Troilus Mining Project Technical Data Report – Human Health Risk Assessment (Inhalation)

Final Report

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Executive Summary

Troilus Gold Corp (Troilus) proposes to develop, reopen, and operate the former Troilus gold-copper mine (the Project) located in the southeastern part of the Nord-du-Québec administrative region in the Eeyou Istchee Baie-James territory, approximately 76 kilometres (km) northwest of the Cree community of Mistissini and approximately 125 km north of the town of Chibougamau. The Project is being assessed in accordance with the *Impact Assessment Act*, 2019.

The Project has the potential to alter existing conditions with respect to the concentrations of chemicals in air, soil, water, and biota. These changes to the environment have the potential to adversely affect the health of human receptors, and as such, this Human Health Risk Assessment (Inhalation) (referred to as the inhalation HHRA) and an HHRA (Problem Formulation Multimedia) were conducted to support the assessment of effects on human health to fulfill a requirement of the Tailored Impact Statement (TIS) Guidelines: Troilus Mining Project. The conclusions of both reports are integrated into the Human Conditions Valued Component of the Impact Statement.

The objective of this inhalation HHRA is to characterize how Project-related changes in air quality could adversely affect human health. The following human health receptor were identified within the Local Study Area (LSA) and Regional Study Area (RSA):

- Indigenous Receptors: Includes Indigenous people who may live within the LSA seasonally or make use of the lands within the LSA/RSA for the harvesting of country foods, or who use the areas for recreational, ceremonial and/or spiritual purposes. This receptor was assumed to be an infant, toddler, child, teen, or adult.
- Recreational Receptors: Includes non-Indigenous people who may make use of the lands within the LSA/RSA for harvesting country foods and/or recreational activities. This receptor was assumed to be an infant, toddler, child, teen, or adult.
- Off-Duty Worker Receptors: Occupational exposures of workers for the project are not assessed within the HHRA. Worker health and safety is addressed through compliance with applicable provincial and federal legislation. However, modelled air concentrations at the worker camp location have been used to estimate non-occupation exposure for Off-Duty Workers present in the worker camp.

The chemicals of potential concern (CoPC) identified based on consideration of their mode of action (threshold vs. non-threshold (carcinogen and non-carcinogen)), whether modelled concentrations approach or exceed an air quality criteria, or if there were no air quality criteria to compare to, were criteria air contaminants coarse particulate matter (PM_{10}), fine particulate matter ($PM_{2.5}$) and nitrogen dioxide (NO_2); volatile organic compounds 1,3-butadiene, acetaldehyde, benzene and formaldehyde; diesel particulate matter; 11 polycyclic aromatic hydrocarbons; and five metals and minerals (including quartz).

Results of the risk characterization suggest that the assumed background concentrations of $PM_{2.5}$ and NO_2 for short-term and long-term exposures periods are at or above health-based exposure limits throughout the LSA/RSA. Based on the Project Alone scenario:

- the NO_2 exposure ratios (ERs) for short-term exposure durations at one or more special receptor locations during construction and operation are higher than the acceptable limit. These are locations frequented by Indigenous Receptors and Recreational Receptors.
- the NO_2 ERs for short-term and long-term exposure durations at the worker camp during construction and operation are higher than the acceptable limit.
- the $PM_{2.5}$ ERs for short-term exposures (during construction and operations) and long-term exposure (during operations) at the worker camp are higher than the acceptable limit. This location is frequented by Off-Duty Workers.

These two CoPC are non-threshold contaminants for which any increase in exposure could result in increased risks. What these results suggest is that NO_2 and $PM_{2.5}$ emissions will need to be actively monitored and mitigations employed should actual emissions approach predicted concentrations.

As described in Appendix H1 of the Impact Statement (the Air Quality Assessment), mitigation measures have been proposed to reduce potential air emissions during construction (and operation) and the development of both a dust management plan and an AQFMP will be developed for the Project. The proposed mitigation, management, and monitoring programs are expected to reduce CoPC emissions from the Project to less than the modelled concentrations, which would consequently reduce potential risks to human health.

Acronyms / Abbreviations

ALCM	Additional Lung Cancer Mortality
AQFMP	Air Quality Follow-up Monitoring Program
ATSDR	Agency for Toxic Substances and Disease Registry
CAAQS	Canadian Ambient Air Quality Standards
CAC	Criteria Air Contaminant
CCME	Canadian Council of Ministers of the Environment
CO	Carbon Monoxide
CoPC	Contaminants of Potential Concern
CSM	Conceptual Site Model
DPM	Diesel Particulate Matter
EL	Exposure Limit
EPC	Exposure Point Concentration
ER	Exposure Ratio
HHERA	Human Health and Ecological Risk Assessment
HHRA	Human Health Risk Assessment
HQ	Hazard Quotient
IARC	International Agency for Research on Cancer
ILCR	Incremental Lifetime Cancer Risk
IRIS	Integrated Risk Information System
IUR	Inhalation Unit Risk
LOAEL	Lowest Observed Adverse Effect Level
LSA	Local Study Area
MECP	Ontario Ministry of the Environment, Conservation and Parks
MELCCFP	Ministère de l’Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs
NC	Not Calculated
ND	No Data

NO_2	Nitrogen Dioxide
NOAEL	No Observed Adverse Effect Level
OLM	Ozone Limiting Method
PA	Project Area
PAH	Polycyclic Aromatic Hydrocarbon
PHC	Petroleum Hydrocarbons
PM_{10}	Particulate Matter less than 10 microns
$PM_{2.5}$	Particulate Matter less than 2.5 microns
RfC	Reference Concentrations
RSA	Regional Study Area
SO_2	Sulphur Dioxide
TC	Tolerable Concentration
TRV	Toxicity Reference Value
TSP	Total Suspended Particulate matter
US EPA	United States Environmental Protection Agency
VOC	Volatile Organic Compound
WHO	World Health Organization

1 Introduction

Troilus Gold Corp (Troilus) proposes to develop, reopen, and operate the former Troilus gold-copper mine (the Project) located in the southeastern part of the Nord-du-Québec administrative region in the Eeyou Istchee Baie-James territory, approximately 76 kilometres (km) northwest of the Cree community of Mistissini and approximately 125 km north of the town of Chibougamau. The Project is being assessed in accordance with the *Impact Assessment Act*, 2019.

The Project has the potential to alter existing conditions with respect to the concentrations of chemicals in air, soil, water, and biota. These changes to the environment have the potential to adversely affect the health of human receptors, and as such, this Human Health Risk Assessment (Inhalation) (referred to as the inhalation HHRA) and a HHRA (Problem Formulation Multimedia; Appendix H.8) were conducted to support the assessment of effects on human health to fulfill a requirement of the Tailored Impact Statement (TIS) Guidelines: Troilus Mining Project. The conclusions of both reports are integrated into the Health Conditions Valued Component chapter, Chapter 22 of the Impact Statement.

1.1 Study Objective

During consultation and engagement activities for the Project, stakeholders expressed concerns about dust from the mine and the addition of dust through transport. Members of the Cree Community also expressed their concerns about the potential presence of silica and cyanide in the dust. The objective of this inhalation HHRA is to characterize how Project-related changes in air quality (including dust) could adversely affect human health. This assessment will help determine whether additional mitigations measures are needed.

1.2 Project Overview

The Project includes the development of four open pits, stockpiles, an ore processing plant, and other mine related infrastructures. Project components are shown on Figure A.1 in Appendix A of this report. Ore will be extracted from four open pits known as Pit 87, Pit J, Pit SW and Pit X22. The Project has a mineral reserve estimate of 380 million tonnes (Mt) and an expected project life of 24 years.

Based on the current Project design, the maximum rate of ore extraction will be up to 238,082 tonnes per day (tpd) during year 6 of operations. The Processing Plant and associated service facilities will process run of mine ore delivered to primary crushers to produce gold/copper/silver concentrate, and tailings at a maximum rate of approximately 50,000 dry tpd.

Based on the proposed processing rate and current information regarding the ore body, the current life of the proposed Project is expected to be approximately 24 years.

Concentrate from the processing plant will be loaded onto trucks and shipped offsite for further processing.

1.3 Key Project Phases

The timing of activities and installation of Project components will occur in sequence to allow for the efficient extraction of materials. Various construction, operations, and decommissioning and closure activities are proposed throughout the life of the mine. For the purposes of the assessment, these Project activities are anticipated to be advanced in three phases:

- Construction phase (Year -3 to Year -1)
- Operations phase (Year 1 to Year 22)
- Decommissioning and Closure phase (Year 22 onward)

1.3.1 Construction Phase

The construction phase (Year -3 to Year -1) includes the following activities:

- Activities in Year -3 involve beginning construction on the main Bibou Creek diversion, secondary diversions, and sedimentation ponds.
- Activities in Year -2 involve construction of a new ore processing plant, construction of water management infrastructure, operation of a small pit west of the existing Pit 97 to create space for the sedimentation pond, and construction of a new access road to the south.
- Activities in Year -1 involve beginning of the removal of overburden in the footprint of Pit 87; initiation of the waste rock dump and overburden disposal for the expansion of Pit 87 to the northeast of the site, over the existing waste rock impoundment area; and expansion of the tailings management facility footprint to the northwest through the construction of a buttress

Additional construction will occur through the operations phase of the Project, with the start of the operations phase defined by the start of ore processing. Refer to Chapter 3 of the Impact Statement (Project Description) for a detailed description of the activities anticipated to occur during this phase.

1.3.2 Operations Phase

The operations phase spans Year 1 to Year 22, with ore extraction ending in Year 21. Activities in Year 22 focus on processing stored material without extracting new ore. Peak ore extraction is during Year 6 to Year 8. An estimated 18.3 megatonnes (Mt) of ore will be mined each year, amounting to a total of 380 Mt of ore. The operations phase involves the following activities:

- Year 1: Initial ore processing, expansion of Pit 87, start of mining of the "southwest" pit. Commence the creation of the waste rock dump and overburden repository for the expansion of Pit 87, southwest of the site.
- Year 2: Continued mining in Pit 87 and SW Pit. Development of the West Waste Rock Dump begins. Construction of a 161 kV transmission line south of the ore processing plant to replace the existing one.

- Years 3-5: Active pits are Pit 87, Pit J4 (from year 5), and SW Pit.
- Years 6-10: Active pits are Pit 87, SW Pit, and Pit J4. Expansion of Waste Rock Dump 87 to the north of the site. Removal of overburden material from landfill 87 to allow expansion of waste rock landfill 87.
- Years 11-15: Tailings deposit begins in the SW Pit. Removal of the overburden dump southwest to allow the disposal of waste rock.
- Years 16-20: Active pits are Pit 87 and Pit X22. Start of mining of Pit X22 (year 18) west of Pit 87. Development of the Southwest Waste Rock Dump on the southwest pit footprint. Progressive deposition of tailings in pit J4, then in pit 87.
- Year 21: Last year of mining (in the Pit X22)
- Year 22: Completion of ore processing on remaining stored material.

Refer to Chapter 3 of the Impact Statement (Project Description) for a detailed description of the activities anticipated to occur during this phase.

1.3.3 Decommissioning and Closure Phase

The decommissioning and closure phase (Year 22 onward) involves gradual closure of infrastructure and restoration in accordance with environmental standards. The site was restored when the first operation closed in 2010. The lessons learned and the findings of the various rehabilitation works will be used to produce a redevelopment plan for the Project operations. This closure and redevelopment plan will be filed with the Ministère des Ressources naturelles et des Forêts before the Project begins operations in accordance with the provisions of the Mining Act (Compilation of Québec Laws and Regulations c M-13.1). The restoration of the site will be done gradually for various developments such as the tailings pond, certain waste rock piles, and open pits. The main decommissioning and closure phase activities are:

- Dismantling of buildings
- Revegetation of waste rock piles
- Diversion of Bibou Creek to the J4, 87, and X22 pools
- Flooding of pits J4, 87, and X22
- Environmental monitoring

Refer to Chapter 3 of the Impact Statement (Project Description) for a detailed description of the activities anticipated to occur during this phase.

2 Spatial Boundaries for the Inhalation HHRA

The Project comprises approximately 2,521 ha and is located in the southeastern part of the Nord-du-Québec Administrative Region, on the Eeyou Istchee James Bay Territory, about 76 km northwest of the Cree community of Mistissini and about 125 km north of the city of Chibougamau. The Project is located at the former Troilus mine and is accessible via a 44 km access road.

The construction, operation, and closure and decommissioning phases of the Project have the potential to alter existing conditions with respect to the concentrations of chemicals in the air, soil, water, and biota near the site. These changes to the environment have the potential to adversely affect the health of human receptors. The spatial boundaries for the inhalation HHRA are described below.

2.1 Project Area

The Project Area (PA) encompasses the Project footprint and is the anticipated area of physical disturbance associated with the construction, operations and decommissioning and closure of the Project. The extent of the PA for the Project is shown in Appendix A, Figure A.2.

2.2 Local Study Area

The Local Study Area (LSA) includes the area in which Project-related effects (direct or indirect) that can be modelled or measured with a level of confidence appropriate for the assessment and in which there is a reasonable expectation that the potential effects in the LSA are of public interest. The LSA for this HHRA is equal to the LSA for air quality as depicted in **Erreur ! Source du renvoi introuvable.**, Figure A.2. The LSA for air quality is an area extending about 10 km from the PA.

2.3 Regional Study Area

The Regional Study Area (RSA) includes the area within which cumulative effects on health conditions as they relate to some of the biophysical determinants of health are likely to occur, depending on the location of other past, present, or reasonably foreseeable future projects or activities. For this HHRA, the RSA is equal to the RSA for air quality, an area extending 40 km from the PA and is depicted in **Erreur ! Source du renvoi introuvable.**, Figure A.2 of this report.

3 Human Health Risk Assessment Methods

This HHRA is focused on the risks to people associated with the inhalation of chemicals in air. As noted in **Section 1**, the assessment of exposure to chemicals in other environmental media (soil, vegetation, groundwater, surface water, wild meat and fish) is conducted in the HHRA (Problem Formulation Multimedia appended to the Chapter 22 of the Impact Statement).

In the context of an impact assessment for major infrastructure projects, HHRA evaluates the potential change in health risk to people that may occur between background environmental conditions and estimated future conditions, during the various phases of the Project. Background environmental conditions may be based on historical monitoring data, measured data collected during baseline studies, or modelled data. Future conditions are based on modelled environmental conditions that reflect the influence of Project activities.

As such, for this inhalation HHRA, three scenarios were evaluated for potential changes in human health risks.

- **Background Scenario**: evaluates the existing exposures and health risks based on existing chemical concentrations in environmental media (e.g., air).
- **Project Alone Scenario**: evaluates health risks associated with exposure to estimated chemical concentrations in environmental media that are attributable only to project activities (i.e. these do not consider the contribution that Baseline Scenario concentrations make to overall exposure).
- **Background Plus Project Scenario**: evaluates the future health risks based on the estimated chemical concentrations in environmental media, as determined through detailed modelling from other valued component chapters (e.g. air quality). These modelling results are used to estimate the future chemical concentrations in exposure media that human receptors may be exposed to (e.g., air).

3.1 Components of Health Risk

The potential for risk from exposure to a chemical requires three factors:

1. The presence of a human or ecological receptor (i.e., receptor).
2. The presence of a chemical with inherent toxicity.
3. An operable exposure pathway.

As illustrated in Figure 3-1, if all three factors are present (i.e., a receptor is exposed to a chemical hazard), a risk may exist. The degree of adverse health risk depends on other factors such as the exposure dose or concentration, exposure duration, and the inherent toxicity of the chemical to the human or ecological receptor. If one or more factors(s) is absent, there would be no potential health risk. For example, if a receptor is exposed to a chemical, but the chemical is inherently non-toxic, then there is no potential risk.

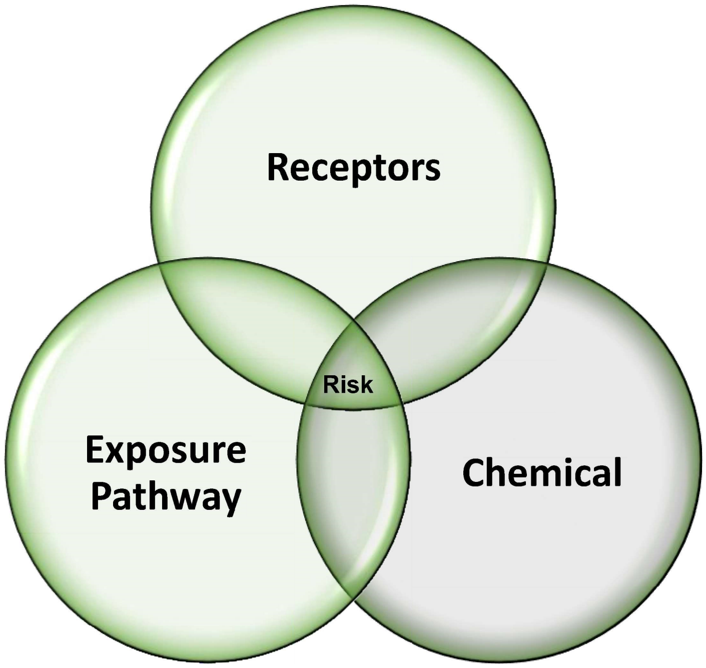


Figure 3-1 Risk Venn Diagram

3.2 Risk Assessment Framework

To determine the potential for Project-related emissions of air quality contaminants to affect human health, a standard HHRA approach was applied, which consists of the following components.

- Problem Formulation: The problem formulation is an information gathering and interpretation stage that defines the nature and scope of a risk assessment. It includes the identification of the boundaries of the study, the current and future contaminants of potential concern (CoPCs), the current and future human receptors, and the current and future exposure pathways. The information is used to develop the conceptual site model (CSM) illustrating the connections existing between the CoPC, the receptors and the exposure routes

- Toxicity Assessment: The toxicity assessment characterizes the potential toxic effects of each CoPC and identifies toxicological reference values (TRVs) or health-based limits for use in the HHRA. Toxicological reference values are dose or exposure concentration benchmarks to which a human receptor can be exposed to without an appreciable risk of adverse health effects. The toxicological reference values (TRVs) applied in this HHRA are guidelines and objectives published by provincial, federal or international regulatory agencies.

- Exposure Assessment: The exposure assessment characterizes the CoPC dose or exposure concentration for each operable exposure pathway in the CSM. The objective is to quantify the amount of CoPC to which people could be exposed.

- Risk Characterization: The risk characterization stage qualitatively and/or quantitatively characterizes potential risk to human receptors from each operable exposure pathway. The risk characterization compares the results of the exposure assessment to the TRVs to quantify potential health risk.

- Uncertainty and Sensitivity Assessment: An uncertainty and sensitivity assessment is also an important part of the risk assessment process. Uncertainties can arise in various aspects of the assessment, such as sample collection and analysis and the assumptions made when applying professional judgment. This uncertainty does not invalidate the results of the risk characterization. However, articulating the uncertainty aids in interpreting the potential of adverse health risk. Similarly, a sensitivity analysis helps identify the effect of assumptions on the results of the risk analysis.

Overall, the industry standard for risk assessment is to overstate, rather than understate, potential health risks. Regulatory guidance supports use of a protective approach (one that overestimates exposures and toxicological responses) when assessing potential health risks. This protective approach (also known as a conservative approach) has been maintained in the assessment of potential human health risks due to Project-related effects on air quality.

4 Regulatory Setting

Health Canada provides general guidance for conducting HHRA and assessing risks to human health associated with Project-related effect on air quality in Impact Assessments, and these were relied on for conducting this HHRA, namely:

- Guidance for Evaluating Human Health Effects in Impact Assessment: Human Health Risk Assessment (Health Canada, 2023a).
- Guidance for Evaluating Human Health Effects in Impact Assessment: Air Quality Health Canada 2023b).

In addition, HHRA guidance applicable to federal contaminated sites in Canada was also considered as needed herein, including:

- Federal Contaminated Site Risk Assessment in Canada: Guidance on Human Health Preliminary Quantitative Risk Assessment, Version 4.0 (Health Canada, 2024).
- Federal Contaminated Sites Risk Assessment in Canada, Part V: Guidance on Human Health Detailed Quantitative Risk Assessment for Chemicals ($DQRA_{CHEM}$) (Health Canada, 2010a).
- Federal Contaminated Site Risk Assessment in Canada: Toxicological Reference Values (TRVs), Version 3.0 (Health Canada, 2021b).

5 Background and Modelled Future Concentrations

An evaluation of background and future air quality for the Project was conducted as part of the air quality assessment (Chapter 8 of the Impact Statement and Appendix H1 of the Impact Statement, the Air Quality

Assessment). As noted in that chapter, since baseline ambient monitoring for CoPCs was not feasible, background air quality data published by the Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs (MELCCFP) in the following documents was used to characterize air quality in the LSA and to develop background concentration levels to be used in the assessment. Background air quality data (referred to as initial concentrations in these documents) was published for 46 modelled parameters.

