4.0 ENVIRONMENTAL EFFECTS ASSESSMENT SCOPE AND METHODS

An environmental assessment (EA) is a planning and decision-making tool used to, among other things, predict environmental effects of a project prior to a project being carried out. This chapter describes the methods used to assess the effects of routine Project activities and components, accidental events and cumulative effects of the Project. The methods used to prepare this Environmental Impact Assessment (EIS) have been developed by Stantec in consideration of the federal requirements under the *Canadian Environmental Assessment Act*, 2012 (CEAA 2012) and the provincial *Environmental Protection Act* (NL EPA). These methods were informed by the federal and provincial regulatory requirements with specific consideration of the Final Guidelines for the Preparation of an Environmental Impact Statement, pursuant to CEAA 2012, dated July 2019 (Federal EIS Guidelines, Appendix 1A) and the requirements set out in the provincial Environmental Impact Statement Guidelines for the Valentine Gold Project, dated January 2020 (Provincial EIS Guidelines, Appendix 1B). A table of concordance is provided for each of these guidelines in Table E.1 and E.2.

The aspects determined to be within the scope of the Project were examined using a precautionary approach to avoid, reduce or mitigate adverse environmental effects. Throughout the EA process for the Project, opportunities have been and will continue to be provided for meaningful Indigenous and stakeholder participation, including opportunities to provide comment on the Project Description, draft guidelines, EIS and the draft EA Report to be prepared by the Impact Assessment Agency of Canada (IAAC). As discussed in Chapter 3, Marathon will continue providing opportunities for such participation and will pursue positive and constructive relationships with Indigenous groups and stakeholders throughout the life of the Project. Information gathered during engagement activities has informed the EIS including the EA methods.

4.1 OVERVIEW OF METHODS

This EIS examines the environmental effects that could result from changes to the environment as a result of the Project being carried out. This EA uses a precautionary, conservative approach, with conservative assumptions generally applied to overestimate rather than underestimate potential adverse effects. A high-level description of the environmental effects assessment method used in the EIS is shown in Figure 4-1. Methods include the following generalized steps and are discussed further in the subsequent sections:

- **Scope of Assessment (see Section 4.2 below) –** Scoping of the assessment includes the selection of valued components (VCs) and the rationale for their selection; description of the regulatory and policy setting; and description of temporal and spatial boundaries. Engagement informed the scope of assessment, as discussed in Chapter 3 (Regulatory, Indigenous and Stakeholder Consultation and Engagement).

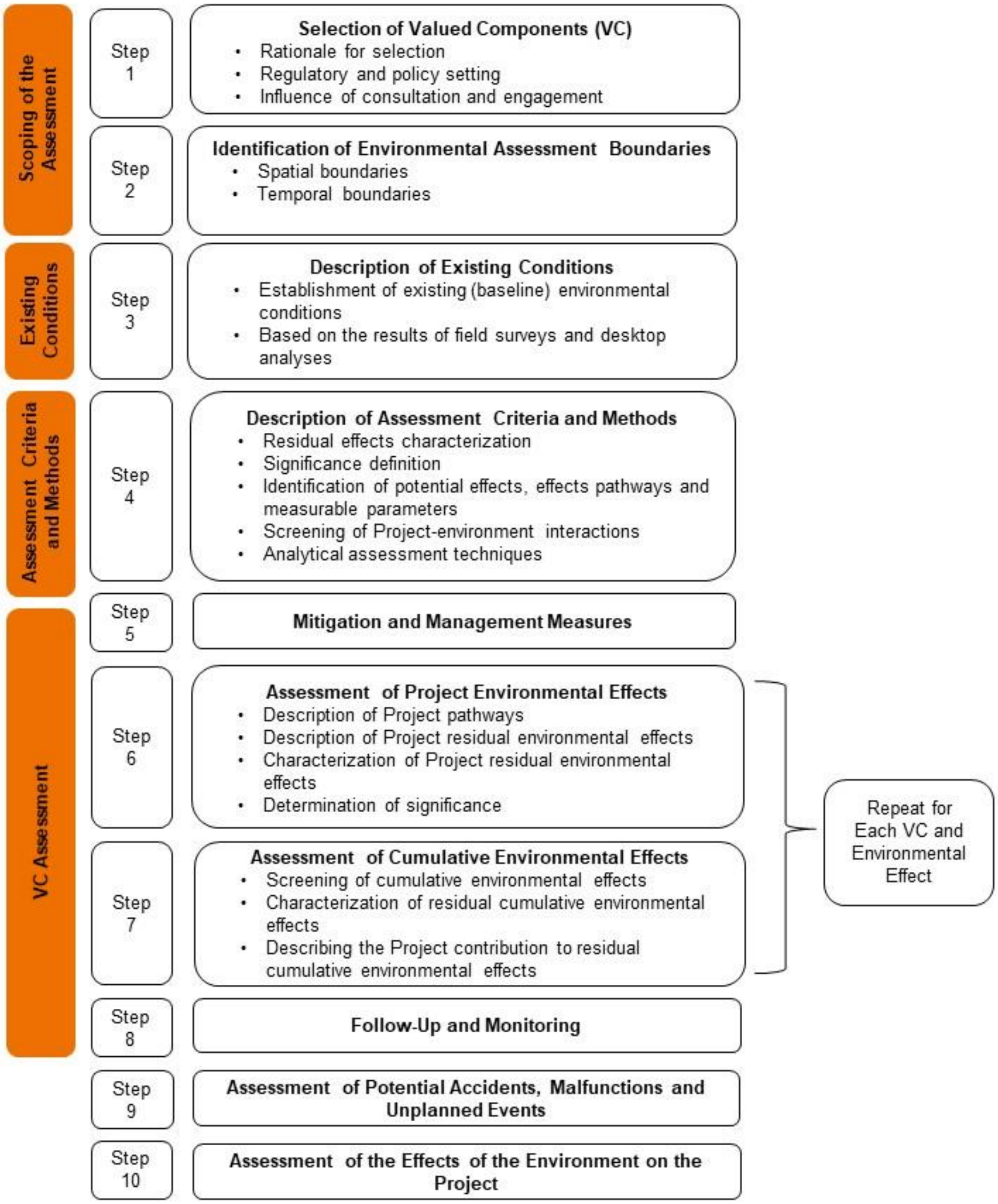

Figure 4-1 Environmental Assessment Approach

- **Existing Conditions (see Section 4.3 below) –** Existing (baseline) environmental conditions are described for each VC. In many cases, existing conditions include those environmental effects that may have been caused by other past or present projects or activities that have been or are being carried out.
- **Assessment Criteria and Methods (see Section 4.4 below) –** This describes the criteria and methods used to assess environmental effects on the VC. This includes the residual effects characterization, significance definition, the environmental effects to be assessed for the VC, and the identification of the physical Project activities that may interact with the environmental effects identified for assessment. Analytical assessment techniques used for the VCs are also provided.
- **Mitigation and Management Measures (see Section 4.5 below) –** Mitigation and management measures are identified for each VC that will reduce or control potential environmental effects.
- **Assessment of Environmental Effects on the VC (see Section 4.6 below) –** The assessment of Project-related effects includes descriptions of how an environmental effect will occur or how the Project will interact with the environment, and the characterization of the residual environmental effects of the Project (i.e., those remaining after application of mitigation).
- **Determination of Significance (see Sections 4.4.2 and 4.7 below) –** The significance of residual Project-related environmental effects is then determined, in consideration of the defined significance criteria.
- **Assessment of Cumulative Environmental Effects (see Section 4.8 below) –** Cumulative environmental effects of the Project are identified in consideration of other past, present or reasonably foreseeable future projects or activities that have been or will be carried out (Chapter 20). The residual cumulative environmental effects of the Project in combination with other projects or activities that have been or will be carried out are evaluated, including the contribution of the Project to those cumulative environmental effects (as applicable).
- **Assessment of Potential Accidents or Malfunctions (see Section 4.9 below) and Effects of the Environment on the Project (see Section 4.10 below)** – The assessment of accidents and malfunctions includes descriptions of the events that may occur outside the normal planned function or activity of the Project, and mitigation and contingency plans to reduce or eliminate the risks of such events (Chapter 21). Effects of the environment (e.g., extreme weather and effects of climate change) on the Project (Chapter 22) are considered, as required under CEAA 2012 and the Provincial EIS Guidelines.
- **Follow-up and Monitoring Programs (see Section 4.11 below) –** EA follow-up and monitoring programs are proposed as required to verify key environmental effects predictions, verify the effectiveness of the key mitigation, and/or verify compliance with regulatory and permitting requirements. Follow-up and monitoring results will inform the need for adaptive management. Where there is a variance between the actual and predicted effects, then modifications to Project operation or other actions (e.g., revision of existing mitigation measures) would be considered, as required.

As per the Provincial EIS Guidelines (Appendix 1B), the capacity of renewable resources and the predicted future condition of the environment are also considered for each VC. This includes the consideration of the capacity of renewable resources that are likely to be affected by the Project to meet the needs of the present and those of the future and the predicted future condition of the environment with respect to the key issues, should the Project not proceed. Further details on the methods that were used in the EIS are provided in the following sections.

4.2 SCOPE OF THE ASSESSMENT

This EIS has been prepared in accordance with the requirements of CEAA 2012, the Federal EIS Guidelines (Appendix 1A), NL EPA, the Provincial EIS Guidelines (Appendix 1B), and EA guidance documents. Tables E.1 and E.2 outline the requirements of the Project-specific guidelines issued by federal and provincial authorities and where these requirements have been addressed within the EIS. The scope of the Project, the selection of VCs, and the spatial and temporal boundaries are discussed in the following subsections.

4.2.1 Scope of the Project

The scope of the Project is defined by the components and activities required to construct and operate the Project's facilities, and ultimately the decommissioning, rehabilitation and closure of Project facilities at the end of the Project life. Project components and activities are described in Chapter 2.

4.2.2 Factors to be Considered

Scoping establishes the parameters of the EA and focuses the assessment on relevant issues and concerns. The factors considered for the EA, as outlined in the Federal EIS Guidelines (Appendix 1A) and Provincial EIS Guidelines (Appendix 1B), for the Project include the following:

- Purpose of and need for the Project (Section 2.9)
- Alternatives to the Project (Section 2.10) and alternative means of carrying out the Project, and assessing their technical and economic feasibility and environmental effects (Section 2.11)
- Public and stakeholder comments and Indigenous group input including specific response to those concerns identified through engagement (Chapter 3)
- Local knowledge (Chapter 3)
- Environmental effects of the Project, including effects due to accidents and malfunctions (Chapters 5 to 21), as well as consideration of cumulative effects of the Project in combination with other past, present and reasonably foreseeable future projects and physical activities (Chapter 20)
- Significance of the identified environmental effects (Chapters 5 to 21)
- Technically and economically feasible mitigation measures to avoid or reduce adverse effects or enhance or prolong beneficial environmental effects (Chapters 5 to 21)
- Residual (post-mitigation) environmental effects that are beneficial or harmful that are likely to be caused by the undertaking regardless of the proper application of control, mitigation, enhancement and remedial measures to be proposed in the EIS (Chapters 5 to 21)
- Requirements for follow-up programs (Chapters 5 to 21 and summarized in Chapter 23)
- Changes to the Project that may be caused by the environment (Chapter 22)
- The results of relevant regional studies pursuant to CEAA 2012 (Chapters 5 to 21)
- The capacity of renewable resources that are likely to be affected by the Project to meet the needs of the present and those of the future (Chapter 23)
- The future predicted condition of the environment without the Project (Chapters 5 to 21)

4.2.3 Selection of Valued Components

The approach to identifying VCs for this Project was consistent with the requirements of the Federal EIS Guidelines and Provincial EIS Guidelines, including consideration of the VC's role in the ecosystem, the value placed on it by humans, including those using the affected area, and the functional relationships within the environment. VCs were selected with consideration of the following:

- Regulatory guidance and requirements including those identified in the Project-specific Federal EIS Guidelines (Appendix 1A) and the Provincial EIS Guidelines (Appendix 1B)
- Discussions with regulatory agencies, technical experts, key stakeholders, the public, and Indigenous groups during the pre-EIS submission period
- Technical knowledge of the Project (i.e., the nature and extent of Project components and activities)
- Existing conditions for the physical, biological and socio-economic environments
- Ongoing engagement with Indigenous groups
- Ongoing consultation with the public and key stakeholders
- Lessons learned from previous similar EAs
- Professional judgement based on the experience of the Project Team (Section 1.2.3)

The following VCs were selected for the EIS:

- Atmospheric Environment
- Groundwater Resources
- Surface Water Resources
- Fish and Fish Habitat
- Vegetation, Wetlands, Terrain and Soils
- Avifauna
- Caribou
- Other Wildlife
- Community Services and Infrastructure
- Community Health
- Employment and Economy
- Land and Resource Use
- Indigenous Groups
- Historic Resources
- Dam Infrastructure

This EIS provides separate chapters to describe each VC, the rationale for the VC's selection, a summary of the Project-related comments that have been raised, and linkages to other VCs. The assessment of VCs is provided in Chapters 5 to 19 of the EIS. Each chapter includes the VC-specific measurable parameters that were identified for each assessment and the rationale for the selection of those parameters. A complete discussion of Project interactions is also provided in each VC chapter, and considers the construction, operation and decommissioning, rehabilitation and closure phases.

4.2.4 Spatial and Temporal Boundaries

4.2.4.1 Spatial Boundaries

The spatial boundaries for the assessment were selected based on the geographic extent of the measurable potential environmental, social, heritage and human effects of the Project. The spatial boundaries include the following:

- The Project Area encompasses the immediate area in which Project activities and components occur and is comprised of two distinct areas: the mine site and the access road. The mine site includes the area within which Project infrastructure will be located, and the access road is the existing road to the site, plus a 20-metre (m) wide buffer on either side. The Project Area is the anticipated area of direct physical disturbance associated with the construction, operation and decommissioning, rehabilitation and closure of the Project.
- The Local Assessment Area (LAA) encompasses the area in which Project-related environmental effects (direct or indirect) can be predicted or measured for assessment. The LAA, which is specific to each VC, encompasses the Project Area and is selected in consideration of the geographic extent of effects on the given VC.
- The Regional Assessment Area (RAA) is the area established for context in the determination of significance of project-specific effects. It is also the area in which accidental events are assessed and it informs the assessment of cumulative effects. The RAA is VC specific and encompasses both the Project Area and the LAA.

4.2.4.2 Temporal Boundaries

Temporal boundaries for the assessment address the potential effects during the Project's construction, operation and decommissioning, rehabilitation and closure phases over relevant timescales. The overall Project schedule is presented in Section 2.2.6.

The temporal boundaries for the Project consist of the following phases:

- Construction Phase – 16 to 20 months, beginning in Q4 2021, with 90% of activities occurring in 2022
- Operation Phase – Estimated 12-year operation life, with commissioning / start-up and mine / mill operation slated to start Q2 2023
- Decommissioning, Rehabilitation and Closure Phase – Closure rehabilitation to occur once it is no longer economical to mine or resources are exhausted

4.3 EXISTING CONDITIONS

The existing conditions characterize the conditions from historical and present activities in the Project Area, LAA and RAA. Existing conditions for each VC are established based on data collected during studies involving desktop analyses, field programs, engagement, and from traditional use studies. An overview of the existing environment is presented using information about the current conditions and includes the identification of data gaps important for the effects assessment. Influences of past and present projects and physical activities on the VC condition leading to the present time is presented along with a discussion of the current condition of the VC. The existing environmental conditions are described in each of the VC chapters (Chapters 5 to 19).

Table 4.1 identifies the baseline studies that have been completed in support of the Project between 2011 and 2020. These studies have been appended to this EIS as Baseline Study Appendices (BSAs). Results from these studies are summarized in the respective VC chapters (Chapters 5 to 19), with the detailed findings provided in the attached BSAs.

Table 4.1 Baseline Study Appendices

Number	Baseline Study Appendix	Attachment Number	Attachment Name
BSA.1	Dam Safety	1-A	Dam Breach Assessment and Inundation Study – Valentine Gold Tailings Management Facility (2020) (Golder)
		1-B	Dam Breach Assimilative Capacity Study for the Valentine Gold Tailings Management Facility (2020) (Golder)
		1-C	Valentine Gold Project Blast Impact Assessment (2020) (Golder)
BSA.2	Woodland Caribou	2-A	Fall 2019 Caribou Survey – Remote Cameras (2019)
		2-B	Spring 2020 Caribou Survey – Remote Cameras (2020)
		2-C	2020 Post-Calving Aerial Survey (2020)
BSA.3	Water Resources	3-A	Valentine Lake Project: Preliminary Baseline Hydrogeology Assessment (2017)
		3-B	Valentine Lake Project: Preliminary Hydrogeology Assessment, Water Level Data (2019)
		3-C	Valentine Gold Project Hydrology and Water Quality Monitoring Baseline Report (2020)
		3-D	Hydrogeology Baseline Report (2020) (GEMTEC)
BSA.4	Fish, Fish Habitat and Fisheries	4-A	Fish and Fish Habitat Data Report (2012)
		4-B	Valentine Project: 2018 Fish and Fish Habitat
		4-C	Aquatic Survey (2019)
		4-D	Ice Thickness Survey (2020)
		4-E	Fisheries Baseline Report
BSA.5	Acid Rock Drainage / Metal Leaching (ARD/ML)	5-A	Phase I Acid Rock Drainage / Metal Leaching (ARD/ML) Assessment (2018)
		5-B	Phase II ARD/ML Assessment (2020)
BSA.6	Atmospheric Environment	Not Applicable	Air, Noise and Light Baseline Field Study (2020)
BSA.7	Avifauna, Other Wildlife and Their Habitats	7-A	Winter Wildlife (2013)
		7-B	2011 Forest Songbird Surveys (2014)
		7-C	2011 Baseline Waterfowl and Waterfowl Habitat Study (2014)
		7-D	Ecological Land Classification (2015)
		7-E	Waterfowl (2017)

Table 4.1 Baseline Study Appendices

Number	Baseline Study Appendix	Attachment Number	Attachment Name
		7-F	Vegetation Baseline Study, Rare Plants Survey (2017)
		7-G	Newfoundland Marten (2018)
		7-H	Forest Songbird Survey (2019)
		7-I	Vegetation Baseline Study (2019)
BSA.8	Species at Risk / Species of Conservation Concern	--	Not Applicable
BSA.9	Community Health, Services and Infrastructure / Employment and Economy	9-A	An Analysis of the Economic Impacts Associated with Marathon Gold's Valentine Gold Project (2020)
		9-B	Estimate of Quarterly Direct Employment by Project Phase and National Occupational Classification (NOC)
		9-C	Educational Requirements by National Occupational Classification (NOC) and Availability of Training Programs within NL
BSA.10	Historic Resources	10-A	Valentine Lake Project: Historic Resources Baseline Study (2017)
		10-B	Valentine Gold Project: Historic Resources Baseline Study 2020 Update (2020)

4.4 ASSESSMENT CRITERIA AND METHODS

4.4.1 Residual Effects Characterization

Following the analysis of environmental effects pathways and mitigation measures, the residual environmental effects are characterized using the following criteria: direction, magnitude, geographic extent, timing, frequency, duration, reversibility, and ecological or socio-economic context. The definitions of these criteria, which are further customized in each VC-specific assessment, are outlined in Table 4.2. Quantitative measures were developed, where possible, to characterize residual effects. Qualitative considerations were used where quantitative measurement was not possible.

Table 4.2 Characterization of Residual Effects on [VC name]

Characterization	Description	Quantitative Measure or Definition of Qualitative Categories
Direction	The long-term trend of the residual effect	**Neutral –** no net change in measurable parameters for the [VC name] relative to baseline **Positive –** a residual effect that moves measurable parameters in a direction beneficial to [VC name] relative to baseline **Adverse –** a residual effect that moves measurable parameters in a direction detrimental to [VC name] relative to baseline

Table 4.2 Characterization of Residual Effects on [VC name]

Characterization	Description	Quantitative Measure or Definition of Qualitative Categories
Magnitude	The amount of change in measurable parameters or the VC relative to existing conditions	**Negligible –** no measurable change **Low –** [To be defined by VC] **Moderate –** [To be defined by VC] **High –** [To be defined by VC]
Geographic Extent	The geographic area in which a residual effect occurs	**Project Area –** residual effects are restricted to the Project Area **LAA –** residual effects extend into the LAA **RAA –** residual effects interact with those of other projects in the RAA
Timing	Considers when the residual environmental effect is expected to occur. Timing considerations are noted in the evaluation of the residual environmental effect, where applicable or relevant.	**Not Applicable –** seasonal aspects are unlikely to affect [VC] **Applicable –** seasonal aspects may affect [VC]
Frequency	Identifies how often the residual effect occurs and how often during the Project or in a specific phase	**Single event** **Multiple irregular event –** occurs at no set schedule **Multiple regular event –** occurs at regular intervals **Continuous –** occurs continuously
Duration	The period of time required until the measurable parameter or the VC returns to its existing (baseline) condition, or the residual effect can no longer be measured or otherwise perceived	**Short term –** residual effect restricted to no more than the duration of the construction phase (16 to 20 months) or decommissioning, rehabilitation and closure phase **Medium term –** residual effect extends through the operation phase (12 years) **Long term –** residual effect extends beyond the operation phase (greater than 12 years) **Permanent –** recovery to baseline conditions unlikely
Reversibility	Describes whether a measurable parameter or the VC can return to its existing condition after the project activity ceases	**Reversible –** the residual effect is likely to be reversed after activity completion and rehabilitation **Irreversible –** the residual effect is unlikely to be reversed
Ecological and Socio-economic Context	Existing condition and trends in the area where residual effects occur	**Undisturbed –** area is relatively undisturbed or not adversely affected by human activity **Disturbed –** area has been substantially previously disturbed by human development or human development is still present

4.4.2 Significance Definition

Significance criteria or thresholds were developed for each VC for the purposes of assessing residual environmental effects and identifying the threshold beyond which a residual effect would be considered significant. In accordance with CEAA 2012, the determination of significance includes considering whether the predicted residual environmental effects of the Project are adverse, significant and likely. The definition and determination of significance criteria and thresholds for this Project align with the guidance provided in the Operational Policy Statement, *Determining Whether a Designated Project is Likely to Cause Significant Environmental Effects Under the Canadian Environmental Assessment Act, 2012* (CEA Agency 2015). Where pre-established standards or thresholds do not exist, significance criteria have been defined qualitatively and justifications for the criteria provided.

For each environmental effect, threshold criteria or standards are identified beyond which a residual environmental effect is considered significant. The thresholds are defined in consideration of federal and provincial regulatory requirements, standards, objectives, or guidelines, as applicable to the VC. Where thresholds are not set by guidelines or regulations, a threshold is developed using the measurable parameters established for the VC, along with professional judgement of the assessors. The thresholds define the limits of a change in a measurable parameter or state of the VC beyond which it would be considered significant, based on resource management objectives, community standards, scientific literature, or ecological processes (e.g., desired states for fish or wildlife habitats or populations). Quantitative thresholds are preferred; however qualitative thresholds for significance may be used where quantitative thresholds are lacking.

4.4.3 Potential Effects, Pathways and Measurable Parameters

For each VC, potential effects and Project effect pathways (both direct and indirect) are identified. The measurable parameters and units of measurement used to assess potential effects are also identified. Quantitative measurable parameters are used where possible, with qualitative parameters and units of measurement identified where the nature of the effect or available data does not allow for a quantitative assessment. Potential environmental effects and measurable parameters have been selected based on review of recent EAs for mining projects in Newfoundland and Labrador and other parts of Canada, comments provided during engagement, and professional judgment.

4.4.4 Project Interactions with VC

For each potential effect, the physical activities that might interact with the VC and result in the identified environmental effect are identified (Table 4.3). These interactions are indicated by a checkmark and are discussed in detail below, in the context of standard and Project-specific mitigation / enhancement, and effects pathways and residual effects. Components and activities that do not interact with the VC are also identified and the reason for the lack of interaction is explained.

Table 4.3 Project-Environment Interactions with [VC name]

Physical Activities	Environmental Effects to be Assessed	
	Effect 1	Effect 2
CONSTRUCTION		
Access Road Upgrade / Realignment: Where required, road widening and replacement / upgrades of roads and culverts.		
Construction-related Transportation along Access Road		

Table 4.3 Project-Environment Interactions with [VC name]

Physical Activities	Environmental Effects to be Assessed	
	Effect 1	Effect 2
Mine Site Preparation and Earthworks: Clearing and cutting of vegetation and removal of organic materials, development of roads and excavation and preparation of excavation bases within the mine site, grading for infrastructure construction. For the open pits, earthworks include stripping, stockpiling of organic and overburden materials, and development of in-pit quarries to supply site development rock for infrastructure such as structural fill and road gravels. Also includes temporary surface water and groundwater management, and the presence of people and equipment on site.		
Construction / Installation of Infrastructure and Equipment: placement of concrete foundations, and construction of buildings and infrastructure as required for the Project. Also includes: • Installation of water control structures (including earthworks) • Installation and commissioning of utilities on-site • Presence of people and equipment on-site		
Emissions, Discharges and Wastes[A]: Noise, air emissions / GHGs, water discharge, and hazardous and non-hazardous wastes.		
Employment and Expenditures[B]		
OPERATION		
Operation-related Transportation Along Access Road		
Open Pit Mining: Blasting, excavation and haulage of rock from the open pits using conventional mining equipment.		
Topsoil, Overburden and Rock Management: Five types of piles: • Topsoil • Overburden • Waste rock • Low-grade ore • High-grade ore Rock excavated from the open pits that will not be processed for gold will be used as engineered fill for site development, maintenance and rehabilitation, or will be deposited in waste rock piles.		
Ore Milling and Processing: Ore extracted from the open pits will be moved to the processing area where it will either be stockpiled for future processing or crushed and milled, then processed for gold extraction via gravity, flotation and leach processes.		
Tailings Management Facility: Following treating tails via cyanide destruction, tailings will be thickened and pumped to an engineered TMF in years 1 to 9, then pumped to the exhausted Leprechaun open pit in years 10 through 12.		

Table 4.3 Project-Environment Interactions with [VC name]

Physical Activities	Environmental Effects to be Assessed	
	Effect 1	**Effect 2**
Water Management (Intake, Use, Collection and Release): Recirculated process water and TMF decant water will serve as main process water supply, and raw water (for purposes requiring clean water) will be obtained from Victoria Lake Reservoir. Site contact water and process effluent will be managed on site and treated prior to discharge to the environment. Where possible, non-contact water will be diverted away from mine features and infrastructure, and site contact and process water will be recycled to the extent possible for use on site.		
Utilities, Infrastructure and Other Facilities • Accommodations camp and site buildings, including vehicle maintenance facilities • Explosives storage and mixing • Site road maintenance and site snow clearing • Access road maintenance and snow clearing • Power and telecom supply • Fuel supply		
Emissions, Discharges and Wastes[A]: Noise, air emissions/GHGs, water discharge, and hazardous and non-hazardous wastes.		
Employment and Expenditures[B]		
DECOMMSSIONING, REHABILITATION AND CLOSURE		
Decommissioning of Mine Features and Infrastructure		
Decommissioning, Rehabilitation and Closure-related Transportation Along Access Road		
Progressive Rehabilitation: Rehabilitating infrastructure or areas not required for ongoing operations (e.g., buildings, roads, laydown areas); covering and revegetating completed tailings areas, where practicable, including commencing closure of TMF beginning in Year 9 (when tailings deposition moves to Leprechaun open pit); erosion stabilization and re-vegetation of completed overburden and/or waste rock piles; infilling or flooding of exhausted mining areas; and completing revegetation studies and trials.		
Closure Rehabilitation: Active rehabilitation based on successes of progressive rehabilitation activities. Includes: demolishing infrastructure (e.g., buildings, equipment, facilities, roads, laydown areas); grading and revegetating cleared areas, where practicable; breaching and regrading ponds to reestablish drainage patterns; completing closure of TMF (covering with overburden and revegetating); erosion stabilization and revegetation of completed overburden and/or waste rock piles; and infilling or flooding of open pits.		
Post-Closure: Long-term monitoring		

Table 4.3 Project-Environment Interactions with [VC name]

Physical Activities	Environmental Effects to be Assessed	
	Effect 1	Effect 2
Emissions, Discharges and Wastes[A]		
Employment and Expenditures[B]		

Notes:
✓ = Potential interaction
– = No interaction
[A] Emissions, Discharges, and Wastes (e.g., air, waste, noise, light, liquid and solid effluents) are generated by many Project activities. Rather than acknowledging this by placing a checkmark against each of these activities, “Wastes and Emissions” is an additional component under each Project phase
[B] Project employment and expenditures are generated by most Project activities and components and are the main drivers of many socio-economic effects. Rather than acknowledging this by placing a checkmark against each of these activities, “Employment and Expenditures” is an additional component under each Project phase

4.4.5 Analytical Assessment Techniques

In each VC chapter, the analytical assessment techniques are described that are specific to that VC, including assumptions made in the VC assessment, as well as conservative assumptions used as part of the precautionary approach.

Project-specific modelling studies were conducted by Marathon to understand the fate and behavior of discharges and emissions from the Project and changes to water flow (surface and ground water) once the Project is operational. The models are applicable to various VCs’ effects assessments for the Project and are summarized below.

4.4.5.1 Air Dispersion Modelling

Air dispersion modelling was completed by Stantec to predict ground level concentrations of potential contaminants of concern associated with the operation of the Project. The modelling was conducted in accordance with the Government of Newfoundland and Labrador’s Guidance Document titled *Guideline for Plume Dispersion Modelling* (NL DEC 2012), and incorporated emissions from the major activities proposed for Project operation. The predicted concentrations were then added to the existing background concentrations and the overall concentration was compared to applicable ambient air quality criteria. The air dispersion modelling methodology and results are presented in Section 5.5.

4.4.5.2 Acoustic Modelling

Sound pressure levels associated with the operation of the Project were predicted using Cadna/A® (Computer Aided Noise Abatement) noise prediction software. The acoustic modelling incorporated estimated sound pressure levels from the major Project activities, as well as the terrain in the Project Area, to predict sound pressure levels at the nearest receptor locations. The predicted sound pressure levels were then added to the existing sound levels in the Project Area and compared to applicable regulatory criteria. The results of the acoustic modelling are provided in Section 5.5.

4.4.5.3 Water Modelling

Water modelling was conducted for the Project to predict the interactions of the Project with groundwater and surface water resources. Stantec conducted groundwater flow modelling, watershed modelling, water quantity and quality modelling, and assimilative capacity modelling.

Groundwater flow modelling was completed to predict the effects of pit dewatering on groundwater levels and baseflow rates in streams, as well as the fate and transport of water that seeps from the waste rock piles and TMF. The modelling was conducted in accordance with the *Guidelines for Groundwater Modelling to Assess Impacts of Proposed Natural Resource Development Activities* (Wels et al. 2012). The predicted groundwater interactions were compared to the existing baseline conditions to assess effects on groundwater resources. The groundwater flow modelling methods and results are presented in Section 6.5.

