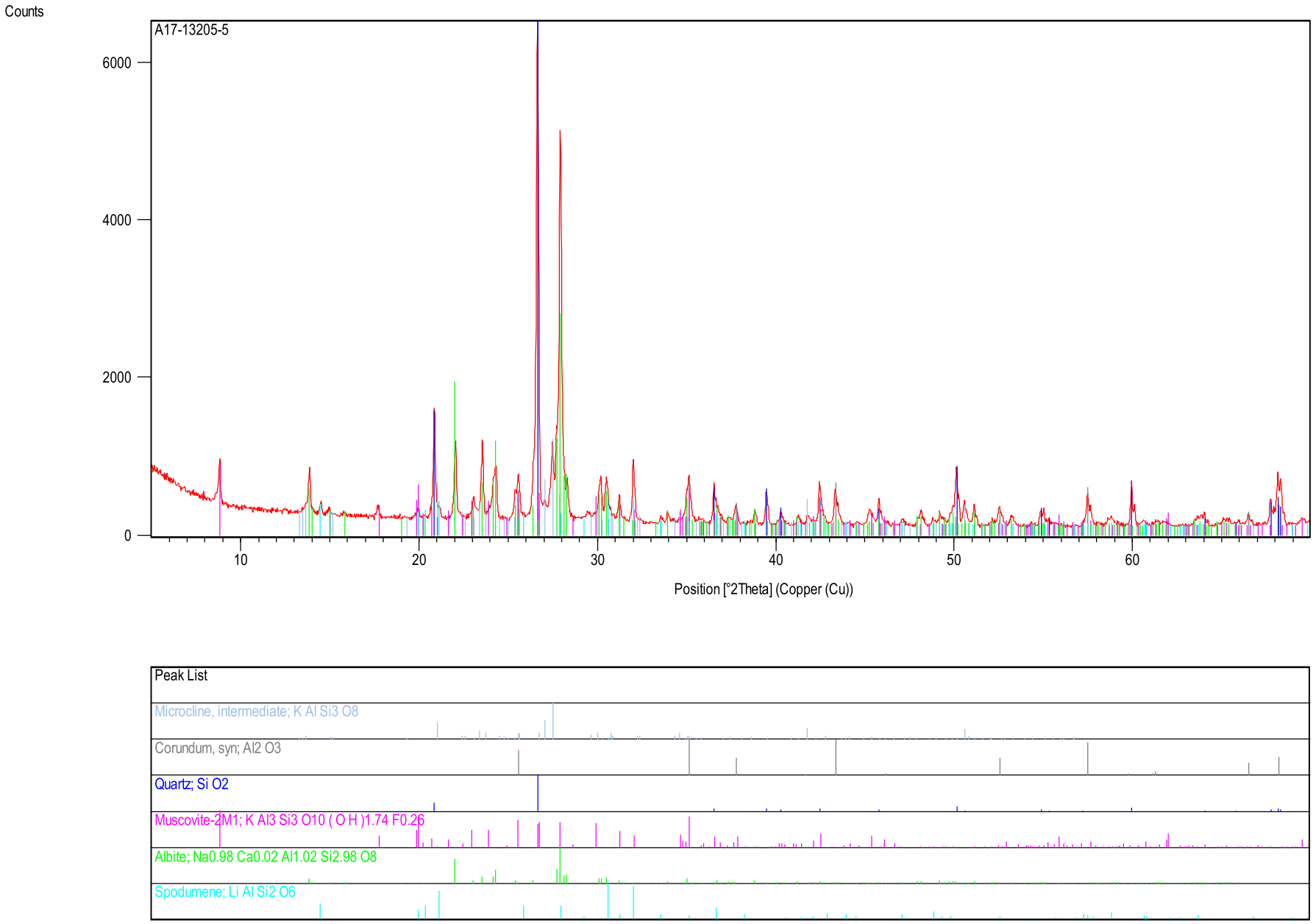
Elitsa Hrischeva, Ph.D.
Senior Scientist
Activation Laboratories Ltd.

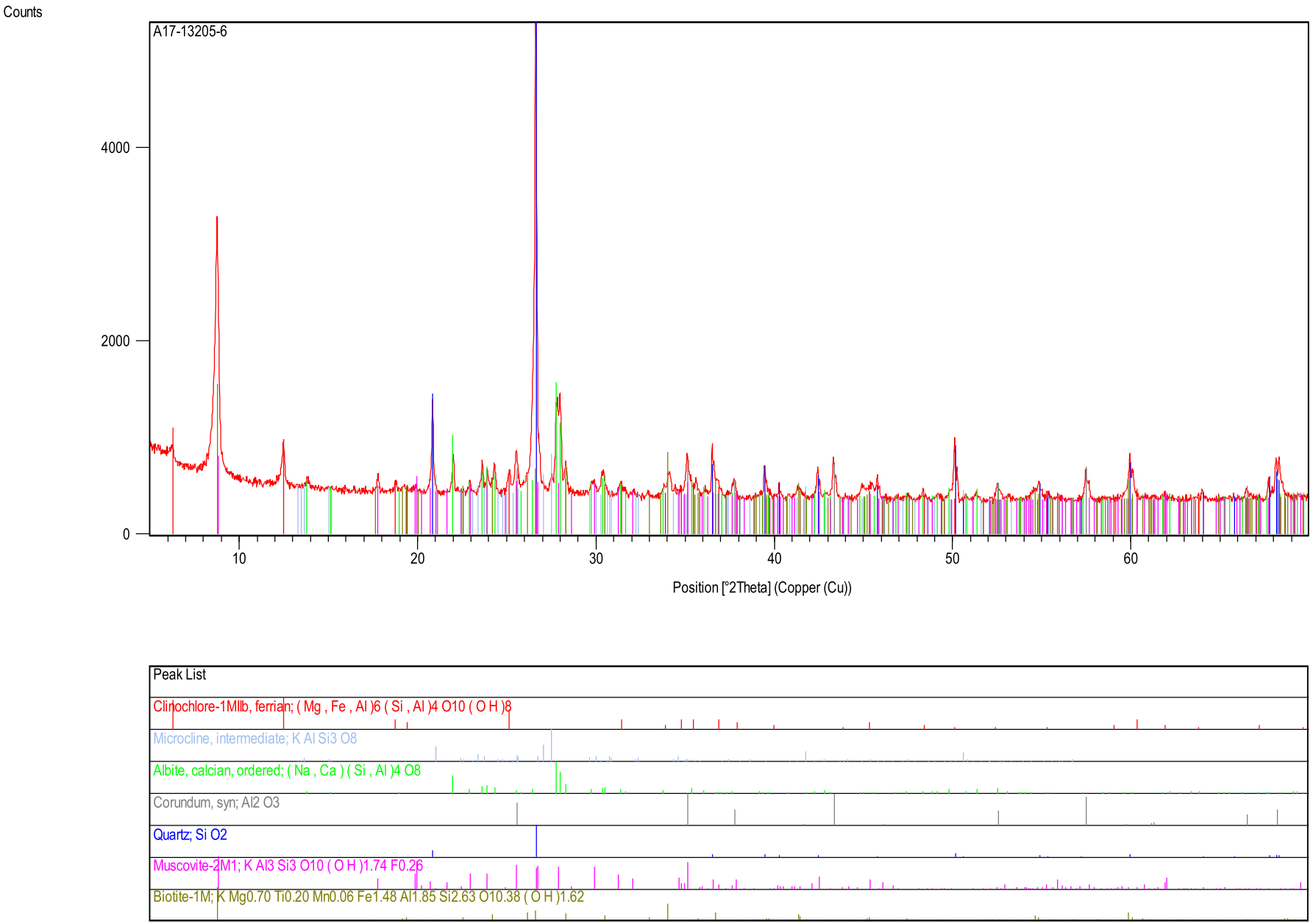
APPENDIX 1

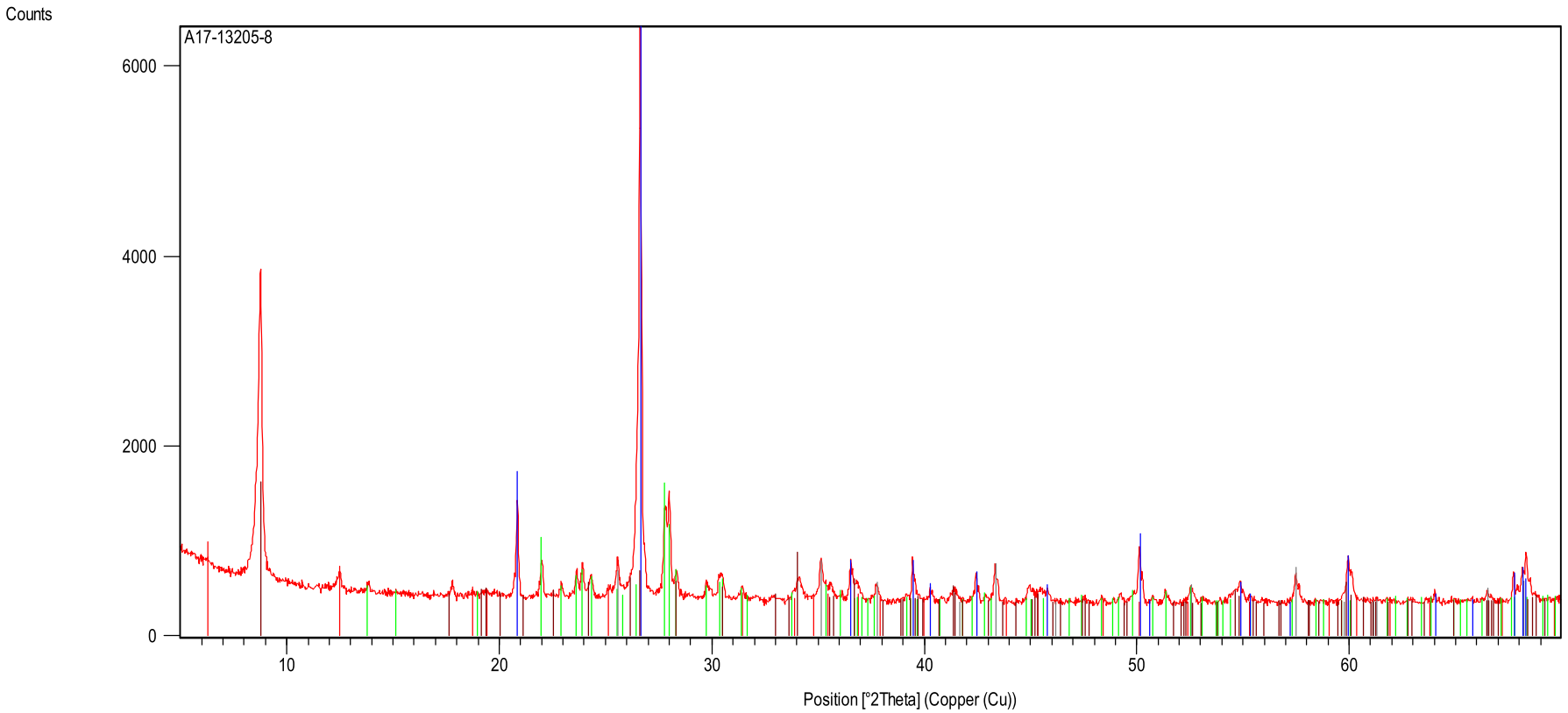
Diffraction patterns

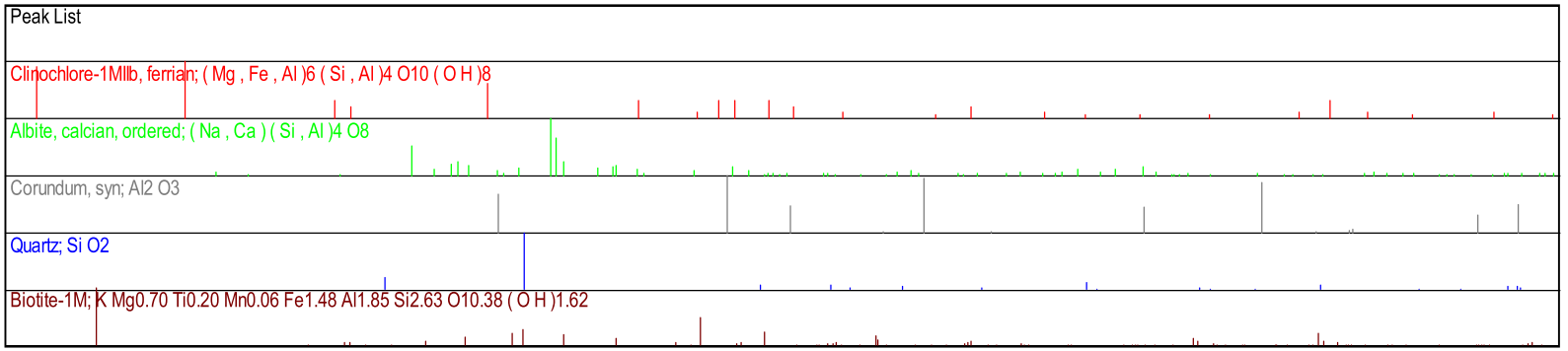

Counts
A17-13205-2
6000
4000
2000
0
10
20
30
40
50
60
Position [°2Theta] (Copper (Cu))
Peak List
Microcline, intermediate; K Al Si3 O8
Corundum, syn; Al2 O3
Quartz; Si O2
Muscovite-2M1; K Al3 Si3 O10 (O H)1.74 F0.26
Albite; Na0.98 Ca0.02 Al1.02 Si2.98 O8