- Quebec Air Quality Standards and Criteria, version 9, Quebec, Air Quality and Climate Branch (MELCCFP, 2025)
- Instruction Guide for Preparation and Realization of Air Emission Dispersion Modelling – Mining Projects (MELCCFP, 2017).

Where background concentrations for CoPCs were not available, representative ambient monitoring data from another proposed mining project was used to estimate baseline concentrations. The Crawford Nickel Project, located approximately 42 km north of the City of Timmins, Ontario, is in a remote area similar to that of the Project. As a result, the background levels for the Crawford Nickel Project are expected to accurately represent the background levels of the Troilus Project. The Crawford Nickel Project ambient monitoring results are presented in Impact Statement Chapter 12: Assessment of the Potential Effects on the Atmospheric Environment dated September 30, 2024 (Stantec, 2024). The MECP normally requires adding the 90th percentile ambient monitoring data to the dispersion model predictions to conservatively account for existing ambient concentrations. Therefore, 90th percentile values were used as the background for short-term averaging periods while annual average values were used as the background level for long-term periods.

The air quality assessment included modelling for the following key groups of chemicals.

- Particulate Matter - Suspended particulate matter (PM or TSP), particulate matter with particles less than 10 microns in diameter (PM10) and particulate matter with particles less than 2.5 microns in diameter (PM2.5). PM is a measure of the particles in the atmosphere that are too small to settle out quickly but remain suspended for substantial periods of time. PM is produced by a variety of activities including wind erosion of agricultural or cleared fields and other open areas, abrasion of vehicle tires on paved and unpaved roads, and combustion processes (e.g., industrial boilers and heaters, power generation, vehicle emissions). Although total suspended particulate matter is an excellent measure of the loading of particulate matter in the air, it does not necessarily reflect the health risks of the particulate matter. The larger aerodynamic particles (PM10) are trapped by the upper airways, and do not enter the lungs. Smaller diameter particles (PM2.5) can make their way deep into the lungs
- Other substances with regulatory limits including sulphur dioxide (SO2), nitrogen oxides (NOX), and carbon monoxide (CO)
- Hazardous Air Pollutants - Substances that are capable of causing environmental or health effects including volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs) and metals. VOCs and PAHs (including benzo(a)pyrene and benzene) from vehicle tailpipe emissions were included in the assessment. PAH derivatives such as nitrated PAHs (nitro-PAHs) and oxygenated PAHs (oxy-PAHs) occur at far lower concentrations than those of parent PAHs in off-

road diesel engine exhaust (California Air Resources Board, 2020) and were therefore not included in the assessment

- Asbestiform minerals - The ore and waste rock types identified by Troilus contain amphibole minerals in the form of tremolite and actinolite. Troilus specified that no traces of asbestos-like amphibole are present due to unfavourable geological conditions. Amphiboles are generally of higher metamorphic grade and in the form of more coarse-grained hornblende-chermakite-gedrite. Therefore, tremolite and actinolite were modelled in the air quality assessment but are considered non-asbestiform based on analysis by Troilus.

Of the substances listed above, NO_2, SO_2, CO, $PM_{2.5}$, PM_{10}, and TSP are defined by the United States Environmental Protection Agency (US EPA) as criteria air contaminants (CACs) because there are objectives, standards, or criteria governing their concentration in ambient air.

Future conditions (i.e., Project Alone and Background Plus Project) were assessed using air dispersion modelling. This modelling accounted for air emissions during Project construction and operation from activities such as material handling, equipment travel, drilling, blasting, tailpipe emissions from mobile equipment, wind erosion, primary crushing, secondary crushing, unpaved road dust.

The air dispersion modelling for construction and operation was conducted assuming the worst-case year for each Project phase based on a review of Project emission sources over time. This means that air dispersion modelling was performed using emissions data from Year -1 of construction and Year 6 of operation. Air quality emissions during Project decommissioning and closure were not explicitly modelled because active closure emissions are expected to be less than construction emissions. Therefore, the assessment of the construction-related scenario was considered to implicitly address emissions during the active closure phase as well.

The locations evaluated in the air quality dispersion modelling that are pertinent to the HHRA include the modelled mine boundary and specific sensitive and representative receptor locations selected to represent places where people are likely to be present and could experience non-occupational exposure to emissions from the Project, as described below.

1. **Modelled Mine Boundary.** In addition to the PA (as described in **Section 2.1**) a separate property boundary has been defined in the air quality assessment provided in Appendix H1 of the Impact Statement, the Air Quality Assessment that is applicable to the evaluation of Project effects on human health. The Modelled Mine Boundary provides a 300 m buffer around the PA as specified in the MELCCFP instruction guide Preparation and Realization of Air Emission Dispersion Modelling (MELCCFP, 2017). In accordance with the instruction guide, if the air quality standards and criteria are not met for one or more contaminants at a distance of 300 metres or more from the project facilities, the proponent must demonstrate that routine mitigation measures have been applied where technically and economically feasible. In addition, the proponent must demonstrate, using the results of the atmospheric dispersion modelling, that the standards and criteria are met at sensitive receptors located beyond 300 m of the facilities. A map of the proposed Modelled Mine Boundary is presented in Appendix A, Figure A.3 of this report.

2. **Special Receptor Locations:** Air quality dispersion modelling was also completed for specific ‘special receptor’ locations selected to represent places where people are more likely to be present outside the modelled mine boundary and exposed to emissions from the Project. This included six locations outside the PA where non-Indigenous or Indigenous overnight use has been confirmed or assumed. A tabular summary of the special receptors is presented in Table 5.1 and the locations are presented in Appendix A, Figure A.4 of this report.

Table 5.1 Special Receptor Locations

Special Receptor ID	Type	Description	UTM E	UTM N
CC1	Non Cree Activities	Outfitting Camp	526877	5640176
CC2	Cree Camps	Projected Camp	543079	5659895
CC3	Cree Camps	Secondary Camp	530948	5643967
CC4	Cree Camps	Main Camp	532176	5644751
CC5	Cree Camps	Main Camp	526931	5640239
F4	Cree Camps	Main Camp	526820	5639873

4. **Worker Camp:** Results were also modelled for the worker camp, where off-duty workers will be present inside the modelled mine boundary during Project construction and operation. It is anticipated that this camp will accommodate a maximum of about 530 people during the construction phase. Following the construction phase, the camp’s capacity will be reduced to accommodate a maximum of approximately 275 to 300 workers for a period of approximately 22 years. At closing, most of the camp's buildings will be dismantled to accommodate the reduced number of workers required for restoration work and environmental monitoring. Troilus Gold estimates that 5 to 30 workers will be needed during this phase. The worker camp location is presented in Appendix A, Figure A.4 of this report.

For some parameters, additional modelling beyond what was reported in Chapter 8 of the Impact Statement and Appendix H1 of the Impact Statement, the Air Quality Assessment was needed to support the HHRA. This additional modelling provided air concentrations for specific averaging periods or statistical representations of the data that align with health-based exposure limits and toxicity reference values identified in the human health risk assessment (see **Section 7**). In such cases, modelling was carried out using the same methods and assumptions described in Chapter 8 of the Impact Statement and Appendix H1 of the Impact Statement, the Air Quality Assessment, adjusted for the applicable averaging periods or statistical representations of the data.

The maximum modelled concentrations along the modelled mine boundary, special receptor locations and worker camp for Background, Project Alone and Background Plus Project Scenarios during construction and operations are provided in Appendix H1 of the Impact Statement, the Air Quality Assessment.

6 Problem Formulation

The key tasks of the problem formulation for the HHRA were:

- Identification of CoPC: Identifying those Project-related chemicals that may be released to the receiving environment and that have the potential to elicit adverse human health effects.
- Receptor Identification: Identifying the individuals that may be affected by the Project, which includes the people with the greatest probability of exposure to the CoPC and/or those that have the greatest potential sensitivity to the CoPC.
- Exposure Pathway Identification: Identifying the potential ways in which CoPC move through the environment from a source to a point of contact with people
- Conceptual Site Model (CSM) Development: Developing a visual CSM showing the release mechanisms, source media, transport mechanisms, exposure pathways and CoPC for the identified receptors.

The spatial and temporal boundaries are also an important part of the problem formulation. These boundaries were discussed in **Section 2**.

6.1 Identification of Contaminants of Potential Concern

As noted by Health Canada (Health Canada, 2023b), to determine the human health impacts of changes to air quality, the concentrations of modelled air contaminants should be compared to “the most stringent federal, provincial or territorial air quality standards” applicable to the PA.

The provincial air quality standards applicable to the PA for this Project comprised the air quality criteria published by the MELCCFP in the document entitled Quebec Air Quality Standards and Criteria, version 9, Quebec, Air Quality and Climate Branch (MELCCFP, 2025). Additionally, Ontario air quality criteria were also considered for parameters without Quebec Air Quality Standards and Criteria. This included Ontario Ambient Air Quality Criteria and Benchmark 1 (Standards and Guidelines) and Benchmark 2 (Screening Levels) from the Ontario Ministry of the Environment, Conservation and Parks (MECP) document “Air Contaminants Benchmarks (ACB) List – Standards, Guidelines and Screening Levels for Assessing Point of Impingement Concentrations of Air Contaminants” (MECP, 2023). Applicable federal air quality criteria comprised the Canadian Ambient Air Quality Standards (CAAQS). A complete list of applied criteria is provided in Chapter 8 of the Impact Statement and Appendix H1 of the Impact Statement, the Air Quality Assessment.

Health Canada (2023b) notes that further health assessment of air quality contaminants may not be necessary if modelled concentrations or levels of these contaminants remain well below the applicable CAAQS or other criteria. However, a health-based risk assessment is recommended for non-threshold contaminants (i.e., those contaminants that may cause health effects at any exposure level) and for contaminants that are modelled to approach or exceed applicable air quality guidelines or standards. Additionally, Health Canada (2023a) notes that chemicals should be screened into a quantitative HHRA if no guidelines exist and modelled concentrations increase above background levels. Therefore, chemicals identified as being potentially released into air by the Project were identified for consideration as CoPCs in air for the HHRA if:

1. The contaminant is a known non-threshold contaminant (includes carcinogens and non-threshold non-carcinogens, see further discussion in **Section 7**),
2. Modelled contaminant concentrations approach or exceed applicable criteria at the maximum location along the modelled Project 'fenceline' (i.e., the modelled mine boundary) for Background Plus Project scenario at the maximum location along the modelled mine boundary was greater than 85% of the applicable air quality criteria as summarized in Chapter 8 of the Impact Statement and Appendix H1 of the Impact Statement, the Air Quality Assessment), or
3. The modelled contaminant concentration is greater than background levels due to the Project and no applicable air quality criterion was identified, as summarized in Chapter 8 of the Impact Statement and Appendix H1 of the Impact Statement, the Air Quality Assessment.

In addition, some chemicals were excluded as CoPCs based on a case-by-case review of additional quantitative and qualitative lines of evidence. A summary of the chemicals identified as CoPCs is provided in Table 6.1. The additional lines of evidence relied to exclude parameters as CoPCs on a case-by-case basis are summarized below.

- Total suspended particulate matter. Although modelled concentrations of total suspended particulate matter (TSP) (i.e., total particulate matter with an aerodynamic diameter less than 44 µm) were greater than applicable air criteria (per Chapter 8 of the Impact Statement and Appendix H1 of the Impact Statement, the Air Quality Assessment), it was not identified as CoPC because existing evidence indicates that health effects related to inhalation of particulate matter are most strongly correlated with smaller particulate size (Health Canada, 2016a). For example, the World Health Organization notes that, "the effects of long-term particulate matter exposure on mortality seem to be attributable to PM2.5 rather than coarse particles" (WHO, 2006). Therefore, PM10 and PM2.5 were retained as CoPCs to assess the potential for particulate matter to affect human health in this HHRA.
- Elemental carbon (from diesel exhaust). Modelled concentrations of elemental carbon (from diesel exhaust) were greater than applicable air criteria (per Chapter 8 of the Impact Statement and Appendix H1 of the Impact Statement, the Air Quality Assessment); however, it was not identified as a CoPC. Rather, this HHRA relies on diesel particulate matter (DPM) as an indicator of exposure to diesel exhaust. This approach is informed by a human health risk assessment for diesel exhaust that was completed by Health Canada in 2016, which chose DPM as the basis for develoment of acute and chronic exposure guidance values for diesel exhaust.
- Non-carcinogenic inorganic components of particulate matter (e.g., carbon, magnesium and compounds (as Mg), amphibole (actinolite and tremolite)1, chlorite, muscovite, mica, sodium

[1] Amphibole minerals (actinolite and tremolite) were identified as being present in geological sources at the Site. Amphibole minerals may be found in asbestiform and non-asbestiform habits (Wylie, Korchevskiy, Orden, & Chatfield, 2022). Asbestiform particles have a fibrous structure and are known to be carcinogenic; however, non-asbestiform amphiboles do not pose similar respiratory risks even at high doses (Williams, Dell, Adams, Rose, & Van Orden,

sulphite and other non-carcinogenic metals and minerals). The Project may release inorganics and minerals from geological sources to the air as particulate matter due to activities such as material handling, equipment travel, grading, drilling, blasting, wind erosion, and unpaved road dust. However, toxicological data based on particulate inhalation for these parameters is limited and the link between specific inorganic components of particulate matter and observed human health outcomes remains poorly understood (Schlesinger, 2007). Therefore, these inorganic parameters will be evaluated as components of PM10 and PM2.5 rather than as individual CoPC.

- Hydrocarbons. The term "hydrocarbons" encompasses a broad group of chemicals that contain carbon and hydrogen atoms. Petroleum products such as gasoline and diesel typically contain hundreds to thousands of hydrocarbon compounds in varying proportions. Total hydrocarbons were modelled as a byproduct of fuel combustion even though certain individual hydrocarbons (e.g., benzene) have also been modelled and evaluated individually. The CCME (2008) has identified reference concentrations (RfCs) for various aliphatic and aromatic subfractions of petroleum hydrocarbons (PHC). These RfCs represent concentrations that can be inhaled continuously over a lifetime without resulting in appreciable risk of deleterious effects for non-carcinogenic effects (i.e., RfCs are equivalent to TCs for threshold effects as described in Section 7. The lowest (most sensitive) RfC from CCME (2008) for a PHC subfraction is 200 µg/m3; which is applicable to C9-C16 range aromatic hydrocarbons. Given that the the maximum modelled 24-hour concentration of total hydrocarbons at the modelled mine boundary due to the Project for either the construction or operation phases as shown in Chapter 8 of the Impact Statement and Appendix H1 of the Impact Statement, the Air Quality Assessment is 2.59 µg/m3 (i.e., two orders of magnitude lower than the most sensitive RfC for a subfraction of PHC from CCME (2008)), it can be concluded that non-cancer risks from exposure to total hydrocarbons in air will be negligible from the Project and therefore total hydrocarbons were not identified as CoPCs in air for human health.

As noted in Appendix H1 of the Impact Statement, crystalline silica is assessed as quartz in particulate matter (Quartz in PM_{10}/PM_4); however, cyanide was not identified as a Project-related air emission.

2012). The baseline geological evaluation at the Site did not identify the presence of asbestiform amphibole at the Site. Therefore, actinolite and tremolite were evaluated as non-carcinogenic components of particulate matter in this HHRA.

Table 6.1 Human Health Contaminants of Potential Concern (CoPCs) in Air

CoPC	Non-Threshold (Carcinogens and Non-carcinogens)	Approaches or Exceeds Criteria (per Appendix H1 of the Impact Statement, the Air Quality Assessment)	No Criteria (per Appendix H1 of the Impact Statement, the Air Quality Assessment)
Criteria Air Contaminants			
Coarse particulate matter (PM_{10})	✓	✓	-
Fine particulate matter ($PM_{2.5}$)	✓	✓	-
Nitrogen dioxide (NO_2)	✓	✓	-
Volatile Organic Compounds			
1,3-butadiene	✓	-	-
Acetaldehyde	✓	-	-
Benzene	✓	-	-
Formaldehyde	✓	-	✓
Diesel Particulate Matter			
Diesel particulate matter (DPM)	✓	-	✓
Polycyclic Aromatic Hydrocarbons (PAHs)			
Acenaphthene		-	✓
Acenaphthylene		-	✓
Anthracene		-	✓
Benzo(a)anthracene	✓	-	✓
Benzo(a)pyrene	✓	-	-
Benzo(b+k)fluoranthene	✓	-	✓
Benzo(g,h,i)perylene	✓	-	✓
Chrysene	✓	-	✓
Fluoranthene	✓	-	✓
Fluorene	-	-	✓
Phenanthrene	✓	-	✓
Metals and Minerals			
Arsenic (As)	✓	-	-
Beryllium (Be)	✓	-	-
Cadmium (Cd)	✓	-	-
Nickel (Ni) in PM_{10}	✓	-	-
Quartz in PM_{10}/PM_4		✓	-

6.2 Identification of Human Receptors

As noted in Land Use (Chapter 19 of the Impact Statement), the Project is located within the Lake Albanel-Mistassini-et-Waconichi (AMW) Wildlife Reserve and the Assinica Wildlife Reserve. Specifically, the Project is located within the Lake AMW Wildlife Reserve, while the access road is located in the Assinica Wildlife Reserve. Wildlife reserves are created under the Loi sur la conservation et la mise en valeur de la faune.

Cree communities of Mistissini and Oujé-Bougoumou are located approximately 76 km southeast and approximately 125 km south of the Project, respectively. The Project is located within two wildlife reserves that are managed by the Nibiischii Corporation, a Cree-owned company. Hunting within the reserves is restricted to Indigenous people. Specifically, the Project overlaps with the hunting territories of the Awashish and Brien families (trapline M34), the Neeposh family (trapline M39) and the Petawabano family (trapline M40) (Golder Associates Ltd. [Golder] 2022). Trapline M35A is also located nearby. There are several camps (e.g., main camp, winter camp, hunting camp) used at different times of the year within each of these hunting territories (Golder 2022).

The Lakes AMW and Assinica wildlife reserves are major tourist attractions for the region. Lakes AMW Wildlife Reserve offers accommodation in the form of cabins, camps, and campgrounds at various sites, including Lake Albanel, Lake Waconichi, Lake Robineau, and Bay Pénicouane. Fishing and canoe-camping are the main activities, but kayaking and paddleboarding are also available. Hiking trails, marina services, and boat and motor rentals are available at some sites. A canoe-camping circuit is available from Lake Robineau (Nibiischii 2021). In the Assinica Wildlife Reserve, accommodation is limited to rustic camping on the shores of various lakes and rivers. The main activities are fishing, canoe-camping, and nature observation. Walleye, lake trout, brook trout, and northern pike can be caught in both reserves (Nibiischii 2021). Personal watercraft are strictly prohibited on reserve waters (Nibiischii 2021).

All terrain vehicle trails are present in the Chapais and Chibougamau areas; however, their use is prohibited in the Lakes AMW and Assinica Wildlife Reserves. The Trans-Québec 93 snowmobile trail and a local trail link Chapais, Oujé-Bougoumou, Chibougamau, and Mistissini (Golder 2020). Similarly, no snowmobile trails cross near the Project. There are several additional land use leases in the area, for various purposes including an outfitter lodge, a resort, a telecommunication tower, forest conservation and protection, and industrial purposes

- **Indigenous Receptors** – This group includes Indigenous people who may live within the LSA or use the lands within the LSA for harvesting of country foods, or for recreational, ceremonial or spiritual purposes. This receptor group encompasses individuals of all ages - infants, toddlers, children, teens, and adults.
- **Recreational Receptors** – This group includes non-Indigenous people who may use the lands within the LSA for harvesting country foods or engaging in recreational activities. This receptor group also includes all ages - infants, toddlers, children, teens, and adults.
- **Off-Duty Worker Receptors** – This group includes workers who are present in the worker camp during their off-duty period. Occupational exposures of workers for the Project are not assessed within the HHRA. Worker health and safety is addressed through compliance with applicable provincial and federal legislation. However, modelled air concentrations at the worker camp location have been used to predict non-occupation exposure for Off-Duty Workers present in the worker camp.

Some populations may be more sensitive to exposures compared to the general population. For example,

- pregnant people – due to fetal development
- toddlers - due to their higher intake rates relative to their body weight,
- elderly – due to potential age-related vulnerabilities

- Indigenous people – due to higher consumption of traditional foods compared to non-Indigenous members of the population, and
- individuals with respiratory diseases – due to their increased susceptibility to airborne contaminants.