Watershed modelling was completed to predict the effects of changing the runoff characteristics of the Project areas on the flow to surface water receptors. The predicted changes in runoff characteristics for disturbed areas were used as inputs for the water quantity modelling described below. The predicted streamflow rates based on disturbed Project areas and undisturbed areas were compared to the existing baseline conditions to assess effects on surface water resources. The watershed modelling methods and results are presented in Section 7.5.

Water quantity and quality modelling was completed to predict the quantity and quality of discharges from the Project Area to the receiving environment over the life of the Project, and the flooding of the pits post-closure. This modelling incorporated the inputs from groundwater and watershed modelling, as well as baseline water flow data, and precipitation inputs for the Project Area. The predicted discharges were combined with geochemical source term data and baseline water quality data to predict the water quality of the discharges from the Project Area. The water quantity and water quality modelling methods and results are presented in Section 7.5 and Appendix 7A (for the Leprechaun Complex and Process Plant and TMF Complex) and Appendix 7B (for the Marathon Complex).

Assimilative capacity modelling was completed to predict the mixed water quality in the receiving environment (Victoria Lake Reservoir, Valentine Lake, Victoria River) due to groundwater discharges predicted from the groundwater modelling, and the Project related discharges from the water balance / water quality modelling, including the potential effects of treatment of the discharges. These data were used to evaluate the Project-related surface water quality compared to baseline conditions. The assimilative capacity modelling methods and results are presented in Section 7.5 and Appendix 7C.

4.4.5.4 Visual Assessment

A visual assessment was conducted in ArcGIS Pro by Stantec using the viewshed analysis tool set and a digital elevation model covering the regional area. The results represent geographical areas that are visible from one or more observer points. The analysis considered a 360-degree view in all directions from the observer point. The viewshed results were used to identify if Project components would be visible to receptors near the mine site. The visual assessment methods and results are presented in Section 5.5.

4.4.5.5 Economic Impacts Analysis

A report was prepared by Strategic Concepts Inc. to evaluate the economic impacts expected from the development and operation of the Project (Strategic Concepts Inc. 2020). The economic impacts were analyzed for the economies of NL, the rest of Canada and the country as a whole. The economic impact model was based upon the principle of tracking expenditures through the economy by applying appropriate coefficients to determine direct, indirect and induced impacts on employment, incomes, gross domestic product and taxation. The primary sources of information included annual capital expenditure profiles and the ongoing operating costs that were provided by Marathon. These cost profiles, in addition to Marathon-provided estimates of the types of expenditures and the expected source of supply, formed the basis of the economic impact analysis undertaken and presented in the report. Additional detail on the methods, as well as the results, is provided in BSA.9, Attachment 9-A.

4.4.5.6 Fate and Effects Modelling

Stantec conducted fate and effects modelling for a hydrocarbon (i.e., diesel) and sodium cyanide and ammonium nitrate releases to the Victoria River at a bridge crossing within the Project Area. A baseline dispersion model was built for the river and two flow scenarios (i.e., low and high flow), which was run using the baseline data. Consequences were assessed assuming a volume of release based on tank size / baffling, pallet size / packaging and then the effect of hydrocarbon / cyanide in the river environment. The fate and effects modeling methods and results are provided in Chapter 21 and Appendix 21A.

4.5 MITIGATION AND MANAGEMENT MEASURES

Mitigation measures that will reduce or control potential environmental effects are identified and described for each VC. Technically and economically feasible mitigation measures constituting standard practice are considered in the evaluation of Project effects. Mitigation can also include VC-specific measures to address VC-specific issues, such as habitat offsetting / compensation, or planned environmental management and response measures. Where applicable, the extent to which technology innovations may help mitigate environmental effects are identified.

Proposed mitigation measures are identified in the VC-specific effects assessment chapters and in the Project Environmental Management Plans as part of a process of adaptive management (Section 2.7).

4.6 ASSESSMENT OF ENVIRONMENTAL EFFECTS ON VC

The environmental effects assessment for each VC examines the degree and nature of change to, and resulting effects on, the existing environment that may occur as a result of planned Project activities. The effects assessment considers the interactions among the VCs, including the extent to which biological diversity may be affected, and how the Project meets the needs of the present as well as future populations. Existing conditions for each VC, therefore, are considered in the effects assessment to determine the sensitivity or resiliency of the VC to further disturbance and/or change. The following subsections describe the organization and approach for the assessment of planned-Project activities.

4.6.1 Project Pathways

The Project pathways describe how the Project could result in the potential environmental effect (i.e., the Project-effect pathway) during each Project phase (i.e., construction, operation and decommissioning, rehabilitation and closure). The assessment of effect pathways is presented in the individual VC assessment chapters.

4.6.2 Residual Effects

The effects assessment considers relevant scientific literature, baseline and monitoring results and other available information (e.g., community, stakeholder and Indigenous knowledge) in the analysis of potential Project-related environmental changes to the VC that may result through one or more mechanisms or pathways. The focus of the effects assessment is on residual effects, which are the effects that remain after application of planned mitigation. Following the analysis of environmental effects pathways and mitigation measures, the residual environmental effects are characterized using the following criteria: direction, magnitude, geographic extent, timing, frequency, duration, reversibility, and ecological or socio-economic context. The definitions of these criteria, which are further customized in each VC-specific assessment, are outlined above in Table 4.2.

4.6.3 Summary of Project Residual Environmental Effects

A summary of the characterization of residual environmental effects is provided in tabular form for each VC. An example summary table is provided in Table 4.4.

Table 4.4 Example of Summary of Residual Environmental Effects Table

Residual Effect	Residual Environmental Effects Characterization							
	Direction	Magnitude	Geographic Extent	Timing	Duration	Frequency	Reversibility	Ecological and Socio-economic Context
Residual Effect 1								
Residual Effect 2								
Residual Effect 3								

Table 4.4 Example of Summary of Residual Environmental Effects Table

Residual Effect	Residual Environmental Effects Characterization							
	Direction	Magnitude	Geographic Extent	Timing	Duration	Frequency	Reversibility	Ecological and Socio-economic Context

KEY
See Table 4.2 for detailed definitions
Project Phase

C: Construction
O: Operation
D: Decommissioning, Rehabilitation and Closure

Direction:
P: Positive
A: Adverse

Magnitude:
N: Negligible
L: Low
M: Moderate
H: High

Geographic Extent:
PA: Project Area
LAA: Local Assessment Area
RAA: Regional Assessment Area

Duration:
ST: Short term
MT: Medium term
LT: Long term
P: Permanent

N/A: Not applicable

Frequency:
S: Single event
IR: Irregular event
R: Regular event
C: Continuous

Reversibility:
R: Reversible
I: Irreversible

Ecological / Socio-Economic Context:
D: Disturbed
U: Undisturbed
R: Resilient
N: Not Resilient

4.7 DETERMINATION OF SIGNIFICANCE

For each environmental effect, threshold criteria or standards beyond which a residual environmental effect is considered significant are identified (Section 4.4.2). Using the VC-specific significance definitions stated within each VC section, the assessment evaluates the significance of these effects and summarizes the residual environmental effects of the Project's activities and components in a concluding paragraph in each VC section. If a significant adverse residual effect is predicted, then the likelihood of this occurrence is also discussed.

4.8 ASSESSMENT OF CUMULATIVE ENVIRONMENTAL EFFECTS

Under cumulative effects assessment, Project residual effects that are likely to interact cumulatively with residual environmental effects from other physical activities (past, present and reasonably foreseeable) are identified and assessed. The Project's contribution to the cumulative effect is then analyzed. The approach used for conducting the cumulative effects assessment for the Project is informed by the *Operational Policy Statement for Assessing Cumulative Environmental Effects* under the *Canadian Environmental Assessment Act, 2012* (CEA Agency 2016), *Technical Guidance for Assessing Cumulative Environmental Effects* under the *Canadian Environmental Assessment Act,* 2012 (CEA Agency 2014), and the Federal EIS Guidelines (Appendix 1A) and Provincial EIS Guidelines (Appendix 1B).

The effects of past and current projects contribute to baseline conditions upon which Project effects are assessed. Cumulative effects are described as those resulting from residual Project effects combined with the effects of reasonably foreseeable future projects and activities. Future projects that are reasonably foreseeable are those that (a) have obtained the necessary authorizations to proceed or are in the process of obtaining the required authorizations, or (b) have been publicly announced with the intention to seek the necessary authorizations to proceed.

Two conditions must be met to initiate an assessment of cumulative effects on a VC:

- The Project is assessed as having adverse residual environmental effects on a VC
- The adverse residual effects from the Project overlap spatially and temporally with residual effects of other physical activities on a VC

If either condition is not met, an assessment of cumulative environmental effects has not been completed.

A project and activity inclusion list (Table 20.1; Figure 20-1) provides known past, present and reasonably foreseeable future projects and physical activities that could overlap spatially and temporally with the Project's residual environmental effects. Chapter 20 evaluates residual environmental effects of the Project (as assessed in Chapters 5 to 19) in the context of residual effects from past, present and certain or reasonably foreseeable future physical activities (i.e., projects or activities) to determine the potential for cumulative effects.

4.9 ASSESSMENT OF POTENTIAL ACCIDENTS OR MALFUNCTIONS

Section 19 (1) (a) of CEAA 2012 and the Federal EIS Guidelines (Appendix 1A) and Provincial EIS Guidelines (Appendix 1B) require that the EA consider the effects of accidents or malfunctions that might occur in connection with the Project. The potential for and consequence (i.e., adverse environmental effects) of accidents or malfunctions to occur over the life of the Project were assessed in the EIS. The assessment provides an initial basis for development of contingency planning and what will eventually be incorporated into the Project's emergency and contingency response plans. Details on the types of accident or malfunction events considered are discussed in Chapter 21.

Potential environmental effects on VCs due to accidents or malfunctions are assessed in a similar fashion to Project environmental effects (Section 4.6). Environmental effects are identified, mitigation and safety measures are described (i.e., incident avoidance measures, design safeguards) and effects are characterized using the same terms used for Project-related environmental effects. The significance of the environmental effects is then determined using the same thresholds used for Project-related environmental effects.

4.10 EFFECTS OF THE ENVIRONMENT ON THE PROJECT

The Federal EIS Guidelines (Appendix 1A) and Provincial EIS Guidelines (Appendix 1B) for the Project and section 19.1(h) of CEAA 2012 require consideration of changes to the Project that may be caused by the environment. Effects that may occur as a result of the environment acting on the Project are therefore assessed. Potential environmental forces and hazards may include climate (e.g., extreme precipitation and storms, hurricanes, droughts, and floods), climate change, seismic events and landslides, and forest fires. The influence that these environmental forces and hazards may have on the Project are predicted and described and the measures to be taken to limit or avoid potential adverse effects are identified. The effects of the environment on the Project are presented in Chapter 22.

4.11 FOLLOW-UP AND MONITORING PROGRAMS

As per CEAA 2012, a follow-up program is a program for "verifying the accuracy of the environmental assessment (EA) of a designated project" and "determining the effectiveness of any mitigation measures." Proposed follow-up and monitoring programs identified as part of this EA will be used to:

- Verify the accuracy of environmental predictions
- Measure compliance with applicable licences, permits and other approvals
- Confirm adherence to general and specific mitigation measures
- Assess the effectiveness of mitigation and management measures
- Identify Project effects requiring further mitigation

A preliminary framework and scope for follow-up and monitoring have been developed in consideration of the Federal EIS Guidelines (Appendix 1A) and Provincial EIS Guidelines (Appendix 1B) for the Project, as well as in consideration of pertinent legislation, regulations, industry standards and legislative guides. Monitoring and follow-up plans are proposed for each VC (Chapters 5 to 19), where applicable, and summarized in Chapter 23. Follow-up and monitoring programs will be more fully developed in consultation with government agencies, Indigenous groups and stakeholders, where relevant.

4.12 REFERENCES

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5.0 ATMOSPHERIC ENVIRONMENT

5.1 SCOPE OF ASSESSMENT

The atmospheric environment as a valued component (VC) consists of four subcomponents: air quality, greenhouse gases, sound quality, and lighting. The atmospheric environment was assessed as a VC to meet the requirements of the Federal Environmental Impact Statement (EIS) Guidelines (Appendix 1A) and the Provincial EIS Guidelines (Appendix 1B) for the Project and because changes in the atmospheric environment may result from the construction, operation and decommissioning, rehabilitation and closure of the Project.

Air quality was selected as a subcomponent of the atmospheric environment because of its intrinsic importance to the health and wellbeing of humans, wildlife, vegetation, and other biota. The atmosphere is an important pathway for the transport of contaminants to the freshwater, terrestrial and human environments. Some Project activities will result in the release of substances to the atmosphere that are classed as air contaminants. These substances are activity-dependent (e.g., dust is raised during mining activities; combustion by-products emitted during the construction and operation phases).

The air quality assessment was conducted to determine potential residual and cumulative changes to ambient air quality. In the air quality assessment, the quantities of air contaminants that may be released to the atmosphere were estimated from the planned Project activities and modelled using an atmospheric dispersion model to predict the potential changes in ambient air quality associated with Project emissions (Section 5.5.1). The air quality assessment considered substances for which there are applicable air quality objectives and standards adopted by either or both the Newfoundland and Labrador Department of Environment, Climate Change and Municipalities (NLDECCM) and Environment and Climate Change Canada (ECCC). The predicted effects were assessed relative to these criteria.

The air quality assessment considered the following air contaminants:

- Nitrogen dioxide (NO_2)
- Carbon monoxide (CO)
- Sulphur dioxide (SO_2)
- Hydrogen Cyanide (HCN)
- Ammonia (NH_3)
- Total suspended particulate (TSP) matter with an aerodynamic diameter less than 30 µm
- Respirable particulate matter (PM_{10}) with an aerodynamic diameter less than 10 µm
- Fine particulate matter ($PM_{2.5}$) with an aerodynamic diameter less than 2.5 µm
- Metals (17 in total, including arsenic [As], cadmium [Cd], copper [Cu], lead [Pb], nickel [Ni], zinc [Zn])

Individual volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs), and metal species associated with diesel combustion exhaust were not included in the air quality assessment. While some releases of these compounds are expected from Project activities (primarily from diesel combustion), these are not expected to be released in substantive quantities and are not typically the primary air contaminants of concern from the operation of a mine. Further, the estimated quantities of air contaminants released from sources associated with the operation of the Project were based on the requirements in the EIS guidelines for assessing potential effects on the atmospheric environment.

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

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

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

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

Acoustic environment was selected as a subcomponent of the atmospheric environment because noise resulting from the Project can affect human health and wellbeing, and wildlife and wildlife habitat. The acoustic assessment includes baseline sound pressure level monitoring near the Project and predicted noise levels associated with construction and operation activities using acoustic modelling. The baseline and predicted noise levels were used to estimate the potential effects of the Project activities on the acoustic environment. The acoustic assessment was based on equivalent sound pressure levels (L_{eq}) for the daytime and nighttime periods (L_d and L_n), and the day-night average sound level (L_{dn}). The predicted and baseline noise levels were assessed using criteria recommended by Health Canada (2017), which includes a threshold associated with an estimate of the change in percentage of people highly annoyed (%HA) by noise emissions from Project activities.

Lighting was selected as a subcomponent of the atmospheric environment because exterior Project lighting can affect nighttime sky views and migrating wildlife, and result in visual aesthetic changes for, and physiological changes in, humans. Potential effects from Project lighting were assessed qualitatively using a viewshed analysis in consideration of the Project infrastructure and locations of nearest sensitive receptors.

The primary pathway for the subcomponents of the atmospheric environment to reach human and ecological receptors is via airborne dispersion during Project activities. Therefore, a key objective of the assessment of air quality, GHGs, acoustics and lighting was to predict changes to these subcomponents of the atmospheric environment that may in turn affect the following VCs:

- Surface Water Resources (Chapter 7)
- Vegetation, Wetlands, Terrain and Soils (Chapter 9)
- Avifauna (Chapter 10)
- Caribou (Chapter 11)
- Other Wildlife (Chapter 12)
- Community Health (Chapter 14)
- Land and Resource Use (Chapter 16)
- Indigenous Groups (Chapter 17)

5.1.1 Regulatory and Policy Setting

In addition to the *Canadian Environmental Assessment Act, 2012* (CEAA 2012) and the Newfoundland and Labrador *Environmental Protection Act* (NL EPA), the Project is subject to other federal and provincial legislation, policies and guidance. This section identifies the primary regulatory requirements and policies of the federal and provincial authorities that influence the scope of the assessment on the atmospheric environment.

5.1.1.1 Air Quality

Air quality in Newfoundland and Labrador (NL) is regulated by the *Air Pollution Control Regulation* under the NL EPA. This Regulation and Act provide measures to regulate the release of air contaminants to the atmosphere from “sources”, provide testing and monitoring provisions, and establish maximum permissible ground-level concentrations of specified air contaminants in ambient air, among other requirements. The NL Ambient Air Quality Standards (NLAAQS) (Government of NL 2004) apply to ambient air and were established under the NL EPA in 2004. These values are also shown in Table 5.1.

The applicable federal air quality criteria considered in the assessment are the Canadian Ambient Air Quality Standards (CAAQS). The CAAQS were implemented to reduce emissions and ground-level concentrations of various air contaminants nationally. The CAAQS have been endorsed by the Canadian Council of Ministers of the Environment (CCME) for SO_2, $PM_{2.5}$, ozone (O_3) and NO_2. These CAAQS are adopted for the 2020 to 2025 period. The CAAQS values are shown in Table 5.1.

The CCME has yet to publish a guidance document on the procedures and methodologies that should be followed to assess whether measured concentrations of SO_2 or NO_2 exceed the CAAQS. However, it is understood that model predictions should not be directly compared to the CAAQS because these are intended to be compared with measured ambient air quality data and are not considered directly applicable to industrial fence-line concentrations. Therefore, although the predicted ground-level concentrations of criteria air contaminants (CACs) (including SO_2, $PM_{2.5}$, and NO_2) are compared to both the CAAQS and the NL *Air Pollution Control Regulations*, only exceedances against the NL regulations are considered in the residual effects assessment as a compliance standard.

The provincially and federally regulated air contaminants that are considered in the assessment are shown in Table 5.1.

Table 5.1 Summary of Federal CAAQSs and NL Air Quality Standards

Air Contaminant	Average Period	Newfoundland and Labrador Ambient Air Quality Standard (µg/m³)	Canadian Ambient Air Quality Standards (µg/m³)	
			2020	2025
Total Suspended Particulate Matter (TSP)	24-hour	120	-	-
	Annual	60	-	-
Respirable Particulate Matter (PM_{10})	24-hour	50	-	-
Fine Particulate Matter ($PM_{2.5}$)	24-hour	25	27 [1]	NA
	Annual	8.8	8.8	NA
Nitrogen Dioxide (NO_2)	1-hour	400	113 [4]	79 [4]
	24-hour	200	-	-
	Annual	100	32 [5]	28.2 [5]
Sulphur Dioxide (SO_2)	1-hour	900	183 [2]	170 [2]
	3-hour	600	-	-
	24-hour	300	-	-
	Annual	60	13.1 [3]	10.5 [3]
Carbon Monoxide (CO)	1-hour	35,000	-	-
	8-hour	15,000	-	-
Ammonia (NH_3)	24-hour	100	-	-
Arsenic (As)	24-hour	0.3	-	-
Cadmium (Cd)	24-hour	2	-	-
Copper (Cu)	24-hour	50	-	-
Lead (Pb)	24-hour	2	-	-
	30-day	0.7	-	-
Mercury (Hg)	24-hour	2	-	-
Nickel (Ni)	24-hour	2	-	-
Zinc (Zn)	24-hour	120	-	-

Notes:
[1] The $PM_{2.5}$ standard applied to the 98^{th} percentile over three consecutive years
[2] The 3-year average of the annual 99th percentile of the SO_2 daily maximum 1-hour average concentrations
[3] The average over a single calendar year of all the 1-hour average SO_2 concentrations
[4] The 3-year average of the annual 98th percentile of the NO_2 daily maximum 1-hour average concentrations
[5] The average over a single calendar year of all the 1-hour average NO_2 concentration
Source: CCME (2014)

In addition to these provincially and federally regulated air contaminants, select air contaminants (not regulated in NL) will be also be assessed for the Project due to small amounts of these compounds being present in the dust and hence may be emitted from the operation. As there are no ambient standards in NL for these select air contaminants, the Ontario Air Contaminant Benchmark (ACB) List will be considered to assess potential effects. The values for the Ontario limits are listed in Table 5.2.

Table 5.2 Summary of Ontario Air Contaminant Benchmarks for Trace Metals

Air Contaminant	Chemical Abstracts Service (CAS) #	Averaging Period	Limit (μg/m^3)	Limiting Effect	Source
Hydrogen Cyanide (HCN)	74-90-8	24-hour	8	Health	Standard (URT)
Barium (Ba)	7440-39-3	24-hour	10	Health	Guideline
Strontium (Sr)	7440-24-6	24-hour	120	Particulate[2]	Guideline
Beryllium (Be)	7440-41-7	24-hour	0.01	Health	Standard
Cobalt (Co)	7440-48-4	24-hour	0.1	Health	Guideline
Lithium (Li)	7439-93-2	24-hour	20	Health	Standard
Antimony (Sb)	7440-36-0	24-hour	25	Health	Standard
Tin (Sn)	7440-31-5	24-hour	10	Health	Standard
Selenium (Se)	7782-49-2	24-hour	10	Health	Guideline
Chromium (Cr [1])	7440-47-3	24-hour	0.5	Health	Standard (URT)
Bismuth (Bi)	7440-69-9	24-hour	2.5	Health	SL-JSL

Notes:
[1] Non-hexavalent forms
[2] The limiting effect relates to strontium within particulate matter
URT - Upper Risk Threshold
SL-JSL - Screening Level – Jurisdictional Screening Level
Source: Ontario MECP (2019)

5.1.1.2 Greenhouse Gases

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

The Government of NL has set the following emission reduction targets in the provincial Climate Change Action Plan (Government of NL 2019):

- a 35% to 45% reduction in regional GHG emissions below 1990 levels by 2030
- a 30% reduction in provincial GHG emissions below 2005 levels by 2030

On a federal level, Canada has committed to GHG emission reduction targets set as follows (ECCC 2019a):

- a 17% reduction of national GHG emissions below 2005 levels by 2020 (under the 2009 Copenhagen Accord)
- a 30% reduction of national GHG emissions below 2005 levels by 2030 (2015 submission to the United Nations Framework Convention on Climate Change, under the Paris Agreement)

- Net zero emissions by 2050 (Strategic Assessment of Climate Change [ECCC 2020a])

To support the initiatives and facilitate achieving the GHG reduction targets, the federal government developed the Pan-Canadian Approach to Pricing Carbon Pollution, providing flexibility to provinces and territories to develop carbon pollution pricing systems of their own, and outlining the required criteria for these systems (ECCC 2019b). For provinces and territories that have not implemented jurisdictional carbon pollution pricing systems that would meet the federal benchmark requirements, they are required to comply with the federal carbon pollution pricing system.

The province of NL created the Made-in-Newfoundland and Labrador Carbon Pricing Plan, which was approved by the federal government to meet the requirements of the Pan-Canadian Approach to Pricing Carbon Pollution in October 2018 (NLDMAE 2018). The plan consists of a hybrid system containing performance standards for large emitting facilities and large-scale electricity generation, and a carbon tax on fuel combustion, as outlined below:

- Performance standards based on sector benchmarks for industrial facilities emitting more than 25,000 tonnes CO_{2e} annually under NL's *Management of Greenhouse Gas Act* (2016). GHG emission reduction requirements are 8% in 2020, 10% in 2021 and 12% in 2022
- Carbon tax imposed by authority under NL's *Revenue Administration Act* (2011) and the *Revenue Administration Regulations* (NL Reg. 73/11). The carbon price was introduced on January 1, 2019 at $20 per tonne of CO_2e

In addition to the GHG reduction targets and carbon pricing, there are GHG emission reporting requirements both federally and provincially. Federally, under the authority of the *Canadian Environmental Protection Ac*t, *1999* (CEPA), the GHG Emission Reporting Program requires operators of facilities to report their annual GHG emissions to ECCC if their emissions are above 10,000 t CO_{2e} per year (ECCC 2019a). Provincially, under the authority of NL's *Management of Greenhouse Gas Act* (2016) and the *Management of Greenhouse Gas Reporting Regulations* (NL Reg 14/17), there are provincial GHG emission reporting requirements. There are three provincial levels of GHG reporting as follows:

- Facilities emitting 15,000 tonnes of CO_{2e} or more annually must report their emissions to the provincial government in accordance with the *Management of Greenhouse Gas Reporting Regulations*
- Facilities emitting between 15,000 and 25,000 tonnes of CO_{2e} annually may apply to be designated as opted-in facilities, in which the facility opts to performing a third-party verification of emissions in compliance with ISO 14064-3 and ISO 14065
- Facilities emitting more than 25,000 tonnes of CO_{2e} are subject to annual GHG reduction targets and require third-party verification of emission quantifications in compliance with ISO 14064-3 and ISO 14065

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

5.1.1.3 Sound Quality

There are no regulations regarding noise emissions in the province. Health Canada provides noise targets for annoyance, sleep disturbance and low-frequency noise effects in their Guidance Document, *Guidance for Evaluating Human Health Impacts in Environmental Assessment* (Health Canada 2017). Health Canada's approach to acoustic assessments is based on international standards and technical publications, including the World Health Organization's (WHO) *Guidelines for Community Noise* (1999) and *Night Noise Guidelines for Europe* (2009). The Health Canada guidance is typically followed when conducting Noise Impact Assessments to support federal environmental assessments.

The primary target recommended by Health Canada for use in acoustic assessments for activities longer than 12 months is the change in percent highly annoyed (%HA). The %HA is an estimate of the percentage of people who are potentially annoyed by noise emissions and is based on studies completed by the United States Environmental Protection Agency (US EPA). To calculate the %HA, the daytime equivalent sound levels (or L_d, a 15-hour time average of sound levels over the daytime period from 7:00 AM to 10:00 PM) and nighttime equivalent sound levels (or L_n, a 9-hour time average over the nighttime period from 10:00 PM to 7:00 AM) are combined to calculate an adjusted day-night average sound level (or L_{dn}). In the L_{dn} calculation, the L_n value is increased by 10-dB to account for higher sensitivity to noise emissions at night. The L_{dn} is then used to calculate the change in %HA due to project-related noise emissions.

Health Canada recommends that the maximum change in %HA due to project activities be no more than 6.5%. If the change in %HA threshold is exceeded, effects are considered to be of concern and may require mitigation.

The noise guidance from Health Canada (Health Canada 2017) references the guidelines and recommendations of the WHO for community noise (WHO 1999) and *Night Noise Guidelines for Europe* regarding sleep disturbance (WHO 2009). The WHO guideline recommends a target for sleep disturbance as being an indoor sound level of no more than 30 dBA L_{eq} for continuous noise during the sleep period (WHO 1999). Health Canada recommends that an outdoor-to-indoor transmission loss with windows at least partially open is 15 dBA and fully closed windows are assumed to reduce outdoor sound levels by approximately 27 dBA (Health Canada 2017). The corresponding outdoor sound level targets for sleep disturbance is 45 dBA and 57 dBA for partially open windows and fully closed windows, respectively.

More recently, the WHO (2009) has published nighttime noise guidelines that are intended to protect the public, including the most vulnerable groups, from adverse health effects associated with sleep disturbance due to nighttime noise. The recommended annual average is 40 dBA L_n to be considered outdoors.

5.1.1.4 Lighting

Most lighting guidelines and regulations have been directed toward the provision of suitable lighting for the safe and efficient activities of humans. For example, street lighting, indoor lighting and lighting around industrial plants are subjects of various guidelines to facilitate a safe work environment. Currently there are no legally binding requirements (e.g., regulations, orders) in NL to regulate obtrusive light from industrial facilities.

Various international organizations, including the International Dark Sky Association (IDA) and the Commission Internationale de L'Éclairage (CIE), also known as the International Commission on Illumination, have developed guidelines and recommendations to limit light pollution and associated effects to humans and wildlife. The Illuminating Engineering Society of North America (IESNA) have adopted such guidelines and recommendations for use in designing new outdoor lighting systems.

The CIE is an independent non-profit organization serving member countries on a voluntary basis. Since its inception in 1913, the CIE has become a professional organization and is currently recognized by the International Organization for Standardization (ISO) as an international standardization body relating to matters on light and lighting, color and vision, photobiology, and image technology (CIE 2017). The CIE has established guidelines for light trespass and glare for various levels of urbanization. These guidelines have been adopted in Great Britain, in particular by the Scottish Executive in their guidance document *Controlling Light Pollution and Reducing Lighting Energy Consumption* (Scottish Executive 2007).

The values represented in the guidelines are based on environmental zones and time of day. Five environmental zones have been established by the CIE (CIE 2017) as a basis for outdoor lighting. The five zones are listed in Table 5.3.

Table 5.3 Environmental Lighting Zones

Zone	Lighting Environment	Examples
E0	Intrinsically Dark	IDA Dark Sky Parks
E1	Dark	Relatively uninhabited rural areas
E2	Low district brightness	Sparsely inhabited rural areas
E3	Medium district brightness	Well inhabited rural and urban settlements
E4	High district brightness	Town and city centres and other commercial areas
Source: CIE 2017		

The maximum values recommended by CIE for light trespass (vertical illuminance) and glare on properties by environmental lighting zone and time of day are presented in Appendix 5A. Reference levels of sky glow are also presented in Appendix 5A.

5.1.2 The Influence of Engagement on the Assessment

As part of ongoing engagement and consultation activities, Marathon has documented interests and concerns about the Project received from communities, governments, Indigenous groups and stakeholders. An overview of Marathon's engagement activities is provided in Chapter 3. Documented interests and concerns have influenced the design and operational plans for the Project, and the development of the EIS, including the scope of assessment on the VCs. Interests and concerns noted that specifically relate to the atmospheric environment are described below.

Questions and concerns raised by Qalipu through Marathon's engagement efforts include:

- Atmospheric environment including the potential impact of tree clearing and increased emissions on air quality
- Interest in involvement in environmental monitoring for the Project

Questions and concerns raised by Miawpukek through Marathon's engagement efforts include:

- Potential impact on Miawpukek land and resource use
- Interest in involvement in environmental monitoring for the Project

Questions and concerns raised by communities and other stakeholders through Marathon's engagement efforts include:

- Air quality including dust, and specifically dust from tailings

Questions and concerns raised by fish and wildlife and civil society organizations through Marathon's engagement efforts include:

- The impact of greenhouse gas emissions from the Project

5.1.3 Boundaries

The scope of the assessment is defined by spatial boundaries (i.e., geographic extent of potential effects) and temporal boundaries (i.e., timing of potential effects). Spatial boundaries for the Atmospheric Environment VC were selected in consideration of the geographic extent over which Project activities, and their effects, are likely to occur on the VC. Temporal boundaries are based on the timing and duration of Project activities and the nature of the interactions with the VC. The spatial and temporal boundaries associated with the effects assessment for the Atmospheric Environment VC are described in the following sections.