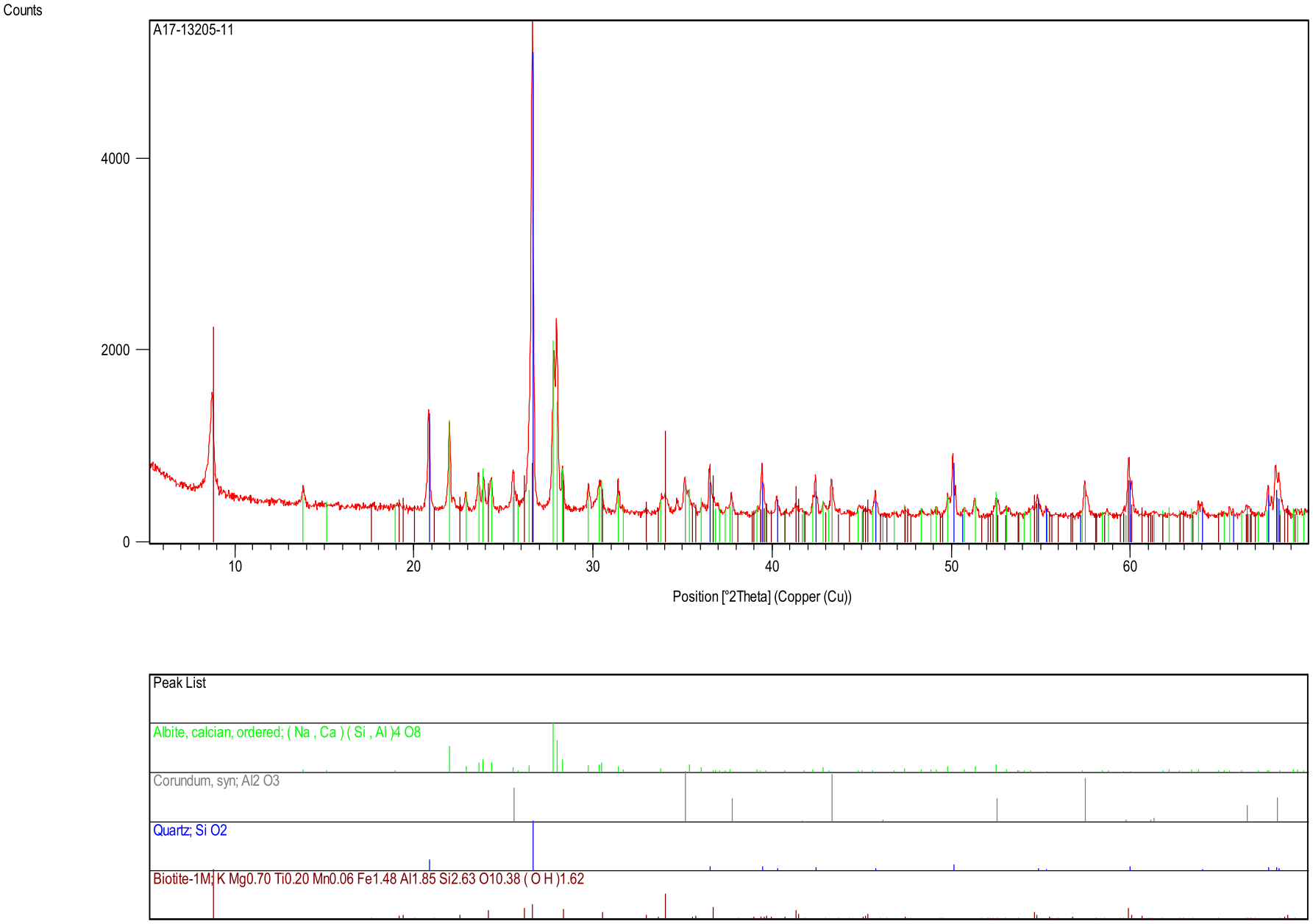

Counts
A17-13205-4
6000
4000
2000
0
10
20
30
40
50
60
Position [°2Theta] (Copper (Cu))
Peak List
Microcline, intermediate; K Al Si3 O8
Corundum, syn; Al2 O3
Quartz; Si O2
Muscovite-2M1; K Al3 Si3 O10 (O H)1.74 F0.26
Albite; Na0.98 Ca0.02 Al1.02 Si2.98 O8
Spodumene; Li Al Si2 O6

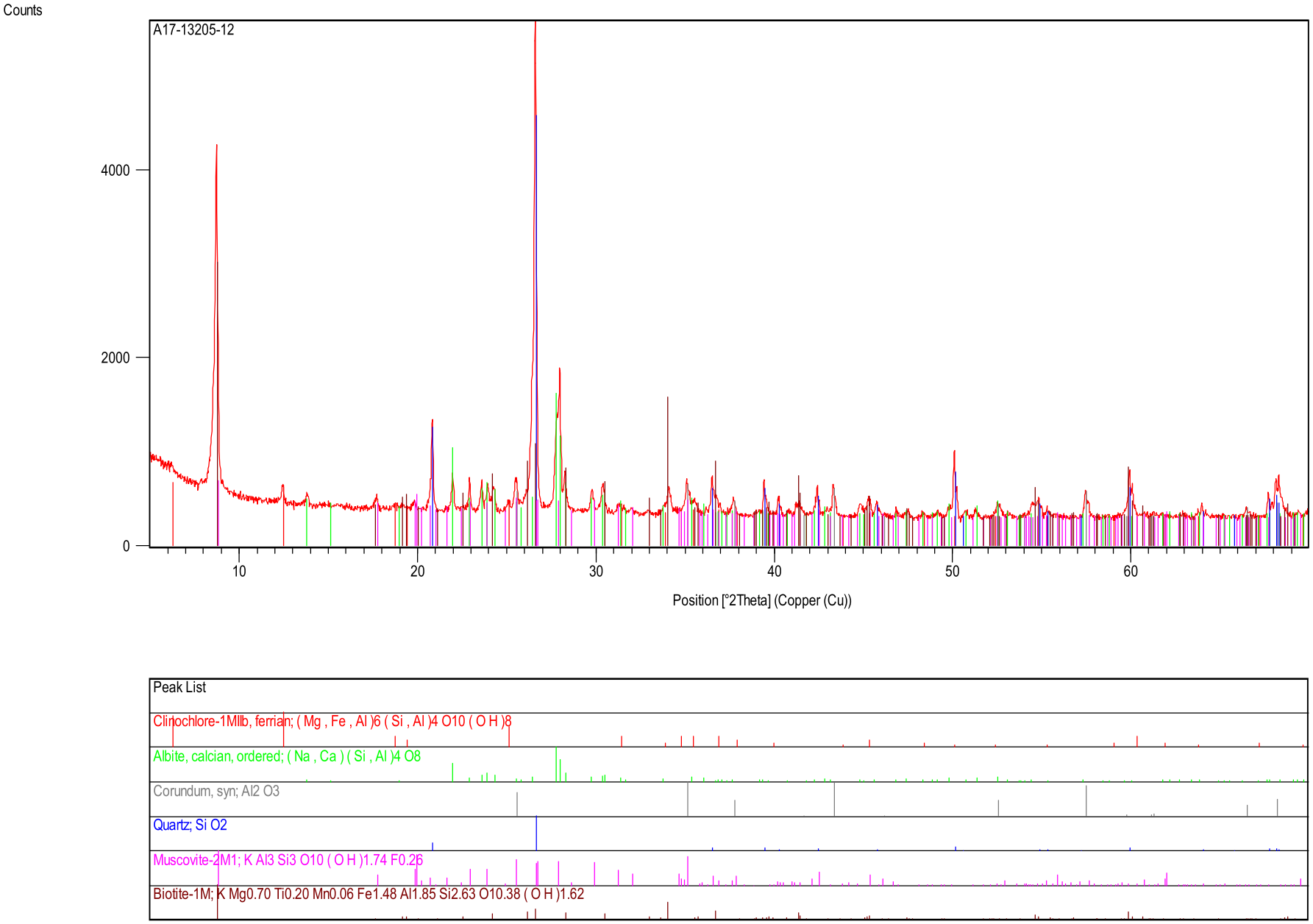

Counts
A17-13205-5
6000
4000
2000
0
10
20
30
40
50
60
Position [°2Theta] (Copper (Cu))
Peak List
Microcline, intermediate; K Al Si3 O8
Corundum, syn; Al2 O3
Quartz; Si O2
Muscovite-2M1; K Al3 Si3 O10 (O H)1.74 F0.26
Albite; Na0.98 Ca0.02 Al1.02 Si2.98 O8
Spodumene; Li Al Si2 O6

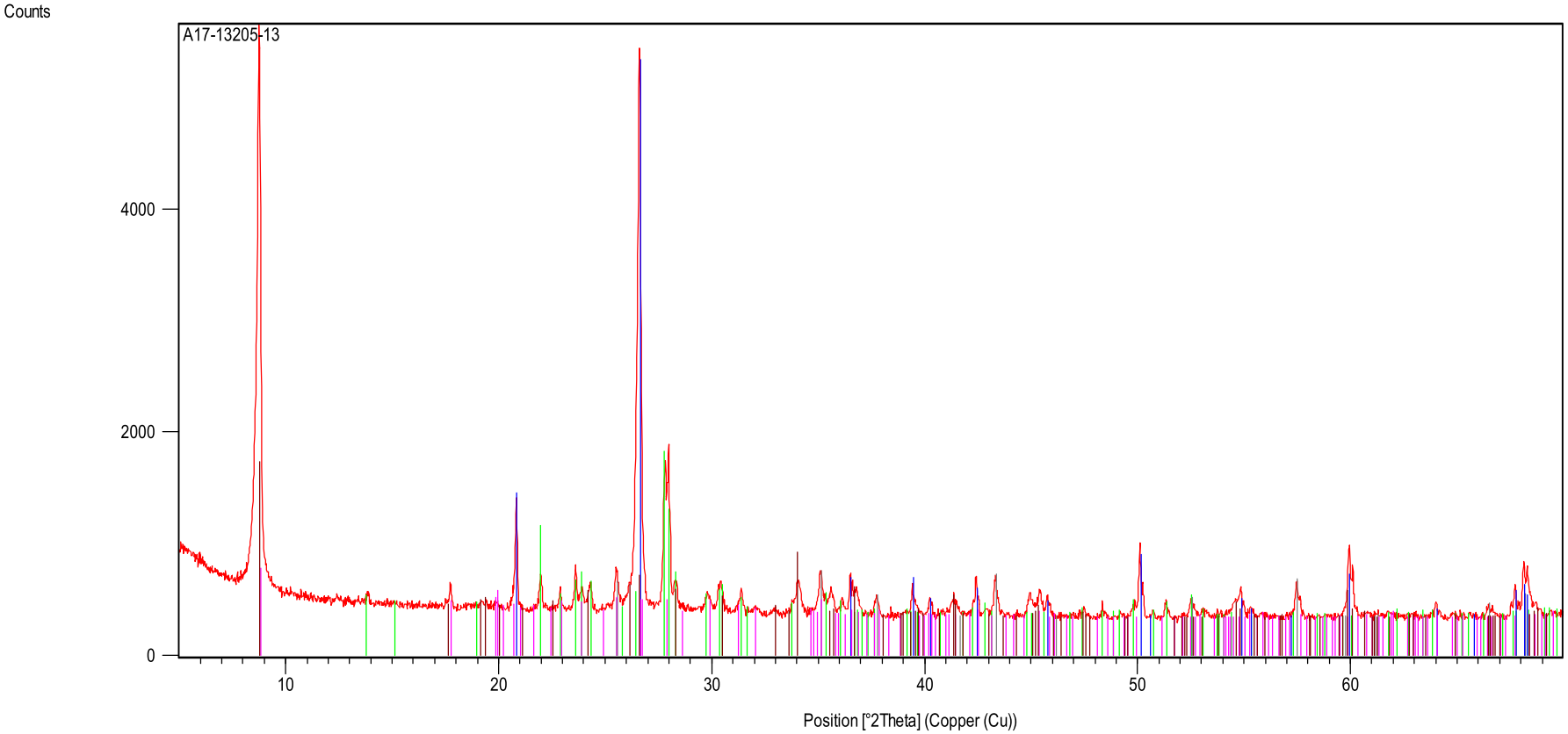

Counts
A17-13205-6
4000
2000
0
10
20
30
40
50
60
Position [°2Theta] (Copper (Cu))
Peak List
Clinochlore-1MIIb, ferrian; (Mg , Fe , Al)6 (Si , Al)4 O10 (O H)8
Microcline, intermediate; K Al Si3 O8
Albite, calcian, ordered; (Na , Ca) (Si , Al)4 O8
Corundum, syn; Al2 O3
Quartz; Si O2
Muscovite-2M1; K Al3 Si3 O10 (O H)1.74 F0.26
Biotite-1M; K Mg0.70 Ti0.20 Mn0.06 Fe1.48 Al1.85 Si2.63 O10.38 (O H)1.62