Human receptor locations are important because exposure to a CoPC is dependent on the location of the person since the concentration of the CoPC may vary throughout the LSA/RSA. Special receptor locations, identified as representative of areas where people live, work, or otherwise spend time in the LSA/RSA are shown on Appendix A, Figure A.4. Locations in the LSA/RSA that are farther away than these special receptor locations would experience less change in air quality, and there would be a lower degree of change in the health risk.

For this assessment, it will generally be assumed that people may be present at the special receptor locations 24 hours a day, 7 days a week, over a lifetime of exposure unless otherwise noted.

6.3 Identification of Exposure Pathways

Exposure pathways are the means by which human receptors may be exposed to CoPCs from the Project. The exposure pathway screening examines the potential exposure pathways the CoPCs and exposure media evaluated in this HHRA.

This Technical Data Report focuses specifically on the evaluation of changes in risks to human health due to Project-related effects on air quality. Therefore, the only exposure pathway evaluated herein is inhalation of air. Because people within the LSA/RSA could inhale the airborne CoPC, each of the identified CoPC in air are assessed for inhalation exposures.

6.4 Conceptual Site Model

An important step in the problem formulation is the development of the CSM. The CSM is a visual representation of CoPCs, the associated source and release mechanisms, and potential exposure pathways to the identified human receptors. The human health CSM is presented in Figure 6-1.

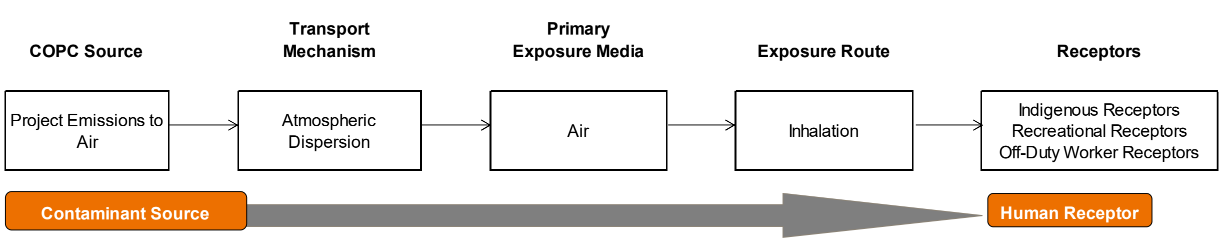


Figure 6-1 Conceptual Site Model

7 Toxicity Assessment

The toxic potency of a chemical is dependent on the inherent properties of the chemical itself (its ability to cause a biochemical or physiological response at the site of action within the receptor's body) as well as the ability of the chemical to reach the site of action. The toxicity assessment (also known as a hazard assessment) involves the selection of toxicological reference values (TRVs), also referred to as exposure limits, for each CoPC. The TRVs are estimates of the maximum exposure dose (from oral exposure) or exposure concentration (from inhalation exposure) to which people (including members of sensitive subgroups such as pregnant women, infants, children, the elderly) could be exposed without an appreciable risk of adverse effects.

When establishing TRVs for a CoPC, the type of dose-response relationship leading to a possible effect needs to be considered as well as the duration of exposure. Effects are typically classified as threshold or non-threshold based on a chemical's mode of action (Health Canada, 2024).

7.1 Threshold Effects

For the inhalation pathways, Health Canada reports chronic TRVs for threshold substances as a tolerable concentration (TC), which represents the maximum concentration of a substance that a receptor can inhale 24 hours/day, every day over a lifetime, below which deleterious effects are not expected. TC units are expressed as a concentration of a contaminant in air (e.g., mg/m^3). A TC can also be described as a Reference Concentration (RfC), depending on the regulatory agency.

7.2 Non-Threshold Effects

A non-threshold effect occurs when there is no specific dose below which a toxic effect does not occur. This implies that any level of exposure to a non-threshold CoPC carries some degree of risk of effect. Consequently, there is no level at which risks could manifest for chemicals with non-threshold effects. The dose-response relationship for non-threshold CoPCs is typically conceptualized as linear. At low doses, the adverse health effect may need to be mathematically extrapolated from higher dose data or larger population studies. Non-threshold effects are further categorized into carcinogenic and non-carcinogenic effects.

7.2.1 Carcinogens

Regulatory agencies such as Health Canada and the US EPA assume that any level of long-term exposure to carcinogens is associated with some "hypothetical cancer risk". The standard TRV for parameters identified as carcinogenic via inhalation is the inhalation unit risk (IUR), defined as the upper-bound excess lifetime cancer risk estimated to result from continuous inhalation exposure to an agent at a unit concentration of 1 $\mu g/m^3$ (US EPA, 1989).

7.2.2 Non-carcinogens

In theory, any level of exposure to a non-threshold non-carcinogen carries some degree of risk for an effect. At very low doses, the toxic effect may be at the cellular level without an observable adverse health effect. As the dose increases, the severity of the adverse health effects can also increase, and additional health effects can appear. For these CoPC, TRVs may not be available. In such cases, exposures may be benchmarked against exposure limits or air quality guidelines that are designed to protect public health.

7.3 Acute and Chronic Toxicity Reference Levels

The toxicity of a chemical varies with the duration of exposure. Thus, it is important to differentiate TRVs based on where the exposure duration is acute (short-term) or chronic (long-term), as described below:

- Acute: The amount or dose of a chemical that can be tolerated without evidence of adverse health outcomes on a short-term basis. As described in Health Canada (2010a), an acute exposure periods is anything less than 14 days and often involves a single high-intensity exposure.
- Chronic: The amount of a chemical that is expected to be without health outcomes, even when exposure occurs continuously or regularly over extended periods (greater than 90 days per Health Canada (2010a).

7.4 Identification of Applicable Exposure Limits and Toxicological Reference Values

Several sources were consulted in the selection of exposure limits and TRVs for assessing inhalation exposures to CoPC. The primary sources that were consulted, based on recommendations in Health Canada (2023a), are listed below.

- Health Canada
- US EPA Integrated Risk Information System (IRIS)
- World Health Organization (WHO)
- National Institute for Public Health and the Environment (Netherlands)
- Agency for Toxic Substances and Disease Registry (ATSDR)
- California Environmental Protection Agency (CalEPA), which includes the California Office of Environmental Health Hazard Assessment (OEHHA)

If no TRVs were available from the above sources, additional sources were considered (e.g., Ontario Ministry of Conservation and Parks (MECP) and peer-reviewed literature).

Per Health Canada (2023a), priority was given to Health Canada TRVs, and these were employed where available. Where TRVs were selected from a source other than Health Canada, additional information is provided below to support that selection.

The exposure limits and TRVs presented in this section are grouped based on effect type (i.e., threshold and non-threshold). Some chemicals can exhibit both threshold and non-threshold effects (Health Canada, 2024) and may therefore have multiple TRVs listed here. In instances where both threshold and non-threshold TRVs are applicable, health risks from exposure were evaluated for both modes of action.

7.4.1 Inhalation Exposure Limits and TRVs

According to Health Canada (2023b), modelled concentrations of CoPCs in air should be evaluated against relevant air quality standards. This was done in Appendix H1 of the Impact Statement, the Air Quality Assessment and reported in Chapter 8 of the Impact Statement. However, the standards used (e.g., the air quality criteria published by MELCCFP and the federal Canadian Ambient Air Quality Standards) are often based on statistical representations of existing airshed data and not necessarily health based. This section describes the exposure limits and TRVs (TCs and IURs) that were relied on to evaluate risk associated with modelled concentrations of CoPCs in air.

7.4.1.1 Criteria Air Contaminants

NO_2, PM_{10}, and $PM_{2.5}$, are non-threshold contaminants, for which it is acknowledged that any increase in exposure to these contaminants may result in adverse health effects. However, the severity of effects increases incrementally with exposure concentration and exposure duration. The absence of clearly defined TRVs for these parameters presents a technical challenge for health regulatory agencies and health risk practitioners on how to assess the incremental increase in health risk resulting from modelled or measured exposure concentrations.

In the absence of standard TRVs such as a TC or IUR for these parameters, inhalation exposure limits (ELs) have been identified based on reviews of the data characterizing the potential health effects from exposure to varying levels of these parameters in ambient air as summarized by Health Canada and WHO.

In most cases, WHO ambient air quality guidelines (WHO, 2021) have been adopted as exposure limits for these parameters. These limits are defined by the WHO as, “The lowest exposure level of an air pollutant above which the guideline development group is confident that there is an increase in adverse health effects,” and that, “It is assumed that adverse health effects do not occur or are minimal below this concentration level.” The WHO air quality guideline is essentially the lowest level of exposure for which there is evidence of adverse health effects (WHO, 2021).

7.4.1.2 Volatile Organic Compounds

VOCs are organic compounds with a high vapour pressure at ambient temperatures that allow these substances to volatilize or evaporate into the air relatively quickly. Fuel-based VOCs associated with Project-related activities include 1,3-butadiene, acetaldehyde, benzene, and formaldehyde.

7.4.1.2.1 1,3-Butadiene

1,3-Butadiene is a flammable, colourless gas with a mild aromatic odour. It is ubiquitous in the environment and is produced from the combustion of organic matter. Emission sources include chemical products industries such as plastics, refined petroleum and coal, automobile exhaust (gasoline- and diesel- motor vehicles) and cigarette smoke. In air, 1,3-butadiene is rapidly degraded by photochemical reactions to form acrolein and formaldehyde (US EPA, 2002b).

There is a paucity of data on acute human exposure to butadiene. The OEHHA (2013) developed an acute (1-hour) exposure limit of 660 µg/m^3 for 1,3-butadiene based on an inhalation study using pregnant mice and offspring, as it addressed the most sensitive non-cancer endpoint associated with butadiene – developmental effects (lowered male fetal weight). As no acute toxicity-based criterion for 1,3-butadiene has been established by regulatory agencies in Canada, nor by the US EPA, the OEHHA value was selected for this HHRA.

The US EPA (2002b) established a chronic inhalation TRV of 2 µg/m^3 for 1,3-butadiene, derived from a human equivalent benchmark response of 1,980 µg/m^3 from a two-year mouse inhalation study (National Toxicology Program (NTP), 1993) and an uncertainty factor of 1,000 (3 for interspecies variation, 10 for intraspecies variability, 10 for extrapolation to a level below the 10% effect level, and an additional 3-fold for an incomplete database). The critical effect was ovarian atrophy. This value was selected as the chronic (annual) ambient air exposure limit by both the Ontario MOECC (2016) and the OEHHA (2013) and was considered appropriate to evaluate long-term non-carcinogenic exposure risks to 1,3-butadiene within the current assessment.

Health Canada (2024) derived an inhalation unit risk of 5.9 x 10^{-6} (µg/m^3)$^{-1}$. This value was derived from a retrospective cohort study (Detzell et al. 1995) of more than 15,000 male styrene-butadiene rubber production workers to provide high-quality epidemiologic data on leukemia risk from 1,3-butadiene exposure. The IUR from Health Canada (2024) was considered appropriate to evaluate long-term carcinogenic exposure risks to 1,3-butadiene within the current assessment.

7.4.1.2.2 Acetaldehyde

Health Canada (2017a) has developed residential indoor air quality guidelines for acetaldehyde. The short-term exposure limit is derived from the results of a controlled human exposure study by Prieto et al. (2000) that investigated bronchoconstriction response in asthmatic human volunteers. Health Canada (2017a) identified 142 mg/m^3 as the point of departure in this study as it represented the lower 95% confidence level of the concentration required to produce a 20% fall in forced expiratory volume in one-second geometric mean for asthmatic subjects following a 2-minute exposure to acetaldehyde. An uncertainty factor of 100 was then applied to account for use of a lowest observed adverse effect level (LOAEL) and to account for sensitive receptors (e.g., more severe asthmatics and children). This resulted in a final short-term residential indoor air quality guideline for acetaldehyde of 1,420 µg/m^3, which is recommended to be compared to a one-hour air sample. As such, this value was considered appropriate to evaluate acute non-carcinogenic exposure risks to acetaldehyde within the current assessment.

With respect to long-term exposure, Health Canada (2017a) reviewed the available toxicological data for acetaldehyde and concluded that acetaldehyde is carcinogenic, but that it exerts its carcinogenic effect through a non-linear mode of action and that non-cancer effects are precursors to a carcinogenic effect. Therefore, Health Canada (2017a) developed a long-term exposure limit based on a non-cancer endpoint that is considered protective of carcinogenic effects. Specifically, the long-term exposure limit developed by Health Canada (2017a) is based on a study by Dorman et al. (2008), who observed a NOAEL of 89 mg/m^3 based on degeneration of the olfactory epithelium in rats. This was converted to a human equivalent concentration of 120 mg/m^3 using a physiologically-based pharmacokinetic model, which was then adjusted for continuous exposure, resulting in an adjusted human equivalent concentration of 21 mg/m^3. Health Canada (2017a) then applied an uncertainty factor of 75 to account for the use of animal rather than human toxicity data, additional sensitivity in the human population, and uncertainty in the shape of the lower region of the concentration-response curve, resulting in a final long-term residential indoor air quality guideline for acetaldehyde of 280 µg/m^3, which is recommended to be compared to a sample collected over at least 24-hours. As such, this value was considered appropriate to evaluate chronic non-carcinogenic and carcinogenic exposure risks to acetaldehyde within the current assessment.

7.4.1.2.3 Benzene

Benzene is a colourless liquid with a high vapour pressure and a sweet odour at room temperature, which is produced by natural (e.g., volcanoes and forest fires) and anthropogenic activities (ATSDR, 2024). Incomplete combustion of gasoline, coal, oil and other petroleum- based fuels are the most significant sources of benzene released into the environment (ATSDR, 2024). Inhalation is the general public's primary route of exposure to benzene (ATSDR, 2024). Acute exposure to benzene may cause dizziness, headaches, and drowsiness while chronic inhalation exposure to benzene affects the bone marrow, and the immune and central nervous systems (ATSDR, 2024).

In both human and animal non-carcinogenic studies, data suggest the most sensitive endpoint for short-term inhalation exposure to benzene is hematotoxicity (ATSDR, 2024; TCEQ, 2015). A lowest-observed-adverse-effect-level of approximately 10 ppm for hematotoxic effects of benzene in mice was indicated in a study by Rozen et al. (1985), which was selected as the key study by both the TCEQ (2015) in their derivation of an acute exposure limit (1 hour) of 580 µg/m^3, and by ATSDR (2024) in their derivation of an acute (1 to 14 day) exposure limit of 30 µg/m^3 (0.009 ppmv), both of which were used in this HHRA.

Health Canada (2021b) provides an IUR for benzene of 1.6 x 10^{-5} (µg/m^3)$^{-1}$. This value was derived based on the incidence of leukemia observed in human occupational studies (Rinsky et al., 1987; Paxton et al., 1994; Hayes et al., 1997). The IUR from Health Canada (2021b) was considered appropriate to evaluate long-term carcinogenic exposure risks to benzene within the current assessment.

7.4.1.2.4 Formaldehyde

Health Canada (2006a) established a 1-hour exposure limit for formaldehyde of 123 µg/m^3 and an 8-hour exposure limit of 50 µg/m^3. The 1-hour exposure limit recommended by Health Canada represents one fifth of the NOAEL for eye irritation in a human clinical study by Kulle (1993). The 8-hour exposure limit is the lower end of the exposure category associated with no significant increase of asthma hospitalization (Rumchev et al., 2002).

More recently, the TCEQ (2008) developed an acute (1-hour) exposure limit of 50 µg/m^3 for formaldehyde based on key inhalation studies on human volunteers by Pazdrak et al. (1993) and Krakowiak et al. (1998). The critical health effect in these studies was eye and nose irritation. The TCEQ (2008) 1-hour exposure limit was selected as the acute exposure limit in this HHRA and is considered protective of the eye irritation and asthma effects identified by Health Canada (2006a).

To derive a chronic exposure limit protective of non-carcinogenic health effects, the TCEQ (2008) relied on a key study by Wilhelmsson and Holmstrom (1992), who identified the specific critical effects of formaldehyde exposure in the key study as increased rates of symptoms such as eye, nasal, and lower airway discomfort (e.g., cough, wheezing) in a study of exposed workers. The TCEQ derived a chronic exposure limit of 11 µg/m^3, which is considered appropriate to assess the potential threshold effects of chronic exposure to formaldehyde.

With respect to carcinogenic effects, Health Canada (2006a) noted that carcinogenicity studies have reported an increased incidence of nasal cavity carcinomas at exposure levels greater than or equal to 6.7 mg/m^3 (6700 µg/m^3) but that no such tumours were observed at lower concentrations of up to 2.4 mg/m^3 (2400 µg/m^3) and therefore concluded that exposure limits protective of irritation and inflammatory responses will also be protective of potential carcinogenic effects. Therefore, the TCEQ (2008) chronic exposure limit of 11 µg/m^3 described above is considered protective of both non-carcinogenic and carcinogenic effects.

7.4.1.3 Diesel Particulate Matter

Diesel exhaust is a complex mixture of hundreds of chemicals including airborne particles and gases from the combustion products of diesel fuel (Health Canada, 2016b). The exact composition of the mixture is variable, and depends on the nature of the engine, operating conditions, fuel composition, emission control system, and additives (NTP, 2021).

Many of the individual components of diesel exhaust have been modelled individually and will be evaluated based on comparison to individual TRVs (e.g., PM_{10}, $PM_{2.5}$, NO_2, VOCs, and PAHs). The risk characterization presented in **Section 9** of this HHRA for each of these individual components of diesel exhaust provides a partial evaluation of potential risks associated with exposure to diesel exhaust (i.e., assessing toxicity of diesel exhaust via the toxicity of some of its components). However, a human health risk assessment for diesel exhaust that was completed by Health Canada in 2016 (Health Canada, 2016b) concluded that "the component or components of diesel exhaust that are the most relevant toxicologically…have not yet been identified" and that "[t]he most appropriate metric for diesel exhaust exposure remains unknown." Thus, an evaluation of the toxicity of diesel exhaust as a mixture, and DPM as a surrogate, is provided below.

Health Canada reviewed a number of studies on the health effects of exposure to diesel exhaust and diesel exhaust particles (synonymous with DPM for the purpose of this HHRA) ranging from rural farm, urban city, and occupational exposures (Health Canada, 2016b). Inhalation of diesel exhaust may result in a variety of health effects, in part due to the mixture of chemical hazards, where each chemical hazard may have different types of health effects and at different concentrations. Sensitive groups of people generally include children, asthmatics, and people with chronic obstructive pulmonary disease.

Acute inhalation of diesel exhaust shows a causal relationship with respiratory effects, and a likely relationship with cardiovascular and immunological effects. There is some evidence to suggest a relationship between exposure to diesel exhaust and reproductive, developmental, and central nervous system effects. However, long-term relationships are more difficult to distinguish due to the co-exposure to other airborne hazards in the air.

For non-cancer health effects, Health Canada (2016b) chose DPM as the basis for development of acute and chronic exposure guidance values as:

- toxicological studies have demonstrated DPM to be the main causative agent of many of the health effects associated with diesel exhaust exposure
- removal of the particulate component of diesel exhaust resulted in fewer or less severe health effects
- the DPM component of exhaust contains compounds known to be hazardous to human health, and DPM contributes to ambient PM, which is also known to be harmful to human health
- DPM is typically the parameter used to set experimental exposure levels

Health Canada (2016b) reviewed controlled human exposure studies to determine the critical effect associated with short-term exposure to diesel exhaust, and concluded that respiratory endpoints are the most sensitive, with effects demonstrated at lower concentrations than for other types of endpoints (such as cardiovascular health). Based on multiple studies conducted with healthy and/or mildly asthmatic participants, increased measures of airway resistance and/or respiratory inflammation were observed at 100 $\mu g/m^3$ diesel exhaust particulate for a 2-hour exposure period (Behndig, et al., 2006; Riedl, et al., 2012; Mudway, et al., 2004; Behndig, et al., 2011; Stenfors, et al., 2004). Based on this lowest-observed adverse effect level of 100 $\mu g/m^3$, Health Canada (2016b) derived a short-term exposure (2-hour) guidance value for diesel exhaust particulate of 10 $\mu g/m^3$. This Health Canada value was used as the TRV for non-carcinogenic effects due to short-term exposures in this HHRA.

For chronic exposure to diesel exhaust, a consistent exposure–response relationship for respiratory effects were observed in studies with animal test species, and epidemiological studies also indicate that respiratory health effects are associated with human exposures (Health Canada, 2016b). Health Canada (2016b) derived a chronic exposure limit using the NOAEL of 0.46 mg/m^3 diesel exhaust particulate from the inhalation study on rats by Ishinishi et al. (1986) by performing dosimetric modelling to derive a human equivalent concentration of 0.12 mg/m^3 diesel exhaust particulate. Based on the human equivalent concentration of 0.12 mg/m^3 diesel exhaust particulate and applying a composite uncertainty factor of 25, Health Canada derived a chronic exposure guidance value of 5 $\mu g/m^3$ diesel exhaust particulate. This value is consistent with values previously developed by the World Health Organization, the US EPA and the

California EPA, and was used as the TRV for non-carcinogenic effects due to chronic exposure to DPM in this HHRA.