5.1.3.1 Spatial Boundaries

The following spatial boundaries were used to assess Project effects, including residual environmental effects, on the atmospheric environment in areas surrounding the mine site and access road (Figure 5-1):

Project Area: The Project Area encompasses the immediate area in which Project activities and components occur and is comprised of two distinct areas: the mine site and the access road. The mine site includes the area within which Project infrastructure will be located, and the access road is the existing road to the site, plus a 20-metre (m) wide buffer on either side. The Project Area is the anticipated area of direct physical disturbance associated with the construction, operation and decommissioning, rehabilitation and closure of the Project.

Local Assessment Area (LAA) / Regional Assessment Area (RAA): For the Atmospheric Environment VC, the LAA (the area in which Project-related effects can be predicted or measured with a level of confidence that allows for assessment) and the RAA (the area in which cumulative effects on the atmospheric environment and the effects of accidental events are most likely to occur) are the same 40 km by 40 km area, plus a 500 m buffer on either side of the access road. This 40 km by 40 km area is the modelling domain used for dispersion modelling, and it includes receptors within and beyond the Project Area. This is the area that is also used to inform the assessment of cumulative effects (Chapter 20). The LAA and RAA are therefore considered together as the LAA/RAA in the remainder of the assessment (Figure 5-1). The acoustic modelling covered a slightly smaller grid domain within the LAA/RAA, 30 km (east-west) by 30 km (north-south).

The three GHGs described above (CO_2, CH_4 and N_2O) are long-lived in the atmosphere and these gases mix and disperse as they move down wind. The environmental effects related to GHGs are global and cumulative in nature, thus the spatial boundary for purposes of assessment is the global area under the Earth's atmosphere.

5.1.3.2 Temporal Boundaries

The temporal boundaries for the assessment of potential effects on the Atmospheric Environment VC include:

- Construction Phase – 16 to 20 months, beginning in Q4 2021, with 90% of activities occurring in 2022
- Operation Phase – Estimated 12-year operation life, with commissioning / start-up and mine / mill operation slated to start Q2 2023
- Decommissioning, Rehabilitation and Closure Phase – Closure rehabilitation to occur once it is no longer economical to mine or resources are exhausted

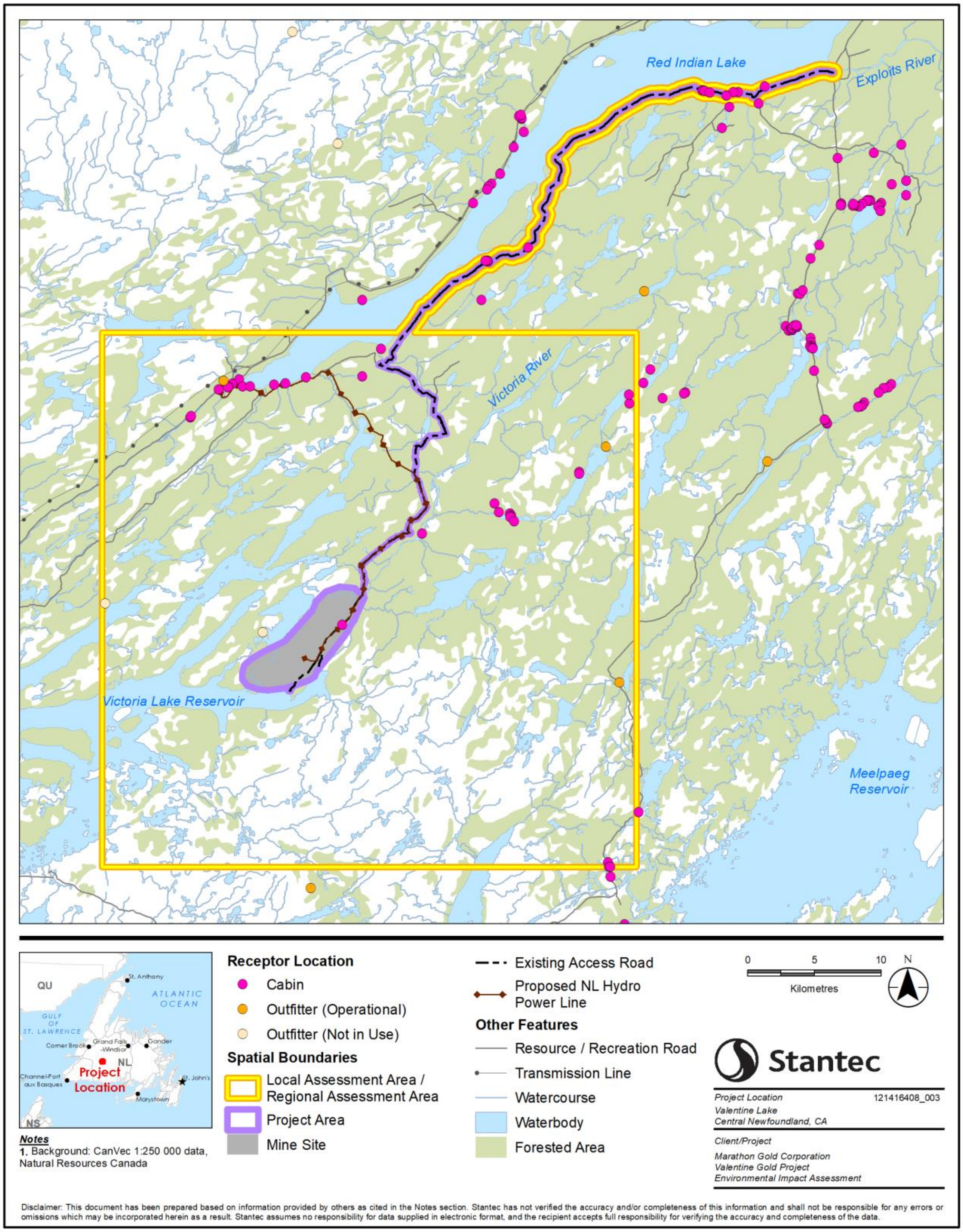


Figure 5-1 Local Assessment Area and Regional Assessment Area

5.2 EXISTING CONDITIONS FOR ATMOSPHERIC ENVIRONMENT

A characterization of the existing conditions within the spatial boundaries defined in Section 5.1.3 is provided in the following sections. This includes a discussion of the influences of past and present physical activities on the VC leading to the present time. The purpose of the description of existing conditions is to provide a baseline for the environmental effects discussion in Section 5.5.

Five distinct subcomponents are used to characterize existing conditions of the atmospheric environment:

- Climate
- Air Quality
- GHGs
- Sound Quality
- Lighting

The approach and methods used to characterize the baseline conditions of the atmospheric environment and an overview of the existing conditions are presented in the following subsections.

5.2.1 Methods

5.2.1.1 Climate

Existing climate in the Project Area is characterized using climate normals and wind data from the representative meteorological stations located nearest to the Project with sufficient data availability. Climate normals for the 30-year period from 1981 to 2010 and wind data from 2015 to 2019 were used in the assessment. The information on climate normals data was obtained from ECCC (ECCC 2019c). The wind information was obtained from the United States based National Climatic Data Center (NCDC) (NCDC 2020).

5.2.1.2 Air Quality

Existing air quality in the Project Area is characterized by obtaining and assessing measured ambient air quality data, as well as data for releases of air contaminants from existing sources within the LAA.

Ambient concentrations of particulate matter (TSP and PM_{10}), trace metals, SO_2 and NO_2 were measured at one location within the Project Area over the period of June 15 to 19, 2020. The methodologies used and a summary of results of the ambient air quality monitoring is provided in Baseline Study Appendix (BSA) 6: Atmospheric Environment (BSA.6).

Ambient concentrations of TSP, PM_{10} and metals were measured using two BGI PQ100 Ambient Air Particulate Samplers, which meet the requirements outlined by the US EPA for approved particulate matter sampling systems. Ambient concentrations of SO_2 and NO_2 were measured using passive air sampling devices. One field blank sample was also collected for each parameter.

Upon completion of the monitoring, the samples, along with field sampling details (i.e., sample date, duration, volume) were sent to Bureau Veritas Laboratories, in Mississauga, ON (particulate and metals samples) and Edmonton, AB (NO_2 and SO_2 samples) for analysis. The sampling results were reported as concentration and weight, over the duration of the sampling period.

In addition to the data collected within the Project Area, the most recently available ambient air quality data (2016 to 2017) from the National Air Pollutant Surveillance (NAPS) Program, the provincial air quality report (2018), as well as air contaminant release information (2017) were obtained and used in the assessment (NLDMAE 2019). Ambient air quality data were obtained from ECCC (ECCC 2019d) and air contaminant release information was obtained from ECCC National Pollutant Release Inventory (NPRI) (ECCC 2018).

5.2.1.3 Greenhouse Gases

Existing releases of GHGs in the LAA are characterized by summarizing provincial and national inventory data. Data published for the 2018 reporting year was used, as it presents the most recently available information. The GHG release information was obtained from the ECCC National Inventory Report (NIR) (ECCC 2020b).

An overview of the existing releases of GHGs in the LAA is also summarized in BSA.6.

5.2.1.4 Sound Quality

An understanding of the existing acoustic environment within the Project Area and at the nearest noise sensitive receptor locations is required to assess the potential effects of noise resulting from the Project. Health Canada recommends that baseline sound measurements being applied in an acoustic assessment, as part of an EIS, be characterized either through direct measurement or estimation (Health Canada 2017). Baseline sound quality monitoring was conducted within the Project Area to establish baseline sound levels for the acoustic assessment.

The acoustic assessment considered the following as potential sensitive receptors:

- Indigenous groups
- Traditional land use area
- Permanent and seasonal residences
- Places of worship
- Recreation area
- Schools
- Hospitals

There are no communities (and no schools, hospitals or places of worship), year around residential receptors, or major roadways located within the LAA/RAA. There are approximately 35 seasonal cabins / outfitter locations and the existing Marathon exploration camp (location 36) located within the LAA/RAA (Figure 5-2). Sleep disturbance is sometimes also considered for off-duty workers residing in or near the Project Area. As a result, the exploration camp and accommodations camp have been included in this assessment as noise sensitive receptors in the context of sleep disturbance effects.

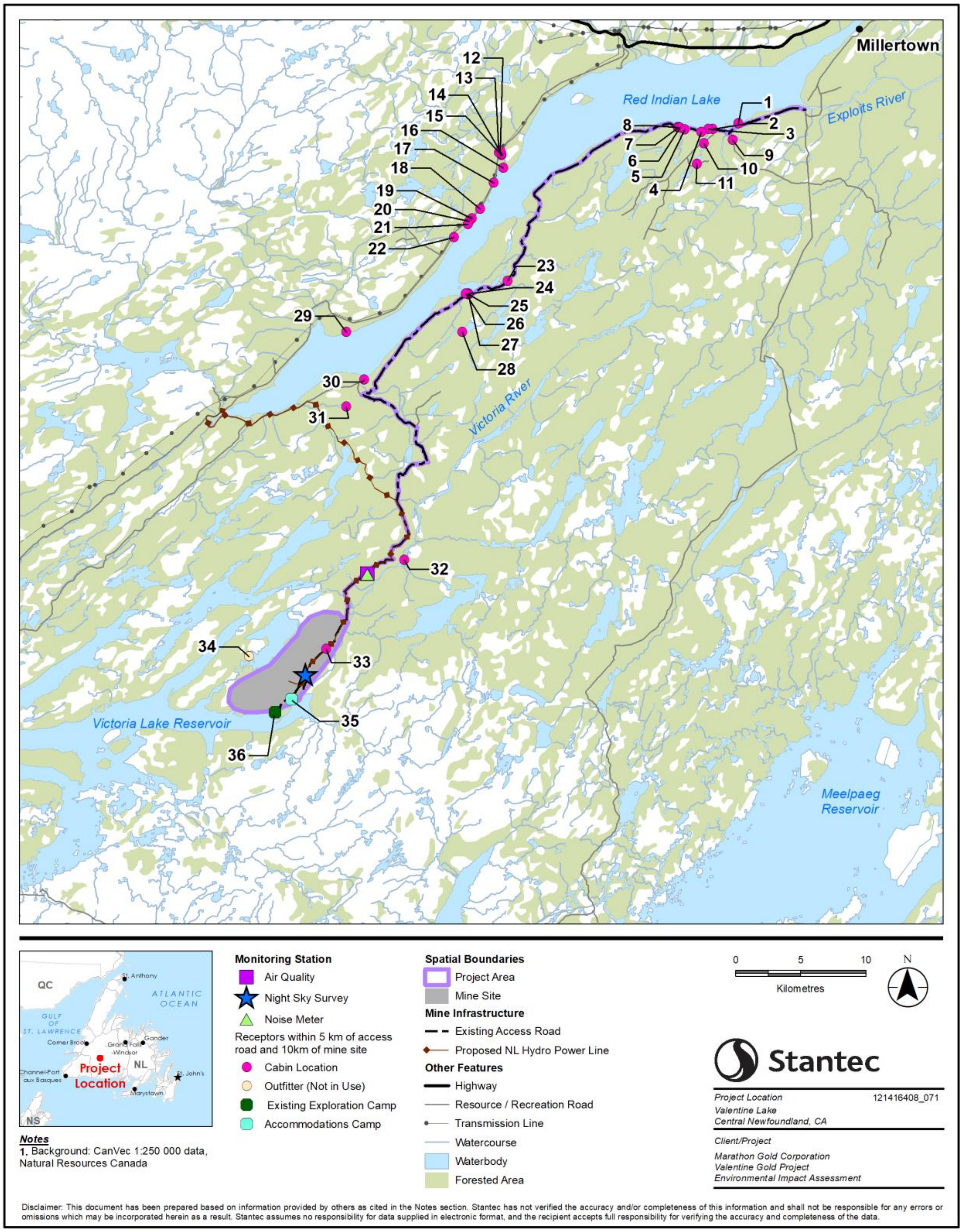


Figure 5-2 Locations of Seasonal Dwellings within 10 km of the Mine Site and 5 km of the Access Road

Details pertaining to the baseline sound quality monitoring survey are provided in BSA.6.

The baseline sound quality monitoring was conducted in accordance with ISO 1996-2:2007 (*Acoustics – Description, measurement and assessment of environmental noise – Part 2L Determination of environmental noise levels*), as recommended by Health Canada (Health Canada 2017). Ambient sound levels were measured using a Larson and Davis Type 1 Sound Pressure Level Meter (Model 831). The sound pressure level meter was set up to log one-minute L_{eq} values for a period of four days.

Upon completion of the sound monitoring the baseline measurements were downloaded from the sound pressure level meter and analyzed in relation to meteorological conditions during the time of monitoring, and potential nearby sources of sound (both natural and anthropogenic). Further calculations were performed on the raw data to obtain the L_d, L_n, L_{dn} and %HA for baseline conditions.

5.2.1.5 Lighting

Three attributes are used to describe potential environmental effects of light:

- Light trespass refers to the transmission of light from fixtures within a facility to the environment and receptors outside the facility. The unit of measure for light incidence either in or outside the facility is a lux. A lux is equal to one lumen lighting up an area of 1 m^2, or 1 lumen/m^2. A 60-watt incandescent light bulb emits approximately 800 lumens. Light trespass reaches problematic levels, for example, when lights (also referred to as luminaires) located on the outside of an industrial facility shine in through the windows of nearby residential homes at levels that could disrupt sleep or distract from normal levels.
- Glare refers to intense, harsh or contrasting lighting conditions associated with incoming light that reduces the ability of humans, birds and other organisms to see clearly. The most common example of glare is oncoming high-beam vehicle headlights that provide ample light for the driver in the oncoming vehicle, however, result in poor visibility, potentially reaching hazardous conditions for the driver meeting the other vehicle. The unit of measure is luminance, which is equal to lumens per steradian: this is the unit candela (cd).
- Sky glow refers to the illumination of the clouds by light sources on the surface of the Earth, such as street lighting, and haze in the atmosphere that replaces the natural nighttime sky with a translucent to opaque lighted dome. The sky appears washed out, or brownish-purple and may be devoid of visible stars in the extreme. Sky glow is the cumulative effect of all the lights at the surface either emitting upward or being reflected upward by the surface plus the emission from photochemical activity in the atmosphere. The unit of measure for the brightness of the sky, including sky glow, is magnitudes per square arcsecond (mag/$arcsec^2$). A sky glow measurement representative of a clear sky would be approximately 21 to 22 mag/$arcsec^2$ and within a city or urban area approximately 18-19 mag/$arcsec^2$ (Berry 1976).

The three types of light (light trespass, glare and sky glow) form the framework for describing the existing environment in the Project Area.

The existing ambient light levels within the Project Area were characterized by conducting ambient light monitoring, reviewing satellite observations of artificial light (World Atlas 2015), and by making assumptions based on the Project location, nearby communities, nearby sources of light, and Stantec's professional experience.

Light monitoring was conducted at one location near the center of the mine site. Ambient light monitoring included measurements of illuminance (lux) and sky glow (mag/arc sec^2). Illuminance was measured using a conventional, integrating hemispherical light meter (Extech EA33) with a resolution of 0.01 lux. Sky glow was measured using a Unihedron Sky Quality Meter with lens (SQM-L). Details pertaining to the baseline lighting survey are provided in BSA.6

5.2.2 Overview

An overview of the data and analysis used to characterize existing conditions for the atmospheric environment, including climate, air quality, GHG, sound quality and lighting for the Project, is provided in the following sections.

5.2.2.1 Climate

Climate normals for the 1981 to 2010 30-year period were obtained for the Buchans, NL, climate station (ECCC 2019c). The Buchans station is located approximately 55 km north-northeast of the mine site. Hourly wind data for the 2015 to 2019 period were obtained for the Deer Lake station, located approximately 95 km north of the mine site (NCDC 2020). Wind data were obtained from the Deer Lake station, as wind data is not measured at the Buchans station, and Deer Lake is the nearest station with observed conditions expected to be most representative of the mine site.

The 1981 to 2010 climate normals for the Buchans station are shown in Table 5.4.

Daily average temperatures at Buchans range between -8.4°C to 16.3°C, with the lowest average temperatures occurring in February and the highest occurring in July. Extreme daily maximum and minimum temperatures range between -33.5°C (February) to 33°C (July).

Total annual average precipitation at Buchans is 1,236 mm, with 359 cm of snow and 877 mm of rain. Monthly average precipitation ranges between 86 to 123 mm, with the least occurring in April and the most occurring in December.

A wind rose plot of the annual winds at Deer Lake from 2015 to 2019 is shown in Figure 5-3. Seasonal wind rose plots are also shown in Figure 5-4. Winds prevail from the southwest and northeasterly directions. The highest wind speeds occur most frequently from the southwest direction and the lowest wind speeds occur most frequently from the north and northeast directions. Calm periods are also common [with wind speeds less than 0.5 metres per second (m/s)], accounting for more than 22% of the observed winds at Deer Lake over the 2015 to 2019 period. Generally, the seasonal winds are consistent, with winds prevailing from the southwest and northeast (i.e., there is limited seasonal variation in the winds at Deer Lake). The small variability in wind direction at Deer Lake is due to local topography. The Deer Lake station (at Deer Lake Airport) is located in the Humber River Valley, which influences the winds in the area (i.e., the prevailing wind directions observed at Deer Lake are parallel to direction of the Humber River Valley (NE-SW direction)).

Table 5.4 Climate Normals, Buchans, NL (1981 – 2010)

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Temperature													
Daily Mean (°C)	-8.2	-8.4	-4.8	1	7	12.1	16.3	16.2	11.9	6	0.5	-4.5	3.8
Daily Maximum (°C)	-4.6	-4.4	-0.9	4.6	11.5	17	21.1	20.9	15.8	9.1	3.1	-1.5	7.6
Daily Minimum (°C)	-11.8	-12.3	-8.7	-2.5	2.5	7.1	11.4	11.6	7.9	2.8	-2.1	-7.5	-0.1
Extreme Daily Maximum (°C)	13.5	10	17	20.6	27.5	32	33	32	30	22.5	15.6	12.8	--
Date (yyyy/dd)	2006/15	1976/02	1999/29	1979/29	1999/08	1999/14	1983/05	1995/11	2001/10	1994/09	1977/10	1969/04	--
Extreme Daily Minimum (°C)	-30	-33.5	-30.5	-22.5	-10	-3.3	1	1.1	-2.2	-8.3	-19	-26	--
Date (yyyy/dd)	2004/25	1993/07	1990/08	1995/06	1972/02	1974/01	1995/02	1976/19	1972/29	1972/22	1992/24	1993/29	--
Precipitation													
Rainfall (mm)	33.7	25.6	39.5	59.5	82.2	87.7	95.3	123	110.3	92.5	81.5	46.3	877
Snowfall (cm)	88.3	72.5	55.5	26.2	4.4	0.1	0	0	0.1	5	30.4	76.9	359.3
Precipitation (mm)	122	98.1	95	85.7	86.6	87.8	95.3	123	110.4	97.5	111.8	123.1	1,236.2
Extreme Daily Rainfall (mm)	58.4	47	52.4	54	63.6	72.8	74.6	139	69	66.8	68.6	66.3	--

Table 5.4 Climate Normals, Buchans, NL (1981 – 2010)

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Date (yyyy/dd)	1983/13	1971/14	1983/22	1994/07	1993/15	1985/06	1996/14	1983/07	1998/05	1966/05	1995/26	1975/22	--
Extreme Daily Snowfall (cm)	40	38.1	70	20	17.8	10.2	0	0	3.8	28.4	25	30	--
Date (yyyy/dd)	1984/11	1973/11	2005/30	1992/06	1972/11	1976/12	1965/01	1965/01	1971/28	1969/22	1994/28	2000/27	--
Extreme Daily Precipitation (mm)	58.4	47	70	54	63.6	72.8	74.6	139	69	66.8	68.6	73.4	--
Date (yyyy/dd)	1983/13	1971/14	2005/30	1994/07	1993/15	1985/06	1996/14	1983/07	1998/05	1966/05	1995/26	1975/22	--
Source: ECCC 2019c													

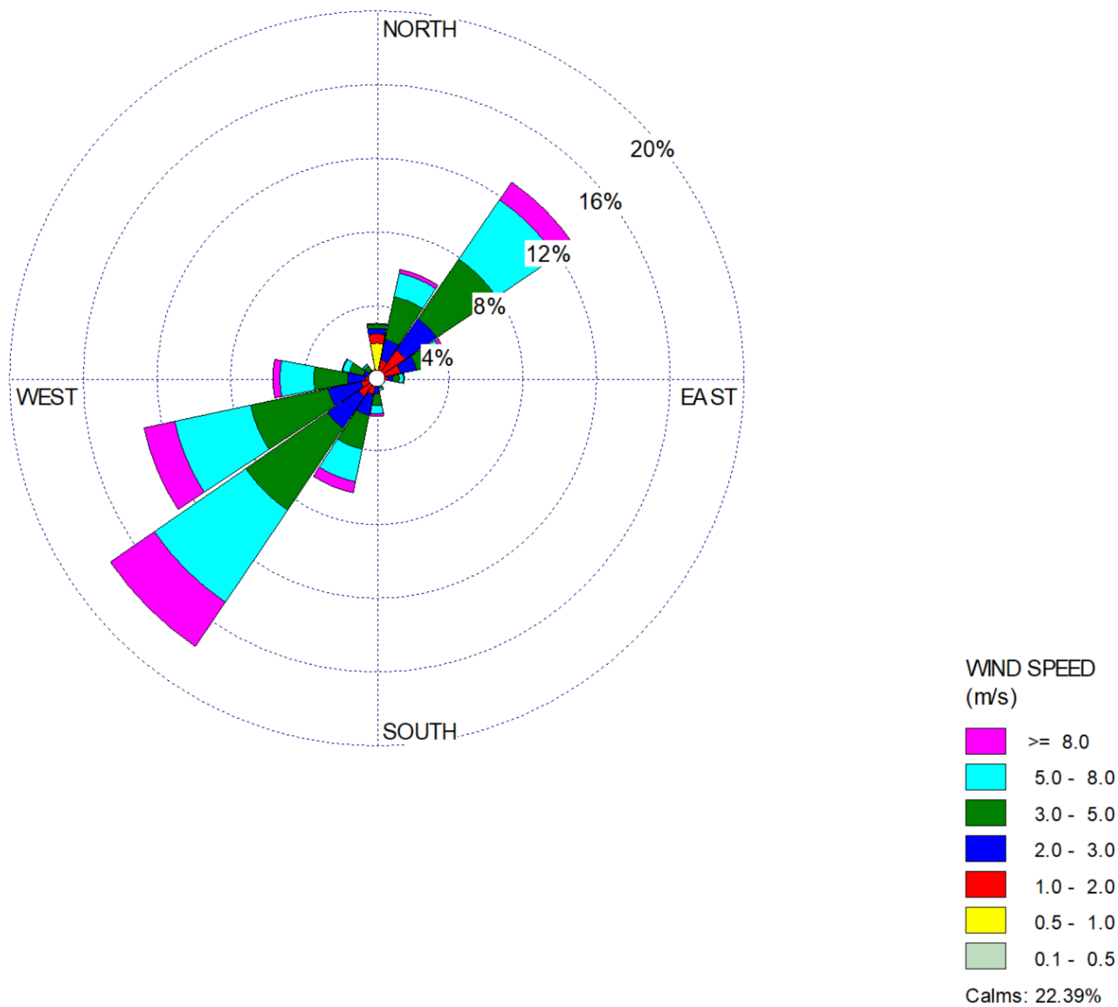


Figure 5-3 Winds at Deer Lake, NL (2015 – 2019)

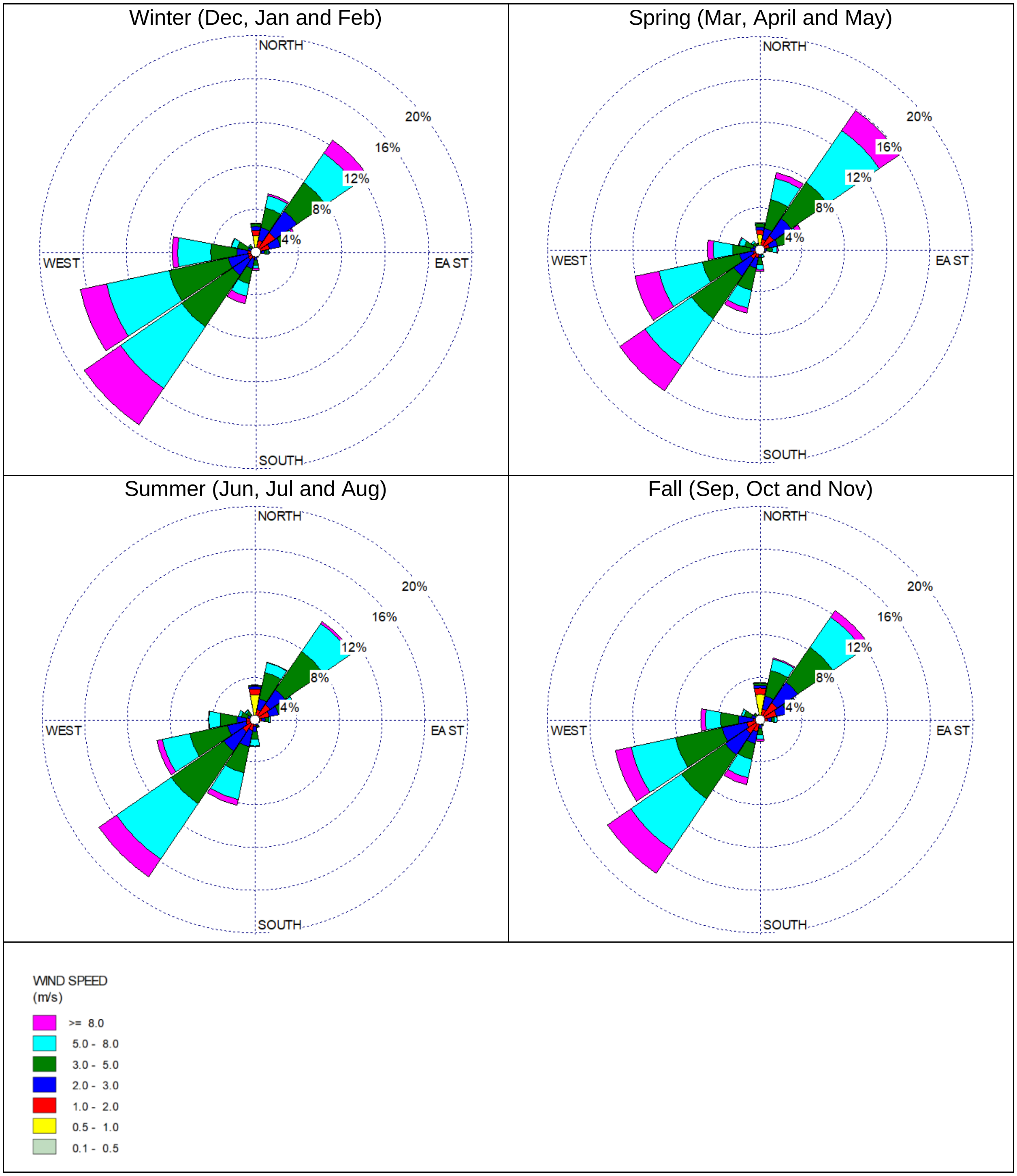


Figure 5-4 Seasonal Winds at Deer Lake, NL (2015 – 2019)

Climate change projections will also be considered in Chapter 22, Effects of the Environment on the Project, as outlined in the Federal EIS Guidelines (Appendix 1A) and Provincial EIS Guidelines (Appendix 1B), and as required as part of the federal guidance for Strategic Assessment of Climate Change (ECCC 2020a).

5.2.2.2 Air Quality

Key information for existing air quality included data provided in the most recently published NL 2018 Ambient Air Monitoring Report (NLDMAE 2019), the most recent year available for this publication at the time of writing. Ambient air quality data for 2019 are not yet available from NLDECCM. The report summarizes data obtained from the air quality monitoring network that has been operated by the government and industry in NL to monitor ambient concentrations of various air contaminants in selected communities.

In addition to the published ambient air quality data from the 2018 Ambient Air Monitoring Report, ambient concentrations of TSP, PM_{10}, trace metals, SO_2 and NO_2 were measured near the Project site over the period of June 15 to 19, 2020, as presented in BSA.6. The concentration data collected near the Project site was used to characterize existing conditions in the LAA/RAA. The most recently available hourly ambient air quality data for the nearest representative monitoring station to the mine site were also obtained to help characterize the existing conditions. The data are available from the ECCC NAPS program (ECCC 2019d).