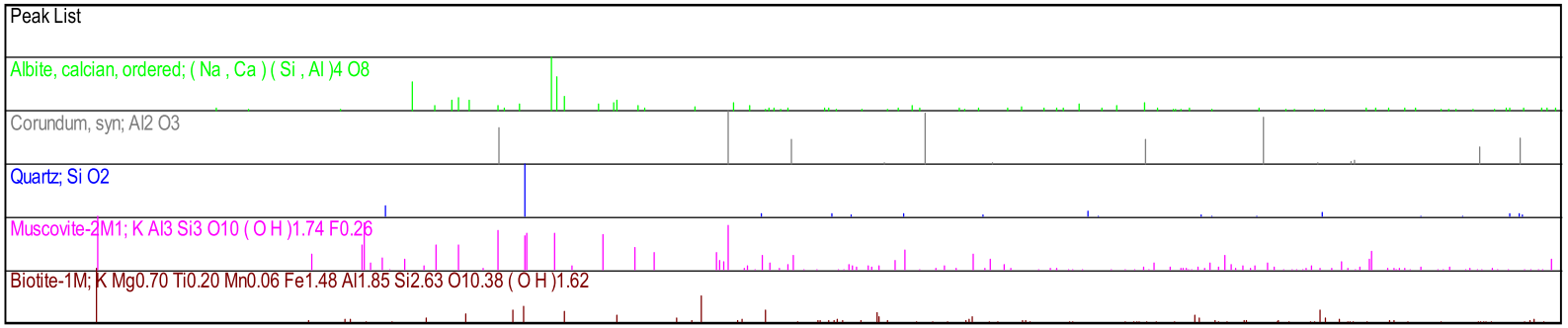

Counts
A17-13205-8
6000
4000
2000
0
10
20
30
40
50
60
Position [°2Theta] (Copper (Cu))

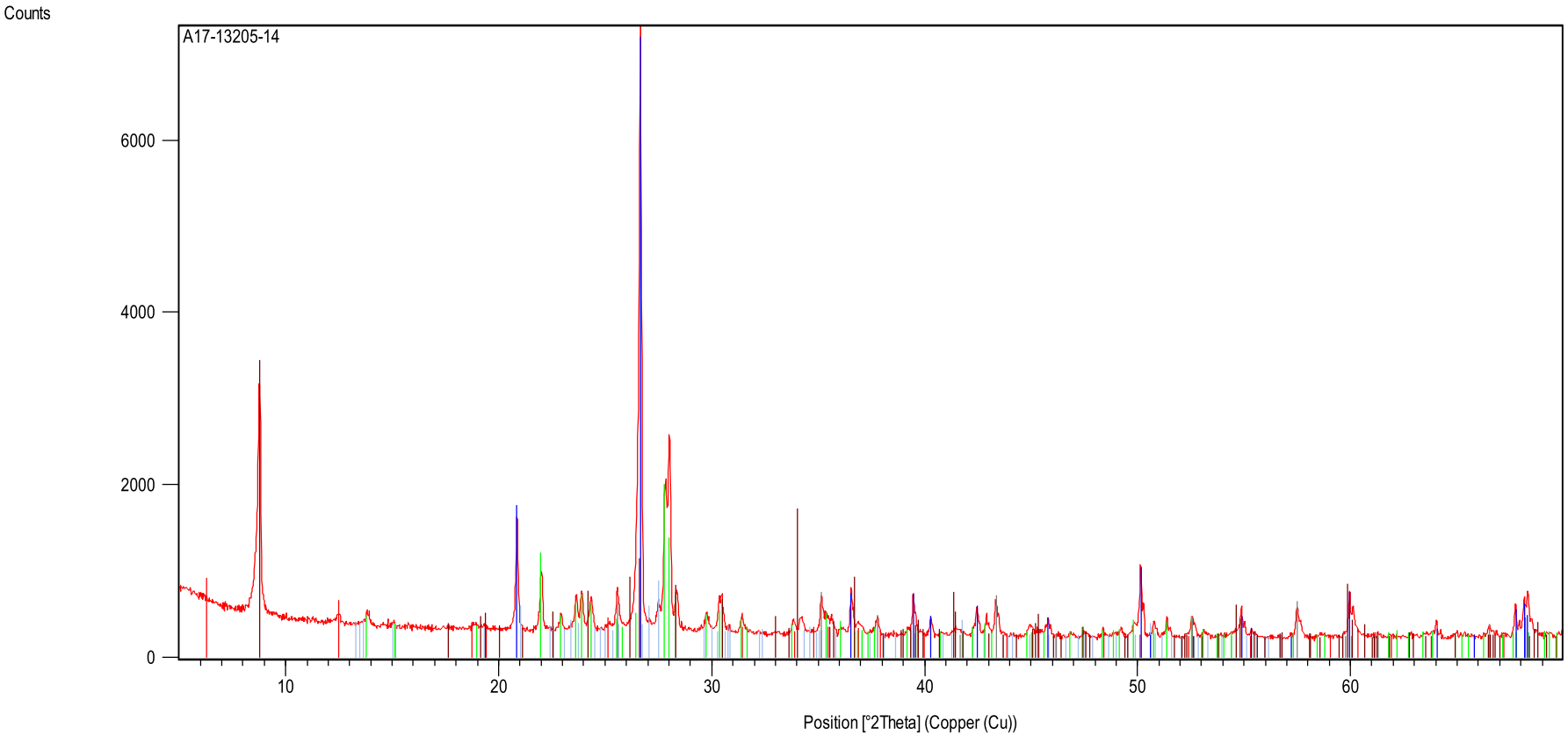

Peak List
Clinochlore-1MIIb, ferrian; (Mg , Fe , Al)6 (Si , Al)4 O10 (O H)8
Albite, calcian, ordered; (Na , Ca) (Si , Al)4 O8
Corundum, syn; Al2 O3
Quartz; Si O2
Biotite-1M; K Mg0.70 Ti0.20 Mn0.06 Fe1.48 Al1.85 Si2.63 O10.38 (O H)1.62

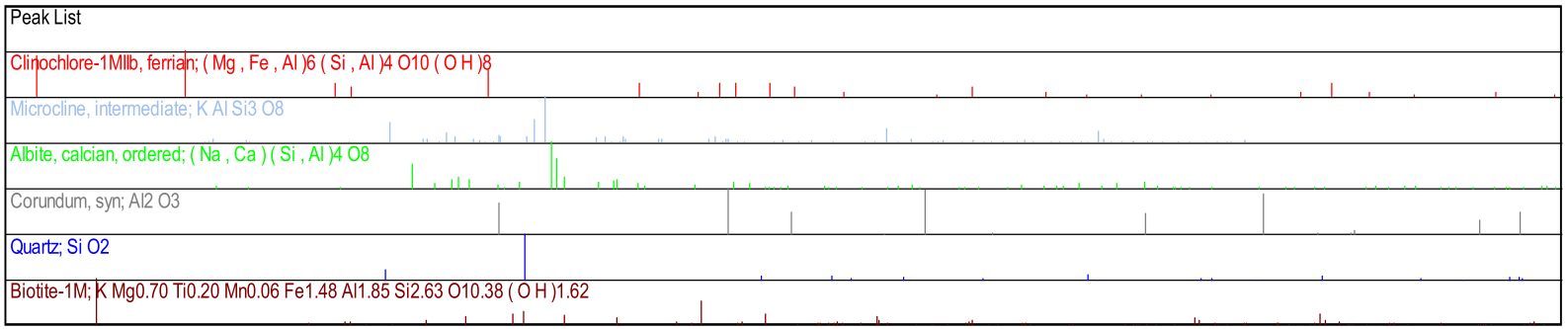

Counts
A17-13205-11
4000
2000
0
10
20
30
40
50
60
Position [°2Theta] (Copper (Cu))
Peak List
Albite, calcian, ordered; (Na , Ca) (Si , Al)4 O8
Corundum, syn; Al2 O3
Quartz; Si O2
Biotite-1M; K Mg0.70 Ti0.20 Mn0.06 Fe1.48 Al1.85 Si2.63 O10.38 (O H)1.62

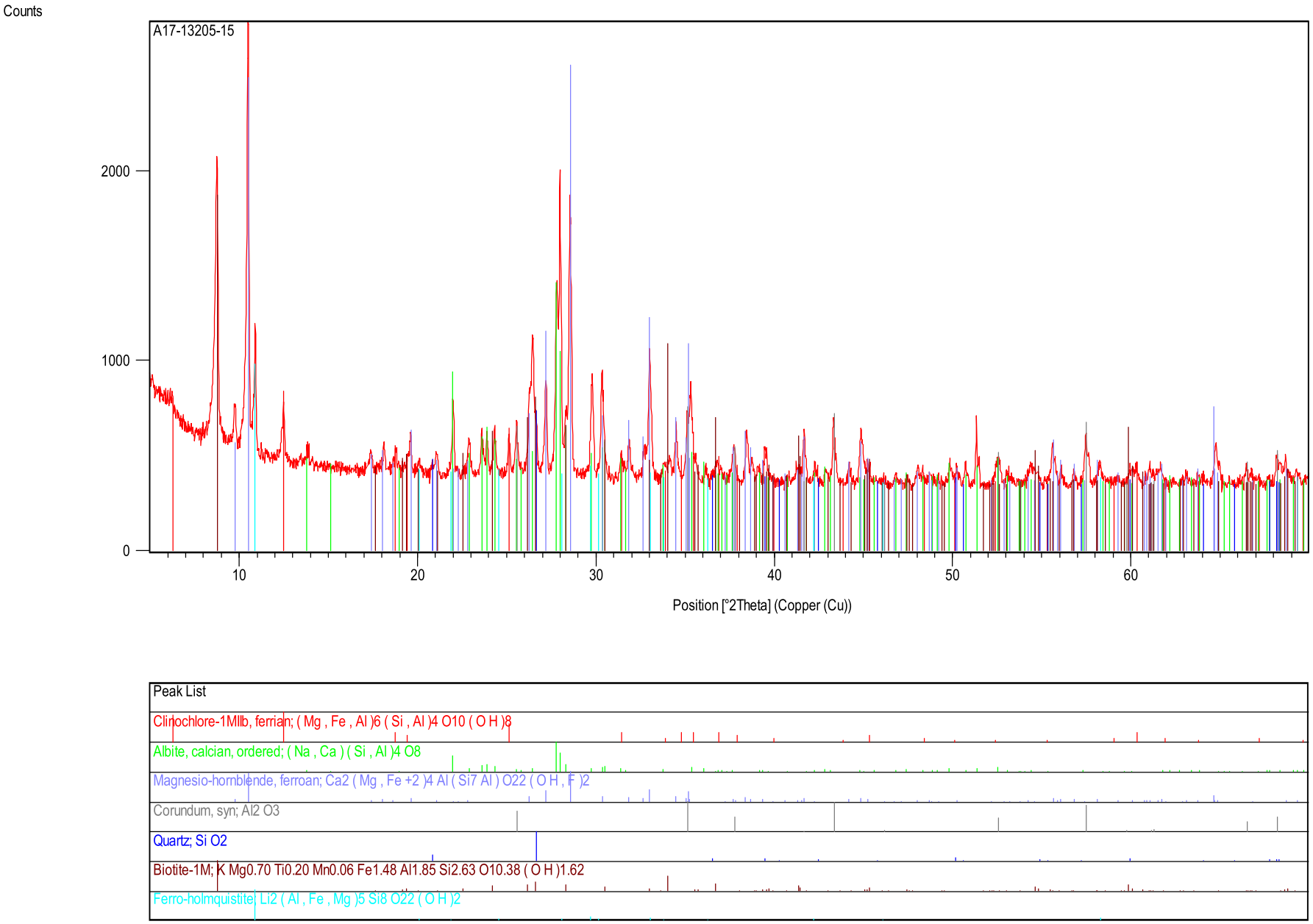

Counts
A17-13205-12
4000
2000
0
10
20
30
40
50
60
Position [°2Theta] (Copper (Cu))
Peak List
Clinochlore-1MIIb, ferrian; (Mg , Fe , Al)6 (Si , Al)4 O10 (O H)8
Albite, calcian, ordered; (Na , Ca) (Si , Al)4 O8
Corundum, syn; Al2 O3
Quartz; Si O2
Muscovite-2M1; K Al3 Si3 O10 (O H)1.74 F0.26
Biotite-1M; K Mg0.70 Ti0.20 Mn0.06 Fe1.48 Al1.85 Si2.63 O10.38 (O H)1.62