In addition to the non-cancer health effects described above, the International Agency for Research on Cancer (IARC) has classified diesel exhaust as a Group 1 human carcinogen. The Group 1 classification indicates that there is sufficient evidence to conclude carcinogenicity in humans. Specifically, diesel exhaust has exhibited a causal relationship with lung cancer, and a suggested relationship with bladder cancer (Health Canada, 2016b; IARC, 2014). However, within their 2016 human health risk assessment for diesel exhaust, Health Canada (2016b) did not evaluate studies for use in a quantitative exposure–response analysis of lung cancer risk with diesel exhaust particulate.

Rather, Health Canada (2022a) provided a quantitative estimate of the risk of lung cancer associated with exposure to $PM_{2.5}$ in Canada that may be used to provide an estimate of the additional lung cancer mortality (ALCM) from DPM according to the following equation:

$$ALCM = \left[{(e^{\beta \cdot Exposure)} - 1)} \Big/ {e^{\beta \cdot Expsoure}} \right] \cdot Baseline\ rate\ \cdot years$$

Equation 7-1

where,

β	=	0.01196 (the slope coefficient for the relationship between the pooled hazard ratio for lung cancer mortality in the Canadian population (1.127 (95% CI: 1.085, 1.170)) per 10 µg/m^3 increase in long-term exposure to ambient $PM_{2.5}$ (Health Canada, 2022a)
Exposure	=	the predicted Project-related annual DPM concentration for each year of Project Construction and Operation
Baseline rate	=	45.5 per 100,000 (the 2021 Canadian age standardized mortality rate for lung cancer) (Health Canada, 2022a)
Years	=	Number of years evaluated

7.4.1.4 Polycyclic Aromatic Hydrocarbons

Polycyclic aromatic hydrocarbons (PAHs) are a class of organic compounds containing only carbon and hydrogen, where the carbon atoms form multiple aromatic rings. These compounds are ubiquitous in the environment and are formed by incomplete combustion of organic matter. Natural processes that produce PAHs include volcanic activity, forest fires, and lightning strikes. Additionally, PAHs are found naturally in fossil fuels such as oil and coal. Human activities including the combustion of fossil fuels, barbequing, flame cooking or smoking food, and tobacco smoking can also produce PAHs and release it into the air through the formation of smoke and soot. Some PAHs are associated with non-carcinogenic effects (e.g., anthracene) and some are associated with carcinogenic effects (e.g., benzo(a)pyrene).

7.4.1.4.1 Threshold (Non-carcinogenic) Effects of PAHs

Non-carcinogenic PAHs potentially emitted by Project-related activities and modelled as individual compounds include: acenaphthene, acenaphthylene, anthracene, fluoranthene, fluorene, and phenanthrene. In addition, benzo(a)pyrene has both threshold (non-carcinogenic) and carcinogenic effects per Health Canada (2021b). A discussion of the TRVs applied to evaluate these PAHs with non-carcinogenic effects is provided below.

For benzo(a)pyrene, the US EPA (2017) developed a chronic exposure limit for benzo(a)pyrene of 0.002 µg/m^3 for developmental toxicity. The key study was an inhalation study in rats exposed for four hours per day for 10 days during gestation that identified decreases in embryo/fetal survival as the critical effect (Archibong, et al., 2002). Health Canada (2021b) cited this TRV and it was used in this HHRA.

Inhalation exposure limits and TRVs were not available for the other non-carcinogenic PAHs modelled as individual compounds (i.e., acenaphthene, acenaphthylene, anthracene, fluoranthene, fluorene, and phenanthrene). However, a TRV representative of aromatic hydrocarbons ranging from C_9 to C_{16} (which would include the non-carcinogenic PAHs listed above) was identified by the Total Petroleum Hydrocarbon Criteria Working Group (TPHCWG) (1997). The TPHCWG (1997) acknowledges that data for this group of compounds is limited; however, of the available information, the TPHCWG (1997) selected an inhalation study using rats (Clark et al., 1989) as the key study to set a chronic RfC of 200 µg/m^3. This chronic RfC is based on a NOAEL of 900,000 µg/m^3 for increased liver and kidney weights in male rats. This NOAEL was adjusted to account for continuous exposure (rats were only exposed for 6 hours/day, 5 days/week for 1 year) and applied a 1,000 fold uncertainty factor (including an uncertainty factor of 10 to account for sensitive subpopulations, a factor of 10 to account for animal to human extrapolation, and a factor of 10 to account for converting a subchronic exposure to a chronic exposure). The chronic reference concentration of 200 µg/m^3 developed by the TPHCWG (1997) was used as the chronic TRV in this HHRA.

7.4.1.4.2 Non-Threshold (Carcinogenic) PAHs

Although there is strong evidence of carcinogenicity for several PAH compounds, benzo(a)pyrene is the compound that has been most reliably studied for carcinogenicity. The IARC classifies benzo(a)pyrene as a Group 1 human carcinogen. The Group 1 classification indicates that there is sufficient evidence to conclude carcinogenicity in humans. Studies on the carcinogenic potential of other PAHs in humans is less certain, and many other PAHs that are suspected carcinogens, such as benz(a)anthracene, are classified as Group 2B human carcinogens. Group 2B carcinogens are those that are considered possible human carcinogens based on limited evidence in human studies, or inadequate evidence in human studies but strong evidence in animal studies.

The mechanism of carcinogenicity among PAHs is believed to be similar. However, the carcinogenic potential differs between PAHs. Health Canada (2021b) recommends assessing exposures to mixtures of carcinogenic PAHs according to the relative potency factors approach, also known as potency equivalency factor approach, in which carcinogenic PAHs are adjusted for their carcinogenic potency relative to benzo(a)pyrene (B(a)P). Concentrations of each compound are multiplied by their relative potency factors and summed to give a B(a)P total potency equivalents (TPE), which represents the carcinogenic potency of the entire mixture. The following relative potency factors were used in this HHRA:

- Benz(a)anthracene = 0.1
- Benzo(a)pyrene = 1.0
- Benzo(b+k) fluoranthene = 0.1
- Benzo(g,h,i) perylene = 0.01
- Chrysene = 0.01
- Fluoranthene = 0.001
- Phenanthrene = 0.001

The final B(a)P TPE is then compared to the chronic carcinogenic exposure limit for B(a)P.

The US EPA (2017) developed a IUR for benzo(a)pyrene of 0.0006 $(\mu g/m^3)^{-1}$ based on a study by Thyssen et al. (1981). Thyssen et al. (1981) exposed groups of Syrian golden hamsters to benzo(a)pyrene in air. Exposure-related neoplasms were found in the nasal cavity, larynx, pharynx, esophagus, and forestomach. Health Canada (2021b) cited this IUR of 0.0006 $(\mu g/m^3)^{-1}$. Therefore, this IUR was selected as the TRV in this HHRA.

7.4.1.5 Metals and Minerals

7.4.1.5.1 Arsenic, Beryllium, Cadmium, Nickel

Health Canada (2021b) has provided inhalation unit risks for arsenic, beryllium, and cadmium based on lung cancer and for nickel based on lung, nasal, kidney, prostate, and buccal cavity cancers. Health Canada (2021b) also provided a chronic non-cancer tolerable concentration for beryllium (based on immunotoxicity and respiratory toxicity). These Health Canada (2021b) values were adopted as the TRVs for inhalation for these metals in this HHRA.

7.4.1.5.2 Crystalline Silica (Quartz)

Crystalline silica is mineral commonly found in the earth's crust. Acute and chronic exposures of humans to crystalline silica via inhalation have been associated with various respiratory effects ranging from respiratory irritation, cough, and shortness of breath to chronic bronchitis, emphysema, silicosis and lung cancer (OEHHA, 2005). An acute (24-hour) reference exposure level for crystalline silica (including quartz, cristobalite, tripoli, and tridymite) was published by TCEQ in 2020 based on pulmonary inflammation and cytotoxicity (TCEQ, 2020). This value was considered appropriate for assessing risk to human health based on acute exposure to crystalline silica via inhalation in this HHRA. In 2005, OEHHA released a chronic toxicity summary for respirable crystalline silica that is applicable to silicon dioxide, quartz, tridymite, and cristobalite. In this summary, OEHHA (2005) derived a chronic inhalation reference exposure level of 3 $\mu g/m^3$ of respirable crystalline silica based on silicosis as the critical effect. Although crystalline silica has been classified as a Class 1 known human carcinogen, no IUR has been identified for this parameter (OEHHA, 2005). The correlation between exposure to crystalline silica and silicosis is better understood than the correlation between exposure to crystalline silica and lung cancer, and there is evidence that silicosis can be a precursor to lung cancer following crystalline silica exposure (Sato at el., 2018). Therefore, in the absence of an applicable IUR, the OEHHA reference exposure level was considered appropriate for assessing risk to human health based on chronic exposure to crystalline silica (quartz) via inhalation in this HHRA.

7.4.2 Summary

The health-based inhalation exposure limits and TRVs applied in this HHRA are summarized in Table 7.1 and Table 7.2, respectively.

Table 7.1 Inhalation Exposure Limits for Criteria Air Contaminants

Chemical of Potential Concern	Exposure Period	Exposure Limit (µg/m^3)	Critical Effect	Reference
Nitrogen Dioxide (NO_2)	Acute (1-hour)	200	Respiratory effects	(WHO, 2021)
	Acute (24-hour)	25[a]	Mortality and respiratory effects	(WHO, 2021)
	Chronic (Annual)	10	Mortality	(WHO, 2021)
Particulate Matter (Coarse) (PM_{10})	Acute (24-hour)	45[a]	Mortality	(WHO, 2021)
	Chronic (Annual)	15	Mortality	(WHO, 2021)
Particulate Matter (Fine) ($PM_{2.5}$)	Acute (24-hour)	15[a]	Mortality	(WHO, 2021)
	Chronic (Annual)	5	Mortality	(WHO, 2021)

Notes

a. 99th percentile of the annual distribution of 24-hour average concentrations (equivalent to 3-4 exceedance days per year)

Table 7.2 Inhalation Toxicological Reference Values

Chemical of Potential Concern	Exposure Period	Non-Carcinogenic	Carcinogenic	Critical Effect	Reference
		Tolerable Concentration (TC) (µg/m³)	Inhalation Unit Risk (IUR) (µg/m³)⁻¹		
Volatile Organic Compounds					
1,3-Butadiene	Acute (1-hour)	660 µg/m³	-	Developmental effects	OEHHA (2013)
	Chronic (Annual)	2 µg/m³	-	Ovarian atrophy	US EPA (2002b)
	Chronic (Annual)	-	5.9×10^{-6} $(\mu g/m^3)^{-1}$	Leukemia	Health Canada (2024)
Acetaldehyde[a]	Acute (1-hour)	1420 µg/m³	-	Respiratory effects	Health Canada (2017a)
	Chronic (Annual)	280 µg/m³	-	Olfactory epithelial degeneration in the nasal cavity of rats	Health Canada (2017a)
Benzene	Acute (1-hour)	580 µg/m³	-	Blood toxicity (bone marrow depression)	TCEQ (2015)
	Acute (24-hour)	30 µg/m³	-	Blood toxicity (bone marrow depression)	ATSDR (2024)
	Chronic (Annual)	-	1.6×10^{-5} $(\mu g/m^3)^{-1}$	Leukemia	Health Canada (2021b)
Formaldehyde[a]	Acute (1-hour)	50 µg/m³	-	Eye and nose irritation	TCEQ (2008)
	Chronic (Annual)	11 µg/m³	-	Eye, nasal, and lower airway discomfort	TCEQ (2008)
Diesel Particulate Matter					
Diesel particulate matter	Acute (2-hour)	10 µg/m³	-	Respiratory effects	Health Canada (2016b)
	Chronic (Annual)	5 µg/m³	-	Respiratory effects	Health Canada (2016b)
	Chronic (Annual)	-	See **Equation 7-1**	Lung cancer mortality	Health Canada (2022a)

Chemical of Potential Concern	Exposure Period	Non-Carcinogenic	Carcinogenic	Critical Effect	Reference
		Tolerable Concentration (TC) (µg/m^3)	Inhalation Unit Risk (IUR) (µg/m^3)$^{-1}$		
PAHs					
Benzo(a)pyrene	Chronic (Annual)	0.002 µg/m^3	-	Developmental effects	Health Canada (2021b)
Aromatic C_9-C_{16}[b]	Chronic (Annual)	200 µg/m^3	-	Liver and kidney effects	TPHCWG (1997)
Benzo(a)pyrene TPE[c]	Chronic (Annual)	-	0.0006 (µg/m^3)$^{-1}$	Cancer (tumours of the upper gastrointestinal tract and upper respiratory tract)	Health Canada (2021b)
Metals and Minerals					
Arsenic	Chronic (Annual)	-	0.0064 (µg/m^3)$^{-1}$	Cancer (lung)	Health Canada (2021b)
Beryllium	Chronic (Annual)	0.02	-	Immunotoxicity and respiratory toxicity	Health Canada (2021b)
	Chronic (Annual)	-	0.0024 (µg/m^3)$^{-1}$	Cancer (lung)	Health Canada (2021b)
Cadmium	Chronic (Annual)	-	0.0042 (µg/m^3)$^{-1}$	Cancer (lung)	Health Canada (2021b)
Nickel	Chronic (Annual)	-	0.0013 (µg/m^3)$^{-1}$	Cancer (lung, nasal, kidney, prostate, buccal cavity)	Health Canada (2021b)
Crystalline silica (Quartz)[a]	Acute (24-hour)	24 µg/m^3	-	Respiratory inflammation	TCEQ (2020)
	Chronic (Annual)	3 µg/m^3	-	Silicosis	OEHHA (2005)

Notes:

a Non-carcinogenic tolerable concentration is also considered protective of carcinogenic effects for acetaldehyde, formaldehyde, and crystalline silica

b Sum of acenaphthene, acenaphthylene, anthracene, fluoranthene, fluorene, phenanthrene

c B(a)P total potency equivalents (TPE) calculated by summing concentrations of carcinogenic PAHs, adjusted by applying total potency equivalents (TPE)

\- indicates that no applicable TRV

8 Exposure Assessment

The objective of the exposure assessment is to estimate the concentrations of each CoPC to which the identified human receptors could be exposed. For airborne CoPCs, the exposure assessment includes the predicted CoPC concentrations in air within the LSA/RSA and the special receptor locations identified as representative of areas where people live, work, or otherwise spend time as summarized in **Section 5**. Additional details and results of this modelling are presented in Chapter 8 of the Impact Statement and Appendix H1 of the Impact Statement, the Air Quality Assessment.

As noted in **Section 5**, the locations evaluated in the air quality dispersion modelling that are pertinent to the HHRA include the modelled mine boundary, special receptor locations selected to represent places where people are more likely to be present outside the modelled mine boundary and exposed to emissions from the Project, and the worker camp where off-duty workers will be present inside the modelled mine boundary. As such, the exposure values used in the risk characterization are based on the maximum modelled air concentrations at the modelled mine boundary, special receptor locations, and the worker camp.

Consistent with Health Canada (2024), initial risk calculations assume an exposure term of 1, which implies that receptors are exposed continuously to media - 24 hours per day, 7 days per week, 52 weeks per year for an assumed lifetime of 80 years. No distinction was made between time spent indoors and time spent outdoors. This means that the CoPC concentrations in air estimated for each receptor location were assumed to be the same indoors and outdoors. This approach assumes that inhalation exposures to CoPC happens on a 24-hour per day basis and is not limited to the time a person spends outdoors. Receptors were assumed to be exposed to the exposure point concentrations (EPCs) for the appropriate exposure averaging periods (e.g., 1-hour, 24-hour, annual average) for each CoPC.

9 Risk Characterization

Inhalation exposure limits and TRVs applicable to the evaluation of Project-related effects on air quality were identified in **Section 7** and are summarized in **Table 7.1** and **Table 7.2**. These values include inhalation exposure limits (ELs) for criteria air contaminants with non-carcinogenic non-threshold effects as well as standard TRVs including TCs applicable to threshold effects and IURs applicable to carcinogenic effects. The quantitative risk characterization compares the estimated exposures to the CoPC for each of the receptors with the toxicity reference values as described below. As discussed in **Section 8**, receptors were assumed to be exposed to the exposure point concentrations (EPCs) for the appropriate exposure averaging periods (e.g., 1-hour, 24-hour, annual average) for each CoPC. Therefore, the 'fraction of time exposed' in the risk characterization formulas provided below was set to 1.0 unless otherwise noted.

For criteria air contaminants with non-carcinogenic, non-threshold effects, exposure ratios (ERs) were calculated as a ratio of the predicted air concentration to the ELs defined for those CoPCs in **Table 7.1** as shown in **Equation 9-1**. These ERs provide an indication of whether predicted air quality concentrations are greater than or less than the EL (i.e., ER>1.0 or ER<1.0). For criteria air contaminants with non-threshold modes of action, it is acknowledged that the ELs are not equivalent to TCs and therefore adverse effects to health may occur even when the ER is less than one.

Exposure Ratio (ER)	$$ER = \frac{Air\ Concentration\ (\mu g/m^3) \times Fraction\ of\ Time\ Exposed}{EL\ (\mu g/m^3)}$$	***Equation 9-1***

For CoPCs with threshold effects or carcinogenic effects (i.e., with TCs or IURs identified in Table 7.2), hazard quotients (HQs) and incremental lifetime cancer risks (ILCRs) were calculated using equations from Health Canada (2023a) (**Equation 9-2** and **Equation 9-3**).

Hazard Quotient (HQ)	$$HQ = \frac{Air\ Concentration\ (\mu g/m^3) \times Fraction\ of\ Time\ Exposed}{TC\ (\mu g/m^3)}$$	***Equation 9-2***
Incremental Lifetime Cancer Risk (ILCR)	$$ILCR = Air\ Concentration\ (\mu g/m^3) \times Fraction\ of\ Time\ Exposed \times IUR\ (\mu g/m^3)^{-1}$$	**Equation 9-3**

For chemicals with a threshold mode of action, Health Canada (2023a) considers a target HQ of 1.0 to be applicable if all potential exposure media and pathways are considered, including background exposure. Where an HHRA evaluates only project-related exposures (excluding background estimated daily intake for sources not related to the project), a target HQ of less than or equal to 0.2 is deemed negligible to compensate for the exposures not taken into consideration (Health Canada, 2023a). Health Canada (2023a) indicates that if the calculated HQ is greater than the applicable target (0.2 or 1.0, as described above), further consideration is warranted to either reduce uncertainty in the risk assessment or identify mitigation measures to reduce exposure to contaminants for which the applicable target HQ was exceeded.

For chemicals with a carcinogenic mode of action, Health Canada (2023a) indicates that only Project-related exposures are to be considered in the ILCR calculation. Health Canada (2024) considers an ILCR of less than one in one hundred thousand (1.0×10^{-5}) to be essentially negligible. Health Canada (2023a) indicates that further examination of the potential risk is recommended if the calculated ILCR is greater than 1×10^{-5}.

The first step in characterizing health risks from inhalation of CoPCs listed in **Table 5.3** or **Table 5.4** was calculating ERs, HQs, and ILCRs based on maximum air concentrations across the locations evaluated in air quality dispersion model that are relevant to the HHRA, as detailed in **Section 5**. These maximums may be located either along the modelled mine boundary or at the worker camp, depending on the CoPC and location of sources for that CoPC. Where risk estimates for the maximums are less than the target value for the Project + Background Scenario, health risks associated with inhalation exposures of these COPCs in the LSA are expected to be negligible as defined by Health Canada (2023a). However, further evaluation for COPCs with risk estimates greater than their applicable target was completed in order to meet the objective of the HHRA, which is to assess potential changes to human health to help determine whether additional mitigation measures are needed.

For CoPCs with maximum air concentrations greater than the applicable target, further assessment of risk focused on estimated health risks at the worker camp and six receptor locations located outside the modelled mine boundary considered representative of areas where people are most likely to be present (i.e., CC1, CC2, CC3, CC4, CC5, and P4 as described in Section 5). This second step included criteria air contaminants with non-threshold modes of action because adverse health effects may occur even when the ER is less than one.

In addition, in the absence of a defined IUR for DPM, the second step of risk characterization for the inhalation pathway includes an evaluation of the potential for cancer risks due to exposure to DPM using the formula described in **Equation 7-1**.