In addition to information on ambient air quality, annual release summaries for large industrial facilities nearest to the Project from the ECCC's NPRI were reviewed. The NPRI is a public inventory of annual releases, disposals and transfers of over 320 pollutants from more than 7,000 facilities across Canada (ECCC 2018).

Ambient Air Quality

Ambient air quality monitoring was conducted at one location within the Project Area (Figure 5-2) over the period from June 15-19, 2020. Three 24-hour samples for TSP (including trace metals) and PM_{10} were collected over the period of June 15–17, 2020, and two passive samples (one for NO_2 and one for SO_2) were collected over the four-day period of June 16-19, 2020.

The baseline measured concentrations of NO_2, SO_2, TSP, PM_{10} and metals were well below applicable 24-hour ambient air quality criteria in NL. Measured concentrations of particulate matter (TSP and PM_{10}) ranged from 5.1 $\mu g/m^3$ to 13.8 $\mu g/m^3$ and the concentrations of TSP and PM_{10} were consistent, suggesting that the existing particulate matter within the LAA is made up mostly of PM_{10}. Metals detected in the samples included aluminum, calcium, magnesium, manganese, sodium and titanium; the measured concentrations were below the regulatory standards, where they exist. The remaining metals that were sampled were not detected above analytical reportable detection limits. The baseline measured concentrations of SO_2 and NO_2 were 3.84 $\mu g/m^3$ and 0.276 $\mu g/m^3$, respectively. Additional details on the monitoring conducted at the site is provided in BSA.6.

The nearest and most representative NAPS ambient air quality monitoring (AAQM) station is at Grand Falls-Windsor, approximately 120 km northeast of the mine site. There is a NAPS station located at Corner Brook, which is closer to the mine site; however, this station is immediately adjacent to the Corner Brook Pulp and Paper Mill. Therefore, air contaminant concentrations measured at the Corner Brook station are likely to be less representative of existing ambient concentrations in the area of the Project than those measured at the Grand Falls-Windsor station, where there are no large emissions sources.

Concentrations of the following air contaminants are measured at the Grand Falls-Windsor station: $PM_{2.5}$, O_3, nitric oxide (NO), NO_2, nitrogen oxides (NO_X), CO and SO_2.

Based on the NL 2018 Ambient Air Quality Report, there were no measured concentrations that exceeded the (NLAAQS) (for SO_2, NO_2 or CO) or the CAAQS (for $PM_{2.5}$) in 2018 at the Grand Falls-Windsor NAPS station. However, there were six exceedances of the 8-hour O_3 CCME CAAQS at the station in 2018 (NLDMAE 2019).

A combination of the ambient data collected at the site and data from the Grand Falls-Windsor NAPS station was used to characterize existing conditions in the Project Area, including background concentrations.

Background Concentrations

Existing conditions are characterized in the LAA using background concentrations of air contaminants of concern based on ambient air quality data measured near the Project. These measured background concentrations are combined with the air quality dispersion modelling results to assess the potential cumulative effects of the Project when combined with other sources of air contaminant emissions in the LAA. Given the rural and undeveloped nature of the mine site, the air contaminant concentrations in the LAA are likely to be low most of the time.

Background concentrations of $PM_{2.5}$, NO_2 and SO_2 are estimated using hourly ambient air quality data from 2016 and 2017, obtained from the ECCC NAPS for the Grand Falls-Windsor AAQM station (ECCC 2019d). Although NO_2 and SO_2 concentrations were measured near the Project site, the background concentrations are estimated based on the NAPS data. This is because hourly data over a longer time frame (multiple years) are available from the NAPS station at Grand Falls-Windsor, where the samples near the Project site were collected passively over a four-day period.

Background concentrations of TSP, PM_{10} and selected trace metals are estimated based on the results of the sampling conducted within the Project Area. The background concentrations are expected to include / cover emissions from potential nearby sources and long-range transport of emissions from the northeastern United States. The background concentrations used in the assessment are provided in Table 5.5.

Table 5.5 Background Concentrations Used in Assessment

Air Contaminant	Average Period	Background Concentration Applied ($\mu g/m^3$)	Monitoring Location	Calculation Basis
TSP	24-hour	13.8	Project site	The 24-hour TSP background concentration is the maximum of the 24-hour measured concentrations at the Project site over the June 15-17, 2020 period, based on three samples.
TPS	Annual	2.6	Project Site	The annual TSP background concentration is estimated using the 24-hour background concentration scaled using the Ontario MECP recommended relationship, $C_1 = C_0 \times (t_0/t_1)^{0.28}$ (Ontario MECP 2018).
PM_{10}	24-hour	13.0		The 24-hour PM_{10} background concentration is the maximum of the 24-hour measured concentrations at the Project site over the June 15-17, 2020 period, based on three samples.
$PM_{2.5}$	24-hour	10.3	Grand Falls-Windsor NAPS station	The 24-hour $PM_{2.5}$ background concentration is the 2016 and 2017 average 98th percentile of the daily average concentrations.
	Annual	3.8		The annual $PM_{2.5}$ background concentration is the maximum of the 2016 and 2017 annual average concentrations.
NO_2	1-hour	3.76	Grand Falls-Windsor NAPS station	The 1-hour NO_2 background concentration is the 90th percentile of hourly concentrations measured over the 2016 to 2017 period.
	24-hour	1.9		The 24-hour NO_2 background concentration is the maximum 24-hour average with hourly values > the 90th percentile excluded from the 24-hour average calculation.
	Annual	1.4		The annual NO_2 background concentration is the maximum of the 2016 and 2017 annual average concentrations with hourly values > the 90th percentile excluded from the annual average.
SO_2	1-hour	2.62	Grand Falls-Windsor NAPS station	The 1-hour SO_2 background concentration is the 90th percentile of hourly concentrations measured over the 2016 to 2017 period.
	3-hour	2.62		The 3-hour SO_2 background concentration is the maximum 3-hour average with hourly values > the 90th percentile excluded from the 3-hour average calculation.
	24-hour	Neg.		The 24-hour SO_2 background concentration is the maximum 24-hour average with hourly values > the 90th percentile excluded from the 24-hour average calculation, which is below detection, background is assumed negligible
	Annual	Neg.		The annual SO_2 background concentration is the maximum of the 2016 and 2017 annual average concentrations, with hourly values > the 90th percentile excluded from the annual average,

Table 5.5 Background Concentrations Used in Assessment

Air Contaminant	Average Period	Background Concentration Applied (μg/m³)	Monitoring Location	Calculation Basis
				which is below detection, background is assumed negligible.
CO	1-hour	206	Grand Falls-Windsor NAPS station	The 1-hour CO background concentration is the 90th percentile of hourly concentrations measured over the 2016 to 2017 period.
	8-hour	200		The 8-hour CO background concentration is the maximum 3-hour average with hourly values > the 90th percentile excluded from the 8-hour average calculation.
NH_3	24-hour	Neg.	NA	Not sampled, assumed negligible.
HCN	24-hour	Neg.	NA	Not sampled, assumed negligible.
As	24-hour	0.0021	Project site	The 24-hour metals background concentration is based on the laboratory method detection limit, as concentrations measured at the Project site over the June 15-17, 2020 period are below detection.
Cd	24-hour	0.00042		
Cu	24-hour	0.0013		
Pb	24-hour	0.0013		
	30-day	5.02E-04		The 30-day Pb background concentration is estimated using the 24-hour background concentration scaled using the Ontario MECP recommended relationship, $C_1 = C_0 \times (t_0/t_1)^{0.28}$ (Ontario MECP 2018).
Hg	24-hour	Neg.	NA	Not sampled, assumed negligible.
Ni	24-hour	0.0021	Project site	The 24-hour metals background concentration is based on the laboratory method detection limit, as concentrations measured at the Project site over the June 15-17, 2020 period are below detection.
Zn	24-hour	0.021		
Ba	24-hour	0.0021		
Sr	24-hour	0.0021		
Be	24-hour	0.0013		
Co	24-hour	0.0013		
Li	24-hour	Neg.	NA	Not sampled, assumed negligible.
Sb	24-hour	0.0021	Project site	The 24-hour metals background concentration is based on the laboratory method detection limit, as concentrations measured at the Project site over the June 15-17, 2020 period are below detection.
Sn	24-hour	0.0013		
Se	24-hour	0.0042		
Cr	24-hour	0.0021		
Bi	24-hour	0.0021		

Notes:
Neg. negligible; NA not applicable – air contaminant not sampled

The background concentrations (98th percentile and averages) are estimated for direct comparison with the 24-hour and annual average CCME CAAQS for $PM_{2.5}$.

Local Emission Sources

Given the largely undeveloped nature of the LAA, there are few anthropogenic sources and no large industrial emissions sources within the LAA for air quality. Based on a review of the NPRI data for the Island of Newfoundland, the nearest emissions sources to the mine site consist of two mines, which are no longer operational, and the Corner Brook Pulp and Paper Mill. The two mine sites include the Teck Resources Duck Pond Mine and Barite Mud Services, located approximately 51 km to 47 km northeast of the mine site. The Duck Pond Mine is no longer operational and is in the closure and rehabilitation phase, while Barite Mud Services is operational on a seasonal basis (Table 20.1). Although both sites are no longer fully operational, the potential exists for fugitive dust to be generated at both sites. In addition to the ongoing activities at these mine sites, fugitive dust from forestry activities in the LAA is also likely, due to equipment and vehicle movement along access roads. The Corner Brook Pulp and Paper Mill is located approximately 90 km to the northwest of the mine site. Based on NPRI reporting data, substantive air contaminant emissions from the pulp and paper mill consist of combustion gases (NO_X, CO, and SO_2), PM, VOCs and selected trace metals.

Given that the nearest sources of air contaminant emissions are outside of the LAA/RAA and distant from the Project site, it is unlikely that these air contaminant releases would contribute materially to reduced air quality within the LAA.

5.2.2.3 Greenhouse Gases

There are no local GHG emission sources that require reporting to the provincial or federal government within or near the Project Area.

Current provincial and national GHG emissions within the LAA were characterized by summarizing provincial and national GHG emissions inventory data. The provincial and national GHG emissions (ECCC 2020b) are presented in Table 5.6. Data published for the 2018 reporting year were used, as it presents the most recently available information. The GHG emissions information was obtained from the ECCC NIR (ECCC 2020b).

The provincial NL GHG emissions accounted for 1.5% of the national GHG emissions.

Table 5.6 Provincial and National GHG Emissions (2018)

Parameter	Units	CO_2	CH_4	N_2O	Other GHGs [a] (expressed as CO_{2e})	Total (expressed as CO_{2e})
NL GHG Emissions	kt CO_{2e} /y	9,780	900	140	192	**11,000**
National GHG Emissions	kt CO_{2e} /y	587,000	91,000	38,000	13,930	**729,000**
NL contribution to National GHG Emissions	%	1.7%	0.99%	0.4%	1.4%	**1.5%**

kt CO_{2e} /y kilotonnes of CO_2 equivalent per year
Note: [a] Other GHGs include sulphur hexafluoride, hydrofluorocarbons, perfluorocarbons and nitrogen trifluoride
Source: ECCC NIR (ECCC 2020b)

5.2.2.4 Sound Quality

The mine site is in a remote area with limited human activity, and no substantive anthropogenic noise sources within 50 km. The mine site is located approximately 49 km southwest of the Town of Buchans and 60 km southwest of the Town of Millertown. Within the LAA/RAA, there are approximately 35 seasonal dwellings (three active outfitters, 2 inactive outfitters and 30 cabins), which represent the nearest sensitive receptors to the Project (Figure 5-2). Baseline sound pressure levels were measured at one location within the Project Area (Figure 5-2), representative of the nearest receptor, following Health Canada (2017) recommended protocols, where feasible.

A summary of the L_d, L_n, L_{dn}, and %HA values for the baseline conditions are provided in Table 5.7. These baseline measurements have been assumed to apply to each receptor location considered within the acoustic assessment (Figure 5-2). The hourly measured baseline sound pressure levels used to calculate the baseline L_d, L_n, L_{dn}, and %HA values are presented in BSA.6.

Table 5.7 Baseline L_d, L_n, L_{dn}, and %HA Values

Parameter	June 16	June 17
Daytime Sound Level, L_d (dBA)	44.4	44.6
Nighttime Sound Level L_n (dBA)	39.6	38.1
Day Night Average Sound Level (dBA)	47.4	46.9
Baseline Percent Highly Annoyed (%HA)	1.57	1.47

The baseline L_{dn} values ranged from 46.9 dBA to 47.4 dBA and as per the Health Canada guidance (Health Canada 2017), these are representative of a quiet rural (< 45 dBA) to quiet suburban (48 – 52 dBA) area, with limited to no existing sources of noise. Health Canada recommends that a 10 dB adjustment be added to receptors in rural areas considered to have a greater expectation of “peace and quiet” and defines a rural area as having a L_{dn} of less than 45 dBA. As the baseline L_{dn} values were measured to be greater than 45 dBA, the adjustment for “peace and quiet” has not been applied in this assessment.

5.2.2.5 Lighting

As indicated in Section 5.2.2.4, the mine site is located approximately 49 km southwest of the Town of Buchans and 60 km southwest of the Town of Millertown. There are no communities, year-round residential receptors, or major roadways located within the LAA/RAA. There are approximately 35 seasonal cabins / outfitter locations located within the LAA/RAA (Figure 5-2).

The existing light environment was characterized using ambient light monitoring data, satellite observations of the global distribution of artificial light, and assumptions based on the Project location, nearby communities, nearby sources of light, and Stantec’s professional experience.

Figure 5-5 shows the distribution of artificial light within and surrounding the Project Area (Interactive world light pollution map based on the National Oceanic and Atmospheric Administration [NOAA] / Earth Observation Group [EOG] overlay 2015, World Atlas 2015). As shown in Figure 5-5, there are essentially no existing sources of artificial light contributing to the existing ambient light environment within the Project Area. The sky glow levels within these areas are 22.0 mag/arc sec^2. As presented in Appendix 5A, Table 5A.5, sky glow levels in this range are representative of an unpolluted starry sky, where, on clear nights with no haze, many thousands of stars would be visible and the Milky Way would be clearly visible (Berry 1976; United States Department of Energy [US DOE] 2017).

Light monitoring was conducted during the night of June 16, 2020 at one location near the center of the mine site (Figure 5-2). Details pertaining to the baseline light monitoring survey are presented in BSA.6.

Measurements of incident light were less than 0.01 lux and sky glow ranged from 21.84 to 22.81 mag/arc sec^2. Based on the ambient light levels (both sky glow and light trespass), the LAA is considered a dark, rural environmental zone, Category E1 (Appendix 5A, Table 5A.1).

The baseline light measurements taken in June occurred during clear skies when the moon was not in the sky. Incident light levels are not sensitive to seasonal variation, and sky glow typically varies by 0.2 mag/arcsec^2 depending on the season (Patat 2007). Sky glow is usually dominated by other factors, including anthropogenic light, celestial objects (e.g., the moon), and meteorological conditions (e.g., cloud cover).

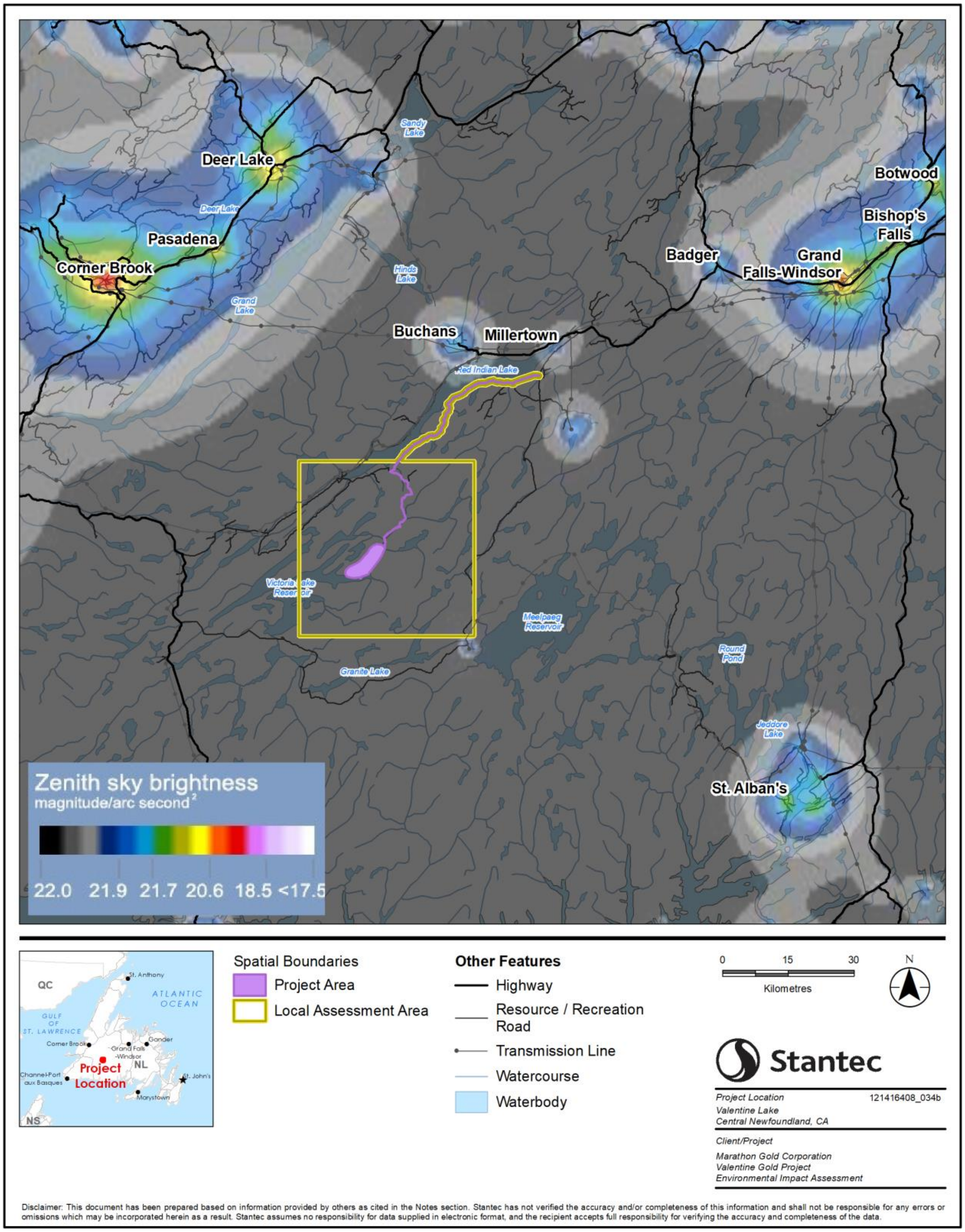


Figure 5-5 Distribution of Artificial Lighting Within and Surrounding the Project Area

5.3 ASSESSMENT CRITERIA AND METHODS

This section describes the criteria and methods used to assess environmental effects on the atmospheric environment. Residual environmental effects (Section 5.5) are assessed and characterized using criteria defined in Section 5.3.1, including direction, magnitude, geographic extent, timing, frequency, duration, reversibility, and ecological or socio-economic context. The assessment also evaluates the significance of residual effects using threshold criteria or standards beyond which a residual environmental effect is considered significant. The definition of a significant effect for the Atmospheric Environment VC is provided in Section 5.3.2. Section 5.3.3 identifies the environmental effects to be assessed for atmospheric environment, including effect pathways and measurable parameters. This is followed by the identification of potential Project interactions with this VC (Section 5.3.4). Analytical assessment techniques used for the assessment of atmospheric environment are provided in Section 5.3.5.

5.3.1 Residual Effects Characterization

Table 5.8 presents definitions for the characterization of residual environmental effects on the atmospheric environment. The criteria describe the potential residual effects that remain after mitigation measures have been implemented. Quantitative measures were developed, where possible, to characterize residual effects. Qualitative considerations were used where quantitative measurement was not possible.

Table 5.8 Characterization of Residual Effects on Atmospheric Environment

Characterization	Description	Quantitative Measure or Definition of Qualitative Categories
Direction	The long-term trend of the residual effect	**Neutral –** no net change in measurable parameters for the atmospheric environment relative to baseline **Positive –** a residual effect that moves measurable parameters in a direction beneficial to atmospheric environment relative to baseline **Adverse –** a residual effect that moves measurable parameters in a direction detrimental to atmospheric environment relative to baseline
Magnitude	The amount of change in measurable parameters or the VC relative to existing conditions	**For Air Quality:** **Negligible –** model predicted air contaminant concentrations due to Project-related emissions are less than 10% of baseline conditions and do not result in exceedances of the ambient air quality criteria **Low –** model predicted air contaminant concentrations due to Project-related emissions are greater than 10% of baseline conditions, but less than 50% of the ambient air quality criteria **Moderate –** model predicted air contaminant concentrations due to Project-related emissions are greater than 50% of the ambient air quality criteria, but the maximum air contaminant concentrations are less than the ambient air quality criteria

Table 5.8 Characterization of Residual Effects on Atmospheric Environment

Characterization	Description	Quantitative Measure or Definition of Qualitative Categories
		High – the predicted air contaminant concentrations due to Project-related emissions combined with background frequently exceed the ambient air quality criteria **For GHGs:** **Negligible –** no measurable change in GHG emissions **Low –** although a change is measurable, based on Agency guidance (CEAA 2003 and ECCC 2020a) and professional judgment, relatively small changes are expected in provincial and national GHG emissions **Moderate –** based on Agency guidance (CEAA 2003) and professional judgment, notable changes are expected in provincial and national GHG emissions **High –** based on Agency guidance (CEAA 2003) and professional judgment, material changes are expected in provincial and national GHG emissions **For Sound Quality:** **Negligible –** no measurable change **Low –** a measurable change but within normal variability of baseline conditions **Moderate –** a measurable change compared with the baseline but within applicable regulatory criteria **High –** Singly or as a substantial contributor in combination with other sources causing exceedances of applicable regulatory criteria beyond the Project Area **For Lighting:** **Negligible –** no measurable change **Low –** effect is detectable but is limited through design mitigation **Moderate –** facility lighting is effectively controlled, but navigation, security and other required lighting have a measurable effect **High –** the design is uncontrolled by Project design criteria and has a pronounced effect
Geographic Extent	The geographic area in which a residual effect occurs	**Project Area –** residual effects are restricted to the Project Area **LAA/RAA –** residual effects extend into the LAA/RAA
Frequency	Identifies how often the residual effect occurs and how often during the Project or in a specific phase	**Single event** **Multiple irregular event –** occurs at no set schedule **Multiple regular event –** occurs at regular intervals (i.e. >1% of the time) **Continuous –** occurs continuously
Duration	The period required until the measurable parameter or the VC returns to its existing (baseline) condition, or the residual effect can no longer	**Short term –** residual effect restricted to construction or decommissioning, rehabilitation and closure phases **Medium term –** residual effect extends through operation (12 years) **Long term –** residual effect extends beyond operation

Table 5.8 Characterization of Residual Effects on Atmospheric Environment

Characterization	Description	Quantitative Measure or Definition of Qualitative Categories
	be measured or otherwise perceived	**Permanent –** recovery to baseline conditions unlikely
Reversibility	Describes whether a measurable parameter or the VC can return to its existing condition after the project activity ceases	**Reversible –** the residual effect is likely to be reversed after activity completion and rehabilitation **Irreversible –** the residual effect is unlikely to be reversed
Ecological and Socio-economic Context	Existing condition and trends in the area where residual effects occur	**Undisturbed –** area is relatively undisturbed or not adversely affected by human activity **Disturbed –** area has been substantially previously disturbed by human development or human development is still present

5.3.2 Significance Definition

A significant residual adverse effect for air quality is one where the Project predicted releases of air contaminants to the atmosphere degrade the quality of ambient air such that the model predicted concentrations (combined with background levels) are likely to exceed applicable regulatory criteria for ambient air quality beyond the Project Area, and are of concern relative to the geographical extent of predicted exceedances, their frequency of occurrence, and the presence of potentially susceptible receptors.

For GHGs, provincial and federal policies and regulations do not identify specific thresholds or standards that could be used to determine significance when assessing the residual effects of a single project's GHG emissions. The assessment considers the Strategic Assessment of Climate Change (ECCC 2020a) guidance by comparing estimated Project GHG emissions to the current provincial and federal GHG emission totals and targets. The Impact Assessment Agency of Canada (IAAC) (formerly the Canadian Environmental Assessment Agency [CEAA]) guidance (CEAA 2003) also recommends ranking Project emission contributions into low, moderate or high as presented in the magnitude definition in Table 5.8.

A significant residual adverse effect for sound quality is one where Project-related noise levels at noise-sensitive receptors are likely to frequently exceed the annoyance and sleep disturbance targets recommended by Health Canada (Health Canada 2017). If the predicted noise levels do not frequently exceed these targets, they are deemed to be not significant.

A significant residual adverse effect on ambient light is defined as an increase in Project-related light emissions such that the CIE guidelines for light trespass and glare in a suburban environment (E3/E4 Environmental Zone [refer to Appendix 5A]) are exceeded, and sky glow levels would be altered toward those of an urban environment.

5.3.3 Potential Effects, Pathways and Measurable Parameters

Table 5.9 lists the potential Project effects on the atmospheric environment and provides a summary of the Project effect pathways and measurable parameters and units of measurement to assess potential effects. Potential environmental effects and measurable parameters were selected based on review of recent environmental assessments for mining projects in NL and other parts of Canada, comments provided during engagement, and professional judgment.

Table 5.9 Potential Effects, Effect Pathways and Measurable Parameters for Atmospheric Environment

Potential Environmental Effect	Effect Pathway	Measurable Parameters and Units of Measurement
Change in Air Quality	• Atmospheric dispersion of air emissions from Project construction, operation and decommissioning, rehabilitation and closure	• Ambient concentrations of particulate matter (TSP, PM_{10}, $PM_{2.5}$), gases (CO, NO_2, SO_2), NH_3, HCN, and metals in µg/m^3
Change in Greenhouse Gas Emissions	• GHGs released to the atmosphere from Project equipment and activities, during Project construction, operation and decommissioning, rehabilitation and closure	• GHG emissions (CO_2, CH_4, N_2O, PFCs, HFCs, SF_6, NF_3) in tonnes per CO_2 equivalent per year (tCO_{2e})
Change in Sound Quality	• Noise emissions from Project equipment and activities during Project construction, operation and decommissioning, rehabilitation and closure	• L_d and L_n measured in dBA; day-night equivalent sound pressure level measured in dBA; and change in %HA, measured in percent
Change in Light Levels	• Light levels from the Project equipment and activities during Project construction, operation and decommissioning, rehabilitation and closure	• Levels of light trespass as measured in Lux; levels of glare as measured in cd; levels of sky glow as measured in mag/arcsec^2; viewshed analysis as measured based on receptor line of sight to Project components

5.3.4 Project Interactions with Atmospheric Environment

Table 5.10 identifies the physical activities that might interact with the VC and result in the identified environmental effect. These interactions are indicated by checkmark and are discussed in detail in Section 5.5, in the context of effects pathways, standard and project-specific mitigation / enhancement, and residual effects. Following the table, justification is provided for where no interaction (and therefore no resulting effect) is predicted.

Table 5.10 Project-Environment Interactions with Atmospheric Environment

Physical Activities	Environmental Effects to Be Assessed			
	Change in Air Quality	Change in GHGs	Change in Sound Quality	Change in Light Levels
CONSTRUCTION				
Access Road Upgrade / Realignment: Where required, road widening and replacement / upgrades of roads and culverts.	-	-	-	-
Construction-related Transportation along Access Road	-	-	-	-
Mine Site Preparation and Earthworks: Clearing and cutting of vegetation and removal of organic materials, development of roads and excavation and preparation of excavation bases within the mine site, grading for infrastructure construction. For the open pits, earthworks include stripping, stockpiling of organic and overburden materials, and development of in-pit quarries to supply site development rock for infrastructure such as structural fill and road gravels. Also includes temporary surface water and groundwater management, and the presence of people and equipment on site.	-	-	-	-
Construction / Installation of Infrastructure and Equipment: Placement of concrete foundations, and construction of buildings and infrastructure as required for the Project. Also includes: • Installation of water control structures (including earthworks) • Installation and commissioning of utilities on-site • Presence of people and equipment on-site	-	-	-	-
Emissions, Discharges and Wastes[A]: Noise, air emissions / GHGs, water discharge, and hazardous and non-hazardous wastes.	✓	✓	✓	✓
Employment and Expenditures[B]	-	-	-	-
OPERATION				
Operation-related Transportation Along Access Road				
Open Pit Mining: Blasting, excavation and haulage of rock from the open pits using conventional mining equipment.	-	-	-	-

Table 5.10 Project-Environment Interactions with Atmospheric Environment

Physical Activities	Environmental Effects to Be Assessed			
	Change in Air Quality	Change in GHGs	Change in Sound Quality	Change in Light Levels
Topsoil, Overburden and Rock Management: Five types of piles: • Topsoil • Overburden • Waste rock • Low-grade ore • High-grade ore Rock excavated from the open pits that will not be processed for gold will be used as engineered fill for site development, maintenance and rehabilitation, or will be deposited in waste rock piles.	-	-	-	-
Ore Milling and Processing: Ore extracted from the open pits will be moved to the processing area where it will either be stockpiled for future processing or crushed and milled, then processed for gold extraction via gravity, flotation and leach processes.	-	-	-	-
Tailings Management Facility: Following treating tails via cyanide destruction, tailings will be thickened and pumped to an engineered TMF in years 1 to 9, then pumped to the exhausted Leprechaun open pit in years 10 through 12.	-	-	-	-
Water Management (Intake, Use, Collection and Release): Recirculated process water and TMF decant water will serve as main process water supply, and raw water (for purposes requiring clean water) will be obtained from Victoria Lake Reservoir. Site contact water and process effluent will be managed on site and treated prior to discharge to the environment. Where possible, non-contact water will be diverted away from mine features and infrastructure, and site contact and process water will be recycled to the extent possible for use on site.	-	-	-	-
Utilities, Infrastructure and Other Facilities • Accommodations camp and site buildings operation, including vehicle maintenance facilities. • Explosives storage and mixing • Site road maintenance and site snow clearing • Access road maintenance and snow clearing • Power and telecom supply • Fuel supply	-	-	-	-
Emissions, Discharges and Wastes[A]: Noise, air emissions / GHGs, water discharge, and hazardous and non-hazardous wastes.	✓	✓	✓	✓
Employment and Expenditure[B]	-	-	-	-

Table 5.10 Project-Environment Interactions with Atmospheric Environment

Physical Activities	Environmental Effects to Be Assessed			
	Change in Air Quality	Change in GHGs	Change in Sound Quality	Change in Light Levels
DECOMMISSIONING, REHABILITATION AND CLOSURE				
Decommissioning of Mine Features and Infrastructure	-	-	-	-
Decommissioning, Rehabilitation and Closure-related transportation Along Access Road	-	-	-	-
Progressive Rehabilitation: Rehabilitating infrastructure or areas not required for ongoing operation (e.g., buildings, roads, laydown areas); covering and revegetating completed tailings areas, where practicable, including commencing closure of TMF beginning in Year 9 (when tailings deposition moves to Leprechaun open pit); erosion stabilization and re-vegetation of completed overburden and/or waste rock piles; infilling or flooding of exhausted mining areas; and completing revegetation studies and trials.	-	-	-	-
Closure Rehabilitation: Active rehabilitation based on successes of progressive rehabilitation activities. Includes: demolishing infrastructure (e.g., buildings, equipment, facilities, roads, laydown areas); grading and revegetating cleared areas, where practicable; breaching and regrading ponds to reestablish drainage patterns; completing closure of TMF (covering with overburden and revegetating); erosion stabilization and revegetation of completed overburden and/or waste rock piles; and infilling or flooding of open pits.	-	-	-	-
Post-Closure: Long-term monitoring	-	-	-	-
Emissions, Discharges and Wastes[A]	✓	✓	✓	✓
Employment and Expenditure[B]	-	-	-	-

Notes:
✓ = Potential interaction
– = No interaction
[A] Emissions, Discharges, and Wastes (e.g., air, waste, noise, light, liquid and solid effluents) are generated by many Project activities. Rather than acknowledging this by placing a checkmark against each of these activities, “Wastes and Emissions” is an additional component under each Project phase
[B] Project employment and expenditures are generated by most Project activities and components and are the main drivers of many socio-economic effects. Rather than acknowledging this by placing a checkmark against each of these activities, “Employment and Expenditures” is an additional component under each Project phase

Emissions of air contaminants, GHGs, noise and light levels are generated by most Project activities, and may result in a change in air quality, a change in atmospheric greenhouse gases, a change in sound quality and/or a change in light levels. Rather than acknowledging this by placing a “checkmark” by each of these activities, Emissions, Discharges and Wastes has been introduced as an additional component under each Project phase for efficiency of discussion. Emissions, Discharges and Wastes includes air contaminant releases, GHG emissions, noise emissions, and lighting.