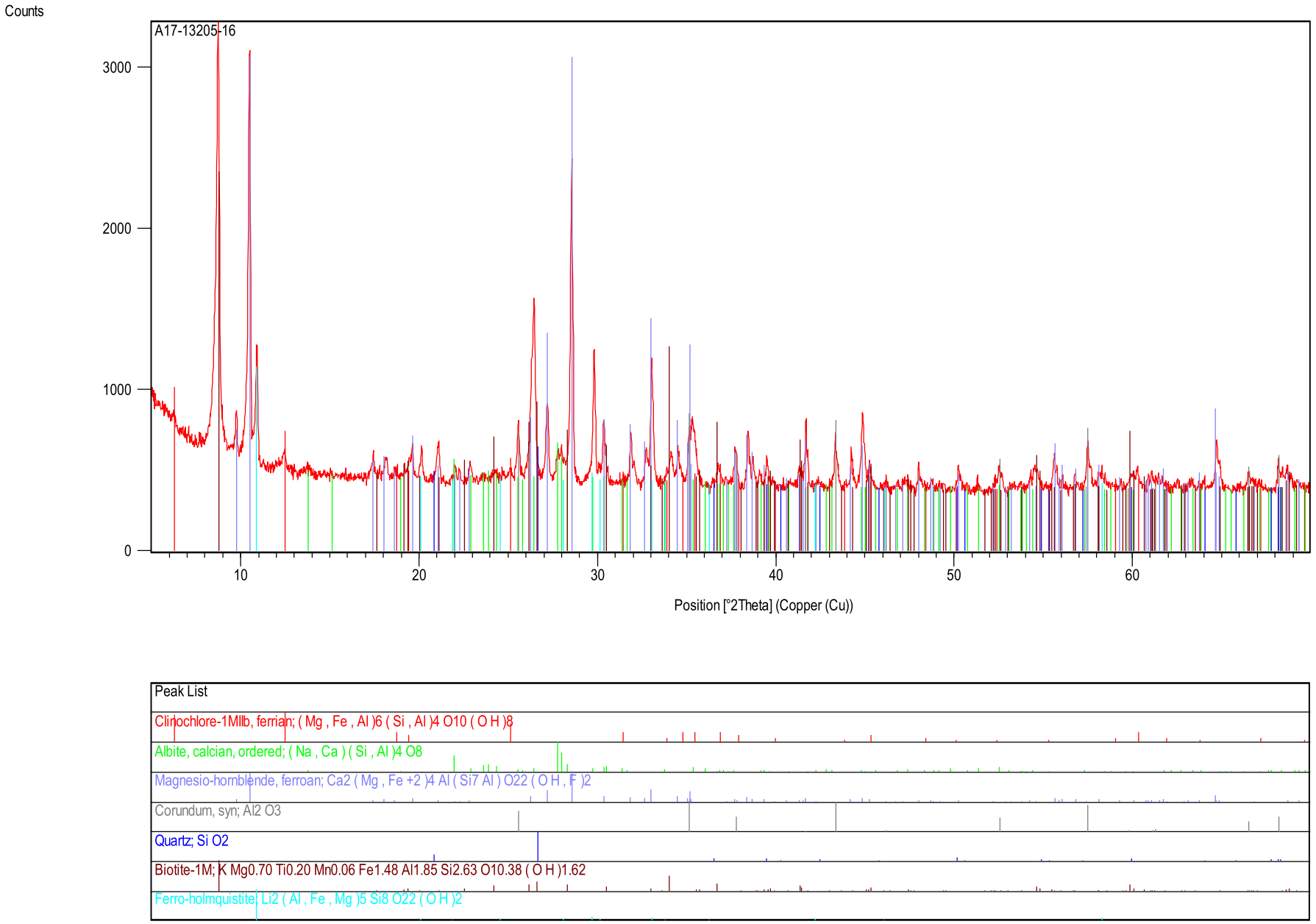

Counts
A17-13205-13
4000
2000
0
10
20
30
40
50
60
Position [°2Theta] (Copper (Cu))

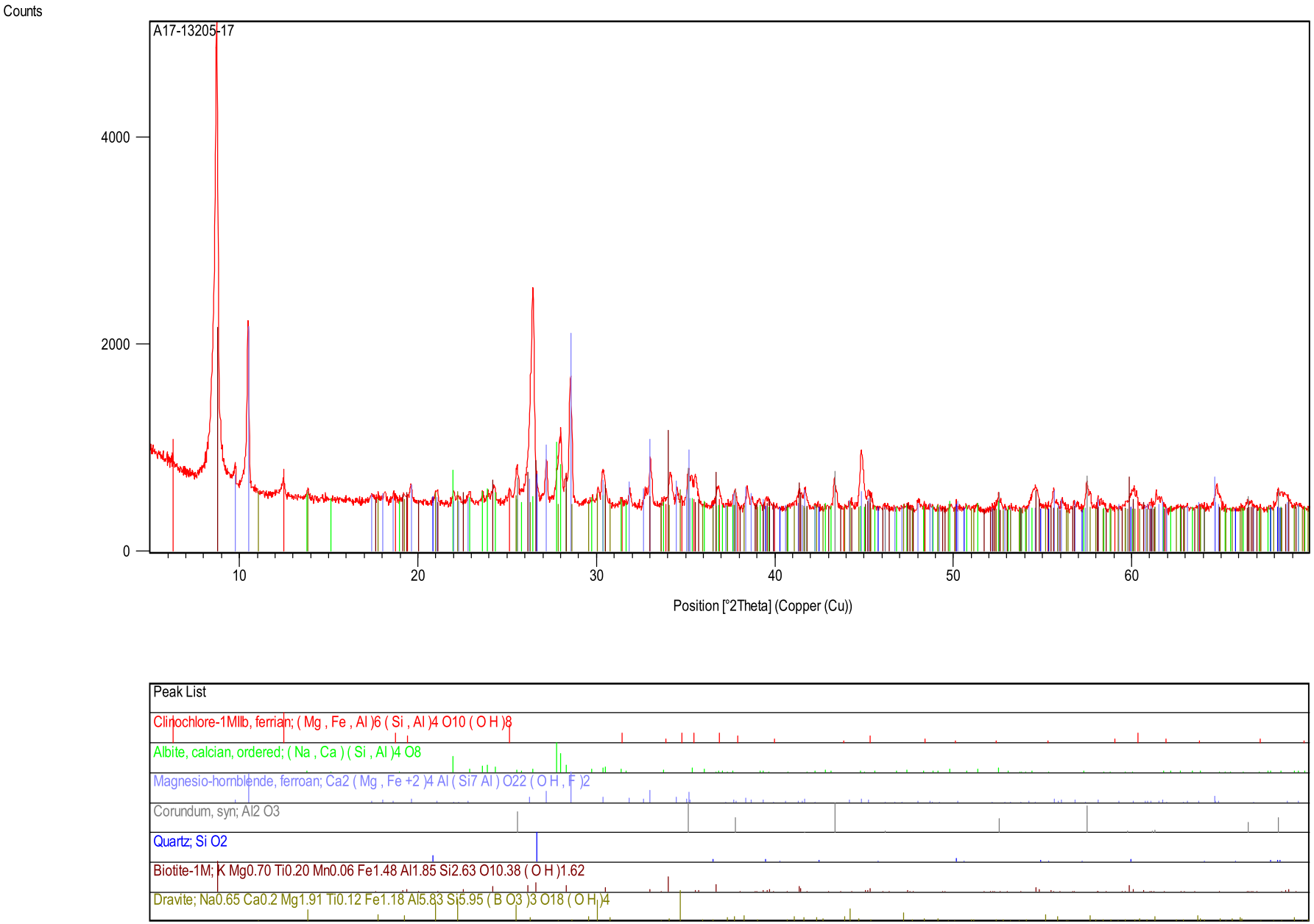

Peak List
Albite, calcian, ordered; (Na , Ca) (Si , Al)4 O8
Corundum, syn; Al2 O3
Quartz; Si O2
Muscovite-2M1; K Al3 Si3 O10 (O H)1.74 F0.26
Biotite-1M; K Mg0.70 Ti0.20 Mn0.06 Fe1.48 Al1.85 Si2.63 O10.38 (O H)1.62

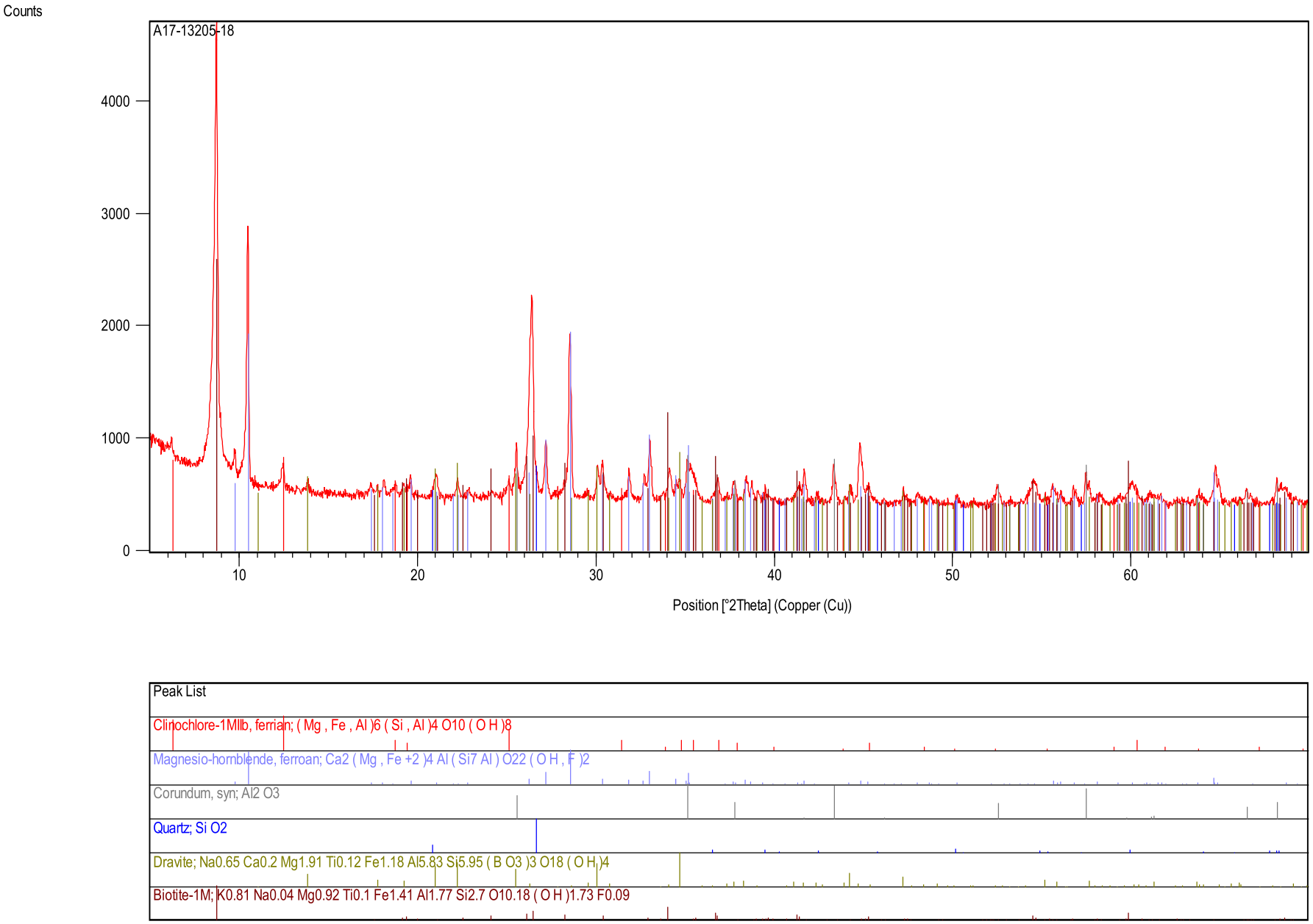

Counts
A17-13205-14
6000
4000
2000
0
10
20
30
40
50
60
Position [°2Theta] (Copper (Cu))


Peak List
Clinochlore-1MIIb, ferrian; (Mg , Fe , Al)6 (Si , Al)4 O10 (O H)8
Microcline, intermediate; K Al Si3 O8
Albite, calcian, ordered; (Na , Ca) (Si , Al)4 O8
Corundum, syn; Al2 O3
Quartz; Si O2
Biotite-1M; K Mg0.70 Ti0.20 Mn0.06 Fe1.48 Al1.85 Si2.63 O10.38 (O H)1.62


Counts
A17-13205-15
2000
1000
0
10
20
30
40
50
60
Position [°2Theta] (Copper (Cu))
Peak List
Clinochlore-1MIIb, ferrian; (Mg , Fe , Al)6 (Si , Al)4 O10 (O H)8
Albite, calcian, ordered; (Na , Ca) (Si , Al)4 O8
Magnesio-hornblende, ferroan; Ca2 (Mg , Fe +2)4 Al (Si7 Al) O22 (O H , F)2
Corundum, syn; Al2 O3
Quartz; Si O2
Biotite-1M; K Mg0.70 Ti0.20 Mn0.06 Fe1.48 Al1.85 Si2.63 O10.38 (O H)1.62
Ferro-holmquistite; Li2 (Al , Fe , Mg)5 Si8 O22 (O H)2