9.1 Construction Phase

9.1.1 Maximum ERs, HQs, and ILCRs

ERs, HQs, and ILCRs based on the maximum modelled air concentrations across all of the locations evaluated in the air quality dispersion modelling that are pertinent to the HHRA (i.e., the modelled mine boundary, the special receptor locations, and the worker camp) are presented in **Table 9.1, Table 9.2,** and **Table 9.3**.

Based on the data presented in these tables, a more detailed evaluation of the potential risk to human health due to inhalation of these following CoPCs during construction was required:

- Criteria air contaminants (PM10, PM2.5, NO2)
- DPM (to evaluate cancer risks using ALCM calculations as described in Section 7.4.1.3).

Table 9.1 Maximum Exposure Ratios for Criteria Air Contaminants During Construction

	Exposure Ratio (ER)[a,b]		
	Background	**Project Alone**	**Project + Background**
CAC			
Coarse particulate matter (PM_{10})			
24-hour	0.3	1.6 ■	1.9 ■
Annual	0.6	0.2	0.7
Fine particulate matter ($PM_{2.5}$)			
24-hour	1.0	0.7 ■	1.7 ■
Annual	1.2 ■	0.2	1.4 ■
Nitrogen Dioxide (NO_2)[c]			
1-hour	0.8	2.4 ■	3.1 ■
24-hour	4.0 ■	2.8 ■	6.8 ■
Annual	3.0 ■	1.4 ■	4.4 ■

NOTES

a. ERs greater than the applicable target (>1.0 if background concentration is provided and >0.2 in the absence of applicable background data) are indicated with an orange square (■).

b. For CO, PM_{10}, $PM_{2.5}$, and NO_2, the 24-hour exposure limit is based on the 99th percentile of the annual distribution of 24-hour average concentrations (equivalent to 3-4 exceedance days per year). In this table, the maximum 24-hour average air concentration over the modelled time period has been used to calculate ERs, which conservatively overestimates risk relative to the available exposure limits.

c. NO_2 concentrations modelled using the Ozone Limiting Method (OLM) following the MELCCFP Modelling Guideline. The OLM method accounts for the oxidation of NO to NO_2 due to photochemical reactions in the atmosphere in the presence of ozone. For further details see Chapter 8 of the Impact Statement and Appendix H1 of the Impact Statement, the Air Quality Assessment.

Table 9.2 Maximum Hazard Quotients During Construction

	Hazard Quotient (HQ) [a,b,c]		
	Background	Project Alone	Project + Background
Metals and Minerals			
Beryllium			
Annual	<0.1	<0.1	<0.1
Quartz (in PM_{10}/PM_4)			
24-hour	<0.1	0.4 ■	0.4
Annual	<0.1	0.1	0.1
Diesel Particulate Matter			
Diesel particulate matter			
2-hour	<0.1	0.7 ■	0.8
Annual	<0.1	<0.1	<0.1
PAHs			
Aromatic C9-C16[b]			
Annual	<0.1	<0.1	<0.1
Benzo(a)pyrene			
Annual	0.2	<0.1	0.2
VOC			
1,3-Butadiene			
1-hour	<0.1	<0.1	<0.1
Annual	0.1	<0.1	0.1
Acetaldehyde			
1-hour	ND	<0.1	<0.1
Annual	ND	<0.1	<0.1
Benzene			
1-hour	<0.1	<0.1	<0.1
24-hour	0.1	<0.1	0.1
Annual	<0.1	<0.1	<0.1
Formaldehyde			
1-hour	ND	<0.1	<0.1
Annual	ND	<0.1	<0.1

NOTES

a. All HQs shown are less than the applicable target (>1.0 if background concentration is provided and >0.2 in the absence of applicable background data). (■)

b. Sum of acenaphthene, acenaphthylene, anthracene, fluoranthene, fluorene, phenanthrene

HQs less than 0.1 were reported as "<0.1" to reflect their negligible contribution to overall risk.ND – No Data

Table 9.3 Incremental Lifetime Cancer Risk (ILCR) for CoPCs with Carcinogenic Effects based on Maximum Modelled Air Concentrations During Construction

	Project Alone
	Incremental Lifetime Cancer Risk (ILCR)[a]
Metals and Minerals	
Arsenic	4.8E-07
Beryllium	6.0E-08
Cadmium	3.5E-06
Nickel (in PM_{10})	9.6E-06
Diesel Particulate Matter	
Diesel particulate matter	NC[b]
PAHs	
Benzo(a)pyrene TPE[c]	2.8E-09
VOCs	
1,3-Butadiene	6.0E-10
Benzene	6.2E-08

NOTES

a. None of the calculated ILCRs were greater than the applicable target (>1.0 x 10^{-5}).

b. For diesel particulate matter, cancer risks will be evaluated using an additional lung cancer mortality (ALCM) calculation.

c. B(a)P total potency equivalents (TPE) calculated by summing concentrations of carcinogenic PAHs, adjusted by applying total potency equivalents (TPE).

NC – Not calculated

9.1.2 Further Evaluation of Criteria Air Contaminants

As described in **Section 7.4.1.1**, any increase in exposure to non-threshold contaminants may result in adverse health effects. However, the severity of effects increases incrementally with exposure concentration and exposure duration.

The exposure limits for these CoPCs identified in **Table 7.1** are WHO ambient air quality guidelines. According to WHO (2021), these guidelines represent the lowest level of exposure for which there is evidence of adverse health effects. It is assumed that adverse health effects do not occur or are minimal below this concentration level (WHO, 2021). As such, risks associated with a CAC during construction are minimal in areas where its Project + Background Scenario ERs are less than 1.0 as shown in **Table 9.1**. For criteria air contaminants and averaging periods for which the Project + Background Scenario ER presented in **Table 9.1** is greater than the applicable target, ERs at the individual locations pertinent to the HHRA (i.e., the modelled mine boundary, the special receptor locations, and the worker camp) are provided in **Table 9.4**. Further discussion of the potential for human health risks due to inhalation of Project-related emissions of these CoPCs is provided below.

Table 9.4 Exposure Ratios based on Maximum Predicted Ground Level Concentrations at Individual Locations During Construction for PM_{10}, $PM_{2.5}$, and NO_2

		Exposure Ratio (ER) [a,b]		
		Background	Project Alone	Project + Background
CAC				
Coarse particulate matter (PM_{10})				
24-hour	CC1	0.3	0.1	0.4
	CC2	0.3	0.2	0.4
	CC3	0.3	0.2	0.5
	CC4	0.3	0.2	0.5
	CC5	0.3	0.1	0.4
	P4	0.3	0.1	0.4
	Worker Camp	0.3	1.0 ■	1.2 ■
	Modelled Mine Boundary	0.3	1.0 ■	1.3 ■
Annual	CC1	0.6	<0.1	0.6
	CC2	0.6	<0.1	0.6
	CC3	0.6	<0.1	0.6
	CC4	0.6	<0.1	0.6
	CC5	0.6	<0.1	0.6
	P4	0.6	<0.1	0.6
	Worker Camp	0.6	<0.1	0.6
	Modelled Mine Boundary	0.6	0.2	0.7
Fine particulate matter ($PM_{2.5}$)				
24-hour	CC1	1.0	0.1	1.1 ■
	CC2	1.0	0.1	1.1 ■
	CC3	1.0	0.1	1.1 ■
	CC4	1.0	0.1	1.1 ■
	CC5	1.0	0.1	1.1 ■
	P4	1.0	<0.1	1.0
	Worker Camp	1.0	0.3 ■	1.3 ■
	Modelled Mine Boundary	1.0	0.4 ■	1.4 ■
Annual	CC1	1.2 ■	<0.1	1.2 ■
	CC2	1.2 ■	<0.1	1.3 ■
	CC3	1.2 ■	<0.1	1.3 ■
	CC4	1.2 ■	<0.1	1.3 ■
	CC5	1.2 ■	<0.1	1.2 ■
	P4	1.2 ■	<0.1	1.2 ■
	Worker Camp	1.2 ■	0.2	1.4 ■
	Modelled Mine Boundary	1.2 ■	0.1	1.3 ■

Table 9.4 Exposure Ratios based on Maximum Predicted Ground Level Concentrations at Individual Locations During Construction for PM_{10}, $PM_{2.5}$, and NO_2

		Exposure Ratio (ER) [a,b]		
		Background	Project Alone	Project + Background
Nitrogen Dioxide (NO_2)[c]				
1-hour	CC1	0.8	0.5 ■	1.2 ■
	CC2	0.8	0.6 ■	1.3 ■
	CC3	0.8	0.6 ■	1.3 ■
	CC4	0.8	0.6 ■	1.4 ■
	CC5	0.8	0.5 ■	1.2 ■
	P4	0.8	0.4 ■	1.2 ■
	Worker Camp	0.8	1.6 ■	2.3 ■
	Modelled Mine Boundary	0.8	2.4 ■	3.1 ■
24-hour	CC1	4.0 ■	0.3 ■	4.3 ■
	CC2	4.0 ■	0.4 ■	4.4 ■
	CC3	4.0 ■	0.4 ■	4.4 ■
	CC4	4.0 ■	0.4 ■	4.4 ■
	CC5	4.0 ■	0.3 ■	4.3 ■
	P4	4.0 ■	0.3 ■	4.3 ■
	Worker Camp	4.0 ■	2.5 ■	6.5 ■
	Modelled Mine Boundary	4.0 ■	1.5 ■	5.5 ■
Annual	CC1	3.0 ■	<0.1	3.0 ■
	CC2	3.0 ■	0.1	3.1 ■
	CC3	3.0 ■	0.1	3.1 ■
	CC4	3.0 ■	0.1	3.1 ■
	CC5	3.0 ■	<0.1	3.0 ■
	P4	3.0 ■	<0.1	3.0 ■
	Worker Camp	3.0 ■	1.4 ■	4.4 ■
	Modelled Mine Boundary	3.0 ■	0.8 ■	3.8 ■

NOTES

a. ERs (Exposure Ratios) greater than the applicable target (>1.0) are indicated with an orange square (■).

b. For PM_{10}, $PM_{2.5}$, and NO_2, the 24-hour exposure limit is based on the 99th percentile of the annual distribution of 24-hour average concentrations (equivalent to 3–4 exceedance days per year). In this table, the ERs for these CoPCs (Contaminants of Potential Concern) for the 24-hour period are based on the 99th percentile of the annual distribution of 24-hour average concentrations at the location with the maximum predicted ground-level concentrations for that CoPC.

c. NO_2 concentrations were modeled using the Ozone Limited Method (OLM) following the MELCCFP Modelling Guideline. The OLM method accounts for the oxidation of NO to NO_2 due to photochemical reactions in the atmosphere in the presence of ozone. For further details, see Appendix H1 of the Impact Statement, the Air Quality Assessment.

9.1.2.1 Particulate Matter (PM_{10} and $PM_{2.5}$)

Of these two types of particulate matter, PM_{10} refers to particles with a diameter of 10 µm (micrometres) or less while $PM_{2.5}$ refers to particles with a diameter of 2.5 µm or less. When inhaled, larger particles are trapped in the upper respiratory system while smaller particle sizes ($PM_{2.5}$) can penetrate deeper into the respiratory system and into the alveoli of the lungs. As such, the data that support an evaluation of health effects from PM_{10} are weaker than for $PM_{2.5}$ and subject to larger measurement errors (Health Canada, 2016a). Additionally, although WHO (2021) provides air quality guidelines for PM_{10}, their guidance notes that in all situations where both $PM_{2.5}$ and PM_{10} measurements are available, preference should be given to the $PM_{2.5}$ air quality guideline level. Therefore, further discussion herein focuses on the ERs calculated at special receptor locations and the worker camp for $PM_{2.5}$ specifically.

Background Scenario ERs for $PM_{2.5}$ are equal to or greater than the applicable target of 1.0. When this occurs, the potential for Project activities to affect human health are better represented by the ERs for the Project Alone Scenario. From Health Canada (2023a):

> “Where an HHRA evaluates only project-related exposures (excluding background estimated daily intake for sources not related to the project, including consumer products, food, air, and water), a target HQ of less than or equal to 0.2 will be deemed negligible to compensate for the exposures not taken into consideration.”

The Project Alone ERs greater than the target of 0.2 were limited to 24-hour exposures to $PM_{2.5}$ at the modelled mine boundary and the worker camp. The calculated risk values at the modeled mine boundary are intended for illustrative purposes only. This is because the location is not expected to be used for activities that would result in meaningful exposure (such as overnight stays, accommodation, hunting/fishing, harvesting, recreating). An ER of 0.3 was calculated at the worker camp, where Off-Duty Workers are expected to spend time.

Because $PM_{2.5}$ has a non-threshold mode of action, any level of exposure carries some degree of risk. As described in Appendix H1 of the Impact Statement (the Air Quality Assessment), mitigation measures have been proposed to reduce potential air emissions during construction (and operation) and both a dust management plan (of which $PM_{2.5}$ is a component) and an air quality follow-up monitoring program plan (AQFMP) will be developed for the Project. The proposed mitigation, management, and monitoring programs are expected to reduce particulate matter emissions from the Project to less than the modelled concentrations, which would further reduce potential risks to human health.

9.1.2.2 Nitrogen Dioxide (NO_2)

As shown in **Table 9.4,** ERs for the Project + Background Scenario during construction for NO_2 were greater than 1.0 for the 1-hour, 24-hour, and annual averaging periods at the modelled mine boundary, the special receptor locations, and the worker camp. As shown in **Table 9.4,** the largest contributor to the Project + Background Scenario ERs for NO_2 during construction was consistently the ‘background’ component, with the Project Alone Scenario contributing proportionally less to the cumulative total as the exposure duration increases from 1-hour to annual.

The critical effect for the 1-hour exposure limit of NO_2 is respiratory effects, such as worsening of asthma, but reversible with treatment. At the special receptor locations frequented by Indigenous Receptors and Recreational Receptors, 1-hour NO_2 ERs for the Project + Background Scenario range from 1.2 to 1.4, slightly greater than the target of 1.0. These risks are primarily driven by assumed background concentrations, as no site-specific monitoring data are available. Given the modest magnitude of risk estimates, it is expected that actual 1-hour concentrations would only occasionally be higher than the health-based guideline at these special receptor locations. By contrast, the 1-hour NO_2 ER at the worker camp is 2.3, suggesting that Off-Duty Workers are at greater risk for short-term exposure to NO_2 concentrations greater than health-based limits.

The critical effect for the 24-hour exposure limit of NO_2 is respiratory effects with possible mortality (e.g., respiratory distress that may not be reversible with treatment), and for chronic annual exposure, the critical effect is mortality (long-term respiratory distress that is not reversible). Background Scenario ERs for 24-hour and annual average NO_2 are greater than the applicable target of 1.0. As noted previously in the discussion of PM, when this occurs, the potential for Project activities to affect human health are better represented by the ERs for the Project Alone Scenario. At the special receptor locations where Indigenous Receptors and Recreational Receptors are expected to spend time, the ERs associated 24-hour exposures to NO_2 for the Project Alone Scenario are greater than the target of 0.2, but the ERs associated with annual average exposures are less than the target of 0.2. It is noted by the WHO (2021) that when the long-term exposures are compliant with the long-term guideline, days with concentrations approaching or greater than the 24-hour guideline will correspond to the far upper tail of the distribution of daily exposures and most days will have much lower values, with close to half having concentrations below or far below the annual exposure limit. The health burden related to a few days with higher concentrations corresponds to a very small fraction of the total pollution related burden (WHO, 2021).

The long-term (annual average) Project Alone ERs greater than the target of 0.2 were limited to the modelled mine boundary and the worker camp. The calculated risk values at the modeled mine boundary are intended for illustrative purposes only. This is because the location is not expected to be used for activities that would result in meaningful exposure (such as overnight stays, accommodation, hunting/fishing, harvesting, recreating). A Project Alone ER for annual exposure of NO_2 of 1.4 was calculated at the worker camp, where people Off-Duty Workers are expected to spend time.

As described in Appendix H1 of the Impact Statement (the Air Quality Assessment), mitigation measures have been proposed to reduce potential air emissions during construction (and operation) and an AQFMP will be developed for the Project. The proposed mitigation, management, and monitoring programs are expected to reduce NO_2 emissions from the Project to less than the modelled concentrations, which would reduce potential risks to human health.

9.1.3 Further Evaluation of Diesel Particulate Matter (DPM)

The ERs based on non-cancer tolerable concentrations for DPM were less than the applicable target value of 1.0 for both acute and chronic exposure at the modelled mine boundary and the worker camp during construction (**Table 9.2**). However, as discussed in **Section 7.4.1.3**, IARC has classified diesel exhaust as a Group 1 human carcinogen. Specifically, diesel exhaust has exhibited a causal relationship with lung cancer, and a suggested relationship with bladder cancer (Health Canada, 2016b; IARC, 2014).

Within their human health risk assessment for diesel exhaust, Health Canada (2016b) did not evaluate studies for use in a quantitative exposure–response analysis of lung cancer risk for diesel exhaust and did not derive an ILCR. Similarly, when the US EPA reviewed the available data on this topic in 2002, they concluded that the uncertainties in the human exposure-response data for diesel exhaust were too large to derive a quantitative estimate of cancer unit risk with any degree of confidence (US EPA, 2002a). However, more recently, Health Canada (2022a) provided a quantitative estimate of the risk of lung cancer associated with exposure to $PM_{2.5}$ in Canada that may be used to provide an estimate of the ALCM from diesel exhaust using DPM as a surrogate according to **Equation 7-1** as reported in **Section 7.4.1.3**.

Applying **Equation 7-1** to the maximum predicted annual DPM concentrations at the modelled mine boundary, the special receptor locations, and the worker camp for the Project Alone Scenario for the three-year construction period results in ALCM values ranging from 0.0046 to 0.21 per 100,000 population (**Table 9.5**). Although Health Canada (2022a) did not provide a target ALCM that would be considered to represent a negligible level of risk, these predicted ALCM values are lower than the ILCR value of one in one hundred thousand (1×10^{-5}) considered to represent a negligible cancer risk by Health Canada (2024). Overall, this suggests risks due to exposure to DPM from the Project via inhalation during Project construction are expected to be negligible. Further consideration of the potential for additive cancer risk over all phases of the Project (construction, operation, and decommissioning) is provided in **Section 9.2**, below**.** As noted previously, the calculated risk values at the modeled mine boundary are intended for illustrative purposes only. This is because the location is not expected to be used for activities that would result in meaningful exposure (such as overnight stays, accommodation, hunting/fishing expectation, harvesting, recreating).

Table 9.5 Additional Lung Cancer Mortality (ALCM) from Diesel Exhaust using Diesel Particulate Matter (DPM) as a Surrogate During Construction

		Project Alone DPM Concentration (Annual) (µg/m³)	ALCM (per 100,000)
Diesel Particulate Matter (DPM)			
	CC1	2.9E-03	4.7E-03
	CC2	7.4E-03	1.2E-02
	CC3	6.0E-03	9.8E-03
	CC4	7.9E-03	1.3E-02
	CC5	3.0E-03	4.9E-03
	P4	2.8E-03	4.6E-03
	Worker Camp	1.3E-01	2.1E-01
	Modelled Mine Boundary	7.2E-02	1.2E-01

9.2 Operations Phase

9.2.1 Maximum ERs, HQs, and ILCRs

ERs, HQs, and ILCRs based on the maximum modelled air concentrations across all of the locations evaluated in the air quality dispersion modelling that are pertinent to the HHRA (i.e., the modelled mine boundary, the special receptor locations, and the worker camp) are presented in **Table 9.6**, **Table 9.7** and **Table 9.8**.

Based on the data presented in these tables, a more detailed evaluation of the potential risk to human health due to inhalation of these following CoPCs during operation was required:

- Criteria air contaminants (PM10, PM2.5, NO2)

- DPM (to evaluate cancer risks using ALCM calculations as described in Section 7.4.1.3).

Table 9.6 Maximum Exposure Ratios for Criteria Air Contaminants During Operation

	Exposure Ratio (ER)[a,b]		
	Background	Project Alone	Project + Background
CAC			
Coarse particulate matter (PM_{10})			
24-hour	0.3	3.0 ■	3.3 ■
Annual	0.6	0.6 ■	1.2 ■
Fine particulate matter ($PM_{2.5}$)			
24-hour	1.0	1.3 ■	2.3 ■
Annual	1.2	0.5 ■	1.7 ■
Nitrogen Dioxide (NO_2)			
1-hour	0.8	3.3 ■	4.1 ■
24-hour	4.0 ■	3.2 ■	7.2 ■
Annual	3.0 ■	1.0 ■	4.0 ■

NOTES

a. ERs greater than the applicable target (>1.0 if background concentration is provided and >0.2 in the absence of applicable background data) are indicated with an orange square (■).

b. For PM_{10}, $PM_{2.5}$, and NO_2, the 24-hour exposure limit is based on the 99^{th} percentile of the annual distribution of 24-hour average concentrations (equivalent to 3-4 exceedance days per year). In this table, the maximum 24-hour average air concentration over the modelled time period has been used to calculate ERs, which conservatively overestimates risk relative to the available exposure limits.

c. NO_2 concentrations modelled using the Ozone Limiting Method (OLM) following the MELCCFP Modelling Guideline. The OLM method accounts for the oxidation of NO to NO_2 due to photochemical reactions in the atmosphere in the presence of ozone. For further details see Appendix H1 of the Impact Statement, the Air Quality Assessment.