Emissions of air contaminants, GHGs, noise, and light during decommissioning, rehabilitation and closure activities will occur using heavy equipment and fugitive releases from material movement and handling. As these emissions are not anticipated to be substantial in comparison to the emissions from construction and operation, the decommissioning, rehabilitation and closure phase of the Project has been assessed qualitatively. The potential environmental effects from this phase of the Project will be less than, or similar to, those quantitatively assessed in Section 5.5 for construction and operation.

5.3.5 Analytical Assessment Techniques

5.3.5.1 Assumptions and the Conservative Approach

A conservative approach was used to address uncertainty in the environmental effects assessment, allowing for increased confidence in the final determination of significance. Specifically, the following assumptions were made:

- Worst-case conditions were incorporated into the development of the air quality and GHG emission inventories.
- Worst-case conditions were incorporated into the air quality dispersion modelling. For example, the air contaminant emissions used in the assessment were estimated based on the year(s) with the highest production rates to establish the potential maximum emissions.
- Three years of hourly meteorological data were used in the model, including a wide range of weather conditions, so that conditions leading to poor dispersion (i.e., resulting in the maximum ground-level concentrations) were considered in the model.
- The air quality assessment approach used a screening type analysis, where maximum air contaminant emissions were modelled continuously over the complete three-year period of the meteorological data, to establish the potential maximum ground-level concentrations that might occur. These maximum concentrations were used as the basis for the assessment of potential residual effects.
- Worst-case conditions were incorporated into the acoustic modelling. For example, in reality, the maximum equipment operation at the mine site and the maximum hauling activities are anticipated to occur at different stages of the mine life. For the acoustics assessment, it was instead assumed that these activity levels will occur simultaneously.
- The noise assessment assumed that all equipment was running simultaneously.
- Noise propagation from mining activities was exaggerated by assuming that the ground was more reflective than is actually anticipated near the Project.
- CIE criteria would be met during the design of the Light Plan.
- Comparison to federal and provincial GHG targets and totals were based on emissions corresponding to the worst-case operating year.
- Indirect emissions from supply deliveries were estimated based on the distance to site from Port aux Basque, the port at which most deliveries to Newfoundland would first arrive, which is further from site than are the local suppliers.
- When estimating GHG emissions from grubbing during construction, a conservative 20 m buffer zone was applied around areas to be developed for conservatism.

- The total GHG emissions during construction assumed continuous release of the maximum construction year GHG emissions over the full construction period (i.e., conservatively using the higher estimated duration of 20 months instead of 16 months).

5.3.5.2 Change in Air Quality

This air quality assessment considers substances that may be released from Project-related sources in substantive quantities for which there are ambient air quality criteria (i.e., objectives, guidelines, or standards) adopted by provincial (NL and Ontario) and/or national regulatory agencies. The predicted ambient concentrations due to Project emissions are combined with ambient background concentrations and the totals are compared to the regulatory criteria. Ambient concentrations are expressed in units of $\mu g/m^3$.

Air contaminant releases during the construction and operation phases of the Project were estimated using standard methods for this type of assessment. During construction, activities result in releases of air contaminants from fuel combustion in heavy equipment and fugitive dust due to earth moving and site preparation activities. During operation, air contaminants are released from mining activities, from fuel combustion in heavy equipment and from processing plant sources. The release estimates were prepared and summarized in an emissions inventory for both construction and operation. The inventories were prepared using operational and design information provided by the Marathon and published emission factors. Additional details on air contaminant release estimates for construction and operation are provided below in Section 5.5.1. During the decommissioning, rehabilitation and closure phase of the Project, air contaminant releases will be similar to, or less than, those during construction and operation and were assessed qualitatively.

An air quality transport and dispersion model provides the link between these air contaminant releases and changes to ambient concentrations in the LAA/RAA. For this assessment, the CALMET / California Puff (CALPUFF) modelling system (Scire et al. 2000) was used to determine the potential effects of the air contaminant releases during operation of the Project on ambient air quality. The potential air contaminant releases during construction were estimated for this assessment, and were not modelled, since these releases are expected to be short-term and lower in magnitude than during operation. The application of the modelling system is generally conducted in accordance with the NL Guideline for Plume Dispersion Modelling (GPDM) (NLDMAE 2002). The CALMET model is used to provide hourly meteorological data required for the CALPUFF transport and dispersion model.

The CALPUFF model is a non-steady-state Gaussian puff dispersion model that incorporates simple chemical transformation mechanisms, complex terrain algorithms and building downwash. It is suitable for estimating ground-level concentrations on local and regional scales, from tens of meters to hundreds of kilometers. The core of this modelling system consists of a meteorological model, CALMET, a transport and dispersion model, CALPUFF, and a post-processor model, CALPOST, which is designed to report the concentrations of the air contaminants of interest.

The CALPUFF model was chosen over AERMOD as it has better algorithms to handle complex terrain and it is the NLDECCM’s preferred model for studies in NL.

Information on the dispersion modelling strategy, such as meteorological data, dispersion model set-up parameters, and source and emission inputs are provided in Appendix 5B.

The CALMET and CALPUFF model domain consists of a 40 km by 40 km area consistent with the LAA/RAA established for the VC assessment.

Maximum predicted ground-level concentrations along and outside the Project Area (combined with the background contribution) are compared to the ambient air quality standards provided in Table 5.1 and Table 5.2 (Section 5.1.1.1).

5.3.5.3 Change in GHGs

In the 2015 submission to the United Nations Framework Convention on Climate Change, the Government of Canada agreed to reduce GHG emissions by 30% below 2005 levels by 2030 as part of the Paris Agreement (ECCC 2019a). The House of Commons reconfirmed Canada's commitment to the Paris Agreement in June 2017. Closely related to these decisions, is the recent guidance published by the federal government for the Strategic Assessment of Climate Change (ECCC 2020a) that applies to federal environmental assessments. This guidance explains how to consider GHG emissions of a designated project in light of addressing public policy beyond the scope of a single project (ECCC 2020a). The focus of the strategic assessment guidance is on the following:

- Quantification of GHG emissions for the project
- Quantification of GHGs from upstream activities
- Review of best available technologies
- Assessment of climate change resilience

Under the strategic assessment guidance, proponents of projects with a lifetime beyond 2050 are encouraged to provide an overview of the measures being considered to demonstrate projects are net-zero emissions by 2050. The duration of Project activities is expected to be completed prior to 2050 as the mine operational life is 12 years, slated to start in Q2 2023; therefore, the requirement for net zero emissions by 2050 would not apply to the Project.

There is a requirement to establish whether a designated project will hinder or contribute to Canada's ability to meet its international commitments in reducing GHG emissions by 30% below 2005 levels by 2030, and to help achieve a low carbon economy by 2050. The assessment considered this guidance by comparing estimated GHG emissions from Project activities to the current regional, national and global totals, and to the current federal targets.

The Government of NL has developed emission reduction targets set out in their provincial Climate Change Action Plan (Government of NL 2019). The provincial targets aim to reduce GHG emissions by 35%-45% below 1980 levels by 2030 and to reduce by 30% below 2005 levels by 2030. The GHG emissions from the Project activities have also been compared to these current provincial reduction targets.

For those activities with more substantial fuel consumption, the releases of air contaminants and GHGs can cause local effects on sensitive receptors and contribute to climate change. These are carried forward for more detailed assessment after consideration of mitigation. Mitigation measures for GHG emissions are most-often related to lower fuel consumption, which is directly proportional to lower GHG emissions. Mitigation measures that reduce GHG emissions are presented in Section 5.4.

The GHG emissions associated with construction and operation activities were estimated and compared to provincial and national totals. During the decommissioning, rehabilitation and closure phase of the Project, releases of GHGs will be similar to, or less than, those during construction and operation and were assessed qualitatively.

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

5.3.5.4 Change in Sound Quality

The following tasks were conducted as part of the acoustic assessment for the construction and operation of the Project:

- Identification of baseline sound pressure levels within the Project Area (Section 5.2.2.4)
- Identification of noise sensitive receptors within the Project Area (Section 5.2.2.4)
- Determination of baseline sound levels at each noise sensitive receptor (Section 5.2.2.4)
- Identification of modelling scenarios that will reflect worst-case construction and operation in terms of noise emissions (Section 5.5.3.2)
- Identification of noise emission sources from Project construction and operation activities (Section 5.5.3.1 and 5.5.3.2)
- Characterization of the sound power levels (PWLs) for each noise emission source using manufacturer’s data, acceptable theoretical calculation methods, or similar equipment noise data from an archived database of measurements (Section 5.5.3.2)
- Development of an acoustic model for construction and operation of the Project (Section 5.5.3.2)
- Prediction of sound levels within the LAA and RAA, and at the noise sensitive receptors (Section 5.5.3.2)
- Assessment of compliance of the construction and operation of the Project by comparing the modelled results plus baseline to the applicable noise targets (i.e., Health Canada noise and sleep disturbance targets) (Section 5.5.3.2)

Noise emission inventories were prepared for the construction and operation phases of the Project using operational and design information provided by Marathon and published noise emission estimates for similar equipment. Future noise emissions from Project construction and operation were predicted using the latest version of the commercially available Cadna/A® software (DataKustik 2019). Cadna/A® incorporates ISO Standard 9613 (ISO 1993, 1996) algorithms. ISO 9613 standards are commonly used by acoustic practitioners for modelling sound propagation and are accepted by Health Canada.

Cadna/A® includes geometrical divergence (distance attenuation), barrier effects due to intervening structures, ground effects, atmospheric absorption, and topography. The model assumes that receptors are always downwind of the source, since it is these conditions which typically lead to the highest sound pressure levels.

Noise emissions during the decommissioning, rehabilitation and closure phase of the Project will be similar to, or less than, those during construction and operation and were assessed qualitatively.

5.3.5.5 Change in Lighting Levels

Light associated with an industrial development is critical to the safe and efficient operation of the enterprise. Excessive or poorly designed lighting can have detrimental effects on the environment whereas careful and progressive design can achieve the operational requirements while reducing adverse effects to the environment. Good lighting meets the required levels on the designated property with low capital, maintenance and energy costs. Badly designed lighting or excessive lighting can result in obtrusive lighting, contributing to light trespass, glare and sky glow.

The analysis of a change in ambient light focuses on the potential effects that the Project infrastructure and activities could have on light trespass, glare and sky glow. Lighting can become obtrusive if the light criteria in Appendix 5A, Tables 5A.2, 5A.3 and 5A.4 are not met.

The effects of the Project lighting on nearby receptors are assessed by comparing predicted light levels to the specified light criteria. As the exterior lighting plan for the Project has not been designed, light levels related to the Project cannot be quantified at this time. Therefore, the lighting assessment method is qualitative. While the predictions are qualitative, they are based on the professional judgment of the study team and incorporate design mitigation to manage potential light effects to acceptable levels, as published in the CIE guidelines (CIE 2017).

The final design of the Project will incorporate the lighting design recommendations presented in this EIS. These recommendations will represent a conservative approach to the reduction of Project-related light pollution.

5.4 MITIGATION AND MANAGEMENT MEASURES

A series of environmental management plans will be developed by Marathon to mitigate the effects of Project development on the environment. A full list of mitigation measures to be applied throughout Project construction, operation and decommissioning, rehabilitation and closure is provided in Section 2.7.4. A summary of the mitigation measures that will be incorporated into the Project design and/or the best management practices to manage and reduce emissions of air contaminants, GHGs, noise, and light levels are provided in Table 5.11.

Table 5.11 Mitigation Measures: Atmospheric Environment

Category	Mitigation	C	O	D
Blasting	• Best practices from Blaster's Handbook (ISEE 2016) and Environmental Code of Practice for Metal Mines (ECCC 2009) will be followed to reduce and monitor noise emissions during blasting.	✓	✓	-
Air Emissions	• An Air Quality Management Plan will be developed and implemented as part of the EPP. The Air Quality Management Plan will specify the mitigation measures for the management and reduction of air emissions during Project construction and operation.	✓	✓	✓
	• During dry periods, water will be applied to the access road, site roads and haul roads as needed to mitigate dust emissions. The application of water will be limited to non-freezing temperatures to avoid icing that can present a safety hazard. Watering is most effective immediately after application, and repeated watering several times a day might be required, depending on surface and meteorological conditions. Water used for dust suppression will be sourced from site contact water, not natural waterbodies.	✓	✓	✓
	• The application of dust suppressants other than water to roads as an alternative option to watering will be considered in consultation with Newfoundland and Labrador Department of Environment, Climate Change and Municipalities (NLDECCM). Dust suppression would be applied on an as-needed basis during high wind conditions or if measured ambient particulate matter (PM) concentrations are in exceedance of the Newfoundland and Labrador Ambient Air Quality Standards, and if an increase of watering is determined ineffective or unfeasible at the time. The chosen dust suppressant will be approved by the NLDECCM prior to application. These suppressants, if required, will be applied, as per the manufacturer's recommendations.	✓	✓	✓
	• Ambient air quality and noise monitoring programs will be implemented throughout the life of the Project, as required and in accordance with Project permitting and conditions of approval.	✓	✓	✓
	• When loading stockpiles, drop heights will be reduced to be as close to the pile as possible.	✓	✓	-
	• Surfaces of topsoil and overburden stockpiles will be stabilized during extended periods between usage by means of vegetating or covering the exposed surfaces.	✓	✓	-
	• Conveyors will be covered to reduce fugitive dust emissions.	-	✓	-
	• Select exhaust sources will be equipped with emission control technologies to reduce contaminant emissions. Exhaust controls are listed as follows: – Lime silo: baghouse – Sodium cyanide mix tank: dust collector – Copper sulphate storage tank: dust collector – Sodium metabisulphate mix tank: dust collector – PAX storage tank: baghouse – Lime mix / storage: baghouse – Elution electrowinning: mist eliminator – ICU Electrowinning: mist eliminator – Barring furnace: baghouse – Carbon regeneration kiln: scrubber	-	✓	-

Table 5.11 Mitigation Measures: Atmospheric Environment

Category	Mitigation	C	O	D
	• A Greenhouse Gas Management Plan will be created to manage Project GHG emissions, and outline and track the effectiveness of mitigation measures, including follow-up and monitoring activities. Additional details are provided in Chapter 5.	✓	✓	✓
Vehicles / Equipment / Roads	• Engines and exhaust systems of construction and mining equipment will be subject to a comprehensive equipment preventative maintenance program to maintain fuel efficiency and performance. To reduce emissions, equipment and vehicle idling times, and cold starts will be reduced to the extent possible. Marathon will develop an idling policy to this effect	✓	✓	✓
	• Vehicles and heavy equipment will be maintained in good working order and will be equipped with appropriate mufflers to reduce noise.	✓	✓	✓
	• Haul roads and infrastructure will be designed to reduce transportation and haul distances where possible.	✓	✓	-
	• Project vehicles will be required to comply with posted speed limits on the access road, site roads and haul roads to limit fugitive dust from vehicle travel on unpaved roads. Speed limits will be set in accordance with provincial regulations and industry standards (e.g., for haul roads). Additional speed restrictions will be implemented during caribou migration periods.	✓	✓	✓
Light Emissions	• Project lighting will be limited to that which is necessary for safe and efficient Project activities. Lighting design guidelines will be followed, such as the Commission Internationale de L'Éclairage, International Dark Sky Association, Illuminating Engineering Society, and the lighting requirements for workspaces, as applicable.	✓	✓	✓
	• Lighting will be located so that the lights are not directed toward oncoming traffic on nearby roads on or off site because of the objectionable nuisance and safety hazard this may present.	✓	✓	✓
	• Lights will be designed to avoid excessive use of mobile flood lighting units and will be turned off when they are not required.	✓	✓	✓
	• Mobile and permanent lighting will be located such that unavoidable light spill off the working area is not directed toward receptors outside of the Project Area, to the extent practicable.	✓	✓	✓
	• Full cut-off luminaires will be used wherever practicable to reduce glare, light trespass and sky glow from Project lighting.	✓	✓	✓
Noise Emissions	• Project facilities and infrastructure will be designed to limit noise emissions.	-	✓	-
	• Where practicable in accessible areas (e.g., along cleared rights-of-ways), trees and other vegetation will be left in place or encouraged to grow to obstruct the view of Project facilities, reducing the change in viewshed and muffling nuisance noise.	✓	✓	-
Tailings Management	• The TMF will be designed and managed to reduce the area of exposed dry surfaces, where possible, to reduce the potential for windblown dust emissions.	-	✓	-

Table 5.11 Mitigation Measures: Atmospheric Environment

Category	Mitigation	C	O	D
Site Facilities and Services	• The worker accommodations will be designed with sufficient ventilation systems to reduce the need to open the windows. This can also be supported through closed-window policies with requirements highlighted during mandatory site orientations for employees, contractors and visitors.	✓	✓	✓

5.5 ASSESSMENT OF ENVIRONMENTAL EFFECTS ON ATMOSPHERIC ENVIRONMENT

For each potential effect identified in Section 5.3.3, specific Project activities that may interact with the VC and result in an environmental effect (i.e., a measurable change that may affect the VC) are identified and described. The following sections first describe the pathways by which a potential Project effect could result from Project activities in the absence of mitigation during each Project phase (i.e., construction, operation and decommissioning, rehabilitation and closure). Mitigation and management measures (Section 5.4) are applied to avoid or reduce these potential pathways and resulting environmental effects. Residual effects are those remaining following implementation of mitigation, which are then characterized using the criteria defined in Section 5.3.1. A summary of predicted residual effects is provided in Section 5.5.5.

5.5.1 Change in Air Quality

5.5.1.1 Project Pathways

Air contaminant releases can generally be characterized as either point or fugitive sources. Point sources are typically stacks or vents (such as exhaust from fuel combustion in stationary heavy equipment or stacks / vents at the processing plant). Fugitive sources include dust generated from material handling and ore processing or wind erosion from stockpiles. The most substantive air contaminant releases are expected during construction and operation of the Project. Although some intermittent releases may occur during decommissioning, the emissions are expected to be lower in magnitude than during construction or operation. Releases expected during construction and operation are described further in the following sections.

Construction

During construction, air contaminant releases are expected from the following activities:

- Air contaminants generated from the combustion of fossil fuels (e.g., diesel and gasoline) by heavy mobile equipment and vehicles
- Particulate matter (dust) generated by land clearing, earth moving activities, material handling, and blasting
- Particulate matter (dust) generated by equipment movements on unpaved roads

Air contaminants that may be released in substantive quantities during construction include particulate matter (TSP, PM_{10} and $PM_{2.5}$), selected trace metals and combustion gases (NO_X, SO_2 and CO).

Operation

During operation of the Project, air contaminants may be released from the following:

- Particulate matter (TSP, PM_{10} and $PM_{2.5}$) and trace metals (within the dust) released during ore handling and crushing (material loading / unloading and transfer, ore and material hauling, crushing and screening)
- Fugitive releases of particulate matter (TSP, PM_{10} and $PM_{2.5}$) and trace metals (within the dust) due to wind erosion of ore stockpiles and waste rock pile surfaces (fugitive releases are characterized as those not originating from a stack or vent, released over an area or with an initial volume)
- Fugitive releases of particulate matter (TSP, PM_{10} and $PM_{2.5}$) and trace metals (within the dust) from the TMF due to wind erosion of dry, exposed tailings beach surfaces
- Fugitive releases of NO_X, SO_2, CO, particulate matter (TSP, PM_{10} and $PM_{2.5}$), and trace metals (within the dust) from blasting at the Marathon and Leprechaun pits
- Releases of NO_X, SO_2, CO, and particulate matter (TSP, PM_{10} and $PM_{2.5}$) from internal combustion engines associated with mobile heavy equipment for material loading, unloading and hauling
- Releases of particulate matter (TSP, PM_{10} and $PM_{2.5}$), trace metals (within the dust), NH_3, and HCN from the processing plant sources

Predicted air contaminant concentrations resulting from releases due to Project activities combined with similar contributions from other sources (characterized by using measured background concentrations) are compared to relevant ambient air quality standards.

5.5.1.2 Residual Effects

Construction

Construction activities will include mine site preparation and earthworks, including the clearing and cutting of vegetation and removal of organic materials, development of roads, excavation and preparation of areas within the mine site, and grading for infrastructure construction, as well as construction along the access road and the construction / installation of infrastructure and equipment. Air contaminants may be released during construction activities in the form of combustion gases (SO_2, NO_x and CO) and particulate matter (TSP, PM_{10} and $PM_{2.5}$) from the operation of diesel and gas powered equipment and fugitive dust (particulate matter including TSP, PM_{10} and $PM_{2.5}$, trace metals) from earth and material moving and handling activities, blasting and equipment movements.

Air contaminant releases resulting from activities during construction that may result in substantive emissions were estimated. Releases were estimated for blasting activities, fugitives from wind erosion of stockpile surfaces, material transfer (loading and unloading) at stockpiles, fugitives from travel on haul roads, and from fuel combustion in mobile heavy equipment. The releases were estimated using activity data provided by Marathon and published emission factors, such as those from ECCC and the US EPA AP-42 Emission Factors. The air contaminant release estimates from construction activities are provided in Table 5.12. The detailed emissions inventory is provided in Appendix 5C.

Table 5.12 Air Contaminant Releases – Construction

Air Contaminant	CAS #	Emission Rate (tonnes/year)					
		Blasting	Stockpile Fugitives	Transfer Points at Stockpiles	Haul Route Fugitives	Mobile Combustion Sources - Heavy Equipment	Total
TSP	N/A-1	0.98	30.0	21.9	434	1.32	
PM_{10}	N/A-2	0.51	15.0	10.4	136	1.32	163
$PM_{2.5}$	N/A-3	0.15	6.00	1.57	17.2	1.32	26.2
NO_X	10102-44-0	17.4	-	-	-	112	129
SO_2	7446-09-5	2.17	-	-	-	37.9	40.1
CO	630-08-0	73.8	-	-	-	123	196
As	7440-38-2	9.81E-06	3.00E-04	6.08E-05	-	-	3.71E-04
Cd	7440-43-9	8.83E-07	2.70E-05	5.47E-06	-	-	3.34E-05
Cu	7440-50-8	9.81E-05	3.00E-03	6.08E-04	-	-	3.71E-03
Pb	7439-92-1	2.94E-05	8.07E-04	1.56E-04	-	-	9.92E-04
Hg	7439-97-6	2.94E-07	9.00E-06	1.82E-06	-	-	1.11E-05
Ni	7440-02-0	8.34E-06	2.41E-04	4.77E-05	-	-	2.97E-04
Zn	7440-66-6	2.39E-05	6.33E-04	1.20E-04	-	-	7.77E-04
Ba	7440-39-3	2.54E-05	6.44E-04	1.19E-04	-	-	7.89E-04
Sr	7440-24-6	3.50E-05	8.39E-04	1.51E-04	-	-	1.02E-03
Be	7440-41-7	1.08E-07	3.11E-06	6.16E-07	-	-	3.84E-06
Cobalt	7440-48-4	7.36E-06	2.02E-04	3.89E-05	-	-	2.48E-04
Li	7439-93-2	1.96E-05	6.00E-04	1.22E-04	-	-	7.41E-04
Sb	7440-36-0	1.96E-05	6.93E-04	1.48E-04	-	-	8.61E-04
Sn	7440-31-5	3.43E-05	1.10E-03	2.26E-04	-	-	1.36E-03
Se	7782-49-2	2.94E-05	9.00E-04	1.82E-04	-	-	1.11E-03
Cr	7440-47-3	4.78E-05	1.57E-03	3.27E-04	-	-	1.94E-03
Bi	7440-69-9	9.81E-06	3.00E-04	6.08E-05	-	-	3.71E-04

Based on the anticipated air emissions rates and in consideration of proposed mitigation measures described in Table 5.11 for the construction phase, residual environmental effects of Project construction on air quality within the LAA/RAA are not expected to be substantive. Although construction activities would add to existing air contaminant concentrations in the Project Area, emissions (and resulting ground-level concentrations) would be low in magnitude and generally confined to the area surrounding the Project Area.

Operation

Changes to air quality as a result of the Project-related releases of air contaminants to the atmosphere during operation are assessed using an atmospheric dispersion model in combination with ambient background air contaminant concentrations. Details of the emissions estimates and dispersion modelling for the operation phase of the Project are provided below.

Air Contaminant Emissions

Air contaminant emissions were estimated using design information provided by Marathon and emission factors published by regulatory agencies such as the US EPA or ECCC. The design information includes stack gas properties, exhaust gas concentrations in stacks or vents (for the processing plant), ore specifications and activity data for the mining operation. This information was used in conjunction with published emissions factors to estimate air contaminant emissions of particulate matter, trace metals, combustion gases, NH_3 and HCN. Particulate matter and trace metal releases from the processing plant stacks were estimated using the provided source characteristics, operating information, stack dust concentrations and ore specifications (for trace metals) provided by Marathon. The release estimates were prepared using a combination of activity data during operation Year 3 and operation Year 6, to establish maximum emission rates.

Air contaminant releases associated with vehicle traffic on the access road were not quantified or included in the dispersion modelling since releases are expected to be localized (confined to the 500 m buffer surrounding the access road) and transient in nature. Given the large distance between the mine site and most of the access road, air contaminant releases are generally not expected to overlap with those from Project activities at the mine site.

The Project sources of air contaminants during operation and the emissions estimation methodologies for each activity are provided in Table 5.13. The Project source locations are shown in Figure 5-6.

Sample calculations are provided in Appendix 5D and the detailed emissions inventory is provided in Appendix 5E.