Counts
A17-13205-16
3000
2000
1000
0
10
20
30
40
50
60
Position [°2Theta] (Copper (Cu))
Peak List
Clinochlore-1MIIb, ferrian; (Mg , Fe , Al)6 (Si , Al)4 O10 (O H)8
Albite, calcian, ordered; (Na , Ca) (Si , Al)4 O8
Magnesio-hornblende, ferroan; Ca2 (Mg , Fe +2)4 Al (Si7 Al) O22 (O H , F)2
Corundum, syn; Al2 O3
Quartz; Si O2
Biotite-1M; K Mg0.70 Ti0.20 Mn0.06 Fe1.48 Al1.85 Si2.63 O10.38 (O H)1.62
Ferro-holmquistite; Li2 (Al , Fe , Mg)5 Si8 O22 (O H)2


Counts
A17-13205-17
4000
2000
0
10
20
30
40
50
60
Position [°2Theta] (Copper (Cu))
Peak List
Clinochlore-1MIIb, ferrian; (Mg , Fe , Al)6 (Si , Al)4 O10 (O H)8
Albite, calcian, ordered; (Na , Ca) (Si , Al)4 O8
Magnesio-hornblende, ferroan; Ca2 (Mg , Fe +2)4 Al (Si7 Al) O22 (O H , F)2
Corundum, syn; Al2 O3
Quartz; Si O2
Biotite-1M; K Mg0.70 Ti0.20 Mn0.06 Fe1.48 Al1.85 Si2.63 O10.38 (O H)1.62
Dravite; Na0.65 Ca0.2 Mg1.91 Ti0.12 Fe1.18 Al5.83 Si5.95 (B O3)3 O18 (O H)4


Counts
A17-13205-18
4000
3000
2000
1000
0
10
20
30
40
50
60
Position [°2Theta] (Copper (Cu))
Peak List
Clinochlore-1MIIb, ferrian; (Mg , Fe , Al)6 (Si , Al)4 O10 (O H)8
Magnesio-hornblende, ferroan; Ca2 (Mg , Fe +2)4 Al (Si7 Al) O22 (O H , F)2
Corundum, syn; Al2 O3
Quartz; Si O2
Dravite; Na0.65 Ca0.2 Mg1.91 Ti0.12 Fe1.18 Al5.83 Si5.95 (B O3)3 O18 (O H)4
Biotite-1M; K0.81 Na0.04 Mg0.92 Ti0.1 Fe1.41 Al1.77 Si2.7 O10.18 (O H)1.73 F0.09

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

LR Internal Dept 14
Attn : Rob Caldwell

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Phone: ---, Fax:---

09-August-2018

Date Rec. : 07 August 2018
LR Report : **CA02217-AUG18**
Project : CA20M-00000-110-13531-02
Client Ref : Galaxy Lithium Canada

CERTIFICATE OF ANALYSIS

Final Report

Sample ID	SiO2 %	Al2O3 %	Fe2O3 %	MgO %	CaO %	Na2O %	K2O %
1: W170598	44.8	14.0	16.7	5.15	8.47	3.18	1.13
2: W170599	45.5	15.0	15.9	5.22	8.06	3.03	1.42
3: W170600	44.8	13.5	16.9	5.34	8.85	3.25	0.76
4: W171906	45.1	13.9	16.8	5.68	8.62	2.19	1.55
5: W171907	62.9	16.1	5.82	4.64	0.56	3.46	1.64

Sample ID	TiO2 %	P2O5 %	MnO %	Cr2O3 %	V2O5 %	LOI %	Sum %
1: W170598	2.85	0.58	0.22	< 0.01	0.08	2.28	99.5
2: W170599	2.63	0.62	0.20	0.02	0.06	1.97	99.7
3: W170600	2.97	0.58	0.22	0.01	0.06	2.26	99.6
4: W171906	2.76	0.66	0.24	0.02	0.07	1.98	99.5
5: W171907	0.57	0.14	0.07	0.02	0.02	3.39	99.3

Control Quality Assay
Not Suitable for Commercial Exchange

<Original signed by>

Tom Watt
Project Coordinator

OnLine LIMS

0001467756

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

SGS Lakefield Environmental Met
Attn : Barb Bowman

Project : CALR-13531-002

13-August-2018

Date Rec. : 07 August 2018
LR Report: **CA14143-AUG18**

Copy: #1

CERTIFICATE OF ANALYSIS
Final Report

Analysis	1: Analysis Start Date	2: Analysis Start Time	3: Analysis Completed Date	4: Analysis Completed Time	5: W170598	6: W170599	7: W170600	8: W171906	9: W171907
Mercury [ug/g]	08-Aug-18	08:18	09-Aug-18	09:00	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Silver [µg/g]	09-Aug-18	11:20	09-Aug-18	14:34	< 1	< 1	< 1	< 1	< 1
Aluminum [µg/g]	09-Aug-18	11:20	09-Aug-18	14:34	71000	71000	64000	68000	82000
Arsenic [µg/g]	09-Aug-18	11:20	09-Aug-18	14:34	9.1	9.0	9.2	4.9	11
Boron [µg/g]	09-Aug-18	11:20	09-Aug-18	14:34	1.1	< 1	< 1	< 1	< 1
Barium [µg/g]	09-Aug-18	11:20	09-Aug-18	14:34	950	690	480	660	76
Beryllium [µg/g]	09-Aug-18	11:20	09-Aug-18	14:34	0.96	0.90	1.0	0.94	2.6
Bismuth [µg/g]	09-Aug-18	11:20	09-Aug-18	14:34	0.16	< 0.09	< 0.09	< 0.09	< 0.09
Calcium [µg/g]	09-Aug-18	11:20	09-Aug-18	14:34	63000	57000	63000	62000	4500
Cadmium [µg/g]	09-Aug-18	11:20	09-Aug-18	14:34	0.52	0.36	0.33	0.28	0.06
Cobalt [µg/g]	09-Aug-18	11:20	09-Aug-18	14:34	56	52	53	56	11
Chromium [µg/g]	09-Aug-18	11:20	09-Aug-18	14:34	73	74	65	78	77
Copper [µg/g]	09-Aug-18	11:20	09-Aug-18	14:34	51	29	25	36	9.9
Iron [µg/g]	09-Aug-18	11:20	09-Aug-18	14:34	130000	120000	120000	130000	42000
Potassium [µg/g]	09-Aug-18	11:20	09-Aug-18	14:34	9700	12000	6400	13000	14000
Lithium [µg/g]	09-Aug-18	11:20	09-Aug-18	14:34	64	41	59	300	600
Magnesium [µg/g]	09-Aug-18	11:20	09-Aug-18	14:34	33000	32000	33000	36000	29000
Manganese [µg/g]	09-Aug-18	11:20	09-Aug-18	14:34	1700	1600	1800	1900	590
Molybdenum [µg/g]	09-Aug-18	11:20	09-Aug-18	14:34	1.8	1.5	1.4	1.5	1.4
Sodium [µg/g]	09-Aug-18	11:20	09-Aug-18	14:34	26000	24000	26000	18000	28000

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Project : CALR-13531-002
LR Report : **CA14143-AUG18**

Analysis	1: Analysis Start Date	2: Analysis Start Time	3: Analysis Completed Date	4: Analysis Completed Time	5: W170598	6: W170599	7: W170600	8: W171906	9: W171907
Nickel [µg/g]	09-Aug-18	11:20	09-Aug-18	14:34	53	41	42	60	33
Lead [µg/g]	09-Aug-18	11:20	09-Aug-18	14:34	18	9.1	7.8	7.7	2.0
Antimony [µg/g]	09-Aug-18	11:20	09-Aug-18	14:34	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8
Selenium [µg/g]	09-Aug-18	11:20	09-Aug-18	14:34	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7
Tin [µg/g]	09-Aug-18	11:20	09-Aug-18	14:34	< 6	< 6	< 6	< 6	7
Strontium [µg/g]	09-Aug-18	11:20	09-Aug-18	14:34	420	390	380	360	55
Thorium [µg/g]	09-Aug-18	11:20	09-Aug-18	14:34	1.2	1.2	1.3	1.3	3.9
Titanium [µg/g]	09-Aug-18	11:20	09-Aug-18	14:34	17000	15000	18000	16000	3000
Thallium [µg/g]	09-Aug-18	11:20	09-Aug-18	14:34	0.26	0.21	0.20	1.1	1.1
Uranium [µg/g]	09-Aug-18	11:20	09-Aug-18	14:34	0.31	0.29	0.29	0.30	1.1
Vanadium [µg/g]	09-Aug-18	11:20	09-Aug-18	14:34	410	340	390	370	94
Tungsten [µg/g]	09-Aug-18	11:20	09-Aug-18	14:34	1.2	0.42	0.54	0.37	4.0
Yttrium [µg/g]	09-Aug-18	11:20	09-Aug-18	14:34	38	36	39	41	8.7
Zinc [µg/g]	09-Aug-18	11:20	09-Aug-18	14:34	200	180	160	180	60

<Original signé par>

B.Sc., C.Chem
Project Specialist
Environmental Services, Analytical

OnLine LIMS

0001472605

APPENDIX G

Material Movement Log

James Bay Project

	Y-2	Y-1	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15	Y16	Y17	Y18	Y19
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
	1-Jan-20	1-Jan-21	1-Jan-22	1-Jan-23	1-Jan-24	1-Jan-25	1-Jan-26	1-Jan-27	1-Jan-28	1-Jan-29	1-Jan-30	1-Jan-31	1-Jan-32	1-Jan-33	1-Jan-34	1-Jan-35	1-Jan-36	1-Jan-37	1-Jan-38	1-Jan-39	1-Jan-40
31-Dec-21	31-Dec-20	31-Dec-21	31-Dec-22	31-Dec-23	31-Dec-24	31-Dec-25	31-Dec-26	31-Dec-27	31-Dec-28	31-Dec-29	31-Dec-30	31-Dec-31	31-Dec-32	31-Dec-33	31-Dec-34	31-Dec-35	31-Dec-36	31-Dec-37	31-Dec-38	31-Dec-39	31-Dec-40
	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12

Waste Material Balance

Total Tonnage by Phase

JB1-1 (West Pit Phase 1)	kt		**2,655**	-	-	-	-	-	-	33	-	-	-	-	-	1,774	848	-	-	-	-	-	-	-
JB1-2 (West Pit Phase 2)	kt		**14,167**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	326	2,047	3,398	6,194	2,202
JB2-1 (Center Pit Phase 1)	kt		**2,521**	-	2,500	21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
JB2-2 (Center Pit Phase 2)	kt		**32,321**	-	-	7,883	8,046	7,066	5,576	2,264	-	-	-	616	544	202	123	-	-	-	-	-	-
JB2-3 (Center Pit Phase 3)	kt		**20,027**	-	-	-	-	934	2,424	5,676	4,091	2,188	1,602	1,699	790	430	193	-	-	-	-	-	-
JB2-4 (Center Pit Phase 4)	kt		**57,491**	-	-	-	-	-	-	-	0	496	2,442	3,186	3,624	3,347	6,196	5,821	8,969	8,674	7,236	4,602	2,898	-
JB3-1 (East Pit Phaes 1)	kt		**43,425**	-	-	96	-	-	-	27	3,909	5,316	6,805	5,135	6,041	5,247	3,640	5,179	2,031	-	-	-	-	-
Total In-Situ Mining	kt		**172,608**	-	2,500	8,000	8,046	8,000	8,000	8,000	8,000	8,000	10,849	10,636	11,000	11,000	11,000	11,000	11,000	9,000	9,283	8,000	9,092	2,202

Waste Tonnage by Phase

JB1-1 (West Pit Phase 1)	kt		**1,805**	-	-	-	-	-	15	-	-	-	-	-	-	1,333	457	-	-	-	-	-	-	-
JB1-2 (West Pit Phase 2)	kt		**12,537**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	326	2,035	3,310	5,565	1,301	
JB2-1 (Center Pit Phase 1)	kt		**2,337**	-	2,316	21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
JB2-2 (Center Pit Phase 2)	kt		**22,561**	-	-	5,940	6,046	5,045	3,719	1,280	-	-	-	254	161	68	49	-	-	-	-	-	-	
JB2-3 (Center Pit Phase 3)	kt		**15,608**	-	-	-	-	934	2,224	4,695	3,146	1,549	1,067	1,149	543	236	65	-	-	-	-	-	-	
JB2-4 (Center Pit Phaes 4)	kt		**45,759**	-	-	-	-	-	-	-	0	496	2,424	3,177	3,610	3,328	6,124	5,636	7,796	6,674	5,247	1,246	-	
JB3-1 (East Pit Phaes 1)	kt		**32,129**	-	-	33	-	-	-	10	2,390	3,955	5,359	4,056	4,715	4,035	2,714	3,589	1,274	-	-	-	-	
Total In-Situ Mining	kt		**132,736**	-	2,316	5,993	6,046	5,978	5,943	6,000	5,536	6,000	8,849	8,636	9,029	9,000	9,409	9,225	9,070	7,000	7,283	4,557	5,565	1,301