Table 9.7 Maximum Hazard Quotients During Operation

	Hazard Quotient (HQ) [a,b,c]		
	Background	Project Alone	Project + Background
Metals and Minerals			
Beryllium			
Annual	<0.1	<0.1	<0.1
Quartz (in PM10/PM4)			
24-hour	<0.1	0.6	0.6
Annual	<0.1	0.4	0.4
Diesel Particulate Matter			
Diesel particulate matter			
2-hour	<0.1	1.0 ■	1.1 ■
Annual	<0.1	<0.1	<0.1
PAHs			
Aromatic C9-C16[b]			
Annual	<0.1	<0.1	<0.1
Benzo(a)pyrene			
Annual	0.2	<0.1	0.2
VOC			
1,3-Butadiene			
1-hour	<0.1	<0.1	<0.1
Annual	0.1	<0.1	0.1
Acetaldehyde			
1-hour	ND	<0.1	<0.1
Annual	ND	<0.1	<0.1
Benzene			
1-hour	<0.1	<0.1	<0.1
24-hour	0.1	<0.1	0.1
Annual	<0.1	<0.1	<0.1
Formaldehyde			
1-hour	ND	<0.1	<0.1
Annual	ND	<0.1	<0.1

NOTES

a. HQs greater than the applicable target (>1.0if background concentration is provided and >0.2 in the absence of applicable background data) are indicated with an orange square (■).

b. Sum of acenaphthene, acenaphthylene, anthracene, fluoranthene, fluorene, phenanthrene

c. HQs less than 0.1 were reported as "<0.1" to reflect their negligible contribution to overall risk.

ND – No Data

Table 9.8 Maximum ILCRs During Operation

	Project Alone Incremental Lifetime Cancer Risk (ILCR)[a]
Metals and Minerals	
Arsenic	5.4E-06
Beryllium	8.1E-08
Cadmium	2.6E-07
Nickel (in PM_{10})	6.6E-07
Diesel Particulate Matter	
Diesel particulate matter	NC[b]
PAHs	
Benzo(a)pyrene TPE[c]	6.9E-10
VOCs	
1,3-Butadiene	8.8E-10
Benzene	8.0E-08

NOTES

a. None of the calculated ILCRs were greater than the applicable target (>1.0 x 10^{-5}).

b. For diesel particulate matter, cancer risks will be evaluated using an additional lung cancer mortality (ALCM) calculation

c. B(a)P total potency equivalents (TPE) calculated by summing concentrations of carcinogenic PAHs, adjusted by applying total potency equivalents (TPE)

NC – Not calculated

9.2.2 Further Evaluation of Criteria Air Contaminants

As described in **Section 7.4.1.1**, any increase in exposure to non-threshold contaminants may result in adverse health effects. However, the severity of effects increases incrementally with exposure concentration and exposure duration.

The exposure limits for these CoPCs identified in **Table 7.1** are WHO ambient air quality guidelines. According to WHO (2021), these guidelines represent the lowest level of exposure for which there is evidence of adverse health effects. It is assumed that adverse health effects do not occur or are minimal below this concentration level (WHO, 2021). Therefore, adverse health effects are also considered to be minimal below this concentration level.

As such, risks associated with a CAC during operation are minimal in areas where its Project + Background Scenario ERs are less than 1.0 as shown in **Table 9.6.** For criteria air contaminants and averaging periods for which the Project + Background Scenario ER presented in **Table 9.6** is greater than the applicable target, ERs at the individual locations pertinent to the HHRA as described in **Section 5** (i.e., the modelled mine boundary, the special receptor locations, and the worker camp) are provided in **Table 9.9.** Further discussion of the potential for human health risks due to inhalation of Project-related emissions of these CoPCs is provided below.

Table 9.9 Exposure Ratios based on Maximum Predicted Ground Level Concentrations at Individual Locations During Operation for PM_{10}, $PM_{2.5}$, and NO_2

		Exposure Ratio (ER) [a,b]		
		Background	**Project Alone**	**Project + Background**
CAC				
Coarse particulate matter (PM_{10})				
24-hour	CC1	0.3	0.2	0.5
	CC2	0.3	0.2	0.5
	CC3	0.3	0.4 ■	0.7
	CC4	0.3	0.5 ■	0.8
	CC5	0.3	0.2	0.5
	P4	0.3	0.2	0.5
	Worker Camp	0.3	1.9 ■	2.2 ■
	Modelled Mine Boundary	0.3	2.4 ■	2.6 ■
Annual	CC1	0.6	<0.1	0.6
	CC2	0.6	<0.1	0.6
	CC3	0.6	<0.1	0.6
	CC4	0.6	0.1	0.6
	CC5	0.6	<0.1	0.6
	P4	0.6	<0.1	0.6
	Worker Camp	0.6	0.6 ■	1.2 ■
	Modelled Mine Boundary	0.6	0.4 ■	1.0
Fine particulate matter ($PM_{2.5}$)				
24-hour	CC1	1.0	0.1	1.1 ■
	CC2	1.0	0.1	1.1 ■
	CC3	1.0	0.2	1.2 ■
	CC4	1.0	0.2	1.2 ■
	CC5	1.0	0.1	1.1 ■
	P4	1.0	0.1	1.1 ■
	Worker Camp	1.0	0.8 ■	1.8 ■
	Modelled Mine Boundary	1.0	1.1 ■	2.1 ■
Annual	CC1	1.2	<0.1	1.3 ■
	CC2	1.2	<0.1	1.3 ■
	CC3	1.2	<0.1	1.3 ■
	CC4	1.2	<0.1	1.3 ■
	CC5	1.2	<0.1	1.3 ■
	P4	1.2	<0.1	1.3 ■
	Worker Camp	1.2	0.5 ■	1.7 ■
	Modelled Mine Boundary	1.2	0.2	1.4 ■

Table 9.9 Exposure Ratios based on Maximum Predicted Ground Level Concentrations at Individual Locations During Operation for PM_{10}, $PM_{2.5}$, and NO_2

		Exposure Ratio (ER) [a,b]		
		Background	Project Alone	Project + Background
Nitrogen Dioxide (NO_2)[c]				
1-hour	CC1	0.8	1.2 ■	1.9 ■
	CC2	0.8	0.7 ■	1.4 ■
	CC3	0.8	1.1 ■	1.8 ■
	CC4	0.8	1.2 ■	2.0 ■
	CC5	0.8	1.2 ■	1.9 ■
	P4	0.8	1.0 ■	1.8 ■
	Worker Camp	0.8	1.2 ■	2.0 ■
	Modelled Mine Boundary	0.8	3.3 ■	4.1 ■
24-hour	CC1	4.0 ■	0.3 ■	4.3 ■
	CC2	4.0 ■	0.3 ■	4.3 ■
	CC3	4.0 ■	0.4 ■	4.4 ■
	CC4	4.0 ■	0.6 ■	4.6 ■
	CC5	4.0 ■	0.3 ■	4.3 ■
	P4	4.0 ■	0.3 ■	4.3 ■
	Worker Camp	4.0 ■	1.6 ■	5.6 ■
	Modelled Mine Boundary	4.0 ■	2.4 ■	6.4 ■
Annual	CC1	3.0 ■	<0.1	3.0 ■
	CC2	3.0 ■	0.1	3.1 ■
	CC3	3.0 ■	0.1	3.1 ■
	CC4	3.0 ■	0.1	3.1 ■
	CC5	3.0 ■	<0.1	3.0 ■
	P4	3.0 ■	<0.1	3.0 ■
	Worker Camp	3.0	1.0 ■	4.0 ■
	Modelled Mine Boundary	3.0 ■	0.9 ■	3.9 ■

NOTES

a. ERs greater than the applicable target (>1.0 if background concentration is provided and >0.2 in the absence of applicable background data) are indicated with an orange square (■).

b. For PM_{10}, $PM_{2.5}$, and NO_2, the 24-hour exposure limit is based on the 99th percentile of the annual distribution of 24-hour average concentrations (equivalent to 3-4 exceedance days per year). In this table, the ERs for these CoPCs for the 24-hour period are based on the 99th percentile of the annual distribution of 24-hour average concentrations at the location with the maximum predicted ground level concentrations for that CoPC.

c. NO_2 concentrations modelled using the Ozone Limiting Method (OLM) following the MELCCFP Modelling Guideline. The OLM method accounts for the oxidation of NO to NO_2 due to photochemical reactions in the atmosphere in the presence of ozone. For further details see Appendix H1 of the Impact Statement, the Air Quality Assessment.

9.2.2.1 Particulate Matter (PM_{10} and $PM_{2.5}$)

Of these two types of particulate matter, PM_{10} refers to particles with a diameter of 10 µm (micrometres) or less while $PM_{2.5}$ refers to particles with a diameter of 2.5 µm or less. When inhaled, larger particles are trapped in the upper respiratory system while smaller particle sizes ($PM_{2.5}$) can penetrate deeper into the respiratory system and into the alveoli of the lungs. As such, the data that support an evaluation of health effects from PM_{10} are weaker than for $PM_{2.5}$ and subject to larger measurement errors (Health Canada, 2016a). Additionally, although WHO (2021) provides air quality guidelines for PM_{10}, their guidance notes that in all situations where both $PM_{2.5}$ and PM_{10} measurements are available, preference should be given to the $PM_{2.5}$ air quality guideline level. Therefore, further discussion herein focuses on the ERs calculated at special receptor locations and the worker camp for $PM_{2.5}$ specifically.

Background Scenario ERs for $PM_{2.5}$ are equal to or greater than the applicable target of 1.0. When this occurs, the potential for Project activities to affect human health are better represented by the ERs for the Project Alone. From Health Canada (2023a):

> "Where an HHRA evaluates only project-related exposures (excluding background estimated daily intake for sources not related to the project, including consumer products, food, air, and water), a target HQ of less than or equal to 0.2 will be deemed negligible to compensate for the exposures not taken into consideration."

The ERs associated 24-hour and annual average exposures to $PM_{2.5}$ for the Project Alone are less than the target of 0.2 at the special receptor locations where Indigenous Receptors and Recreational Receptors are expected to spend time. The Project Alone ERs greater than the target of 0.2 were limited to 24-hour exposures to $PM_{2.5}$ at the modelled mine boundary and 24-hour and annual average exposures at the worker camp. The calculated risk values at the modeled mine boundary are intended for illustrative purposes only. This is because the location is not expected to be used for activities that would result in meaningful exposure (such as overnight stays, accommodation, hunting/fishing, harvesting, recreating). An ERs of 0.8 (24-hour) and 0.5 (annual average) were calculated at the worker camp, where Off-Duty Workers are expected to spend time.

Because $PM_{2.5}$ has a non-threshold mode of action, any level of exposure carries some degree of risk. As described in Appendix H1 of the Impact Statement (the Air Quality Assessment), mitigation measures have been proposed to reduce potential air emissions during construction (and operation) and both a dust management plan (of which $PM_{2.5}$ is a component) and an air quality follow-up monitoring program plan (AQFMP) will be developed for the Project. The proposed mitigation, management, and monitoring programs are expected to reduce particulate matter emissions from the Project to less than the modelled concentrations, which would further reduce potential risks to human health.

9.2.2.2 Nitrogen Dioxide (NO_2)

As shown in **Table 9.9** ERs for the Project + Background Scenario during construction for NO_2 were greater than 1.0 for the 1-hour, 24-hour, and annual averaging periods at the modelled mine boundary, the special receptor locations, and the worker camp. As shown in **Table 9.9** the largest contributor to the Project + Background Scenario ERs for NO_2 during operation was generally the 'background' component, with the Project Alone Scenario contributing proportionally less to the cumulative total as the exposure duration increases from 24-hour to annual.

The critical effect for the 1-hour exposure limit of NO_2 is respiratory effects, such as worsening of asthma, but reversible with treatment. At the special receptor locations frequented by Indigenous Receptors and Recreational Receptors, 1-hour NO_2 ERs for the Project + Background Scenario range from 1.4 to 2.0. These risks are almost equally split between assumed background concentrations, as no site-specific monitoring data are available, and Project alone contributions. The 1-hour NO_2 ER at the worker camp is 2.0, suggesting that Off-Duty Worker risks are similar to that at the special receptor locations.

The critical effect for the 24-hour exposure limit of NO_2 is respiratory effects with possible mortality (e.g., respiratory distress that may not be reversible with treatment), and for chronic annual exposure, the critical effect is mortality (long-term respiratory distress that is not reversible). Background Scenario ERs for 24-hour and annual average NO_2 are greater than the applicable target of 1.0. As noted previously in the discussion of PM, when this occurs, the potential for Project activities to affect human health are better represented by the ERs for the Project Alone Scenario. At the special receptor locations where Indigenous Receptors and Recreational Receptors are expected to spend time, the ERs associated 24-hour exposures to NO_2 for the Project Alone Scenario are greater than the target of 0.2, but the ERs associated with annual average exposures are less than the target of 0.2. It is noted by the WHO (2021) that when the long-term exposures are compliant with the long-term guideline, days with concentrations approaching or greater than the 24-hour guideline will correspond to the far upper tail of the distribution of daily exposures and most days will have much lower values, with close to half having concentrations below or far below the annual exposure limit. The health burden related to a few days with higher concentrations corresponds to a very small fraction of the total pollution related burden (WHO, 2021).

The long-term (annual average) Project Alone ERs greater than the target of 0.2 were limited to the modelled mine boundary and the worker camp. The calculated risk values at the modeled mine boundary are intended for illustrative purposes only. This is because the location is not expected to be used for activities that would result in meaningful exposure (such as overnight stays, accommodation, hunting/fishing, harvesting, recreating). A Project Alone ER for annual exposure of NO_2 of 1.0 was calculated at the worker camp, where people Off-Duty Workers are expected to spend time.

As described in Appendix H1 of the Impact Statement (the Air Quality Assessment), mitigation measures have been proposed to reduce potential air emissions during construction (and operation) and an AQFMP will be developed for the Project. The proposed mitigation, management, and monitoring programs are expected to reduce NO_2 emissions from the Project to less than the modelled concentrations, which would reduce potential risks to human health.

9.2.3 Further Evaluation of Diesel Particulate Matter (DPM)

The ER based on non-cancer tolerable concentrations for DPM was greater than the applicable target value of 1.0 for acute exposure at the modelled mine boundary; however, the ERs for this CoPC and averaging period were less than 1.0 at the special receptor locations and the worker camp (see **Table 9.10**). Additionally, ERs for DPM were less than 1.0 for chronic exposure at the modelled mine boundary, special receptor locations, and worker camp (see **Table 9.10**). Therefore, non-cancer risks due to exposure to DPM are acceptable for people spending time in the LSA/RSA and off-duty workers.

With respect to cancer risks, as described in **Section 7.4.1.3**, diesel exhaust is recognized as a Group 1 human carcinogen with an identified causal relationship with lung cancer, and a suggested relationship with bladder cancer (Health Canada, 2016b; IARC, 2014). Therefore, further evaluation of diesel exhaust carcinogenicity was carried out using **Equation 7-1**.

Applying **Equation 7-1** to the maximum predicted annual DPM concentrations at the modelled mine boundary, the special receptor locations, and the worker camp for the Project Alone Scenario for the 22 year operation period results in ALCM values ranging from 0.038 to 0.96 per 100,000 population (**Table 9.11**). Although Health Canada (2022a) did not provide a target ALCM that would be considered to represent a negligible level of risk, these predicted ALCM values are lower than the ILCR value of one in one hundred thousand (1×10^{-5}) considered to represent a negligible cancer risk by Health Canada (2024). Overall, this suggests that there will be no unacceptable human health risks due to exposure to DPM from the Project via inhalation during Project operation.

Furthermore, to account for cancer risk over the Project lifetime due to inhalation of DPM from the Project, the ALCM for the construction phase can be summed with the ALCM for the operation phase, as well as an ALCM calculated for the active decommissioning phase. The results of this analysis, based on the maximum modelled DPM concentrations at the modelled mine boundary, the special receptor locations, and the worker camp for the Project Alone Scenario are summarized in **Table 9.12**. As shown in **Table 9.12**, this results in total Project lifecycle ALCMs ranging from 0.05 to 0.16 per 100,000 at the special receptor locations, an ALCM of 1.2 per 100,000 population at the modelled mine boundary, and an ALCM of 1.5 per 100,000 population at the worker camp.

Although Health Canada (2022a) did not provide a target ALCM that would be considered to represent a negligible level of risk, these predicted ALCM values are lower than or similar to the ILCR value of one in one hundred thousand (1×10^{-5}) considered to represent a negligible cancer risk by Health Canada (2024). Overall, this suggests risks due to exposure to DPM from the Project via inhalation during Project construction are expected to be negligible. As noted previously, the calculated risk values at the modeled mine boundary are intended for illustrative purposes only. This is because the location is not expected to be used for activities that would result in meaningful exposure (such as overnight stays, accommodation, hunting/fishing expectation, harvesting, recreating).

Table 9.10 Exposure Ratios based on Maximum Predicted Ground Level Concentrations at Individual Special Receptor Locations During Operation for DPM

		Exposure Ratio (ER) [a,b]			
		Background	Project Alone	Project + Background	
CAC					
Diesel particulate matter (DPM)					
2-hour	CC1	<0.1	0.3	0.3	
	CC2	<0.1	0.1	0.2	
	CC3	<0.1	0.2	0.3	
	CC4	<0.1	0.3	0.3	
	CC5	<0.1	0.3	0.3	
	P4	<0.1	0.2	0.3	
	Worker Camp	<0.1	0.2	0.2	
	Modelled Mine Boundary	<0.1	1.0	1.1	■
Annual	CC1	<0.1	<0.1	<0.1	
	CC2	<0.1	<0.1	<0.1	
	CC3	<0.1	<0.1	<0.1	
	CC4	<0.1	<0.1	<0.1	
	CC5	<0.1	<0.1	<0.1	
	P4	<0.1	<0.1	<0.1	
	Worker Camp	<0.1	<0.1	<0.1	
	Modelled Mine Boundary	<0.1	<0.1	<0.1	

NOTES

a. ERs greater than the applicable target (>1.0 if background concentration is provided and >0.2 in the absence of applicable background data) are indicated with an orange square (■).

Table 9.11 Additional Lung Cancer Mortality (ALCM) from Diesel Exhaust using Diesel Particulate Matter (DPM) as a Surrogate During Operation

		Project Alone DPM Concentration (Annual) (µg/m³)	ALCM (per 100,000 population)
Diesel Particulate Matter (DPM)			
	CC1	3.4E-03	4.1E-02
	CC2	6.7E-03	8.1E-02
	CC3	7.7E-03	9.2E-02
	CC4	1.1E-02	1.3E-01
	CC5	3.4E-03	4.1E-02
	P4	3.2E-03	3.8E-02
	Worker Camp	8.0E-02	9.6E-01
	Modelled Mine Boundary	7.8E-02	9.3E-01

Table 9.12 *Additional Lung Cancer Mortality (ALCM) due to Inhalation of Diesel Particulate Matter from Project Activities Calculated for the Active Phases of the Project (Construction, Operation, and Active Decommissioning)*

Location	ALCM (per 100,000 population)[a,b]			
	Construction	Operation	Decommissioning	Total (Sum of Construction, Operation, and Decommissioning)
CC1	4.7E-03	4.1E-02	7.9E-03	5.3E-02
CC2	1.2E-02	8.1E-02	2.0E-02	1.1E-01
CC3	9.8E-03	9.2E-02	1.6E-02	1.2E-01
CC4	1.3E-02	1.3E-01	2.1E-02	1.6E-01
CC5	4.9E-03	4.1E-02	8.2E-03	5.4E-02
P4	4.6E-03	3.8E-02	7.6E-03	5.0E-02
Worker Camp	2.1E-01	9.6E-01	3.5E-01	1.5
Modelled Mine Boundary	1.2E-01	9.3E-01	2.0E-01	1.2

NOTES

a. ALCM calculated according to Equation 7-1

b. Air quality emissions during Project decommissioning and closure were not explicitly modelled given that active closure emissions are expected to be less than construction emissions and therefore the assessment of the construction-related scenarios were considered to implicitly address active closure phase emissions as well. As such, the predicted exposure concentration during active decommissioning was assumed to be equivalent to the predicted value during construction for this calculation.