Table 5.13 Sources of Air Contaminants and Release Estimation Methodologies - Operation

Source	Operating Year	Operating Schedule	Estimation Approach / Emission Factor Reference	Expected Contaminants
Fugitive Sources				
Pits	Year 3	Blasting will be limited to daytime hours. For each pit, blasts will be every second day - average 1 per day for both pits combined, approximately 350 per year total	Emissions are estimated using US EPA AP-42 Chapter 13.3 Explosives Detonation, Chapter 11.9 Western Surface Coal Mining (US EPA 1998), ECCC NPRI Pits and Quarries Reporting Guide 2017 (ECCC 2017), pit retention factors (for particulate matter) from the Australian National Pollutant Release Inventory Emission Estimation Technique Manual for Mining - Wings equation 1981 based on 50 m pit depth (AUS 2012), expected explosive mass, metals are estimated using dust emissions and ore specification	Fugitive dust (TSP, PM_{10}, $PM_{2.5}$), trace metals and combustion gases (NO_X, SO_2, CO)
Stockpiles	Year 3	-	Emissions are estimated using US EPA AP-42 Chapter 13.2.4 Aggregate Handling and Storage Piles (US EPA 2006a), CALMET predicted winds at the Project site, approximate stockpile surface areas, metals are estimated using dust emissions and ore specification	Fugitive dust (TSP, PM_{10}, $PM_{2.5}$) and trace metals
TMF	Year 6	-	Emissions are estimated using US EPA AP-42 Chapter 13.2.5 Industrial Wind Erosion (US EPA 2006c), CALMET predicted winds at the Project site, approximate dry tailings surface area, metals are estimated using dust emissions and specifications provided by Marathon	Fugitive dust (TSP, PM_{10}, $PM_{2.5}$) and trace metals
Material Handling and Transfer	Year 6 - conveyor transfer rates Year 3 - drop rates on stockpiles	8-24 hours per day	Emissions are estimated using US EPA AP-42 Chapter 13.2.4 Aggregate Handling and Storage Piles (US EPA 2006a), CALMET predicted winds at the Project site, material transfer rates, metals are estimated using dust emissions and ore specification	Fugitive dust (TSP, PM_{10}, $PM_{2.5}$) and trace metals
Ore Processing Equipment (crushing and screening)	Year 6	18-22 hours per day	Emissions are estimated using US EPA AP-42 Chapter 11.19.2 - Crushed Stone Processing and Pulverized Mineral Processing (US EPA 2004), Australian National Pollutant Inventory document "Emission estimation technique manual for Gold Ore Processing", Version 2.0 (AUS 2006a), Nevada Division of Environmental Protection (NDEP) Guidance on Emission Factors for the Mining Industry (NDEP 2017), ore processing rates, metals are estimated using dust emissions and ore specification	Fugitive dust (TSP, PM_{10}, $PM_{2.5}$) and trace metals
Haul Route Fugitives	Year 3	Approximately 291,000 truck trips per year (along the combined haul routes)	Emissions are estimated using US EPA AP-42 Chapter 13.2.2 Unpaved Roads (US EPA 2006b), pit retention factors from the Australian National Pollutant Release Inventory Emission Estimation Technique Manual for Mining (applied to release estimates for portions of haul routes within the pits) - Wings equation 1981 based on 50 m pit depth (AUS 2012) haul route lengths, haul truck weight and annual truck trips along haul routes	Fugitive dust (TSP, PM_{10}, $PM_{2.5}$)
Point Sources				
Processing Plant Sources	Year 3	Range from 4-24 hours per day	Emissions are estimated using provided stack dust concentrations and stack gas properties, ore specifications (dust assumed as 100% $PM_{2.5}$), Australian Government National Pollution Inventory (NPI) guide for gold ore processing, referenced from Heath et al. "A method for measuring HCN emissions from CIP / CIL tanks." (AUS 2006b). Development and Selection of Ammonia Emission Factors prepared for the US EPA (Battye et al. 1994)	Particulate matter (TSP, PM_{10}, $PM_{2.5}$), trace metals, NH_3 and HCN
Mobile Combustion Sources - Heavy Equipment	Year 3 and Year 6 (for haul truck fuel)	Assumed at 18-24 hours per day	Emissions are estimated using US EPA / Canada CEPA Tier 1, 2, 3 and 4 NO_X, CO and PM Emission Standards for Off-Road Heavy-Duty Diesel Engines (US EPA 2016), US EPA AP-42 Chapter 3.4 Large Stationary Diesel (US EPA 1996a) and All Stationary Dual-fuel Engines and Chapter 3.3 Gasoline and Diesel Industrial Engines (US EPA 1996b), pit retention factors (for particulate matter) from the Australian National Pollutant Release Inventory Emission Estimation Technique Manual for Mining (applied to release estimates from mobile equipment within the pits) - Wings equation 1981 based on 50 m pit depth (AUS 2012) and provided fuel consumption rates	Combustion gases (NO_X, SO_2, CO) and Particulate matter (TSP, PM_{10}, $PM_{2.5}$)

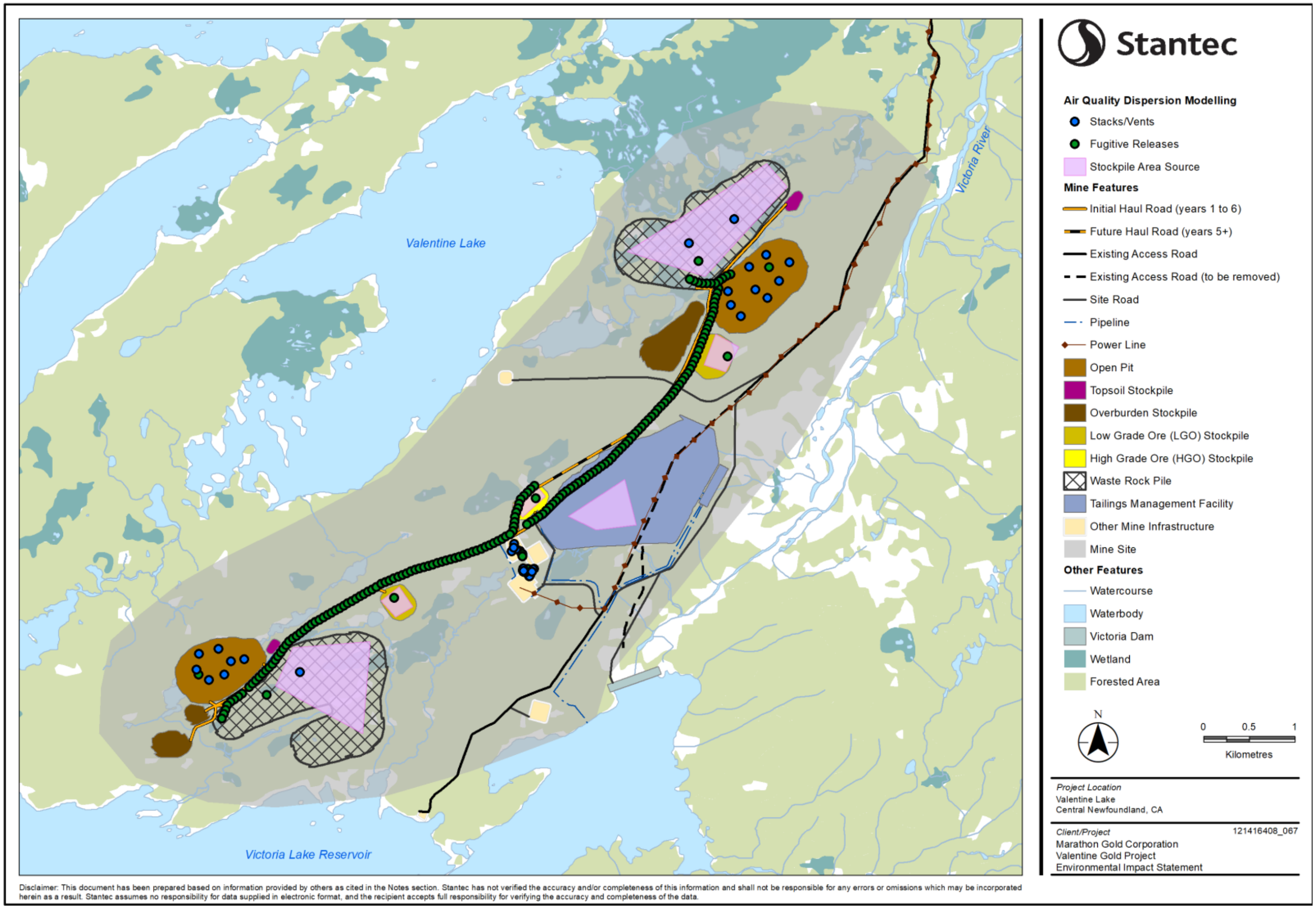


Figure 5-6 Proposed Project Source Locations - Operation

A summary of the provided activity data for operation used for the emissions estimates is provided in Table 5.14.

Table 5.14 Activity Data – Operation

Activity	Value
Blasting	
Explosives (t/blast)	51.0
Blasts per year	350
Crushing and screening	
Primary crushing rate (t/d)	11,000
Pebble crushing (t/d)	2,500
Screening rate (t/d)	11,000
Material Handling Transfer and Loading Rates (t/d)	
Primary crusher discharge conveyor	11,000
Crushed ore stockpile feed conveyor	11,000
SAG mill feed conveyor	11,000
Pebble crusher conveyors	2,500
Crushed ore stockpile discharge apron feeders	11,000
Intensive leaching feed hopper	5.5
Marathon - waste rock stockpile	72,316
Marathon – low-grade stockpile	40,406
Leprechaun - waste rock stockpile	67,230
Leprechaun - low-grade ore stockpile	40,406
Leprechaun – high-grade ore stockpile	8,689
Haul Routes	
Distance travelled (km/yr)	5,926,140
Truck trips per year	716,667
Mobile Equipment Fuel Usage (m^3/yr)	
DTH Drill, Tracked, 165 mm diameter	2,671
Wheel Loader, 13 m^3 bucket	1,313
Hydraulic Excavator, 12 m^3 bucket	3,678
Rigid Frame Hauler, 91t payload	18,569
Track Dozer, 447 kW	986
Track Dozer, 325 kW	568

The detailed emissions estimates and information used to prepare the estimates, including operating schedules of each source, are provided in Appendix 5E.

A summary of the estimated annual air contaminant releases during operation is provided in Table 5.15.

Table 5.15 Annual Air Contaminant Release Estimates – Operation

Source/Activity	Emissions (t/a)											
	TSP	PM_{10}	$PM_{2.5}$	NO_X	SO_2	CO	HCN	NH_3	As	Cd	Cu	Pb
Pit Blasting	4.04	4.04	4.04	143	17.9	607	-	-	4.04E-05	3.63E-06	4.04E-04	1.21E-04
Stockpiles	69.4	34.7	13.9	-	-	-	-	-	6.94E-04	6.25E-05	6.94E-03	2.03E-03
TMF	0.040	0.020	2.98E-03	-	-	-	-	-	6.23E-07	4.67E-08	3.76E-06	1.03E-06
Conveyors / transfer points	21.2	10.0	1.51	-	-	-	-	-	5.88E-05	5.29E-06	5.88E-04	1.50E-04
Loading / unloading at stockpiles	80.7	38.2	5.78	-	-	-	-	-	2.24E-04	2.02E-05	2.24E-03	5.74E-04
Ore Processing Equipment	99.1	36.8	5.58	-	-	-	-	-	9.91E-04	8.92E-05	9.91E-03	1.98E-03
Haul Route Fugitives	1,287	467	68.5	-	-	-	-	-	-	-	-	-
Processing Plant Sources	12.4	12.4	12.4	-	-	-	3.63	3.70	1.24E-04	1.12E-05	1.24E-03	3.17E-04
Mobile Combustion Sources - Heavy Equipment	7.54	7.54	7.54	639	216	698	-	-	-	-	-	-
Total	*1,581*	*611*	*119*	*782*	*234*	*1,306*	*3.63*	*3.70*	*2.13E-03*	*1.92E-04*	*2.13E-02*	*5.17E-03*
Source/Activity	**Hg**	**Ni**	**Zn**	**Ba**	**Sr**	**Be**	**Cobalt**	**Li**	**Sb**	**Sn**	**Se**	**Cr**
Pit Blasting	1.21E-06	3.43E-05	9.85E-05	1.05E-04	1.44E-04	4.44E-07	3.03E-05	8.07E-05	8.07E-05	1.41E-04	1.21E-04	1.96E-04
Stockpiles	2.08E-05	5.82E-04	1.64E-03	1.72E-03	2.34E-03	7.53E-06	5.07E-04	1.39E-03	1.44E-03	2.45E-03	2.08E-03	3.44E-03
TMF	1.19E-08	2.77E-07	2.00E-06	2.16E-06	1.61E-06	5.27E-09	2.08E-07	7.53E-07	8.26E-07	1.33E-06	1.62E-06	2.14E-06
Conveyors / transfer points	1.76E-06	4.61E-05	1.16E-04	1.15E-04	1.46E-04	5.95E-07	3.76E-05	1.18E-04	1.43E-04	2.19E-04	1.76E-04	3.16E-04
Loading / unloading at stockpiles	6.73E-06	1.76E-04	4.43E-04	4.40E-04	5.56E-04	2.27E-06	1.44E-04	4.48E-04	5.47E-04	8.34E-04	6.73E-04	1.21E-03
Ore Processing Equipment	2.97E-05	6.94E-04	1.37E-03	1.16E-03	1.08E-03	8.92E-06	4.95E-04	1.98E-03	2.97E-03	3.96E-03	2.97E-03	5.98E-03
Haul Route Fugitives	-	-	-	-	-	-	-	-	-	-	-	-
Processing Plant Sources	4.43E-05	9.72E-05	2.45E-04	2.43E-04	3.07E-04	1.25E-06	7.93E-05	2.48E-04	3.02E-04	4.61E-04	3.72E-04	6.67E-04
Mobile Combustion Sources - Heavy Equipment	-	-	-	-	-	-	-	-	-	-	-	-
Total	*1.05E-04*	*1.63E-03*	*3.91E-03*	*3.78E-03*	*4.58E-03*	*2.10E-05*	*1.29E-03*	*4.26E-03*	*5.49E-03*	*8.07E-03*	*6.40E-03*	*1.18E-02*

Dispersion Modelling Results

The CALPUFF dispersion modelling system was used to predict the maximum ground level concentrations of the substances of interest in the LAA/RAA during the normal operation of the Project. Further information on CALPUFF is included in Section 5.3.5.1.

The maximum predicted concentrations (outside the Project Area) of the air contaminants of concern released during normal operation of the Project combined with measured background concentrations (to account for existing conditions) are provided in Table 5.16.

The maximum predicted concentrations, combined with measured background, at the camps (exploration camp, accommodations camp, outfitters camp) and cabin locations in the LAA/RAA are provided in Table 5.17; these are the highest predicted concentrations that occur at camp / cabin locations within the LAA/RAA. This shows the maximum concentrations that could occur out of all camps / cabins in the LAA/RAA. The locations vary depending on the air contaminant; maximum concentration does not necessarily occur at the nearest receptor; rather, this depends on the sources contributing to the maximum concentration.

The predicted concentrations are also presented graphically in the form of isopleth plots (concentration contour plots). Plots were prepared for 1-hour NO_2, 24-hour TSP, PM_{10}, $PM_{2.5}$ and HCN, and annual $PM_{2.5}$. An example contour plot generated for 24-hour TSP is provided in Figure 5-7. The remaining contour plots are provided in Appendix 5F. The highest predicted concentrations generally occur within 1-2 km of the Project Area boundary.

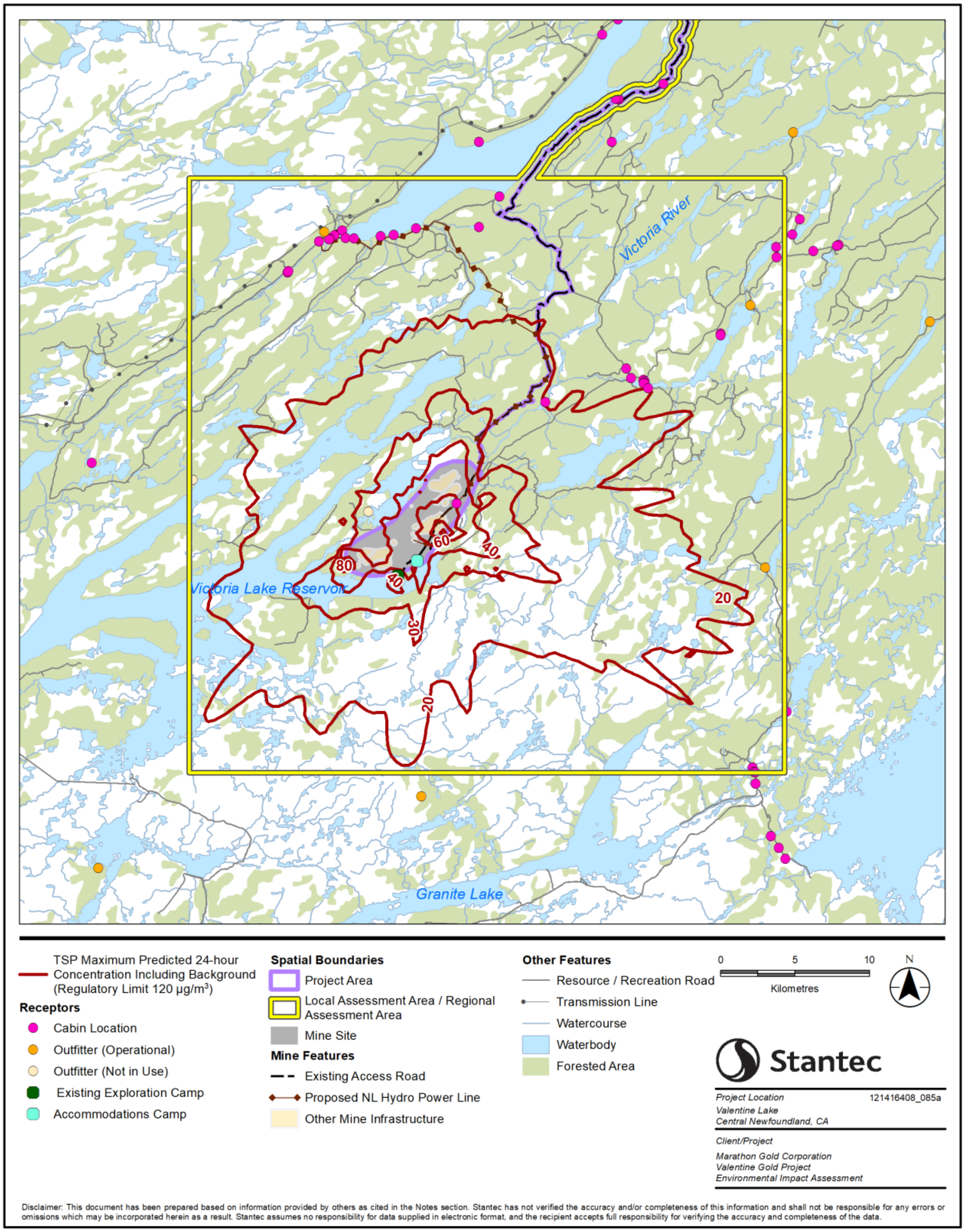


Figure 5-7 Maximum Predicted 24-hour Concentration of TSP (including background)

Maximum predicted concentrations of most air contaminants modelled (due to Project related air contaminant releases combined with measured ambient background concentrations) are below the provincial ambient air quality standards and the adopted ambient air quality standards outside the Project Area, with the exception of the 24-hour PM_{10} predictions.

Maximum predicted 24-hour concentrations of PM_{10} due to Project-related releases combined with the measured ambient background concentration are above the ambient air quality standard (adopted for the assessment) as presented in Table 5.16. The exceedances of the 24-hour PM_{10} standard are predicted to occur in a small area within 500 m of the eastern mine site boundary (near the TMF), at 119 receptor locations (out of nearly 15,000 modelled). Exceedances are expected to be infrequent and of short duration. For example, at the receptor location where the maximum point of impingement occurs, concentrations above the 24-hour standard are predicted to occur seven times over the three-year modelling period (or less than 1% of the time). The predicted exceedances of the PM_{10} standard are likely a result of the fugitive releases from the TMF, based on the location of occurrence of the maximum predicted concentrations (500-900 m to the east of the TMF).

Generally, the predicted concentrations reach background levels within 10 to 15 km of the Project Area boundary. Maximum predicted air contaminant concentrations (including background) are also below the adopted standards at the camps (existing exploration camp, accommodations camp, outfitters camp) and cabin locations (at camp / cabin locations within the LAA/RAA).

The maximum predicted concentrations (including background) of $PM_{2.5}$, are also below the 24-hour CAAQS.

Table 5.16 Maximum Predicted Ground-level Concentrations – Operation

Contaminant	Average Period	Background Concentrations (µg/m³)	Predicted Concentrations (µg/m³)	Predicted plus Background (µg/m³)	NL AQ Standard (µg/m³)	2020 CAAQS (µg/m³)	2025 CAAQS (µg/m³)	Ontario ACB (µg/m³)	Percent of NL/Adopted Standard
TSP	24-hour	13.8	105	119	120	-	-	-	99%
	Annual	2.6	2.3	4.9	60	-	-	-	8%
PM_{10}	24-hour	13.0	52.7	65.7	50	-	-	-	131%
$PM_{2.5}$	24-hour	10.3	11.0	21.3	25	27.0	NA	-	85%
	Annual	3.8	1.23	5.08	8.8	8.8	NA	-	58%
NO_2	1-hour	3.8	165	169	400	112.9	79	-	42%
	24-hour	1.9	70.7	72.6	200	-	-	-	36%
	Annual	1.4	7.13	8.5	100	32.0	28.2	-	9%
SO_2	1-hour	2.6	339	341	900	183.4	170	-	38%
	3-hour	2.6	203	206	600	-	-	-	34%
	24-hour	neg.	75.3	75.3	300	-	-	-	25%
	Annual	neg.	2.69	2.69	60	13.1	10.5	-	4%
CO	1-hour	206	1,428	1,634	35,000	-	-	-	5%
	8-hour	200	722	923	15,000	-	-	-	6%
NH_3	24-hour	neg.	3.42	3.42	100	-	-	-	3%
HCN	24-hour	neg.	3.87	3.87	-	-	-	8	48%
As	24-hour	2.1E-03	2.85E-03	4.95E-03	0.3	-	-	-	2%
Cd	24-hour	4.2E-04	2.14E-04	6.34E-04	2	-	-	-	<1%
Cu	24-hour	1.3E-03	1.72E-02	0.0185	50	-	-	-	<1%
Pb	24-hour	1.3E-03	4.70E-03	6.00E-03	2	-	-	-	<1%
	30-day	5.0E-04	1.81E-03	2.32E-03	0.7	-	-	-	<1%
Hg	24-hour	neg.	3.07E-04	3.07E-04	2	-	-	-	<1%
Ni	24-hour	2.1E-03	1.27E-03	3.37E-03	2	-	-	-	<1%

Table 5.16 Maximum Predicted Ground-level Concentrations – Operation

Contaminant	Average Period	Background Concentrations (µg/m³)	Predicted Concentrations (µg/m³)	Predicted plus Background (µg/m³)	NL AQ Standard (µg/m³)	2020 CAAQS (µg/m³)	2025 CAAQS (µg/m³)	Ontario ACB (µg/m³)	Percent of NL/Adopted Standard
Zn	24-hour	2.1E-02	9.14E-03	3.01E-02	120	-	-	-	<1%
Ba	24-hour	2.1E-03	9.86E-03	1.20E-02	-	-	-	10	<1%
Sr	24-hour	2.1E-03	7.37E-03	9.47E-03	-	-	-	120	<1%
Be	24-hour	1.3E-03	2.42E-05	1.32E-03	-	-	-	0.01	13%
Cobalt	24-hour	1.3E-03	9.52E-04	2.25E-03	-	-	-	0.1	2%
Li	24-hour	neg.	3.44E-03	3.44E-03	-	-	-	20	<1%
Sb	24-hour	2.1E-03	3.77E-03	5.87E-03	-	-	-	25	<1%
Sn	24-hour	1.3E-03	6.11E-03	7.41E-03	-	-	-	10	<1%
Se	24-hour	4.2E-03	7.41E-03	1.16E-02	-	-	-	10	<1%
Cr	24-hour	2.1E-03	9.77E-03	1.19E-02	-	-	-	0.5	2%
Bi	24-hour	2.1E-03	2.27E-03	4.37E-03	-	-	-	2.5	<1%

Table 5.17 Maximum Predicted Concentrations – Camp / Cabin Locations – Operation

Contaminant	Average Period	Background Concentrations (µg/m³)	Predicted Concentrations (µg/m³)	Predicted plus Background (µg/m³)	NL Standard (µg/m³)	2020 CAAQS (µg/m³)	2025 CAAQS (µg/m³)	Ontario ACB (µg/m³)	Percent of NL/Adopted Standard
TSP	24-hour	13.8	56.9	70.7	120	-	-	-	59%
	Annual	2.6	1.93	4.58	60	-	-	-	8%
PM_{10}	24-hour	13.0	21.2	34.2	50	-	-	-	68%
$PM_{2.5}$	24-hour	10.3	9.04	19.3	25	27.0	NA	-	77%
	Annual	3.8	0.63	4.48	8.8	8.8	NA	-	51%
NO_2	1-hour	3.8	97.6	101	400	112.9	79	-	25%
	24-hour	1.9	43.8	45.7	200	-	-	-	23%
	Annual	1.4	7.13	8.53	100	32.0	28.2	-	9%
SO_2	1-hour	2.6	122	125	900	183.4	170	-	14%
	3-hour	2.6	60.3	62.9	600	-	-	-	10%
	24-hour	neg.	26.8	26.8	300	-	-	-	9%
	Annual	neg.	2.55	2.55	60	13.1	10.5	-	4%
CO	1-hour	206	729	935	35,000	-	-	-	3%
	8-hour	200	279	480	15,000	-	-	-	3%
NH_3	24-hour	neg.	2.65	2.65	100	-	-	-	3%
HCN	24-hour	neg.	2.65	2.65	-	-	-	8	33%
As	24-hour	2.1E-03	1.58E-03	3.68E-03	0.3	-	-	-	1%
Cd	24-hour	4.2E-04	1.19E-04	5.39E-04	2	-	-	-	<1%
Cu	24-hour	1.3E-03	0.0095	0.0108	50	-	-	-	<1%
Pb	24-hour	1.3E-03	2.61E-03	3.91E-03	2	-	-	-	<1%
	30-day	5.0E-04	1.01E-03	1.51E-03	0.7	-	-	-	<1%
Hg	24-hour	neg.	2.17E-04	2.17E-04	2	-	-	-	<1%
Ni	24-hour	2.1E-03	7.03E-04	2.80E-03	2	-	-	-	<1%

Table 5.17 Maximum Predicted Concentrations – Camp / Cabin Locations – Operation

Contaminant	Average Period	Background Concentrations (µg/m³)	Predicted Concentrations (µg/m³)	Predicted plus Background (µg/m³)	NL Standard (µg/m³)	2020 CAAQS (µg/m³)	2025 CAAQS (µg/m³)	Ontario ACB (µg/m³)	Percent of NL/Adopted Standard
Zn	24-hour	2.1E-02	5.05E-03	2.61E-02	120	-	-	-	<1%
Ba	24-hour	2.1E-03	5.45E-03	7.55E-03	-	-	-	10	<1%
Sr	24-hour	2.1E-03	4.08E-03	6.18E-03	-	-	-	120	<1%
Be	24-hour	1.3E-03	1.34E-05	1.31E-03	-	-	-	0.01	13%
Cobalt	24-hour	1.3E-03	5.28E-04	1.83E-03	-	-	-	0.1	2%
Li	24-hour	neg.	1.91E-03	1.91E-03	-	-	-	20	<1%
Sb	24-hour	2.1E-03	2.34E-03	4.44E-03	-	-	-	25	<1%
Sn	24-hour	1.3E-03	3.40E-03	4.70E-03	-	-	-	10	<1%
Se	24-hour	4.2E-03	4.10E-03	8.30E-03	-	-	-	10	<1%
Cr	24-hour	2.1E-03	5.42E-03	7.52E-03	-	-	-	0.5	2%
Bi	24-hour	2.1E-03	1.26E-03	3.36E-03	-	-	-	2.5	<1%

5.5.1.3 Summary

Construction

The residual environmental effects on air quality during construction are adverse, as the Project construction results in a predicted increase of ambient concentrations compared to baseline conditions. The magnitude of residual effects is conservatively predicted to be low to moderate (with the latter being a conservative prediction) because the annual emissions during construction are estimated to be less than the emissions during operation. The geographic extent for change in air quality is limited to the LAA/RAA, and the residual effects will be short-term (i.e., limited to the 16 to 20 month construction period) and continuous as construction activities were assumed to occur throughout the 16 to 20 month construction phase. The residual effects are predicted to be reversible as the predicted increase in ambient concentrations would return to baseline conditions after the end of construction. The LAA/RAA in which the changes in air quality are assessed is considered undisturbed; there has been little human development (anthropogenic sources of emissions) within the LAA/RAA prior to the Project.

Operation

The residual environmental effects on air quality during operation are adverse, as the Project operation results in a predicted increase of ambient concentrations compared to baseline conditions. The magnitude of residual adverse effects on change in air quality during operation is predicted to be moderate; the Project operation results in predicted ambient concentrations for the various substances of interest and averaging periods that are greater than 10% of baseline concentrations, and less than 50% of the AAQC (i.e., low in magnitude), greater than 50% of the AAQC (i.e., moderate in magnitude), or greater than 100% of the AAQC (i.e., high in magnitude for PM_{10}). Residual effects will be limited to the LAA/RAA. The duration for change in air quality during operation is medium-term, with the predicted operation-related increase in ambient concentrations continuing through the operation phase (12 years). Residual effects will be continuous, although ambient concentrations may change with meteorological conditions. The predicted increase in air contaminant concentrations would return to baseline conditions after the end of the operation phase; therefore, effects will be reversible. The ecological / socio-economic context of the LAA/RAA is considered undisturbed; there has been little human development (anthropogenic sources of emissions) within the LAA/RAA prior to the Project.

Decommissioning, Rehabilitation and Closure

The residual environmental effects on air quality during decommissioning, rehabilitation and closure are adverse, as the associated activities result in a predicted increase of ambient concentrations compared to baseline conditions. The magnitude of residual effects is predicted to be low, because the quantities of air contaminant emissions released during decommissioning, rehabilitation and closure are typically much less than during construction and operation, and can be managed to negligible levels through the application of standard operating procedures (SOPs) and best management practices (BMPs). The geographic extent for change in air quality is limited to the Project Area and the residual effects will be short term and regular in occurrence. The residual effects are predicted to be reversible, as the increase in ambient concentrations would return to baseline conditions after the end of decommissioning, rehabilitation and closure activities. The LAA/RAA in which the changes in air quality are assessed is considered undisturbed; there has been little human development (anthropogenic sources of emissions) within the LAA/RAA prior to the Project.

5.5.2 Change in GHGs

5.5.2.1 Project Pathways

The substantive sources of direct GHG emissions during construction and operation are the mobile and stationary equipment exhausts, and blasting using an ammonium nitrate / fuel oil (ANFO) emulsion. Land clearing, specifically grubbing, also contributes to the direct GHG emissions during the construction phase only. These GHG emissions consist primarily of CO_2, with smaller amounts of CH_4 and N_2O. GHGs also include PFC, HFC, SF_6, and NF_3. These gases are expected to be released in insubstantial amounts, or not at all, and are therefore not considered further in the GHG assessment.

As per the Provincial EIS Guidelines (Appendix 1B) and the Strategic Assessment of Climate Change guidance (ECCC 2020a), the GHG emissions inventory are to also include indirect emissions associated with the consumption of purchased electricity, and those from shipping of products and delivery of supplies from outside the Project boundary. Other indirect GHG emissions associated with upstream sources, such as production of purchased materials and associated upstream transportation and distribution, have not been evaluated for this assessment.

The GHG emissions from explosives detonation during construction and operation were estimated using an emission factor (0.189 t CO_2/tonnes explosives) recommended by the Mining Association of Canada (MAC 2014) and based on predicted annual explosive quantities.

The GHG emissions quantified from land clearing only occur during the construction phase and only include grubbing, as tree clearing is expected to be completed prior to the peak construction year. Emissions from grubbing were estimated using diesel combustion emission factors from the ECCC NIR (ECCC 2020b) for off-road equipment, and the predicted diesel consumption. Estimated fuel usage per area grubbed (4000 L / ha) required by the equipment was provided by Marathon. The area grubbed included all developed areas on site, such as the buildings, infrastructure, roads, pits, and powerline corridors, along with the access road. A 20 m buffer around development areas was conservatively assumed. The area grubbed was estimated to be 14 km^2 or 1,400 hectares.

Emissions from off-road mobile equipment (excluding those used for land clearing) during construction and operation were estimated using diesel combustion emission factors from the ECCC NIR (ECCC 2020b) paired with fuel consumptions rates. The estimated fuel usages were provided by Marathon. Similarly, emissions from on-site, on-road transportation (including haul trucks) were estimated using combustion emission factors from the ECCC 2020 NIR, based on fuel type and vehicle size, and fuel consumption provided by Marathon. Estimated annual fuel usages for the peak construction year and peak operation year are presented per individual vehicle / piece of equipment in Tables 5G.4 and 5G.5, respectively, of Appendix 5G. The GHG emission factors used for the on-site mobile equipment are presented in Table 5.18.

Table 5.18 Transportation and Mobile Equipment Emission Factors

Vehicle Class	CO_2 EF (g/L)	CH_4 EF (g/L)	N_2O EF (g/L)
Light-Duty Diesel Trucks (LDDTs)[A]	2,681	0.068	0.21
Heavy-Duty Diesel Vehicles (HDDVs)[A]	2,681	0.14	0.082
Light-Duty Gasoline Vehicles (LDGVs)[B]	2,307	0.52	0.20
Off-Road Diesel Equipment[c]	2681	0.073	0.022

Notes:
[A] Emission factors used for on-road diesel vehicles with "Moderate Control"
[B] Emission factors used for on-road gasoline vehicles with "Oxidation Catalysts"
[C] Emission factors used for off-road diesel >19 kW, Tier 1-3
Source: 2019 NIR (ECCC 2020b)

Emissions from stationary combustion during construction and operation were estimated using the estimated fuel usages, provided by Marathon, and emission factors from ECCC's publication *2019 Canada's Greenhouse Gas Quantification Requirements* (ECCC 2019e). The GHG emission factors used for stationary combustion are presented in Table 5.19.