Tailings Tonnage

Ore Milled	kt			**36,902**	-	-	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	902
Wet Tailings Generated	kt	85%		**31,366**	-	-	1,700	1,700	1,700	1,700	1,700	1,700	1,700	1,700	1,700	1,700	1,700	1,700	1,700	1,700	1,700	1,700	1,700	766
Dry Tailings Generated	000'm3	1.26	2.70	**13,941**	-	-	756	756	756	756	756	756	756	756	756	756	756	756	756	756	756	756	756	341
Dry Tailings Generated	kt	1.79		**23,699**	-	-	1,284	1,284	1,284	1,284	1,284	1,284	1,284	1,284	1,284	1,284	1,284	1,284	1,284	1,284	1,284	1,284	1,284	579

Ore Tonnage by Phase

JB1-1 (West Pit Phase 1)	kt			**850**	-	-	-	-	-	-	18	-	-	-	-	-	441	391	-	-	-	-	-	-	-
JB1-2 (West Pit Phase 2)	kt			**1,630**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	11	88	628	902
JB2-1 (Center Pit Phase 1)	kt			**184**	-	184	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
JB2-2 (Center Pit Phase 2)	kt			**9,760**	-	-	1,943	2,000	2,022	1,857	985	-	-	-	362	384	135	74	-	-	-	-	-	-	-
JB2-3 (Center Pit Phase 3)	kt			**4,419**	-	-	-	-	-	200	980	945	639	536	550	247	194	128	-	-	-	-	-	-	-
JB2-4 (Center Pit Phaes 4)	kt			**8,763**	-	-	-	-	-	-	-	0	0	18	9	14	19	72	185	1,173	1,999	1,989	1,912	1,372	-
JB3-1 (East Pit Phaes 1)	kt			**11,297**	-	-	63	-	-	-	17	1,519	1,361	1,446	1,079	1,326	1,212	926	1,590	757	-	-	-	-	-
Total In-Situ Mining	kt			**36,902**	-	184	2,007	2,000	2,022	2,057	2,000	2,464	2,000	2,000	2,000	1,971	2,000	1,591	1,775	1,930	2,000	2,000	2,000	2,000	902

Avg. Mining Level

JB1-1 (West Pit Phase 1)	bench			**196**							214						199	174							
JB1-2 (West Pit Phase 2)	bench			**171**																	209	202	186	152	104
JB2-1 (Center Pit Phase 1)	bench			**201**		209	194																		
JB2-2 (Center Pit Phase 2)	bench			**115**			207	182	156	126	99				81	70	60	54							
JB2-3 (Center Pit Phase 3)	bench			**128**					211	201	180	152	131	115	97	79	64	50							
JB2-4 (Center Pit Phaes 4)	bench			**147**								240	219	210	201	191	181	167	148	124	93	62	41	39	
JB3-1 (East Pit Phaes 1)	bench			**195**			244				244	232	221	210	199	188	175	162	145	121					
Average Mining Level	bench			**156**		209	215	182	183	164	184	208	190	178	145	132	136	121	147	123	151	132	113	96	104

Dump Movement

		Capacity																					
West Dump	kt	81,016		**16,698**	-	-	1,284	1,284	1,284	1,284	1,284	1,284	1,284	1,284	1,284	1,284	1,284	1,284	1,284					
North Dump	kt	49,960		**46,775**							3,750	5,536	6,000	8,849	8,636	9,029	4,976							
JB1 Dump	kt	22,659		**22,659**													4,024	9,409	9,225					
East Dump	kt	28,526		**28,526**	-	2,316	5,993	6,046	5,978	5,943	2,250														
East Dump Extension	kt	33,949		**41,777**																10,355	8,284	8,567	5,841	6,850	1,880
Total In-Situ Mining	kt			**156,435**	-	2,316	7,278	7,330	7,263	7,227	7,284	6,820	7,284	10,133	9,920	10,314	10,284	10,694	10,510	10,355	8,284	8,567	5,841	6,850	1,880

Dump % Full

		Capacity																					
West Dump	kt	-		**3**	-	-	2%	3%	5%	6%	8%	10%	11%	13%	14%	16%	17%	19%	21%	21%	21%	21%	21%	21%	21%
North Dump	kt	-		**12**	-	-	-	-	-	-	8%	19%	31%	48%	66%	84%	94%	94%	94%	94%	94%	94%	94%	94%	94%
JB1 Dump	kt	-		**9**	-	-	-	-	-	-	-	-	-	-	-	-	18%	59%	100%	100%	100%	100%	100%	100%	100%
East Dump	kt	-		**19**	-	8%	29%	50%	71%	92%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
East Dump Extension	kt	-		**5**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	24%	42%	62%	75%	91%	95%

Haulage Summary

Haulage Hours

		Tonnes																						
JB1-1 (West Pit Phase 1)	hrs	90.00		**9,058**	-	-	-	-	-	-	88	-	-	-	-	-	5,771	3,199	-	-	-	-	-	-	-
JB1-2 (West Pit Phase 2)	hrs			**59,059**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,156	7,673	13,541	26,863	9,825
JB2-1 (Center Pit Phase 1)	hrs			**7,294**	-	7,233	61	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
JB2-2 (Center Pit Phase 2)	hrs			**115,086**	-	-	22,796	26,651	26,286	23,188	9,460	-	-	-	2,721	2,477	934	575	-	-	-	-	-	-	-
JB2-3 (Center Pit Phase 3)	hrs			**70,671**	-	-	-	-	2,879	7,945	17,721	13,538	8,039	6,447	7,413	3,742	2,025	923	-	-	-	-	-	-	-
JB2-4 (Center Pit Phaes 4)	hrs			**270,975**	-	-	-	-	-	-	-	0	1,274	7,145	10,299	12,907	11,713	22,575	24,770	44,177	48,084	45,005	27,199	15,826	-
JB3-1 (East Pit Phaes 1)	hrs			**163,446**	-	-	235	-	-	-	72	11,850	17,584	24,730	19,687	24,427	20,941	14,674	22,416	6,831	-	-	-	-	-
Total	hrs	Op. Hrs		**695,589**	-	**7,233**	**23,091**	**26,651**	**29,165**	**31,133**	**27,341**	**25,387**	**26,898**	**38,322**	**40,119**	**43,553**	**41,383**	**41,945**	**47,186**	**51,008**	**49,240**	**52,678**	**40,740**	**42,689**	**9,825**
# Number Trucks	hb	5,550			0.0	1.3	4.2	4.8	5.3	5.6	4.9	4.6	4.8	6.9	7.2	7.8	7.5	7.6	8.5	9.2	8.9	9.5	7.3	7.7	1.8

Fuel Consumption Rates

JB1-1 (West Pit Phase 1)	L/hr	Pit	54	-	-	-	-	-	47.8	-	-	-	-	-	48.5	49.1	-	-	-	-	-	-	-	-
JB1-2 (West Pit Phase 2)	L/hr	Surface	43	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	49.4	49.5	49.6	49.9	50.3	
JB2-1 (Center Pit Phase 1)	L/hr	Dump	52	-	-	49.5	49.9	50.2	50.5	50.2	-	-	-	51.3	51.4	51.0	51.6	-	-	-	-	-	-	-
JB2-2 (Center Pit Phase 2)	L/hr			-	-	49.5	49.9	50.2	50.5	50.2	-	-	-	51.3	51.4	51.0	51.6	-	-	-	-	-	-	-
JB2-3 (Center Pit Phase 3)	L/hr			-	-	-	-	51.0	49.5	49.1	50.6	50.9	51.0	51.2	51.4	51.0	51.7	-	-	-	-	-	-	-
JB2-4 (Center Pit Phaes 4)	L/hr			-	-	-	-	-	-	-	49.0	49.6	49.9	50.1	50.3	49.9	50.9	51.2	50.6	50.9	51.2	51.3	52.6	-
JB3-1 (East Pit Phaes 1)	L/hr			-	-	49.0	-	-	-	47.7	48.4	48.5	48.7	48.8	48.9	47.8	49.1	49.2	50.8	-	-	-	-	-	-
Total	kl			-	-	**1,144**	**1,329**	**1,467**	**1,565**	**1,352**	**1,259**	**1,325**	**1,889**	**1,995**	**2,163**	**2,016**	**2,103**	**2,370**	**2,583**	**2,505**	**2,683**	**2,068**	**2,174**	**494**

Average Cycle Time

JB1-1 (West Pit Phase 1)	mins			**18.4**	-	-	-	-	-	-	14.35	-	-	-	-	-	17.57	20.37	-	-	-	-	-	-	-
JB1-2 (West Pit Phase 2)	mins			**22.5**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	19.15	20.24	21.52	23.42	24.09
JB2-1 (Center Pit Phase 1)	mins			**15.6**	-	15.62	15.64	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
JB2-2 (Center Pit Phase 2)	mins			**19.2**	-	-	15.62	17.89	20.09	22.46	22.56	-	-	-	23.87	24.57	24.92	25.24	-	-	-	-	-	-	-
JB2-3 (Center Pit Phase 3)	mins			**19.1**	-	-	-	-	16.65	17.70	16.86	17.87	19.84	21.72	23.56	25.57	25.43	25.81	-	-	-	-	-	-	-
JB2-4 (Center Pit Phaes 4)	mins			**25.5**	-	-	-	-	-	-	-	10.95	13.87	15.80	17.45	19.23	18.90	19.67	22.98	26.60	29.94	33.58	31.92	29.49	-
JB3-1 (East Pit Phaes 1)	mins			**20.3**	-	-	13.18	-	-	-	14.51	16.37	17.86	19.62	20.70	21.83	21.55	21.77	23.37	18.16	-	-	-	-	-
Average	mins			**21.76**	-	**15.6**	**15.6**	**17.9**	**19.7**	**21.0**	**18.5**	**17.1**	**18.2**	**19.1**	**20.4**	**21.4**	**20.3**	**20.6**	**23.2**	**25.0**	**29.5**	**30.6**	**27.5**	**25.4**	**24.1**

Average Haulage Distance

JB1-1 (West Pit Phase 1)	m			**4,363.6**	-	-	-	-	-	-	3,544	-	-	-	-	-	4,156	4,997	-	-	-	-	-	-	-
JB1-2 (West Pit Phase 2)	m			**5,778.0**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5,225	5,439	5,671	5,979	5,862
JB2-1 (Center Pit Phase 1)	m			**4,011.6**	-	4,016	3,499	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
JB2-2 (Center Pit Phase 2)	m			**4,240.2**	-	-	3,637	4,044	4,440	4,882	4,847	-	-	-	5,243	5,468	5,475	5,447	-	-	-	-	-	-	-
JB2-3 (Center Pit Phase 3)	m			**4,044.3**	-	-	-	-	3,762	3,931	3,632	3,744	4,198	4,726	5,083	5,495	5,496	5,727	-	-	-	-	-	-	-
JB2-4 (Center Pit Phaes 4)	m			**5,526.6**	-	-	-	-	-	-	-	2,401	2,885	3,373	3,686	4,046	3,853	3,906	4,609	6,822	7,527	8,338	5,671	3,560	-
JB3-1 (East Pit Phaes 1)	m			**4,829.9**	-	-	2,851	-	-	-	3,504	4,267	4,606	5,027	5,117	5,222	4,994	4,900	4,993	2,323	-	-	-	-	-
Average	m			**4,953.67**	-	**4,016**	**3,627**	**4,044**	**4,361**	**4,594**	**3,975**	**3,999**	**4,388**	**4,610**	**4,690**	**4,866**	**4,540**	**4,368**	**4,790**	**5,991**	**7,444**	**7,699**	**5,671**	**5,207**	**5,862**

Detailed Haulage

Dump Haualge		Bot	Top																						
West Dump	mins			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
North Dump	mins	3.0	7.6	3.02	3.02	3.02	3.02	3.02	3.02	3.36	3.87	4.41	5.22	6.00	6.83	7.28	7.28	7.28	7.28	7.28	7.28	7.28	7.28	7.28	7.28
JB1 Dump	mins	2.3	6.4	2.27	2.27	2.27	2.27	2.27	2.27	2.27	2.27	2.27	2.27	2.27	2.27	3.00	4.70	6.37	6.37	6.37	6.37	6.37	6.37	6.37	6.37
East Dump	mins	3.2	7.1	3.16	3.48	4.30	5.13	5.95	6.76	7.07	7.07	7.07	7.07	7.07	7.07	7.07	7.07	7.07	7.07	7.07	7.07	7.07	7.07	7.07	7.07
East Dump Extension	mins	2	6	2.21	2.21	2.21	2.21	2.21	2.21	2.21	2.21	2.21	2.21	2.21	2.21	2.21	2.21	2.21	3.07	3.76	4.48	4.96	5.53	5.69	