9.3 Decommissioning and Rehabilitation

As discussed in **Section 5**, air quality emissions during Project decommissioning and closure were not explicitly modelled because active closure emissions are expected to be less than construction emissions. Therefore, the assessment of the construction-related scenario was considered to implicitly address emissions during the active closure phase as well.

10 Uncertainty and Sensitivity Assessment

Uncertainty is inherent in many aspects of evaluating health risks to human receptors. The level of uncertainty is dependent upon the availability and quality of information, as well as the variability associated with many of the processes and factors being considered. Since uncertainty can influence the overall risk, it is important to identify and understand the uncertainties and potentially reduce the uncertainties through additional investigations.

10.1 Baseline Data

Due to the schedule for the Project Environmental Impact Assessment, baseline ambient monitoring for CoPs was not conducted. Rather, background air quality data published by the MELCCP or ambient monitoring data from another proposed mining project were used to estimate background CoPC concentrations (Chapter 8 of the Impact Statement).For PM_{10}, $PM_{2.5}$, and NO_2, the background air quality data from the MELCCP are approaching or exceeding health-based guidelines. This introduces considerable uncertainty with respect to whether existing ambient air quality is affecting health, even in absence of the Project, and complicates the assessment of potential health risks associated with Project + Background Scenarios. To address this concern, the HHRA also evaluated the Project Alone Scenario to assess the potential risks.

10.2 Air Quality Dispersion Modelling

The effects of Project releases of air CoPCs are based on calculated emission rates and the AERMOD dispersion modelling results. Prediction confidence is high because emission rates used in the modelling were estimated based on a combination of emission factors, engineering estimates and maximum emission levels. Actual emissions vary from hour to hour and day to day. Emissions from the Project employed a conservative, worst-case hourly emission approach which is expected to over-estimate longer-term averaging periods. Because of the approach, there is a high degree of confidence that emissions are over-estimated. Air quality dispersion models such as AERMOD also employ assumptions to simplify the random behaviour of the atmosphere into short periods of average behaviour. These assumptions limit the capacity of the model to replicate every meteorological event. To compensate for these simplifications, five years of meteorological data are applied to evaluate a wide range of possible conditions. Regulatory models, such as AERMOD, as also designed to have a bias toward over estimation of contaminant concentrations.

10.3 Toxicity Data

TRVs were obtained from Health Canada, US EPA IRIS, WHO, ATSDR, Netherlands and CalEPA. This approach is in accordance with standard practice and provides the current scientific basis with which to conduct a risk assessment. Uncertainties associated with the estimation of the toxicological effects of chemicals are inherent in the risk assessment process. For instance, when assessing the toxicity of a chemical, it is not generally considered appropriate to use human beings as test subjects. As a result, toxicologists must rely on animal data, toxicological models, and epidemiological studies to estimate the effects of chemicals on human receptors. In addition, the availability of toxicological data is often limited because of the vast number of chemicals potentially present in the environment and the high costs associated with conducting these studies; in relative terms only a fraction of existing compounds are well documented toxicologically.

To compensate for such shortcomings, the related uncertainties, and differences in effects to sensitive individuals, a number of uncertainty factors are typically built into the dose-response process, which estimates the toxicity of a chemical. This practice results in a conservative estimate of risk. The confidence in the accuracy of that risk is often the single largest contributor to conservatism in the risk assessment process.

10.4 Exposure Limits

NO_2, PM_{10}, and $PM_{2.5}$ are non-threshold contaminants, meaning any exposure may pose some health risk, with severity increasing with concentration and duration. However, the lack of defined TRVs introduces uncertainty in quantifying incremental health risks from measured or modelled exposures. In lieu of TRVs, exposure limits based on WHO ambient air quality guidelines (2021) were used. These guidelines represent the lowest exposure levels above which adverse effects are expected; however, they were not developed as toxicity values for assessment of individual risk but rather are intended to be used as objectives for protection of population-level exposures. These guidelines are not dose-response values and assume minimal or no population-level effects below the threshold, creating uncertainty when used to assess risk for non-threshold pollutants at specific locations (e.g., a cabin or camp).

11 HHRA Summary and Recommendations

Results of the risk characterization suggest that the assumed background concentrations of $PM_{2.5}$ and NO_2 for short-term and long-term exposures periods are at or above health-based exposure limits throughout the LSA/RSA. Based on the Project Alone scenario:

- the NO_2 ERs for short-term exposure durations at one or more special receptor locations during construction and operation are higher than the acceptable limit. These are locations frequented by Indigenous Receptors and Recreational Receptors.
- the NO_2 ERs for short-term and long-term exposure durations at the worker camp during construction and operation are higher than the acceptable limit. The $PM_{2.5}$ ERs for short-term exposures (during construction and operations) and long-term exposure (during operations) at the worker camp are higher than the acceptable limit. This location is frequented by Off-Duty Workers.

These two CoPC are non-threshold contaminants for which any increase in exposure could result in increased risks. What these results suggest is that NO_2 and $PM_{2.5}$ emissions will need to be actively monitored and mitigations employed should actual emissions approach predicted concentrations.

As described in Appendix H1 of the Impact Statement (the Air Quality Assessment), mitigation measures have been proposed to reduce potential air emissions during construction (and operation) and the development of both a dust management plan and an AQFMP will be developed for the Project. The proposed mitigation, management, and monitoring programs are expected to reduce CoPC emissions from the Project to less than the modelled concentrations, which would consequently reduce potential risks to human health.

12 References

Archibong, A. E., Inyang, F., Ramesh, A., Greenwood, M., Nayyar, T., Kopsombut, P., . . . Nyanda, A. M. (2002). Alteration of Pregnancy Related Hormones and Fetal Survival in F-344 Rats Exposed by Inhalation to Benzo(a)Pyrene. *Reproductive Toxicology, 16*(6), 801–8.

ATSDR. (2024). *Toxicological Profile for Benzene.* Agency for Toxic Substances and Disease Registry.

Behndig, A. F., Larsson, N., Brown, J., Stenfors, N., Helleday, R., Duggan, S. T., . . . Blomberg, A. (2011). Proinflammatory doses of diesel exhaust in healthy subjects fail to elicit equivalent or augmented airway inflammation in subjects with asthma. *Thorax, 66*(1), 12–19.

Behndig, A. F., Mudway, I. S., Brown, J. L., Stenfors, N., Helleday, R., Duggan, S. T., . . . Blomberg, A. (2006). Airway antioxidant and inflammatory responses to diesel exhaust exposure in healthy humans. *Eur Respir J, 27*, 359–365.

California Air Resources Board. (2020). *A Review of Polycyclic Aromatic Hydrocarbon and Polycyclic Aromatic Hydrocarbon Derivative Emissions from Off-Road, Light-Duty, Heavy-Duty, and Stationary Sources.*

CCME. (2008). *Canada-Wide Standard for Petroleum Hydrocarbons (PHC) in Soil: Scientific Rationale Supporting Technical Document.*

CCME. (2020). *Ecological Risk Assessment Guidance Document.* Canadian Council of Ministers of the Environment.

Clark, D. G., Butterworth, S. T., Martin, J. G., Roderick, H. R., & Bird, M. G. (1989). Inhalation Toxicity of High Flash Aromatic Naphtha. *Toxicology and Industrial Health, 5*(3), 415–28.

Delzell, E., Sathiakumar, N., & Macaluso, M. (1995). *A follow-up study of synthetic rubber workers: Prepared for the International Institute of Synthetic Rubber Workers, October 2, 1995.*

Dorman, D. C., Struve, M. F., Wong, B. A., Gross, E. A., Parkinson, C., Willson, G. A., . . . Andersen, M. E. (2008). Derivation of an Inhalation Reference Concentration Based upon Olfactory Neuronal Loss in Male Rats following Subchronic Acetaldehyde Inhalation. *Inhalation Toxicology, 20*(3), 245–256.

FCSAP. (2012a). *Ecological Risk Assessment Guidance.* Federal Contaminated Sites Action Plan.

Golder. (2022). *Project minier Troilus – Description détaillée de project.*

Hayes, R. B., Yin, S. N., Dosemeci, M., Li, G. L., Wacholder, S., Travis, L. B., . . . Linet, M. D. (1997). Benzene and the dose-related incidence of hematologic neoplasms in China. *Journal of the National Cancer Institute, 89*(14), 1065-1071.

Health Canada. (2006a). *Residential Indoor Air Quality Guideline: Formaldehyde.*

Health Canada. (2010a). *Federal Contaminated Site Risk Assessment in Canada, Part V: Guidance on Human Health Detailed Quantitative Risk Assessment for Chemicals (DQRACHEM).* Retrieved June 2024, from https://www.canada.ca/en/health-canada/services/environmental-workplace-health/reports-publications/contaminated-sites/federal-contaminated-site-risk-assessment-canada-part-guidance-human-health-detailed-quantitative-risk-assessment-chemicals-dqrachem-hea

Health Canada. (2010b). *Supplemental Guidance on Human Health Risk Assessment for Country Foods.*

Health Canada. (2013). *Residential Indoor Air Quality Guideline Science Assessment Document - Naphthalene.* Ottawa, ON.

Health Canada. (2016a). *Human Health Risk Assessment for Coarse Particulate Matter.* Ottawa, ON.

Health Canada. (2016b). *Human Health Risk Assessment for Diesel Exhaust.* Ottawa, Ontario: Healthy Environments and Consumer Safety Branch, Health Canada.

Health Canada. (2016c). *Human Health Risk Assessment for Sulphur Dioxide (CAS RN: 7446-09-5). Analysis of Ambient Exposure to and Health Effects of Sulphur Dioxide in the Canadian Population.*

Health Canada. (2017a). *Residential indoor air quality guideline: acetaldehyde.*

Health Canada. (2021b). *Federal Contaminated Site Risk Assessment in Canada: Toxicological Reference Values (TRVs), Version 3.0.*

Health Canada. (2022a). *Lung cancer and ambient PM2.5 in Canada: a systematic review and meta-analysis.* Health Canada.

Health Canada. (2023a). *Guidance for Evaluating Human Health Effects in Impact Assessment: Human Health Risk Assessment.*

Health Canada. (2023b). *Guidance for Evaluating Human Health Effects in Impact Assessment: Air Quality.*

Health Canada. (2023c). *Guidance for Evaluating Human Health Impacts in Environmental Assessment: Country Foods.*

Health Canada. (2023d). *Guidance for Evaluating Human Health Impacts in Environmental Assessment: Drinking and Recreational Water Quality.*

Health Canada. (2024). *Federal Contaminated Site Risk Assessment in Canada: Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA). Version 4.0.*

Health Canada. (2024). *Indoor air reference levels for chronic exposure to volatile organic compounds.* Water and Air Quality Bureau, Ottawa, ON.

Health Canada. (2024, June). *Summary Tables.* Retrieved from Guidelines for Canadian Drinking Water Quality : https://www.canada.ca/en/health-canada/services/environmental-workplace-health/reports-publications/water-quality/guidelines-canadian-drinking-water-quality-summary-table.html

IARC. (2014). *IARC Monographs on the Evaluation of Carcinogenic Risks to Humans: Diesel and Gasoline Engine Exhausts and Some Nitroarenes, Volume 105.* Lyon, France: International Agency for Research on Cancer.

Ishinishi, N., Kuwabara, N., Nagase, S., Suzuki, T., Ishiwata, S., & Kohno, T. (1986). Long-Term Inhalation Studies on Effects of Exhaust from Heavy and Light Duty Diesel Engines on F344 Rats. *International Satellite Symposium on Toxicological Effects of Emissions from Diesel Engines.*

Tsukuba Science City, Japan, July 26-28, 1986., edited by Koizumi, RO McClellan, and W Stober, (pp. 329–48).

Krakowiak, A., Górski, P., Pazdrak, K., & Ruta, U. (1998). Airway Response to Formaldehyde Inhalation in Asthmatic Subjects with Suspected Respiratory Formaldehyde Sensitization. *American Journal of Industrial Medicine, 33*(3), 274–81.

Kulle, T. J. (1993). Acute Odor and Irritation Response in Healthy Nonsmokers with Formaldehyde Exposure. *Inhalation Toxicology, 5*(3), 323-32.

Lee, K. K., Spath, N., Miller, M. R., Mills, N. L., & Shah, A. S. (2020). Short-term exposure to carbon monoxide and myocardial infarction: A systematic review and meta-analysis. *Environment International, 143*.

MECP. (2020). *Ambient Air Quality Criteria.* Toronto, ON, Canada. : Ontario Ministry of the Environment, Conservation and Parks.

MECP. (2023). *Air Contaminants Benchmarks List: standards, guidelines and screening levels for assessing point of impingement concentrations of air contaminants. Available at: https://www.ontario.ca/docu.*

MELCCFP. (2017). *Instruction Guide for Preparation and Realization of Air Emission Dispersion Modelling – Mining Projects. Available at: https://www.environnement.gouv.qc.ca/air/criteres/secteur_minier.pdf.*

MELCCFP. (2025). *Quebec Air Quality Standards and Criteria, version 8, Quebec Air Quality and Climate Branch.*

Mudway, I. S., Stenfors, N., Duggan, S. T., Roxborough, H., Zielinksi, S. L., Marklund, A., . . . Kelly, F. J. (2004). An in vitro and in vivo investigation of the effects of diesel exhaust on human airway lining fluid antioxidants. *Arch Biochem Biophys, 423*, 200–212.

National Research Council (US). (1984). Measurement of Exposure to Asbestiform Fibers. In N. R. (US), *Asbestiform Fibers: Nonoccupational Health Risks.* Washington (DC): National Academies Press (US).

National Toxicology Program (NTP). (1993). *Toxicology and carcinogenesis studies of 1,3-butadiene (CAS No. 106-99-0) in B6C3F1 mice (inhalation studies) .* Research Triangle Park, NC: US Department of Health and Human Services. NTP TR 434, NIH Pub. No. 93-3165.

NTP. (2000). *NTP Technical Report on the Toxicology and Carcinogenesis Studies of Naphthalene (CAS No. 91-20-3) in F344/N Rats (Inhalation Studies).* Rockville, MD.

NTP. (2021). *Report on Carcinogens, Fifteenth Edition - Diesel Exhaust Particulates.* Research Triangle Park, NC.

OEHHA. (2005). *Chronic Toxicity Summary: Silica (Crystalline, Respirable).* OEHHA.

OEHHA. (2013). *1,3-Butadiene Reference Exposure Levels. Final. July 2013.*

Ontario MOECC (Ontario Ministry of the Environment and Climate Change. (2016). *Ontario Ambient Air Quality Criteria.*

Paxton, M. B., Chinchilli, V. M., Brett,, S. M., & Rodricks, J. V. (1994). Leukemia risk associated with benzene exposure in the Pliofilm cohort: I. Mortality update and exposure distribution. *Risk Analysis, 14*(2), 147–154.

Pazdrak, K., Górski, P., Krakowiak, A., & Ruta, U. (1993). Changes in Nasal Lavage Fluid Due to Formaldehyde Inhalation . *International Archives of Occupational and Environmental Health, 64*(7), 515–19.

Prieto, L., Sanchez-Toril, F., Brotons, Soriano, S., Casan, R., & Belenguer, J. L. (2000). Airway responsiveness to acetaldehyde in patients with asthma: Relationship to methacholine responsiveness and peak expiratory flow variation. *Clin Exp Allergy, 30*(1), 71-78.

Riedl, M. A., Diaz-Sanchez, D., Linn, W. S., Gong , H., ClarK, K. W., Effros , R. M., . . . Berhane, K. T. (2012). Allergic Inflammation in the Human Lower Respiratory Tract Affected by Exposure to Diesel Exhaust. *Research Report (Health Effects Institute), 165*, 5–64.

Rinsky, R. A., Smith, A. B., Hornung, R., Filloon, T., Young, R. J., Okun, A. H., & Landrigan, P. J. (1987). Benzene and leukemia - An epidemiologic risk assessment. *New England Journal of Medicine, 316*(17), 1044–1050.

Rozen, M. G., & Snyder, C. A. (1985). Protracted Exposure of C57BL/6 Mice to 300 Ppm Benzene Depresses B- and T-Lymphocyte Numbers and Mitogen Responses. Evidence for Thymic and Bone Marrow Proliferation in Response to the Exposures. *Toxicology, 37*(1-2), 13-26.

Rumchev, K. B., Spickett, J. T., Bulsara, M. K., Phillips, M. R., & Stick, S. M. (2002). Domestic Exposure to Formaldehyde Significantly Increases the Risk of Asthma in Young Children . *The European Respiratory Journal, 20*(2), 403–8.

Sato, T., Shimosato, T., & Klinman, D. (2018). Silicosis and lung cancer: current perspectives. *Lung Cancer (Auckl), 9*, 91-101.

Schlesinger, R. (2007). The Health Impact of Common Inorganic Components of Fine Particulate Matter (PM2.5) in Ambient Air: A Critical Review. *Inhalation Toxicology*, 811-832.

Stantec. (2024). *Crawford Nickel Project. Impact Statement Chapter 12: Assessment of Potential Effects on the Atmospheric Environment. Available at https://iaac-aeic.gc.ca/050/evaluations/document/160391.*

Stenfors, N., Nordenhäll, C., Salvi, S. S., Mudway, I., Söderberg, M., Blomberg, A., . . . Sandström, T. (2004). Different airway inflammatory responses in asthmatic and healthy humans exposed to diesel. *Eur Respir J, 23*, 82–86.

TCEQ. (2008). *Development Support Document - Formaldehyde, CAS Registry Number: 50-00-0.*

TCEQ. (2015). *Development Support Document, Benzene.* Retrieved from Texas Commission on Environmental Quality: www.tceq.texas.gov/downloads/toxicology/dsd/final/benzene.pdf

TCEQ. (2020). *Silica, Crystalline Forms: 24-h ReV Development Support Document.* Texas Commission on Environmental Quality (TCEQ).

Thyssen, J., Althoff, J., Kimmerle, G., & Mohr, U. (1981). Inhalation Studies with Benzo[a]Pyrene in Syrian Golden Hamsters. *Journal of the National Cancer Institute, 66*(3), 575–77.

TPHCWG. (1997). *Development of Fraction Specific Reference Doses (RfDs) and Reference Concentrations (RfCs) for Total Petroleum Hydrocarbons (TPH), Total Petroleum Hydrocarbon Criteria Working Group Series, Volume 4.*

US DOE. (2016). *Temporary emergency exposure limits for chemicals: methods and practice.*

US EPA. (1989). *Risk Assessment Guidance for Superfund (RAGS), Volume I, Human Health Evaluation Manual. (TRVs for human health) – threshold and non-threshold approaches.*

US EPA. (2002a). *Health Assessment Document For Diesel Engine Exhaust (Final 2002).* Washington, DC: United States Environmental Protection Agency.

US EPA. (2002b). *IRIS, 1, 3-Butadiene.* Washington, DC: US Environmental Protection Agency Integrated Risk Information System Database. Office of Research and Development, National Center for Environmental Assessment.

US EPA. (2017). *Toxicological Review of Benzo[a]Pyrene in Support of Integrated Risk In Formation System (IRIS) – Executive Summary (Final Report).* Washington, DC.

US EPA. (2020). *Risk Evaluation for Asbestos Part I: Chrysotile Asbestos.* US EPA Office of Chemical Safety and Pollution Prevention.

WHO. (2006). *Air Quality Guidelines: Global Updated 2005: Particulate Matter, Ozone, Nitrogen Dioxide and Sulfur Dioxide. .*

WHO. (2010). *WHO guidelines for indoor air quality: selected pollutants.*

WHO. (2021). *WHO Global Air Quality Guidelines. Particulate Matter (PM2.5 and PM10), Ozone, Nitrogen Dioxide, Sulfur Dioxide and Carbon Monoxide.* Geneva. Retrieved from https://www.who.int/publications/i/item/9789240034228.