Table 5.19 Stationary Equipment Combustion Emission Factors

Fuel Type	CO_2 EF (kg/kL)	CH_4 EF (kg/kL)	N_2O EF (kg/kL)
Diesel	2,681	0.133	0.4
Propane	1,515	0.024	0.108

Source: 2019 Canada's Greenhouse Gas Quantification Requirements (ECCC 2019e)

The indirect GHG emissions from electricity consumption during operation were calculated using the electricity consumption emission factor for NL (27 g CO_{2e}/kWh) from the ECCC NIR (ECCC 2020b) and the estimated annual electricity usage at the site during the peak operational year. There will be no grid-supplied power during the construction phase.

The indirect GHG emissions from the shipping of delivered supplies, with the exception of fuel, during construction and operation were estimated assuming a shipping distance from Port aux Basques, the port at which most supplies delivered to the Island of Newfoundland would first arrive. Similarly, for product shipping (i.e., gold doré), the shipping distance from Port aux Basques was assumed. Shipping from/to Port aux Basques was assumed, as the original supplier or the end product destinations are unknown and may change over the Project timeline. Intermediate local suppliers on the Island of Newfoundland would be able to be sourced; however, using Port aux Basques is more conservative than the distance to local suppliers and more conservative than the closer port at Botwood, NL. Fuel deliveries are known to be shipped from Corner Brook. The GHG emissions from shipping of supplies and of product were based on estimated fuel usage and emission factors for on-site diesel transportation obtained from the ECCC NIR (ECCC 2020b). The fuel usage was estimated using the distance of the routes and an assumed fuel economy, based on the average of the Canadian trucking industry (39.5 L/100 km) as reported by Natural Resources Canada (NRCan 2019). The distance from the mine site to Port aux Basques / Corner Brook was estimated using mapping of existing roads and the known route of the access road.

Releases of GHG emissions will occur during decommissioning, rehabilitation and closure activities because of the combustion of gasoline and diesel in heavy equipment. These releases are expected to be lower than those released during Project construction and operation and were therefore not quantified.

5.5.2.2 Residual Effects

Construction

The maximum estimated annual GHG emissions (both direct and indirect) from Project construction activities are presented in Table 5.20. Sample calculations of the GHG emission estimates are provided in Appendix 5G. The site construction direct GHG emissions include emissions from heavy off-road equipment, on-road trucks and vehicles, stationary generators, blasting and land clearing. Indirect GHG emissions from site construction include the shipping of supplies to site. Approximately 33.3 kt CO_{2e} are estimated to be released (including both direct and indirect) during the construction year with the highest GHG emissions (occurring in 2022). By conservatively assuming continuous release of the maximum year GHG emissions over the construction period (16-20 months), the total GHG emissions during construction, assuming a duration of 20-months, are estimated to be 55.6 kt CO_{2e}.

Table 5.20 Summary of Maximum Estimated Annual Construction GHG Emissions

Activity	Units	CO_2	CH_4	N_2O	Total (expressed as CO_{2e})
ANFO Blasting[A]	t/y	410.2	-	-	410.2
Stationary Combustion[B]	t/y	2,244	0.11	0.33	2,346
On-Road Transportation[C]	t/y	9,494	0.49	0.30	9,596
Off-Road Mobile Equipment [c]	t/y	5,629	0.15	0.05	5,647
Land Clearing [c]	t/y	15,014	0.41	0.12	15,061
Shipping of Delivered Supplies (indirect) [c]	t/y	274.0	0.01	0.01	277
Total Direct Emissions	*t/y*	*32,791*	*1.16*	*0.12*	*33,060*
Total Indirect Emissions	*t/y*	*274*	*0.01*	*0.01*	*277*
Total (direct + indirect)	*t/y*	*33,065*	*1.18*	*0.81*	*33,336*

Notes:
[A] Based on MAC emission factors (MAC 2014)
[B] Based on ECCC's 2019 Canada's Greenhouse Gas Quantification Requirements (ECCC 2019e)
[C] Based on ECCC emission factors provided in Table A6-13 of the NIR (ECCC 2020b)

The on-road transportation and off-road mobile equipment emissions that are presented in Table 5.20 are presented again in Table 5G.4 of Appendix 5G separated by specific equipment / vehicle. The estimated fuel usage values per vehicle / equipment are also provided in Table 5G.4.

The contribution of the Project construction GHG emissions (direct and indirect) to provincial and federal totals are presented in Table 5.21. On an annual basis, the construction of the Project contributes approximately 0.30% and 0.005% to provincial and national GHG emission totals, respectively.

Table 5.21 Estimated Contribution of Construction GHG Emissions to Federal and Provincial Totals

Parameter	Units	CO_2	CH_4	N_2O	Total (expressed as CO_{2e})
Construction GHG Emissions (direct & indirect)	kt/y	33.065	0.001	0.001	33.336
NL GHG Emissions[A,B]	kt/y	9,780	900	140	11,000
National GHG Emissions[A,B]	kt/y	587,000	91,000	38,000	729,000
Project Construction Contribution to NL GHG Emissions	%	0.34%	0.000%	0.001%	0.30%
Project Construction Contribution to National GHG Emissions	%	0.006%	0.000%	0.000%	0.005%

Notes:
[A] Provincial and national GHG emission totals from ECCC NIR (ECCC 2020b)
[B] Provincial and national GHG emission totals include other fluorinated GHGs

Operation

The maximum estimated annual GHG emissions from Project operation are presented in Table 5.22. Sample calculations of the GHG emission estimates are provided in Appendix 5G. GHG emissions during operation include emissions from heavy off-road equipment, on-road trucks and vehicles, stationary combustion, and blasting. Indirect GHG emissions during operation include electricity consumption and shipping related to supplies and product deliveries. Approximately 87.7 kt CO_{2e} direct emissions are estimated to be released during the year of operation with maximum GHG emissions (Year 3; 2025). The estimated total indirect annual GHG emissions during the operation phase is 4.4 kt CO_{2e}/year, which is approximately 5% of the total direct annual GHG emissions (87.7 kt CO_{2e}/year). Indirect GHG emissions are included into the annual GHG emissions totals for the Project in Table 5.22.

Table 5.22 Summary of Maximum Estimated Annual GHG Emissions During Project Operation

Activity	Units	CO_2	CH_4	N_2O	Total (expressed as CO_{2e})
ANFO Blasting[A]	t/y	3,376	-	-	3,376
Stationary Combustion[B]	t/y	1,835	0.07	0.24	1,907
On-Road Transportation[C]	t/y	51,603	2.70	1.60	52,149
Off-Road Mobile Equipment[C]	t/y	30,179	0.82	0.23	30,266
Electricity Consumption (indirect)[D]	t/y	2,506	-	-	2,506
Shipping of Delivered Supplies (indirect)[C]	t/y	1,894	0.10	0.06	1,914

Table 5.22 Summary of Maximum Estimated Annual GHG Emissions During Project Operation

Activity	Units	CO_2	CH_4	N_2O	Total (expressed as CO_{2e})
Total Direct Emissions	*t/y*	*89,499*	*4*	*2*	*90,204*
Total Indirect Emissions	*t/y*	*1,894*	*0.10*	*0.06*	*1,914*
Total (direct + indirect)	*t/y*	*91,393*	*3.69*	*2.12*	*92,118*

Notes:
[A] Based on MAC emission factors (MAC 2014)
[B] Based on ECCC's 2019 Canada's Greenhouse Gas Quantification Requirements (ECCC 2019e)
[C] Based on ECCC emission factors provided in Table A6-13 of the NIR (ECCC 2020b)
[D] Based on electricity consumption emission factor for NL (27 g CO_{2e}/kWh) from Table A13-2 the ECCC NIR (ECCC 2020b)

The on-road transportation and off-road mobile equipment emissions that are presented in Table 5.22 are presented again in Table 5G.5 of Appendix 5G separated by specific equipment / vehicle. The estimated fuel usage per vehicle / equipment are also provided in Table 5G.5.

The contribution of the maximum estimated annual GHG emissions from Project operation (direct and indirect) to provincial and federal totals are presented in Table 5.23. On an annual basis, Project operation contributes a maximum of 0.84% and 0.013% to provincial and national GHG emission totals, respectively.

Table 5.23 Estimated Contribution of Operation GHG Emissions to Federal and Provincial Totals

Parameter	Units	CO_2	CH_4	N_2O	Total (expressed as CO_{2e})
Operation GHG Emissions (direct & indirect)	kt/y	91.393	0.004	0.002	92.118
NL GHG Emissions[A, B]	kt/y	9,780	900	140	11,000
National GHG Emissions[A, B]	kt/y	587,000	91,000	38,000	729,000
Project Operation Contribution to NL GHG Emissions	%	0.93%	0.00%	0.00%	0.84%
Project Operation Contribution to National GHG Emissions	%	0.02%	0.00%	0.00%	0.013%

Notes:
[A] Provincial and national GHG emission totals from ECCC NIR (ECCC 2020b)
[B] Provincial and national GHG emission totals include other fluorinated GHGs

The overall GHG emissions from the expected lifetime of Project operation were projected using the GHG emissions calculated for the maximum year of GHG emissions (direct and indirect) during operation (Year 3), scaled by the annual mining and milling rates, depending on the activity. The projected GHG emissions are shown in Table 5.24, with the rates that were used for scaling. The operation emissions over the lifetime of the Project are estimated to be approximately 574,822 tCO_{2e}. The annual GHG emissions from Project operation range from 5,994 tCO_2e to 92,118 tCO_{2e}. On an annual basis, the

Project operation contribution to provincial and national GHG emissions totals range from 0.05% to 0.84% and 0.001% to 0.013%, respectively.

Table 5.24 Projected Operation GHG Emissions Over the Lifetime of the Project

Year	Total Material Mined (ktonnes)	Total Resource Milled (ktonnes)	Total GHG Emissions tCO_{2e}/y [A]
1	40,384	1,875	62,933
2	44,458	2,500	69,698
3	59,962	2,500	92,118
4	52,951	3,250	83,026
5	49,284	4,000	78,769
6	41,158	4,000	67,019
7	33,172	4,000	55,469
8	14,863	4,000	28,991
9	5,749	4,000	15,811
10	0	4,000	7,497
11	0	4,000	7,497
12	0	2,923	5,994
Total Lifetime	352,980[B]	41,049	574,822

Notes:
[A] GHG emissions from each activity were scaled by either mining or milling rates. GHG emissions from on-site transportation and mobile equipment were separated by those related to the processing plant and those related to the mining
[B] The total lifetime material mined also includes the portion not presented in the table from the construction year

Once operational, the Project will be regulated under the NL *Management of Greenhouse Gas Act* (2016) (MGGA) during the years for which the annual GHG emissions are greater than 15,000 tonnes CO_{2e}/year (predicted for the first nine years of operation). During the years in which GHG emissions are greater than 25,000 tonnes CO_{2e}/year (predicted for the first eight years of operation), the Project will be subject to greenhouse gas reduction targets as per section 5 of the MGGA and regulated under a performance standard, measured in terms of GHG emissions per unit of output within the facility boundary. As the GHG emissions within the Project boundary are expected to be regulated under a performance standard pursuant to the MGGA (section 5), they will not be subject to the *Revenue Administration Act* carbon tax provisions. The GHG emissions from the first three years of operation will serve to build the baseline in which the GHG reduction targets under the MGGA will be set. The reduction targets are phased in over the subsequent five years (Project operational Years 4 to 8). Table 5.25 presents the annual percent reductions required by the MGGA from the Facility's baseline GHG emissions.

Table 5.25 Facility GHG Annual Percent Reduction Targets

Operational Year	Percent Reduction below Facility Baseline GHG Emissions
Year 4	2.4%
Year 5	4.8%
Year 6	7.2%
Year 7	9.6%
Year 8 and Subsequent Years	12%

The reduction targets presented in Table 5.25 demonstrate the percent below the facility's baseline GHG emission intensity by which Marathon is required to reduce Project-related emissions, starting in Year 4. The required percent reduction becomes more stringent until it reaches 12% in Year 8, in which subsequent years are required to continue operating at a 12% GHG reduction from the baseline emission intensity.

As the predicted annual GHG emissions are >25,000 CO_{2e}/year during the first eight operational years, the Project will be subject to the Best Available Control Technologies (BACT) requirements for activities inside the Project's boundaries, as outlined in section 12.1 of the *Management of Greenhouse Gas Reporting Regulations*. As such, the Project will be required to implement BACT to reduce overall emissions. Mitigation measures for GHG emissions are most-often related to lower fuel consumption, which is directly proportional to lower GHG emissions. Mitigation and controls that will be applied to reduce GHG emissions have been presented in Section 5.4. Mitigation measures for GHG emissions are most-often related to lower fuel consumption which is directly proportional to lower GHG emissions. Some of these measures include equipment / vehicle maintenance to increase fuel efficiency, reducing idling times, and reducing cold starts.

5.5.2.3 Summary

Construction

The residual environmental effects on GHG emissions during construction are adverse, as Project construction will result in a predicted increase of GHG emissions compared to baseline conditions. The magnitude of the residual effect is predicted to be low, with Project construction resulting in a relatively small change of GHG emissions compared to provincial and national emissions. The geographic extent for change in GHGs during construction is not applicable as the effect is global. The residual effect will be short term (i.e., restricted to the 16 to 20 -month construction period) and continuous as GHG emissions will occur continuously during the construction phase. The residual effect is considered irreversible as effects related to the release of GHG emissions from Project construction would not be reversible for at least 100 years. The ecological and socio-economic context for change in GHG emissions during construction is considered disturbed, as the geographic extent is global, in which there have been anthropogenic sources of GHG emissions prior to the Project.

Operation

The residual environmental effects on GHG emissions during operation are adverse, as the Project operation results in a predicted increase of GHG emissions compared to baseline conditions. The magnitude is predicted to be low, with the Project operation resulting in a relatively small change of GHG emissions compared to provincial and national emissions. The geographic extent for change in GHGs during operation is not applicable because the effect is global. Residual effects on change in GHGs during operation is medium term (i.e., will occur over the operation of the Project) and continuous. As with construction, the residual effect is considered irreversible as effects related to the release of GHG emissions from Project operation would not be reversible for at least 100 years. The ecological and socio-economic context for change in GHG emissions during operation is considered disturbed, as the geographic extent is global, in which there have been anthropogenic sources of GHG emissions prior to the Project.

Decommissioning, Rehabilitation and Closure

The residual environmental effects on GHG emissions during decommissioning, rehabilitation and closure are adverse, as related activities will result in a predicted increase of GHG emissions compared to baseline conditions. The magnitude of the residual effect is predicted to be negligible, since the quantities of GHGs released during decommissioning, rehabilitation and closure are typically much less than during construction and operation. The geographic extent for change in GHGs during decommissioning, rehabilitation and closure is not applicable, as the effect is global. The residual effect will be short term and multiple regular events. The residual effect is considered irreversible, as effects related to the release of GHG emissions from Project decommissioning, rehabilitation and closure would not be reversible for at least 100 years. The ecological and socio-economic context for change in GHG emissions during decommissioning, rehabilitation and closure is considered disturbed, as the geographic extent is global, in which there have been anthropogenic sources of GHG emissions prior to the Project.

5.5.3 Change in Sound Quality

5.5.3.1 Project Pathways

During Project construction, sound emissions are expected from the operation of heavy mobile equipment and vehicles for land clearing, earth moving activities and material handling. Other vehicle activities, such as those associated with the access road (e.g., delivery of supplies, rotation changes), will also generate sound emissions. Sound emissions will also result from blasting during construction. Blast energy that liberates into the atmosphere can generate air overpressure and noise. Blasting is expected to be limited to daytime hours and will follow BMPs outlined in guidance documents such as the Blasters Handbook (ISEE 2016) and the Environmental Code of Practice for Metal Mines (ECCC 2009). These guidance documents provide detailed information on designing and carrying out blasting to reduce sound emissions, and these will be consulted during blasting design.

Sound emissions during Project operation will result from activities similar to those expected during construction. Material handling and earth moving will continue throughout mining, and some heavy truck traffic will increase relative to an increase in production levels in the initial few years of operation. Rock breaking, crushing and processing, and blasting will also occur during operation.

Sound emissions are also expected from the use of heavy equipment during the decommissioning of mine features and infrastructure, progressive rehabilitation, and closure rehabilitation. As the amount of heavy equipment operating during the decommissioning, rehabilitation and closure of the mine is expected to be less than that required during Project construction and operation, the resulting sound emissions are also anticipated to be lower and were therefore not quantified; however, residual effects during this phase are characterized below.

As there are no communities, year around residential receptors, or major roadways located within the LAA/RAA, receptors considered as potential pathways for effects include approximately 35 seasonal cabins / outfitter locations located within the LAA/RAA (Figure 5-2). The existing exploration camp and accommodations camp have been included in this assessment as noise sensitive receptors in the context of sleep disturbance effects.

5.5.3.2 Residual Effects

Construction

The construction phase of the Project is anticipated to occur over a period of 16 to 20 months, beginning in Q4 2021, with approximately 90% of the construction-related activity occurring within 2022. For construction activities lasting longer than one year, Health Canada recommends a quantitative assessment of noise emissions (Health Canada 2017), as outlined in Section 5.3.5.4. Based on the review of the mine plan and equipment list, the time period from the second quarter of 2022 to the fourth quarter of 2022 was chosen for modelling of the construction phase of the Project as it represents highest predicted equipment usage.

A list of the equipment and quantities that could be used during the construction of the Project is provided in Appendix 5H, Table 5H.1. Estimates of the sound power levels that could be emitted from the operation of the construction equipment, as presented in Appendix 5H, Table 5H.1, were established using the following information sources:

- Equipment lists and design data provided by Marathon and Ausenco Engineering Canada Inc. (Ausenco)
- Measurement data of similar equipment from Stantec acoustic database
- Publications that provide reference sound power levels and sound pressure levels for construction equipment (Caterpillar 2018; DEFRA 2005; DEFRA 2006)

The locations of the sources of sound associated with Project construction are shown in Figure 5-8. The equipment sources related to mine construction were modelled as area sources covering the Leprechaun and Marathon open pits. The vehicle traffic between mine locations (e.g., between an open pit and a waste rock pile) and traffic to/from the Project (i.e., vehicles for crew rotation changes) were modelled as line sources.

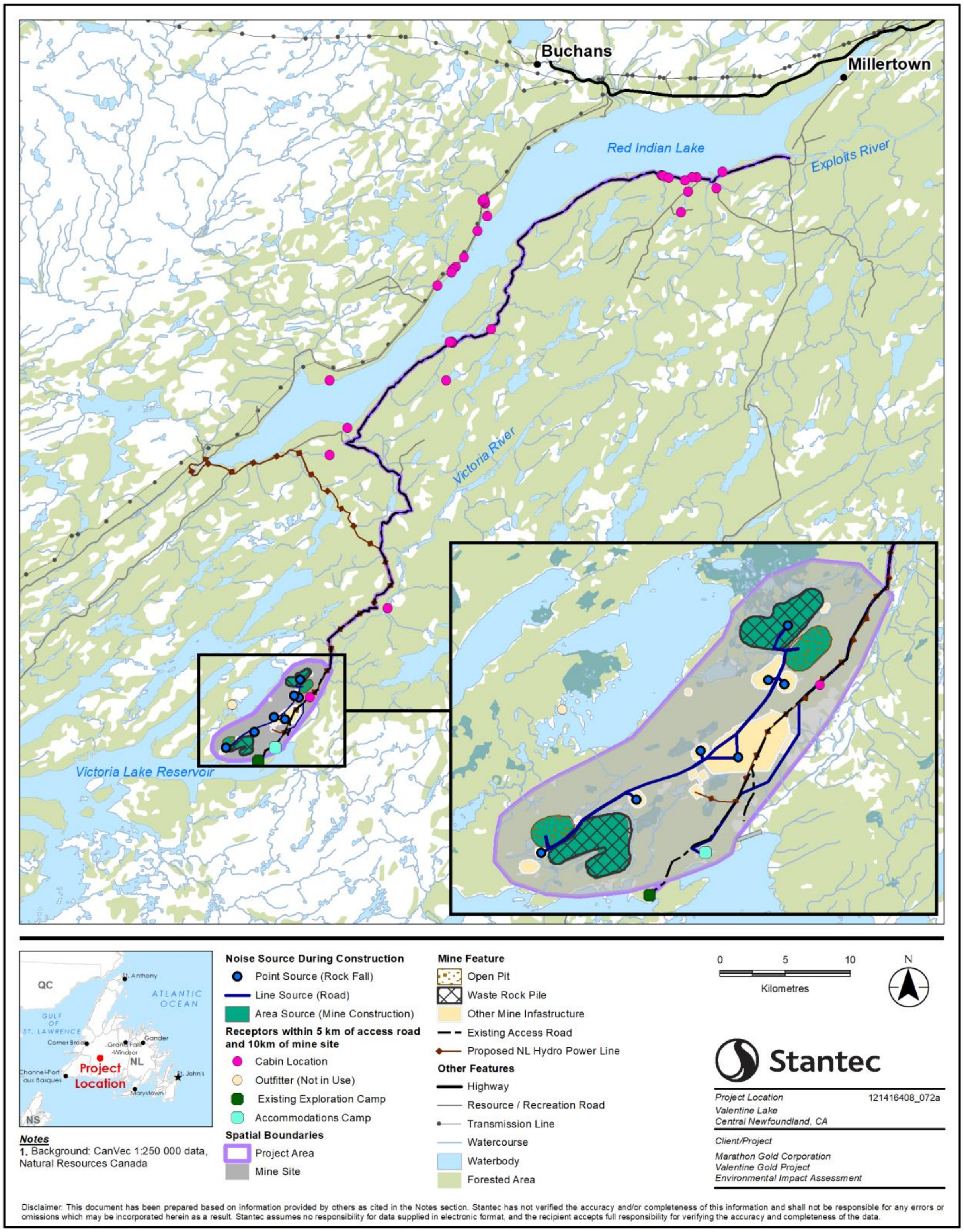


Figure 5-8 Location of Sound Sources during Project Construction

As construction activities will be primarily limited to daytime hours, existing nighttime sound levels will not be affected by the proposed construction activities. There is potential for such activities to occur during night conditions depending on the construction schedule and the time of year (e.g., during the fall and winter when days are shorter).

The predicted L_d, L_n and L_{dn} sound pressure levels for the construction of the Project at the noise sensitive receptors (see Figure 5.2 for locations) within the LAA/RAA are presented in Table 5.26. Project related sound pressure levels were 0 for the nighttime period since construction activities are not anticipated to occur at night. The predicted day-night average sound pressure levels for Project construction and operation are also illustrated in Figure 5-9. A reference example calculation for L_{dn} is provided in Appendix 5I.

Table 5.26 Predicted L_d, L_n and L_{dn} for Project Construction

Receptor[A]	Receptor Description	Project Daytime Sound Level, L_d (dBA)	Project Nighttime Sound Level, L_n (dBA)	Project Day-Night Sound Level, L_{dn} (dBA)
1	Cabin Location	36.7	-	34.9
2	Cabin Location	46.1	-	44.3
3	Cabin Location	47.9	-	46.2
4	Cabin Location	43.8	-	42.0
5	Cabin Location	43.5	-	41.7
6	Cabin Location	43.7	-	41.9
7	Cabin Location	41.1	-	39.3
8	Cabin Location	39.4	-	37.7
9	Cabin Location	28.3	-	26.5
10	Cabin Location	25.0	-	23.3
11	Cabin Location	16.4	-	14.6
12	Cabin Location	11.0	-	9.2
13	Cabin Location	10.9	-	9.1
14	Cabin Location	11.5	-	9.7
15	Cabin Location	11.6	-	9.9
16	Cabin Location	13.7	-	11.9
17	Cabin Location	13.3	-	11.5
18	Cabin Location	12.6	-	10.9
19	Cabin Location	12.0	-	10.3
20	Cabin Location	11.9	-	10.1
21	Cabin Location	11.9	-	10.2
22	Cabin Location	11.8	-	10.0
23	Cabin Location	42.0	-	40.2
24	Cabin Location	38.3	-	36.5

Table 5.26 Predicted L_d, L_n and L_{dn} for Project Construction

Receptor[A]	Receptor Description	Project Daytime Sound Level, L_d (dBA)	Project Nighttime Sound Level, L_n (dBA)	Project Day-Night Sound Level, L_{dn} (dBA)
25	Cabin Location	38.7	-	36.9
26	Cabin Location	37.7	-	36.0
27	Cabin Location	42.9	-	41.1
28	Cabin Location	18.5	-	16.8
29	Cabin Location	12.0	-	10.2
30	Cabin Location	27.2	-	25.4
31	Cabin Location	16.8	-	15.1
32	Cabin Location	27.7	-	26.0
33	Cabin Location	45.1	-	43.3
34	Outfitter (Not in Use)	37.2	-	35.4
35	Marathon Accommodations Camp	43.2	-	41.5
36	Exploration Camp	45.3	-	43.5

Notes:
[A] See Figure 5.2 for receptor locations
"-" The L_n is not applicable during the construction phase of the Project as construction activities will not occur during nighttime hours (i.e., between 10 pm and 7 am)
See Appendix 5I for an example calculation of L_{dn}

The predicted daytime sound levels at the nearest noise sensitive receptors ranged from 10.9 dBA to 47.9 dBA. The predicted day-night average sound levels ranged from 9.1 dBA to 46.2 dBA.

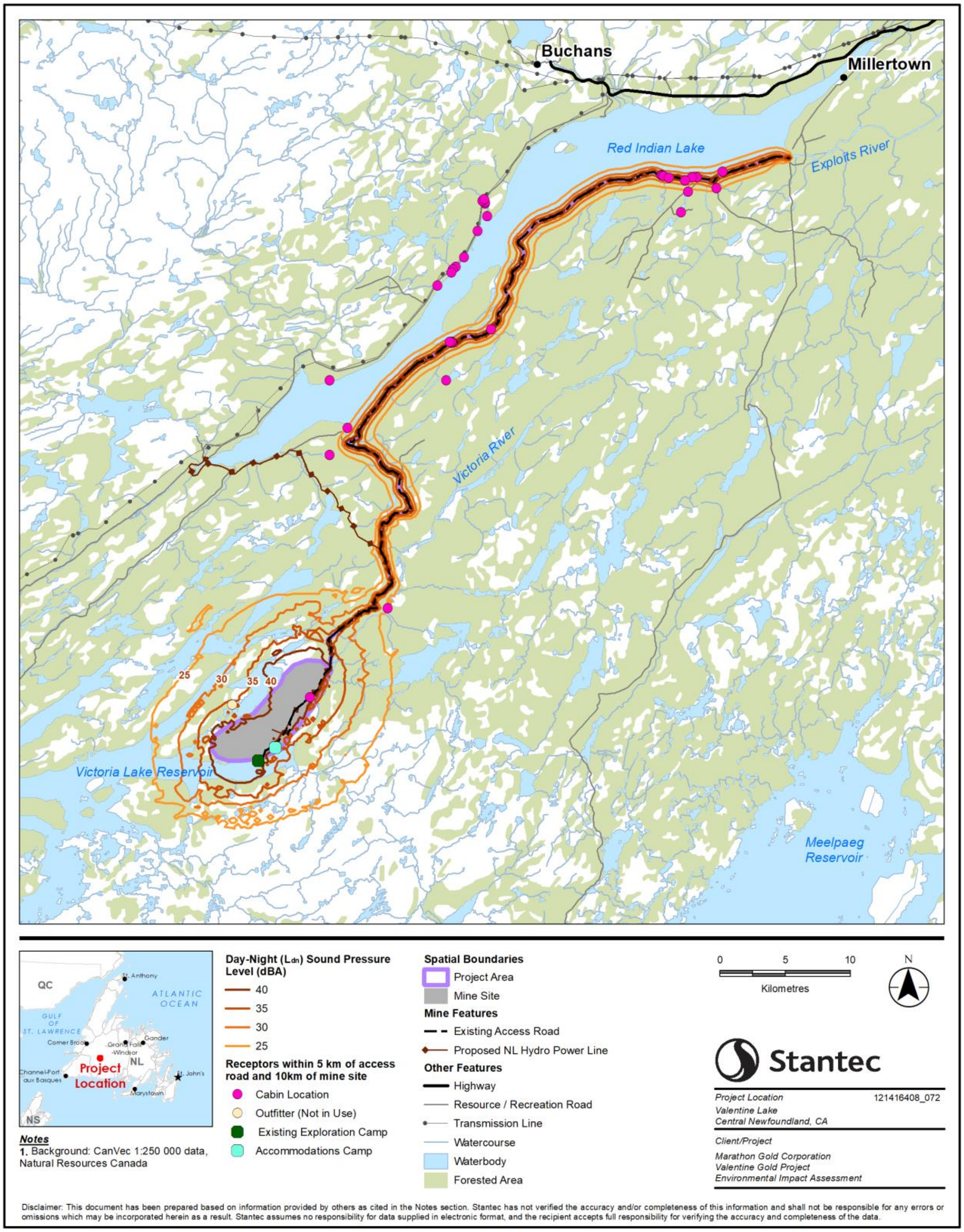


Figure 5-9 Predicted Day-Night (L_{dn}) Sound Pressure Levels from Construction

For Project construction, the change in %HA associated with the Project is compared with the threshold of 6.5% advised by Health Canada (2017). The change is %HA at a noise sensitive receptor is based on the difference between the baseline %HA (Section 5.2.2.4) and total Project construction (Project and Baseline) %HA.

The %HA is determined from the baseline sound level and the total sound level, based on an equation from the Health Canada guidance. The total sound level is the combined noise effect of the baseline sound level and Project predicted sound level. An example calculation of the change in %HA at a receptor is presented in Appendix 5I.

The changes in %HA associated with the Project construction are presented in Table 5.27.