Dump Haualge Distances		Bot	Top																						
West Dump	m			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
North Dump	m	1,199.9	2,025.6	#######	1,199.95	1,199.95	1,199.95	1,199.95	1,199.95	1,261.87	1,353.29	1,452.37	1,598.50	1,741.11	1,890.21	1,972.38	1,972.38	1,972.38	1,972.38	1,972.38	1,972.38	1,972.38	1,972.38	1,972.38	1,972.38
JB1 Dump	m	772.6	1,657.5	772.56	772.56	772.56	772.56	772.56	772.56	772.56	772.56	772.56	772.56	772.56	772.56	929.69	1,297.07	1,657.26	1,657.26	1,657.26	1,657.26	1,657.26	1,657.26	1,657.26	1,657.26
East Dump	m	1,289.8	1,811.1	#######	1,332.14	1,441.66	1,552.14	1,661.38	1,769.98	1,811.10	1,811.10	1,811.10	1,811.10	1,811.10	1,811.10	1,811.10	1,811.10	1,811.10	1,811.10	1,811.10	1,811.10	1,811.10	1,811.10	1,811.10	1,811.10
East Dump Extension	m	789	1,521	783.45	783.45	783.45	783.45	783.45	783.45	783.45	783.45	783.45	783.45	783.45	783.45	783.45	783.45	783.45	957.33	1,096.44	1,240.31	1,338.40	1,453.42	1,484.99	

JB1-1 (West Pit Phase 1)	WP1	Top	Bot																						
Tonnage to Surface	kt	213.8	153.6	-	-	-	-	-	-	33	-	-	-	-	-	1,774	848	-	-	-	-	-	-	-	-
Tonnage to Ore	kt	9.51	14.24	-	-	-	-	-	-	18	-	-	-	-	-	441	391	-	-	-	-	-	-	-	-
Tonnage to North Dump	kt	#######	2,734.95	-	-	-	-	-	-	2.67	-	-	-	-	-	166.49	54.84	-	-	-	-	-	-	-	-
Tonnage to JB1 Dump	kt			-	-	-	-	-	-	7.80	-	-	-	-	-	644.94	-	-	-	-	-	-	-	-	-
Tonnage to East Dump	kt			-	-	-	-	-	-	-	-	-	-	-	-	521.67	401.74	-	-	-	-	-	-	-	-
Tonnage to East Dump Ext	kt			-	-	-	-	-	-	4.68	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bench to Surface	mins	Exit	Center Pit	-	-	-	-	-	-	9.51	-	-	-	-	-	10.65	12.60	-	-	-	-	-	-	-	-
Surface to Ore	mins	#######	4.27	-	-	-	-	-	-	4.27	-	-	-	-	-	4.27	4.27	-	-	-	-	-	-	-	-
Surface to North Dump	mins	806.65	2.21	-	-	-	-	-	-	2.21	-	-	-	-	-	2.21	2.21	-	-	-	-	-	-	-	-
Surface to JB1 Dump	mins	595.49	1.81	-	-	-	-	-	-	1.81	-	-	-	-	-	1.81	-	-	-	-	-	-	-	-	-
Surface to East Dump	mins	#######	3.88	-	-	-	-	-	-	-	-	-	-	-	-	3.88	3.88	-	-	-	-	-	-	-	-
Surface to East Dump Ext.	mins	#######	5.65	-	-	-	-	-	-	5.65	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bench to Surface	m			-	-	-	-	-	-	1,601	-	-	-	-	-	1,874	2,342	-	-	-	-	-	-	-	-
Surface to Ore	m			-	-	-	-	-	-	1,826.85	-	-	-	-	-	1,826.85	1,826.85	-	-	-	-	-	-	-	-
Surface to North Dump	m			-	-	-	-	-	-	806.65	-	-	-	-	-	806.65	806.65	-	-	-	-	-	-	-	-
Surface to JB1 Dump	m			-	-	-	-	-	-	595.49	-	-	-	-	-	595.49	-	-	-	-	-	-	-	-	-
Surface to East Dump	m			-	-	-	-	-	-	-	-	-	-	-	-	1,634.13	1,634.13	-	-	-	-	-	-	-	-
Surface to East Dump Ext.	m			-	-	-	-	-	-	2,486.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	hrs			-	-	-	-	-	-	88	-	-	-	-	-	5,771	3,199	-	-	-	-	-	-	-	-
Avg. Cycle	mins			-	-	-	-	-	-	14	-	-	-	-	-	18	20	-	-	-	-	-	-	-	-
Avg. Distance	m			-	-	-	-	-	-	3,544	-	-	-	-	-	4,156	4,997	-	-	-	-	-	-	-	-

JB1-2 (West Pit Phase 2)	WP2	Top	Bot																						
Tonnage to Surface	kt	214	64	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	326	2,047	3,398	6,194	2,202	
Tonnage to Ore	kt	9.51	17.94	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	11	88	628	902	
Tonnage to North Dump	kt	#######	3,205.04	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Tonnage to JB1 Dump	kt			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Tonnage to East Dump	kt			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Tonnage to East Dump Ext	kt			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	325.51	2,035.45	3,310.21	5,565.47	1,300.62	
Bench to Surface	mins	Exit	Center Pit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9.74	10.15	11.07	12.94	15.65	
Surface to Ore	mins	#######	4.27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.27	4.27	4.27	4.27	4.27	
Surface to North Dump	mins	806.65	2.21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Surface to JB1 Dump	mins	595.49	1.81	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Surface to East Dump	mins	#######	3.88	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Surface to East Dump Ext.	mins	#######	5.65	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.65	5.65	5.65	5.65	5.65	
Bench to Surface	m			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,645	1,723	1,898	2,253	2,768	
Surface to Ore	m			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,826.85	1,826.85	1,826.85	1,826.85	1,826.85	
Surface to North Dump	m			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Surface to JB1 Dump	m			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Surface to East Dump	m			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Surface to East Dump Ext.	m			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2,486.00	2,486.00	2,486.00	2,486.00	2,486.00	
Total	hrs			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,156	7,673	13,541	26,863	9,825	
Avg. Cycle	mins			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	19	20	22	23	24	
Avg. Distance	m			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5,225	5,439	5,671	5,979	5,862	

JB2-1 (Center Pit Phase 1)	CP1	Top	Bot																						
Tonnage to Surface	kt	229	194	-	2,500	21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tonnage to Ore	kt	7.94	8.94	-	184	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tonnage to North Dump	kt	#######	1,134.34	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tonnage to JB1 Dump	kt			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tonnage to East Dump	kt			-	2,316.41	17.02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tonnage to East Dump Ext	kt			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bench to Surface	mins	Exit	Center Pit	-	8.49	8.94	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surface to Ore	mins	#######	4.27	-	4.27	4.27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surface to North Dump	mins	806.65	2.21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surface to JB1 Dump	mins	595.49	1.81	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surface to East Dump	mins	#######	3.88	-	3.88	3.88	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surface to East Dump Ext.	mins	#######	5.65	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bench to Surface	m			-	1,134	1,134	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surface to Ore	m			-	1,826.85	1,826.85	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surface to North Dump	m			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surface to JB1 Dump	m			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surface to East Dump	m			-	1,634.13	1,634.13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surface to East Dump Ext.	m			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	hrs			-	7,233	61	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Avg. Cycle	mins			-	16	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Avg. Distance	m			-	4,016	3,459	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

JB2-2 (Center Pit Phase 2)	CP2	Top	Bot																						
Tonnage to Surface	kt	229	54	-	-	7,883	8,046	7,066	5,576	2,264	-	-	-	616	544	202	123	-	-	-	-	-	-	-	-
Tonnage to Ore	kt	7.94	20.28	-	-	1,943	2,000	2,022	1,857	985	-	-	-	362	384	135	74	-	-	-	-	-	-	-	-
Tonnage to North Dump	kt	#######	3,871.49	-	-	-	-	-	-	658.86	-	-	-	220.96	140.83	32.80	-	-	-	-	-	-	-	-	-
Tonnage to JB1 Dump	kt			-	-	-	-	-	-	-	-	-	-	-	-	26.53	43.50	-	-	-	-	-	-	-	-
Tonnage to East Dump	kt			-	-	4,891.39	4,986.27	4,152.46	3,058.09	395.32	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tonnage to East Dump Ext	kt			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bench to Surface	mins	Exit	Center Pit	-	-	9.49	11.24	13.09	15.20	17.17	-	-	-	18.41	19.22	19.91	20.38	-	-	-	-	-	-	-	-
Surface to Ore	mins	#######	4.27	-	-	4.27	4.27	4.27	4.27	4.27	-	-	-	4.27	4.27	4.27	4.27	-	-	-	-	-	-	-	-
Surface to North Dump	mins	806.65	2.21	-	-	-	-	-	-	2.21	-	-	-	2.21	2.21	2.21	-	-	-	-	-	-	-	-	-
Surface to JB1 Dump	mins	595.49	1.81	-	-	-	-	-	-	-	-	-	-	-	-	1.81	1.81	-	-	-	-	-	-	-	-
Surface to East Dump	mins	#######	3.88	-	-	3.88	3.88	3.88	3.88	3.88	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surface to East Dump Ext.	mins	#######	5.65	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bench to Surface	m			-	-	1,474	1,860	2,267	2,731	3,165	-	-	-	3,439	3,616	3,768	3,871	-	-	-	-	-	-	-	-
Surface to Ore	m			-	-	1,826.85	1,826.85	1,826.85	1,826.85	1,826.85	-	-	-	1,826.85	1,826.85	1,826.85	1,826.85	-	-	-	-	-	-	-	-
Surface to North Dump	m			-	-	-	-	-	-	806.65	-	-	-	806.65	806.65	806.65	-	-	-	-	-	-	-	-	-
Surface to JB1 Dump	m			-	-	-	-	-	-	-	-	-	-	-	-	595.49	595.49	-	-	-	-	-	-	-	-
Surface to East Dump	m			-	-	1,634.13	1,634.13	1,634.13	1,634.13	1,634.13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surface to East Dump Ext.	m			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	hrs			-	-	22,796	26,651	26,286	23,188	9,460	-	-	-	2,721	2,477	934	575	-	-	-	-	-	-	-	-
Avg. Cycle	mins			-	-	16	18	20	22	23	-	-	-	24	25	25	25	-	-	-	-	-	-	-	-
Avg. Distance	m			-	-	3,637	4,044	4,440	4,882	4,847	-	-	-	5,243	5,468	5,475	5,447	-	-	-	-	-	-	-	-

JB2-3 (Center Pit Phase 3)	CP3	Top	Bot																						
Tonnage to Surface	kt	219	54	-	-	-	-	934	2,424	5,676	4,091	2,188	1,602	1,699	790	430	193	-	-	-	-	-	-	-	-
Tonnage to Ore	kt	7.94	21.54	-	-	-	-	-	200	980	945	639	536	550	247	194	128	-	-	-	-	-	-	-	-
Tonnage to North Dump	kt	#######	4,235.29	-	-	-	-	-	-	2,417.12	2,553.47	1,276.07	931.35	1,000.41	475.72	114.20	-	-	-	-	-	-	-	-	-
Tonnage to JB1 Dump	kt			-	-	-	-	-	-	-	-	-	-	-	-	92.37	57.47	-	-	-	-	-	-	-	-
Tonnage to East Dump	kt			-	-	-	-	768.60	1,828.41	1,450.27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tonnage to East Dump Ext	kt			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bench to Surface	mins	Exit	Center Pit	-	-	-	-	8.56	9.32	10.95	13.09	14.73	15.98	17.35	18.80	19.95	21.04	-	-	-	-	-	-	-	-
Surface to Ore	mins	#######	4.27	-	-	-	-	-	4.27	4.27	4.27	4.27	4.27	4.27	4.27	4.27	4.27	-	-	-	-	-	-	-	-
Surface to North Dump	mins	806.65	2.21	-	-	-	-	-	-	2.21	2.21	2.21	2.21	2.21	2.21	2.21	-	-	-	-	-	-	-	-	-
Surface to JB1 Dump	mins	595.49	1.81	-	-	-	-	-	-	-	-	-	-	-	-	1.81	1.81	-	-	-	-	-	-	-	-
Surface to East Dump	mins	#######	3.88	-	-	-	-	3.88	3.88	3.88	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surface to East Dump Ext.	mins	#######	5.65	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bench to Surface	m			-	-	-	-	1,275	1,448	1,820	2,308	2,682	2,967	3,279	3,610	3,872	4,122	-	-	-	-	-	-	-	-
Surface to Ore	m			-	-	-	-	-	1,826.85	1,826.85	1,826.85	1,826.85	1,826.85	1,826.85	1,826.85	1,826.85	1,826.85	-	-	-	-	-	-	-	-
Surface to North Dump	m			-	-	-	-	-	-	806.65	806.65	806.65	806.65	806.65	806.65	806.65	-	-	-	-	-	-	-	-	-
Surface to JB1 Dump	m			-	-	-	-	-	-	-	-	-	-	-	-	595.49	595.49	-	-	-	-	-	-	-	-
Surface to East Dump	m			-	-	-	-	1,634.13	1,634.13	1,634.13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surface to East Dump Ext.	m			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	hrs			-	-	-	-	2,879	7,945	17,721	13,538	8,039	6,447	7,413	3,742	2,025	923	-	-	-	-	-	-	-	-
Avg. Cycle	mins			-	-	-	-	17	18	17	18	20	22	24	26	25	26	-	-	-	-	-	-	-	-
Avg. Distance	m			-	-	-	-	3,762	3,931	3,632	3,744	4,198	4,726	5,083	5,495	5,496	5,727	-	-	-	-	-	-	-	-