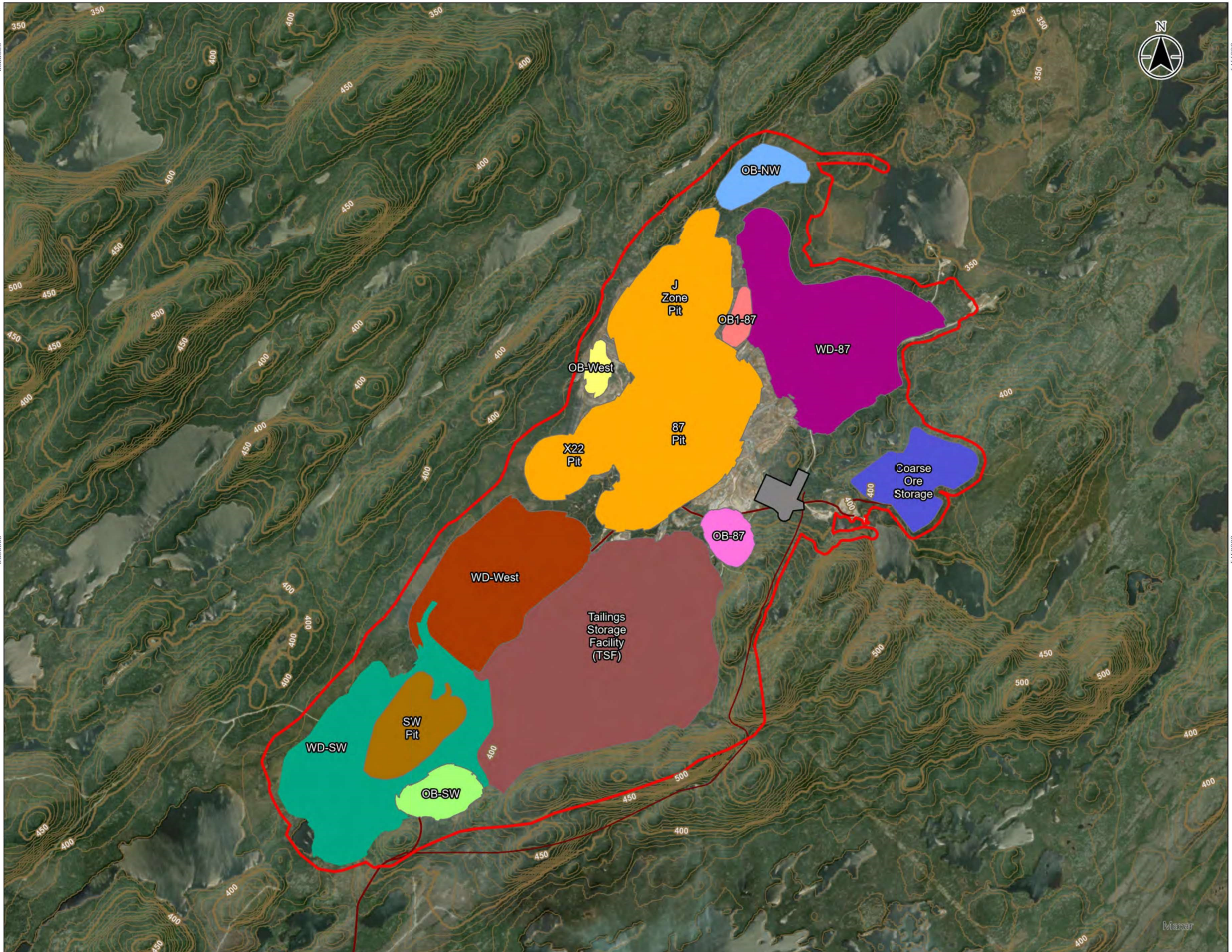
Wilhelmsson, B., & Holmström, M. (1992). Possible Mechanisms of Formaldehyde-Induced Discomfort in the Upper Airways. *Scandinavian Journal of Work, Environment & Health, 18*(6), 403–7.

Williams, C., Dell, L., Adams, R., Rose, T., & Van Orden, D. (2012). State-of-the-science assessment of non-asbestos amphibole exposure: Is there a cancer risk? *Environmental Geochemistry and Health*, 357-377.

Wylie, A. G., Korchevskiy, A. A., Orden, D. R., & Chatfield, E. J. (2022). Discriminant analysis of asbestiform and non-asbestiform amphibole particles and its implications for toxicological studies. *Computational Toxicology, 23*.

Appendices

APPENDIX A - Figures



Project Components

- Project Area
- Process Plant

Pit

- 87, J, X22 Pit
- SW Pit

Storage Area

- OB-87
- OB-NW
- OB-SW
- OB-West
- OB1-87
- WD-87
- WD-SW
- WD-West
- Coarse Ore Storage

TSF

- Tailings Storage Facility (TSF)

Road

- Access Road

0 500 1 000 metres

1:40 000 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 CSRS UTM Zone 18N
2. Project Componants, Pit, Storage Area, TSF, Acces Road : Troilus Gold Corp., 2024
3. Road Network-Route du Nord : Adresses Québec, 2024
4. Imagery : Esri World Imagery, 2023.

Project Location

Mistissini
Québec

167040485 REV0
Prepared by P. Ravo on 2025/06/12
Technical Review by M. Stachejczuk on 2025/06/12
Independent Review by G. Crooks on 2025/06/12

Client/Project

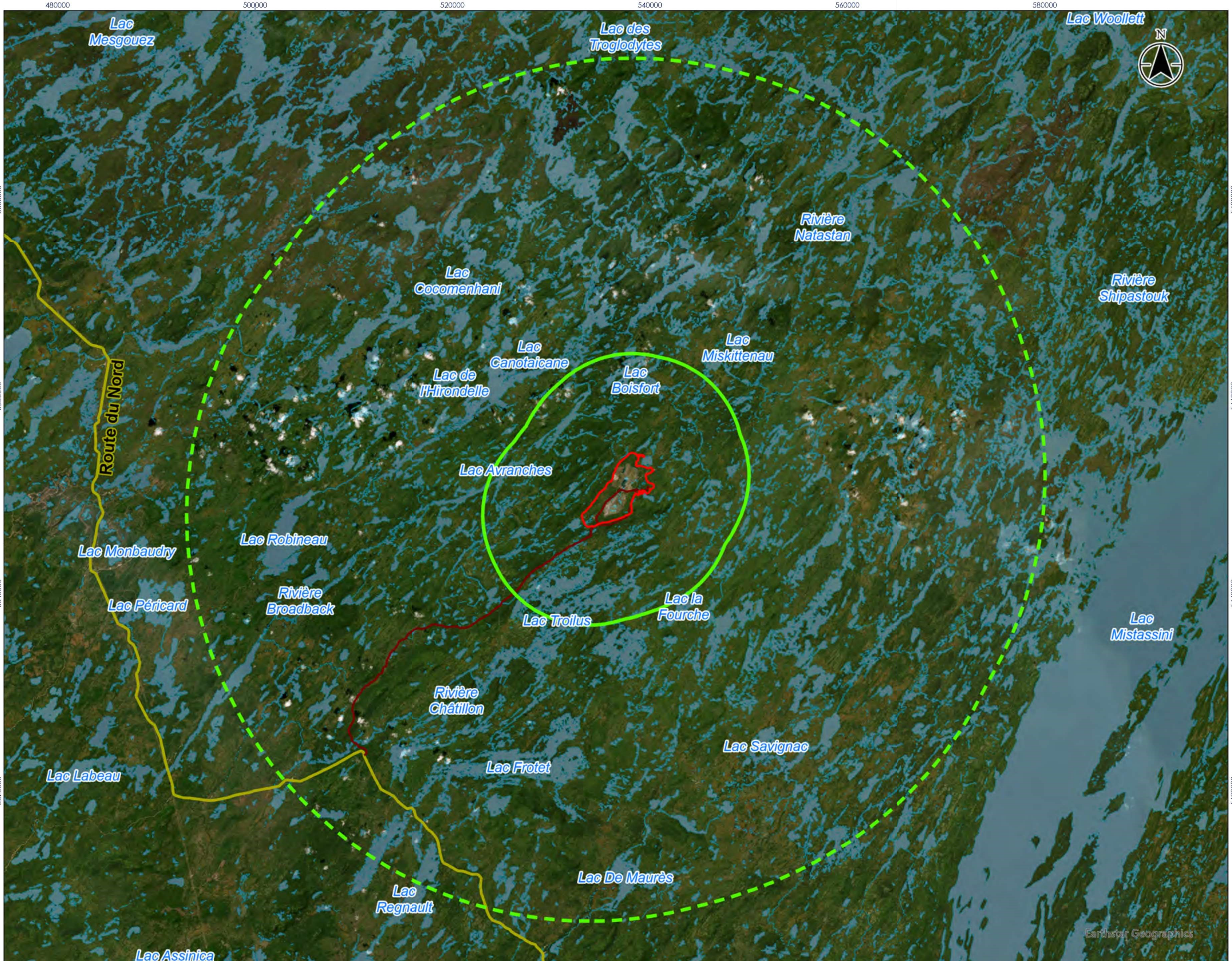
Troilus Gold Corp
Troilus Mining Project

Figure No.

A.1

Title

Site Layout



Stantec

Project Components

- Project Area (PA)
- Locale Study Area (10km Buffer of PA)
- Regional Study Area (40km Buffer of PA)

Road

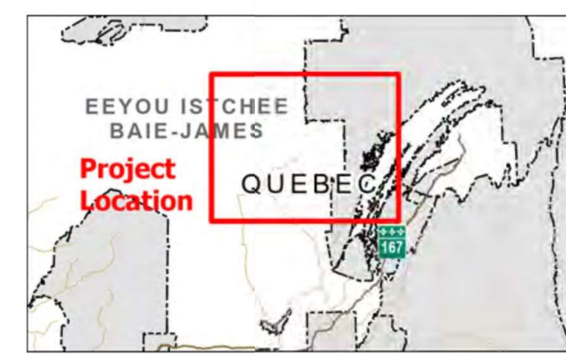
- Access Road
- Route du Nord

0 5 10 Kilometers

1:400 000 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 CSRS UTM Zone 18N
2. Project Componants, Acces Road : Troilus Gold Corp., 2024
3. Road Network-Route du Nord : Adresses Québec, 2024
4. Imagery : Esri World Imagery, 2023.



Project Location

Mistissini
Québec

167040485 REV0

Prepared by P. Ravo on 2025/06/12
Technical Review by M. Stachejczuk on 2025/06/12
Independent Review by G. Crooks on 2025/06/12

Client/Project

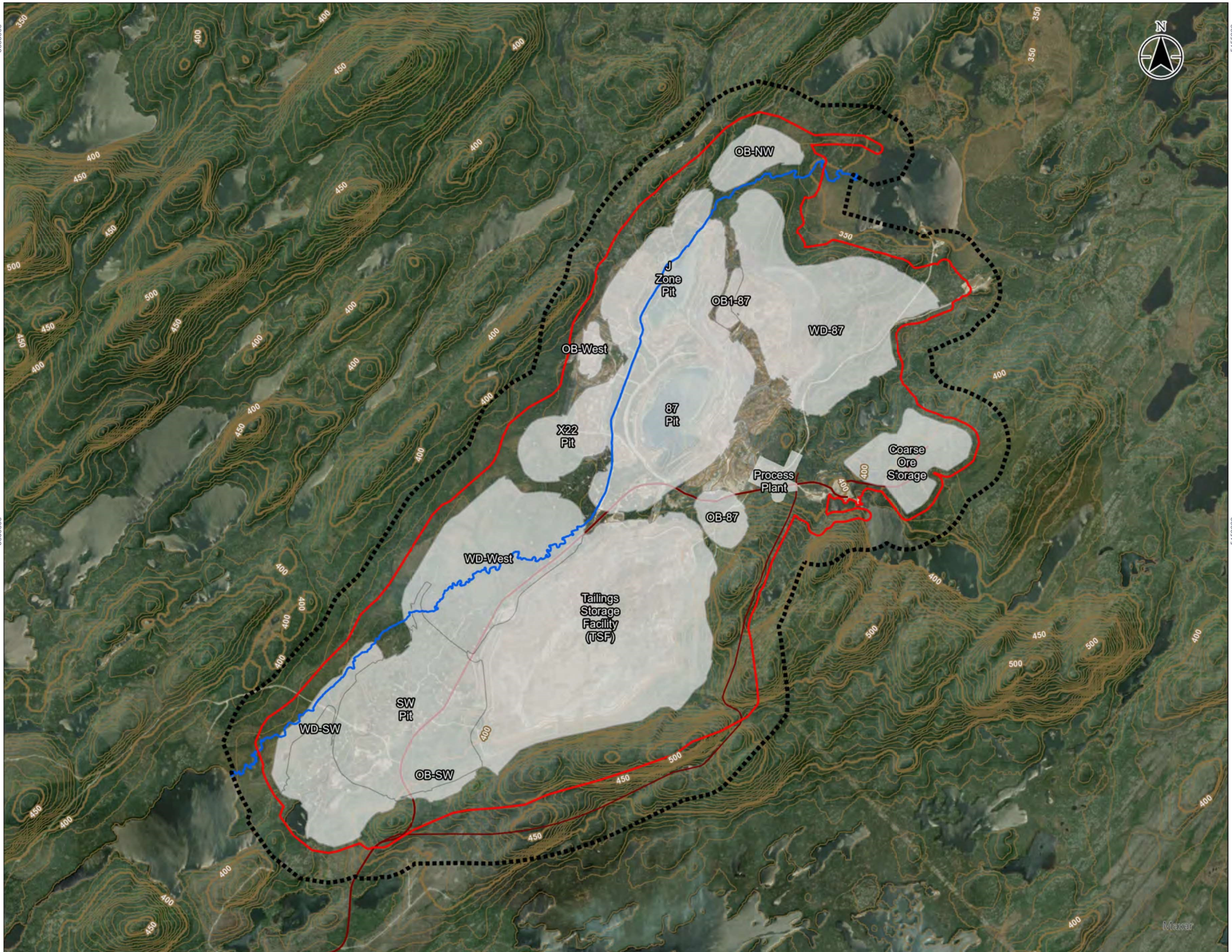
Troilus Gold Corp
Troilus Mining Project

Figure No.

A.2

Title

Project Area, Local Study Area and Regional Study Area



Stantec

Project Components

- Project Area (PA)
- Proposed Project Components
- Modelled Mine Boundary

Watercourse

- Bibou Watercourse (Wachiih)

Road

- Access Road

Topography

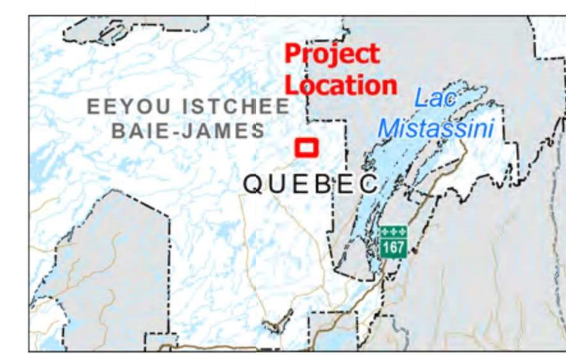
- Contour Line (50m)
- Contour Line (5m)

0 500 1 000 Meters

1:40 000 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 CSRS UTM Zone 18N
2. Project Componants, Acces Road, Topography : Troilus Gold Corp., 2024
3. Watercourse : Wachiih, 2024
4. Imagery : Esri World Imagery, 2023.



Project Location

Mistissini
Québec

167040485 REV0

Prepared by P. Ravo on 2025/06/12
Technical Review by M. Stachejczuk on 2025/06/12
Independent Review by G. Crooks on 2025/06/12

Client/Project

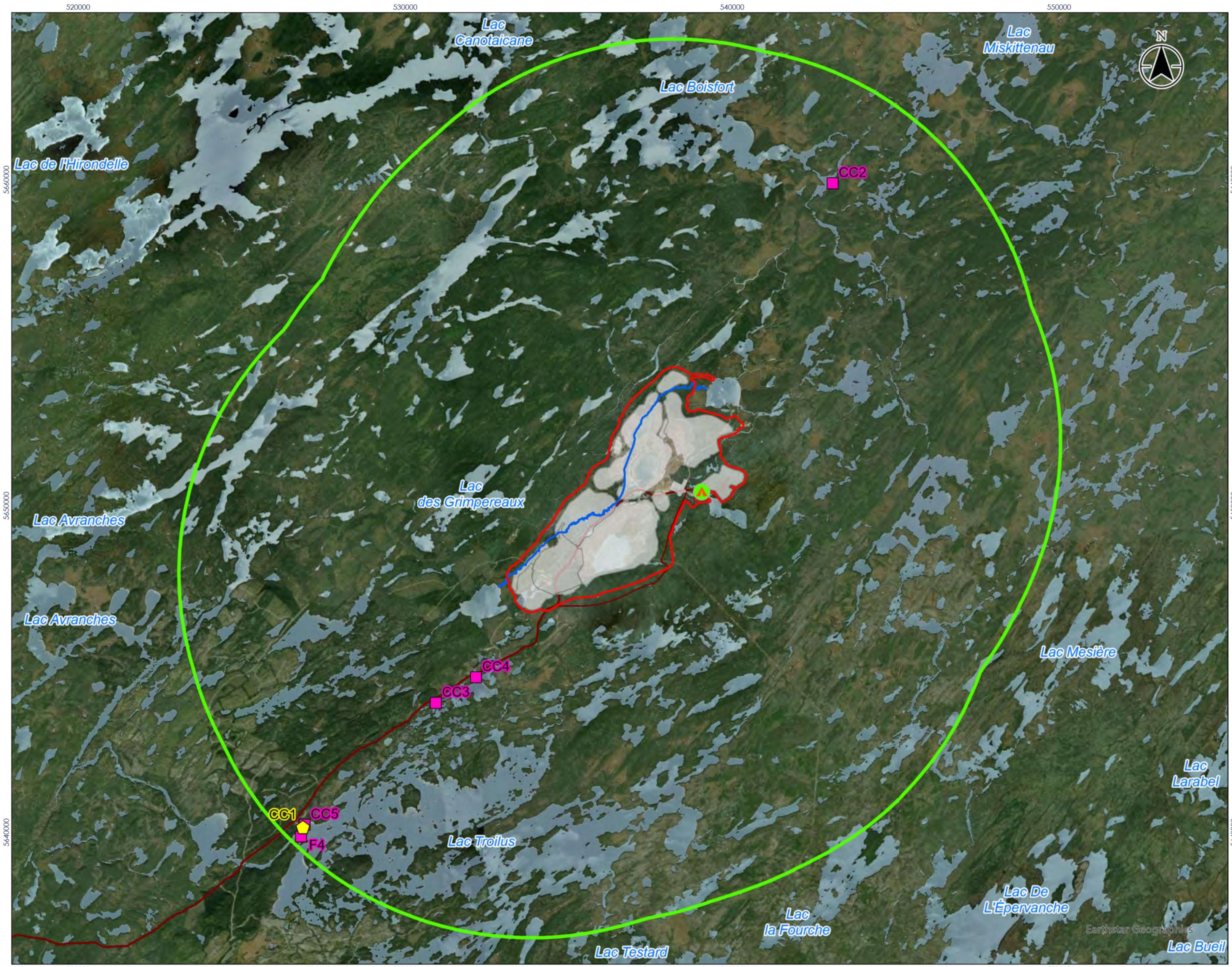
Troilus Gold Corp
Troilus Mining Project

Figure No.

A.3

Title

Extent of Modelled Mine Boundary Used in the Air Quality Assessment



Stantec

Project Components

- Project Area (PA)
- Proposed Project Components
- Local Study Area (10km Buffer of PA)
- Worker Camp

Receptor

- Cree Camps (CC)
- Non Cree Activities (CC)

Watercourse

- Bibou Watercourse (Wachiih)

Hydrography

- Waterbody (GRHQ)

Road

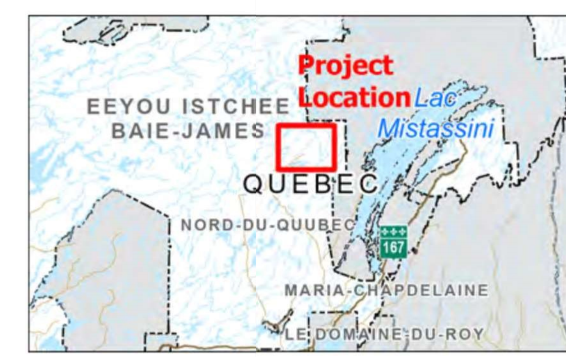
- Access Road

0 2,5 5 Kilometers

1:120 000 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 CSRS UTM Zone 18N
2. Project Componants, Receptor : Troilus Gold Corp., 2024
3. Watercourse : Wachiih, 2024
4. Hydrography : GRHQ, 2020
5. Imagery : Esri World Imagery, 2023.



Project Location
Mistissini
Québec

167040485 REV0
Prepared by P. Ravo on 2025/06/12
Technical Review by M. Stachejczuk on 2025/06/12
Independent Review by G. Crooks on 2025/06/12

Client/Project

Troilus Gold Corp
Troilus Mining Project

Figure No.

A.4

Title

Special Receptor Locations and Worker Camp

Stantec is a global leader in sustainable engineering, architecture, and environmental consulting. The diverse perspectives of our partners and interested parties drive us to think beyond what's previously been done on critical issues like climate change, digital transformation, and future-proofing our cities and infrastructure. We innovate at the intersection of community, creativity, and client relationships to advance communities everywhere, so that together we can redefine what's possible.