JB2-4 (Center Pit Phaes 4)	CP4	Top	Bot																				
Tonnage to Surface	kt	224	39	-	-	-	-	-	-	-	0	496	2,442	3,186	3,624	3,347	6,196	5,821	8,969	8,674	7,236	4,602	2,898	-
Tonnage to Ore	kt	7.94	27.52	-	-	-	-	-	-	-	0	0	18	9	14	19	72	185	1,173	1,999	1,989	1,912	1,372	-
Tonnage to North Dump	kt	#######	5,706.79	-	-	-	-	-	-	-	0.00	408.47	2,116.60	2,765.62	3,160.18	1,610.05	-	-	-	-	-	-	-	-
Tonnage to JB1 Dump	kt			-	-	-	-	-	-	-	-	-	-	-	-	1,302.30	5,388.78	4,947.21	-	-	-	-	-	-
Tonnage to East Dump	kt			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tonnage to East Dump Ext	kt			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7,795.76	6,674.49	5,247.36	1,246.46	-	-
Bench to Surface	mins	Exit	Center Pit	-	-	-	-	-	-	-	6.20	8.41	9.33	10.31	11.34	12.44	13.96	15.89	18.46	21.71	25.07	27.27	27.47	-
Surface to Ore	mins	#######	4.27	-	-	-	-	-	-	-	4.27	4.27	4.27	4.27	4.27	4.27	4.27	4.27	4.27	4.27	4.27	4.27	4.27	-
Surface to North Dump	mins	806.65	2.21	-	-	-	-	-	-	-	2.21	2.21	2.21	2.21	2.21	2.21	-	-	-	-	-	-	-	-
Surface to JB1 Dump	mins	595.49	1.81	-	-	-	-	-	-	-	-	-	-	-	-	1.81	1.81	1.81	-	-	-	-	-	-
Surface to East Dump	mins	#######	3.88	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surface to East Dump Ext.	mins	#######	5.65	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.65	5.65	5.65	5.65	-	-
Bench to Surface	m			-	-	-	-	-	-	-	727	1,244	1,459	1,687	1,926	2,184	2,540	2,990	3,590	4,349	5,134	5,648	5,694	-
Surface to Ore	m			-	-	-	-	-	-	-	1,826.85	1,826.85	1,826.85	1,826.85	1,826.85	1,826.85	1,826.85	1,826.85	1,826.85	1,826.85	1,826.85	1,826.85	1,826.85	-
Surface to North Dump	m			-	-	-	-	-	-	-	806.65	806.65	806.65	806.65	806.65	806.65	-	-	-	-	-	-	-	-
Surface to JB1 Dump	m			-	-	-	-	-	-	-	-	-	-	-	-	595.49	595.49	595.49	-	-	-	-	-	-
Surface to East Dump	m			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surface to East Dump Ext.	m			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2,486.00	2,486.00	2,486.00	2,486.00	-	-
Total	hrs			-	-	-	-	-	-	-	0	1,274	7,145	10,299	12,907	11,713	22,575	24,770	44,177	48,084	45,005	27,199	15,826	-
Avg. Cycle	mins			-	-	-	-	-	-	-	11	14	16	17	19	19	20	23	27	30	34	32	29	-
Avg. Distance	m			-	-	-	-	-	-	-	2,401	2,885	3,373	3,686	4,046	3,853	3,906	4,609	6,822	7,527	8,338	5,671	3,560	-

JB3-1 (East Pit Phaes 1)	EP1	Top	Bot																				
Tonnage to Surface	kt	249	193	-	-	96	-	-	-	27	3,909	5,316	6,805	5,135	6,041	5,247	3,640	5,179	2,031	-	-	-	-	-
Tonnage to Ore	kt	7.46	14.92	-	-	63	-	-	-	17	1,519	1,361	1,446	1,079	1,326	1,212	926	1,590	757	-	-	-	-	-
Tonnage to North Dump	kt	826.89	826.89	-	-	-	-	-	-	4.99	1,939.74	3,257.18	4,679.30	3,530.72	4,128.12	1,952.12	-	-	-	-	-	-	-	-
Tonnage to JB1 Dump	kt			-	-	-	-	-	-	-	-	-	-	-	-	1,578.98	2,387.60	3,150.42	-	-	-	-	-	-
Tonnage to East Dump	kt			-	-	27.08	-	-	-	2.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tonnage to East Dump Ext	kt			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,274.48	-	-	-	-	-
Bench to Surface	mins	Exit	East Pit	-	-	7.70	-	-	-	7.72	8.30	8.89	9.44	10.00	10.57	11.27	11.90	12.78	14.02	-	-	-	-	-
Surface to Ore	mins	#######	5.94	-	-	5.94	-	-	-	5.94	5.94	5.94	5.94	5.94	5.94	5.94	5.94	5.94	5.94	-	-	-	-	-
Surface to North Dump	mins	#######	7.75	-	-	-	-	-	-	7.75	7.75	7.75	7.75	7.75	7.75	7.75	-	-	-	-	-	-	-	-
Surface to JB1 Dump	mins	#######	8.04	-	-	-	-	-	-	-	-	-	-	-	-	8.04	8.04	8.04	-	-	-	-	-	-
Surface to East Dump	mins	302.90	1.30	-	-	1.30	-	-	-	1.30	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surface to East Dump Ext.	mins	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bench to Surface	m			-	-	827	-	-	-	827	827	827	827	827	827	827	827	827	827	-	-	-	-	-
Surface to Ore	m			-	-	2,404.71	-	-	-	2,404.71	2,404.71	2,404.71	2,404.71	2,404.71	2,404.71	2,404.71	2,404.71	2,404.71	2,404.71	-	-	-	-	-
Surface to North Dump	m			-	-	-	-	-	-	3,886.63	3,886.63	3,886.63	3,886.63	3,886.63	3,886.63	3,886.63	-	-	-	-	-	-	-	-
Surface to JB1 Dump	m			-	-	-	-	-	-	-	-	-	-	-	-	4,092.36	4,092.36	4,092.36	-	-	-	-	-	-
Surface to East Dump	m			-	-	302.90	-	-	-	302.90	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surface to East Dump Ext.	m			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	hrs			-	-	235	-	-	-	72	11,850	17,584	24,730	19,687	24,427	20,941	14,674	22,416	6,831	-	-	-	-	-
Avg. Cycle	mins			-	-	13	-	-	-	15	16	18	20	21	22	22	22	23	18	-	-	-	-	-
Avg. Distance	m			-	-	2,851	-	-	-	3,504	4,267	4,606	5,027	5,117	5,222	4,994	4,900	4,993	2,323	-	-	-	-	-

APPENDIX H

James Bay Lithium Mine Project,
James Bay Road Shipping Emissions

Stantec

Memo

To:	Gail Amyot, HSE Director Galaxy Lithium (Canada) Inc.	From:	Gillian Hatcher Stantec Consulting Ltd.
File:	121416913	Date:	July 29, 2021

Reference: James Bay Lithium Mine Project, James Bay Road Shipping Emissions

The James Bay Lithium Mine Project consists of an open pit mine, concentrator mill, stockpiles (for topsoil, overburden, waste rock, tailings and ore), retention basins, a water treatment unit, administrative buildings, a camp for workers, garages, and an explosives storage site. The extracted spodumene pegmatites will be processed on-site, via the concentrator mill, and the product will be shipped to Matagami, QC by truck via the James Bay Road (approximately 385 km).

Stantec Consulting Ltd. (Stantec) was contracted by Galaxy Lithium (Canada) Inc. (Galaxy) to conduct an air quality dispersion modelling assessment and greenhouse gas (GHG) emission estimate to support the James Bay Lithium Project (the Project) following the completion of the Project's Value Engineering Feasibility Assessment. This modelling focused on the activities occurring within the mine site and along the site access road and is presented in a modelling report titled "Environmental and Social Impact Assessment Modelling – Air Dispersion Modelling" (Stantec 2021). The transportation of concentrate from the mine site to Matagami, along the James Bay Road, is largely located outside of the modelling domain for the mine site and assess road; therefore, this activity was assessed separately, and the results of the assessment are presented in this memo.

Air dispersion modelling for the transport of concentrate from the mine site to Matagami was conducted previously by WSP (WSP 2020) to respond to information requests received following government review of the original Environmental Impact Statement for the Project. Since that time there have been changes made to the trucks that will be transporting concentrate, and therefore a need to update the 2020 air dispersion modelling for dust emissions.

During the operation of the Project approximately 22 trucks per day (11 full, 11 empty) will travel between the James Bay mine site and Matagami hauling concentrate. In addition to the vehicles transporting concentrate, other Project related traffic will be present on the James Cay Road, such has fuel delivery trucks (31 trucks per day). For modelling purposes, it was assumed that mine-related truck traffic on the James Bay Road would be limited to the daytime and could occur 365 days per year.

Air Dispersion Model Methodology

The modelling methodology used to predict ground level concentrations from the transportation of concentrate from the mine site to Matagami was consistent with the methodology used to predict the maximum concentrations from the construction and operation of the mine and associated activities located at the mine site (refer to Section 5.0 of the 2021 air dispersion modelling report (Stantec 2021).

As with the previous modelling conducted by WSP for transportation on the James Bay Road (refer to IR response to CEAA-QC 60 and 104), only the section of the James Bay Road that falls within the air dispersion modelling domain was modelled. The predicted ground level concentrations along the entire length of the James Bay Road are considered to be the same as those predicted for the section that lies within the air dispersion modelling domain based on the nature of the source of emissions.

Reference: **James Bay Lithium Mine Project, James Bay Road Shipping Emissions**

Emission Sources

Truck traffic on paved roads can result in emissions of dust from the movement of the vehicle on the road, and from the combustion of fuel by the truck. The particulate emissions rates from the dust and from the combustion of fuel are summarized in Tables 1 and 2, respectively. Combustion of fuel also results in the release of combustion gases (i.e., carbon monoxide, sulphur dioxide and nitrogen oxides).

Table 1 Physical Parameters and Fugitive Dust Emission Rate

Parameters	Units	Value
Release Height	m	2.4
Sigma Y	m	12.09
Sigma Z	m	2.25
Silt Load	g/m^2	0.6
Average Vehicle Weight	tonnes	78.99
Number of Trips	trips per day	53
Segment Length	m	13912
Vehicle Kilometers Travelled	km	736
Emission Factor		
TPM	lb/VMT	0.596
PM_{10}	lb/VMT	0.119
$PM_{2.5}$	lb/VMT	0.029
Emission Rate		
TPM	g/s	2.86
PM_{10}	g/s	0.572
$PM_{2.5}$	g/s	0.140

Table 2 Combustion Emission Rates for Particulate Matter

Parameters (g/s)	TPM	PM_{10}	$PM_{2.5}$
Combustion Emissions	0.00127	0.00127	0.00127

Modelling Results

The results of the air dispersion modelling for concentrate transport along the James Bay Road is presented in Table 3.

Reference: **James Bay Lithium Mine Project, James Bay Road Shipping Emissions**

Table 3 Predicted Concentration from Emissions associated with Concentrate Shipping

Substance	CAS No.	Averaging Period	Statistical	Limit (µg/m^3)	Type of Limit	Authority	Initial Concentration (µg/m^3)	Model Concentration (µg/m^3)	Concentration Total[1] (µg/m^3)	Contribution of Project[2] (%)	Percentage of Limit[3] (%)
Total Suspended Particulate (TPM)	N/A-1	24 hours	1st Maximum	120	Standard	MELCC	40	35.8	75.8	47%	63%
Particulate Matter < 10 µm (PM10)	N/A-2	24 hours	99th Percentile	50	Guideline	WHO	21.8	5.00	26.8	19%	54%
		Annual	1st Maximum	20	Guideline	WHO	5.5	1.83	7.33	25%	37%
Fine particulate matter ($PM_{2.5}$)	N/A-3	24 hours	1st Maximum	30	Standard	MELCC	15	1.77	16.8	11%	56%
		24 hours	98th Percentile[4]	27	CAAQS	CCME	15	0.980	16.0	6%	59%
		Annual	1st Maximum[5]	8.8	CAAQS	CCME	4.5	0.441	4.94	9%	56%

Notes:
[1]The modeled total concentration is the sum of the modeled maximum concentration and the initial concentration.
[2]The project contribution is the maximum modeled concentration divided by the total concentration, as a percentage.
[3]The percentage of the limit value is the total concentration divided by the limit value, as a percentage.
[4]The 3-year average of the annual 98th percentile of the daily 24-hour average concentrations
[5]The 3-year average of the annual average concentrations

Reference: **James Bay Lithium Mine Project, James Bay Road Shipping Emissions**

The predicted concentrations of total particulate matter, PM_{10} and $PM_{2.5}$ from the transportation of concentrate along the James Bay Road from the mine site to Matagami are below the applicable ambient air quality criteria.

References

Stantec Consulting (Stantec) Ltd. 2021. Environmental and Social Impact Assessment Modelling – Air Dispersion Modelling.

WSP. 2020. James Bay Lithium Mine Project: Answers to the Request for Additional Information January 8, 2020 received from the Canadian Environmental Assessment Agency as part of the Environmental Review of the Project.

Regards,

Stantec Consulting Ltd.

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