Table 5.27 Project Construction – Change in %HA

Receptor ID	Baseline		Project Predicted L_{dn} (dBA)	Total (Baseline plus Project)		Change in %HA (Between Total and Baseline)
	L_{dn} (dBA)*	%HA		L_{dn} (dBA)	%HA	
1	46.9	1.47	34.9	47.2	1.52	0.05
2	46.9	1.47	44.3	48.8	1.87	0.40
3	46.9	1.47	46.2	49.6	2.07	0.60
4	46.9	1.47	42.0	48.1	1.71	0.24
5	46.9	1.47	41.7	48.0	1.70	0.23
6	46.9	1.47	41.9	48.1	1.71	0.24
7	46.9	1.47	39.3	47.6	1.60	0.13
8	46.9	1.47	37.7	47.4	1.56	0.09
9	46.9	1.47	26.5	46.9	1.47	0.00
10	46.9	1.47	23.3	46.9	1.47	0.00
11	46.9	1.47	14.6	46.9	1.46	No Change
12	46.9	1.47	9.2	46.9	1.46	No Change
13	46.9	1.47	9.1	46.9	1.46	No Change
14	46.9	1.47	9.7	46.9	1.46	No Change
15	46.9	1.47	9.9	46.9	1.46	No Change
16	46.9	1.47	11.9	46.9	1.46	No Change
17	46.9	1.47	11.5	46.9	1.46	No Change
18	46.9	1.47	10.9	46.9	1.46	No Change
19	46.9	1.47	10.3	46.9	1.46	No Change
20	46.9	1.47	10.1	46.9	1.46	No Change
21	46.9	1.47	10.2	46.9	1.46	No Change
22	46.9	1.47	10.0	46.9	1.46	No Change
23	46.9	1.47	40.2	47.7	1.63	0.16
24	46.9	1.47	36.5	47.3	1.54	0.07

Table 5.27 Project Construction – Change in %HA

Receptor ID	Baseline		Project Predicted L_{dn} (dBA)	Total (Baseline plus Project)		Change in %HA (Between Total and Baseline)
	L_{dn} (dBA)*	%HA		L_{dn} (dBA)	%HA	
25	46.9	1.47	36.9	47.3	1.55	0.08
26	46.9	1.47	36.0	47.2	1.53	0.06
27	46.9	1.47	41.1	47.9	1.67	0.20
28	46.9	1.47	16.8	46.9	1.46	No Change
29	46.9	1.47	10.2	46.9	1.46	No Change
30	46.9	1.47	25.4	46.9	1.47	0.00
31	46.9	1.47	15.1	46.9	1.46	No Change
32	46.9	1.47	26.0	46.9	1.47	0.00
33	46.9	1.47	43.3	48.5	1.80	0.33
34	46.9	1.47	35.4	47.2	1.52	0.05
35	46.9	1.47	41.5	48.0	1.69	0.22
36	46.9	1.47	43.5	48.5	1.81	0.34

Note:
* The lowest measured baseline L_{dn} was considered in the assessment

The change in %HA from baseline, to baseline plus Project construction are compared to the target for change in %HA of 6.5%. The changes in %HA at each noise sensitive receptor within the LAA are well below the 6.5% target for the construction phase of the Project. The results indicate compliance with the Health Canada guidance (Health Canada 2017).

As construction activities are not currently planned to occur overnight, the sleep disturbance target of 45 dBA will not be exceeded.

Operation

The operation phase of the Project is anticipated to begin in Q2 of 2023 and the estimated mine operation life is 12 years. For operation activities, Health Canada recommends a quantitative assessment of noise emissions (Health Canada 2017), as outlined in Section 5.3.5.4.

Based on the review of the mine plan and equipment list, the operation scenario that was considered representative of the maximum case for noise emissions (and thus modelled in the acoustic assessment) was Year 3 for mining activities and Year 6 for material hauling.

The Project operation phase noise emissions were established using the following information sources:

- Equipment lists and design data provided by Marathon and Ausenco
- Measurement data of similar equipment from Stantec acoustic database
- Equipment specifications and referenced formula from acoustic literature (Bies and Hansen 2009, Caterpillar 2018)

- Publication that provides reference sound power levels and sound pressure levels for common material handling equipment (DEFRA 2005 and DEFRA 2006)

A summary of the mobile equipment used during operation and their sound power level is provided in Table 5H.2. Sound power levels for stationary outdoor equipment is summarized in Table 5H.3 and the sound power levels from the processing plant are provided in Table 5H.4.

The equipment sources related to mining were modelled as area sources that covered the Leprechaun and Marathon open pit sites (Figure 5-10). The vehicle traffic between mine locations (e.g., between an open pit and a waste rock pile) and traffic to/from the Project (i.e., vehicles for crew rotation changes) were modelled as line sources. Additional point sources were modelled for rock breaking and crushing, and additional line sources were modelled related to conveyor operation. Area sources, capturing processing noise emitted from the processing plant openings, were also included in the model.

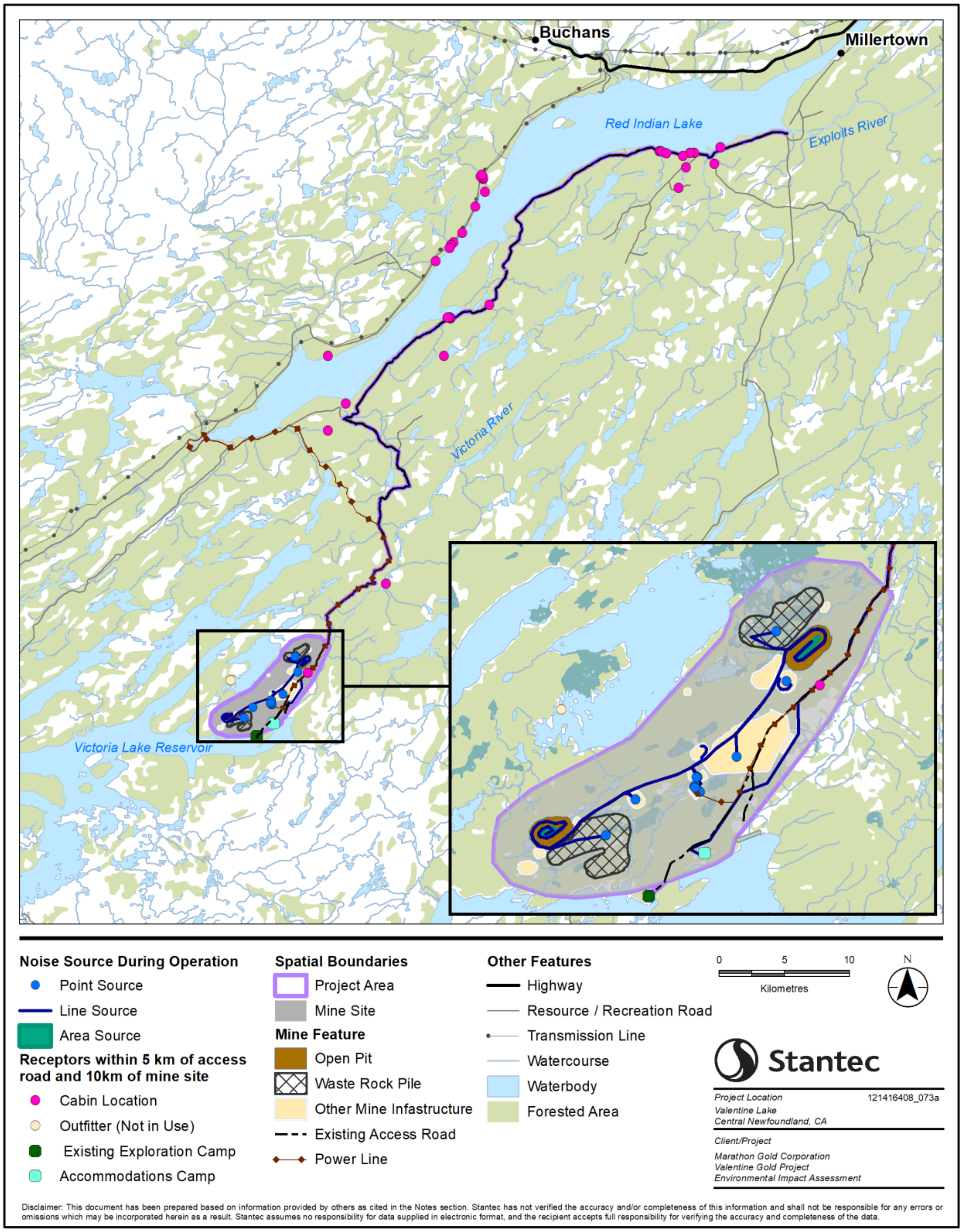


Figure 5-10 Noise Source Locations during Project Operation

The predicted L_d, L_n, and L_{dn} for the operation of the Project at the noise sensitive receptors (see Table 5.4 for locations) located within the LAA/RAA are presented in Table 5.28. Some receptors were predicted to have an L_n of 0 at night, given their distance from the noise generating activities. The predicted day night average sound pressure levels for Project operation are also illustrated in Figure 5-11.

Table 5.28 Predicted L_d, Ln and L_{dn} for Project Operation

Receptor[A]	Receptor Description	Project Daytime Sound Level, L_d (dBA)	Project Nighttime Sound Level L_n (dBA)[B]	Project Day-Night Sound Level L_{dn} (dBA)
1	Cabin Location	34.2	0	32.5
2	Cabin Location	43.6	0	41.9
3	Cabin Location	45.5	0	43.7
4	Cabin Location	41.3	0	39.5
5	Cabin Location	41.0	0	39.3
6	Cabin Location	41.2	0	39.4
7	Cabin Location	38.6	0	36.9
8	Cabin Location	37.0	0	35.2
9	Cabin Location	25.8	0	24.1
10	Cabin Location	22.6	0	20.8
11	Cabin Location	13.9	0	12.1
12	Cabin Location	8.5	0	6.7
13	Cabin Location	8.4	0	6.7
14	Cabin Location	9.0	0	7.3
15	Cabin Location	9.2	0	7.4
16	Cabin Location	11.2	0	9.4
17	Cabin Location	10.8	0	9.0
18	Cabin Location	10.1	0	8.4
19	Cabin Location	9.6	0	7.8
20	Cabin Location	9.4	0	7.6
21	Cabin Location	9.5	0	7.7
22	Cabin Location	9.3	0	7.5
23	Cabin Location	39.5	0	37.8
24	Cabin Location	35.8	0	34.0
25	Cabin Location	36.2	0	34.5
26	Cabin Location	35.2	0	33.5
27	Cabin Location	40.4	0	38.7
28	Cabin Location	16.1	0	14.3
29	Cabin Location	9.5	0	7.8
30	Cabin Location	24.8	9.7	23.6

Table 5.28 Predicted L_d, Ln and L_{dn} for Project Operation

Receptor[A]	Receptor Description	Project Daytime Sound Level, L_d (dBA)	Project Nighttime Sound Level L_n (dBA)[B]	Project Day-Night Sound Level L_{dn} (dBA)
31	Cabin Location	17.0	11.9	19.3
32	Cabin Location	26.7	25.4	31.7
33	Cabin Location	43.4	42.6	48.8
34	Outfitter (Not in Use)	39.0	39.0	45.1
35	Marathon Accommodations Camp	46.4	45.9	52.0
36	Exploration Camp	41.0	41.0	47.1

Note:
[A] See Figure 5.2 for receptor locations
[B] Some receptors were predicted to have an Ln of 0 due to their distance from the noise generating activities at night
See Appendix 5I for an example calculation of L_{dn}

The predicted daytime and nighttime sound levels at the nearest noise sensitive receptors to the Project Area ranged from 8.4 dBA to 46.4 dBA and 0 dBA to 45.9 dBA, respectively. The predicted day night average sound levels ranged from 6.7 dBA to 52 dBA.

Sound pressure levels at receptors beyond the property boundary were not predicted to exceed the sleep disturbance threshold of 45 dBA recommended by Health Canada (2017). Nighttime sound pressure levels were greater than the nighttime target of 45 dBA at the accommodations camp. Health Canada indicates that the threshold of 45 dBA relates to structures where operable windows may be in use. Mitigating the accommodations camp with sufficient ventilation systems to reduce the need to open windows would improve the sound attenuation and reduce nighttime sound levels inside the accommodations camp to levels below the Health Canada targets. This can also be supported through closed-window policies, with requirements highlighted during mandatory site orientations for all employees, contractors and visitors.

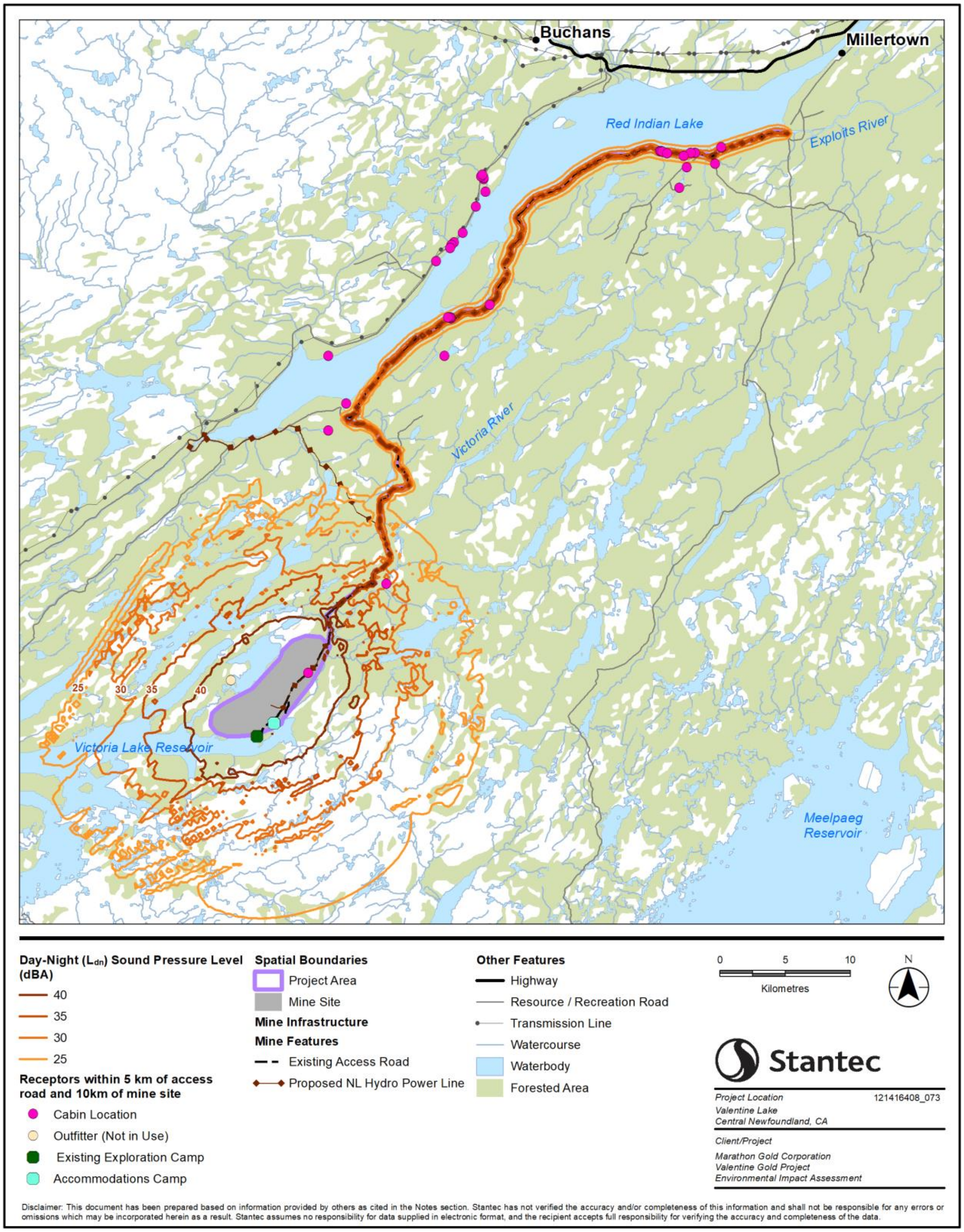


Figure 5-11 Predicted Day-Night (L_{dn}) Sound Pressure Levels during Operation

For the Project operation, the change in %HA associated with the Project is compared with the threshold of 6.5% advised by Health Canada (2017). The change in %HA at a noise sensitive receptor is based on the difference between the baseline %HA (Section 5.2.2.4) and total Project operation (Project and Baseline) %HA.

The %HA is determined from the baseline sound level and the total sound level, based on an equation from the Health Canada guidance. The total sound level is the combined noise effect of the baseline sound level and Project predicted sound level. A detail sample calculation of the change in %HA at a receptor is presented in Appendix 5I.

The changes in %HA associated with Project operation are presented in Table 5.29.

Table 5.29 Project Operation Change in %HA

Receptor ID	Baseline		Project Predicted L_{dn} (dBA)	Total (Baseline plus Project)		Change in %HA (Between Total and Baseline)
	L_{dn} (dBA)*	%HA		L_{dn} (dBA)	%HA	
1	46.9	1.47	32.5	47.1	1.49	0.02
2	46.9	1.47	41.9	48.1	1.71	0.24
3	46.9	1.47	43.7	48.6	1.83	0.36
4	46.9	1.47	39.5	47.6	1.61	0.14
5	46.9	1.47	39.3	47.6	1.60	0.13
6	46.9	1.47	39.4	47.6	1.61	0.14
7	46.9	1.47	36.9	47.3	1.55	0.08
8	46.9	1.47	35.2	47.2	1.52	0.05
9	46.9	1.47	24.1	46.9	1.47	No Change
10	46.9	1.47	20.8	46.9	1.47	No Change
11	46.9	1.47	12.1	46.9	1.46	No Change
12	46.9	1.47	6.7	46.9	1.46	No Change
13	46.9	1.47	6.7	46.9	1.46	No Change
14	46.9	1.47	7.3	46.9	1.46	No Change
15	46.9	1.47	7.4	46.9	1.46	No Change
16	46.9	1.47	9.4	46.9	1.46	No Change
17	46.9	1.47	9	46.9	1.46	No Change
18	46.9	1.47	8.4	46.9	1.46	No Change
19	46.9	1.47	7.8	46.9	1.46	No Change
20	46.9	1.47	7.6	46.9	1.46	No Change
21	46.9	1.47	7.7	46.9	1.46	No Change
22	46.9	1.47	7.5	46.9	1.46	No Change
23	46.9	1.47	37.8	47.4	1.56	0.09
24	46.9	1.47	34	47.1	1.51	0.04

Table 5.29 Project Operation Change in %HA

Receptor ID	Baseline		Project Predicted L_{dn} (dBA)	Total (Baseline plus Project)		Change in %HA (Between Total and Baseline)
	L_{dn} (dBA)*	%HA		L_{dn} (dBA)	%HA	
25	46.9	1.47	34.5	47.1	1.51	0.04
26	46.9	1.47	33.5	47.1	1.50	0.03
27	46.9	1.47	38.7	47.5	1.59	0.12
28	46.9	1.47	14.3	46.9	1.46	No Change
29	46.9	1.47	7.8	46.9	1.46	No Change
30	46.9	1.47	23.6	46.9	1.47	No Change
31	46.9	1.47	19.3	46.9	1.47	No Change
32	46.9	1.47	31.7	47.0	1.49	0.02
33	46.9	1.47	48.8	51.0	2.48	1.01
34	46.9	1.47	45.1	49.1	1.95	0.48
35	46.9	1.47	52	53.2	3.29	1.82
36	46.9	1.47	47.1	50.0	2.19	0.72

Note:
* The lowest measured baseline L_{dn} was considered in the assessment

The change in %HA from baseline to baseline plus Project operation are compared to the target for change in %HA of 6.5%. The changes in %HA at each noise sensitive receptor within the LAA are below the 6.5% target during Project operation. The results indicate compliance with the Health Canada guidance (Health Canada 2017).

5.5.3.3 Summary

Construction

The residual environmental effects on sound quality during construction are adverse, as the Project construction results in a predicted increase of sound levels compared to baseline conditions. The magnitude is predicted to be low and limited to the LAA/RAA, with a relatively small change in sound levels predicted for nearby sensitive receptors. The duration is short-term, the frequency is continuous, and the residual effect on change in sound quality during construction is predicted to be reversible as the predicted increase in sound levels due to the Project construction would end once construction is complete. The LAA/RAA where the changes in sound quality are assessed is considered undisturbed, given the limited development (anthropogenic sources of emissions) within the LAA/RAA prior to the Project.

Operation

The residual environmental effects on sound quality during operation are adverse, as the Project operation results in a predicted increase of sound levels compared to baseline conditions. The magnitude of residual effects is predicted to be moderate; while Project operation results in a change in sound levels to nearby sensitive receptors, the change is less than applicable guideline levels and expected to occur within the geographical extent of the LAA/RAA. The duration for change in sound quality during operation is medium-term and continuous. Residual effects on change in sound quality during operation is predicted to be reversible because the predicted increase in sound levels due to the Project operation would end once this phase is over. The LAA/RAA in which the changes in sound quality are assessed is considered undisturbed; there has been little human development (anthropogenic sources of emissions) within the LAA/RAA prior to the Project.

Decommissioning, Rehabilitation and Closure

The residual environmental effects on sound quality during decommissioning, rehabilitation and closure are adverse, as the related activities result in a predicted increase of sound levels compared to baseline conditions. The magnitude is predicted to be low and limited to the LAA/RAA since noise emissions during decommissioning, rehabilitation and closure are typically much less than during construction and operation and can be effectively managed through the application of SOPs and BMPs. The duration is short term, the frequency is regular, and the residual effect on change in sound quality during decommissioning, rehabilitation and closure is predicted to be reversible as the predicted increase in sound levels would end once closure is complete. The LAA/RAA in which the changes in sound quality are assessed is considered undisturbed, given the limited development (anthropogenic sources of emissions) within the LAA/RAA prior to the Project.

5.5.4 Change in Light Levels

5.5.4.1 Project Pathways

Construction

The construction of the Project includes mine site preparation and earthworks, construction related traffic along the access road, and the construction and installation of Project infrastructure and equipment.

Most of the mine site preparation and construction activities will occur during daytime hours; however, there is potential for such activities to occur during night conditions depending on the construction schedule and the time of year (i.e., during the fall and winter when days are shorter). During this time, it is likely that portable lighting units would be used to meet visibility and worker safety needs. There would also be light associated with the use of vehicles along the access road to support the construction-related transportation.

Operation

The operation of the Project includes operation-related traffic along the access road, open pit mining (e.g., blasting, excavation, haulage of rock), overburden and waste rock management, ore milling and processing, tailings and water management, and utilities and site infrastructure (i.e., accommodations camp and site buildings).

As the final design of the Project has not yet been completed, the locations, type or number of permanent lighting structures are unknown at this time. Permanent lighting structures will use directed lighting (when and where required), and will likely include a combination of street, flood and wall pack lighting. These will be installed along site roads within the Project Area and surrounding vehicle parking lots and site buildings (e.g., accommodations camp, processing facilities, mine services area).

5.5.4.2 Residual Effects

Construction

As most Project construction will occur during daytime hours, Project-related lighting during nighttime will be limited. The use of mobile artificial lighting may occur for short periods of time during the fall and winter seasons when the working day extends into the dark. During these times, the use of mobile lighting will be required to so that there is a secure and safe work environment for construction workers and the public. The exact number of mobile lighting units that would be required and their locations are currently unknown, as the design of the Project is not complete. However, it is likely that such equipment would be used throughout the Project Area, surrounding the proposed locations of construction and installation activities.

With mitigation, levels of light trespass and glare from mobile lighting units would typically be less than CIE guidelines for a sparsely inhabited rural area (i.e., environmental lighting zone E2) during the post-curfew period (i.e., less than 1 lux and less than 500 cd) (refer to Appendix 5A, Table 5A.2 and Table 5A.3) within a kilometer from the source of the mobile light (Stantec 2018). In consideration of the potential levels of light trespass and glare from the operation of mobile lighting units and the proposed mitigation, it is unlikely that sky glow levels would increase to such a level that would be representative of an urban environment (18.5 mag/arcsec^2) (refer to Appendix 5A, Table 5A.5).

In the unusual case that nighttime construction was to occur and mobile lighting units required, it would be limited and mitigated through use of directional lighting.

Operation

During Project operation, nighttime safety lighting will be required for the site buildings (e.g., accommodations camp, mill buildings), surrounding vehicle parking lots, and along the site roads within the Project Area. The final lighting design has not yet been completed, and will be developed using the recommended minimum lighting levels provided by the Illuminating Engineering Society (IES) of North America’s IES Lighting Handbook for outdoor worksite lighting, and in consideration of the CIE criteria.

Light trespass and glare from the permanent structures will be reduced where practicable using full cut-off luminaires to focus light on the work area, and the light design for the Project will incorporate the design criteria of the IES and CIE. With this approach, levels of light trespass and glare are anticipated to be maintained below criteria representative of an E2 environmental lighting zone (i.e., a rural environmental lighting zone; refer to Appendix 5A, Table 5A.3 and Table 5A.4) within the LAA/RAA for both the pre- and post-curfew time application conditions. Levels of trespass would likely be less than 5 lux pre-curfew and less than 1 lux post-curfew and levels of glare would be less than $10*_d$ cd pre-curfew (in this case 110 cd) and less than 5.1*d cd post-curfew (56.1 cd in this case) (Stantec 2020).

Full cut-off lighting and the incorporation of the IES and CIE criteria in the Project's lighting design are also expected to reduce sky glow contributions to light reflected off nearby surfaces.

A viewshed analysis was conducted by Stantec to illustrate whether Project components would be visible from various viewpoints considered representative of nearby receptor locations (i.e., cabins). The viewshed analysis was conducted using the Viewshed Analysis tool in ArcMap. The viewshed analysis estimates the change in elevation from each viewpoint location to the highest point of the Project. To determine if the Marathon and Leprechaun pits and associated Project components would be visible from various viewpoints, the software estimates the change in elevation at a number of locations between the viewpoint location and the Project location to determine if there is a line of sight. If there are locations in-between with higher elevation, the line of sight between the Project and viewpoint is considered blocked, and therefore the Project components would not be visible from that location.

This viewshed analysis focused on three viewshed scenarios, including:

- Viewpoints that could be observed from the highest Project component (i.e. the high-grade stockpile) (Viewshed Scenario 1)
- Viewpoints that could be observed by each nearby receptor (i.e., cabin and/or outfitter location) (Viewshed Scenario 2)
- Viewpoints that could be observed by the only cabin with a direct line of sight to the Project Area (Viewshed Scenario 3)

Each of the viewshed analysis scenarios listed above are graphically presented in Figure 5-12, Figure 5-13, and Figure 5-14.

Figure 5-12 illustrates the locations that would be visible from the top of the high-grade stockpile, and hence, the locations that the high-grade stockpile could be visible from. Figure 5-13 illustrates the locations that would be visible from each receptor located within the LAA/RAA. As shown in Figure 5-12, the high-grade stockpile would be visible from several viewpoints surrounding the Project Area; however, there is limited overlap with the nearby receptor locations that fall elsewhere in the extent of the viewshed analysis. Figure 5-13 illustrates the locations that can be observed from each receptor located within the extent of the viewshed analysis.

As shown in Figure 5-13, there is only one receptor (i.e., cabin) location that would potentially have a direct line of sign to the Project Area. The viewpoint from this one location is further illustrated in Figure 5-14. The area that is illustrated to be potentially visible from this cabin location does not overlap with Project components, with the exception of a small portion of the Marathon waste rock pile, the Marathon pit and an overburden stockpile. This analysis does not consider the presence of trees that may impede the line of sight. As permanent lighting will likely not be installed in these areas, nighttime views should not be affected.

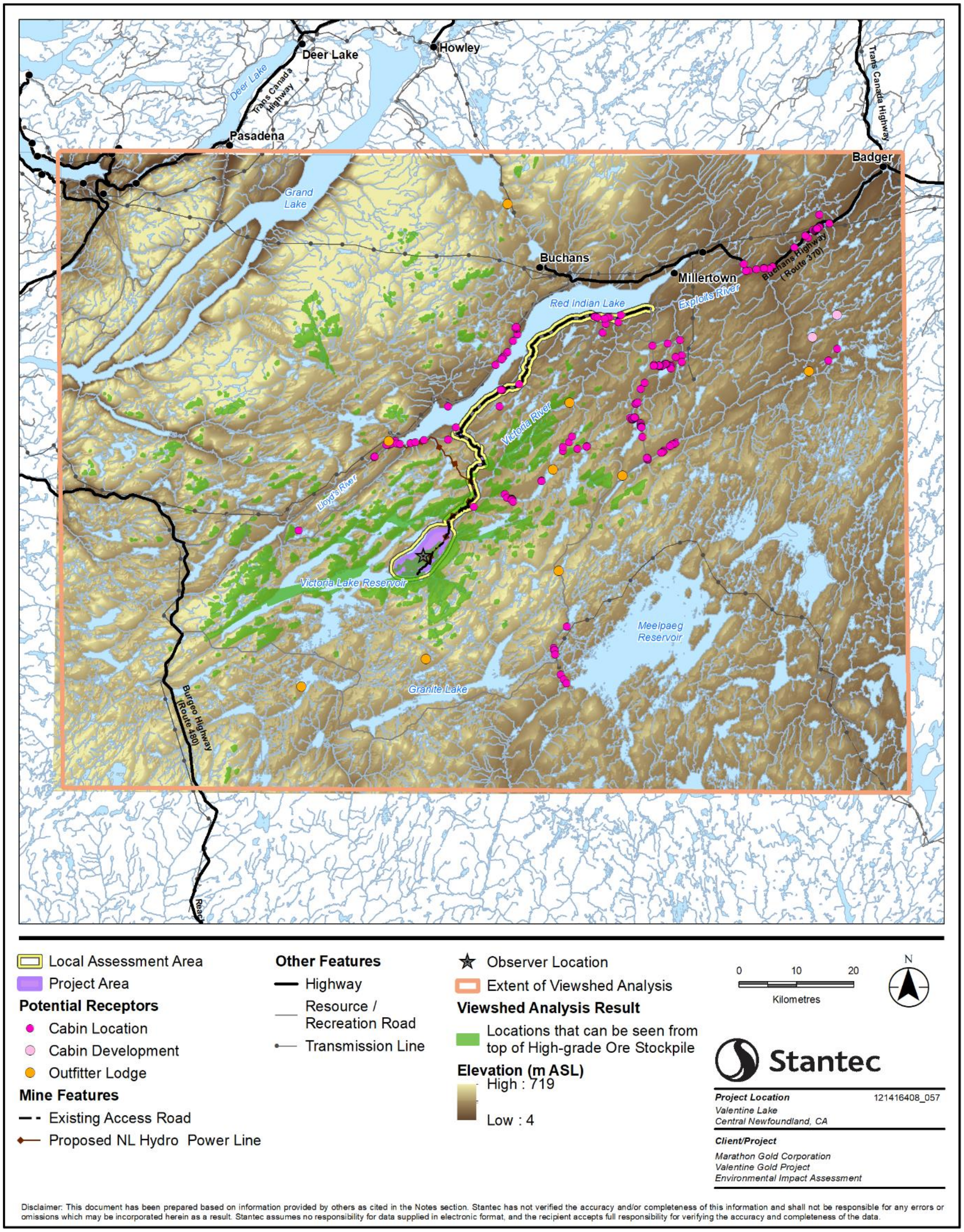


Figure 5-12 Estimated Viewshed from the High-Grade Ore Stockpile (Scenario 1)

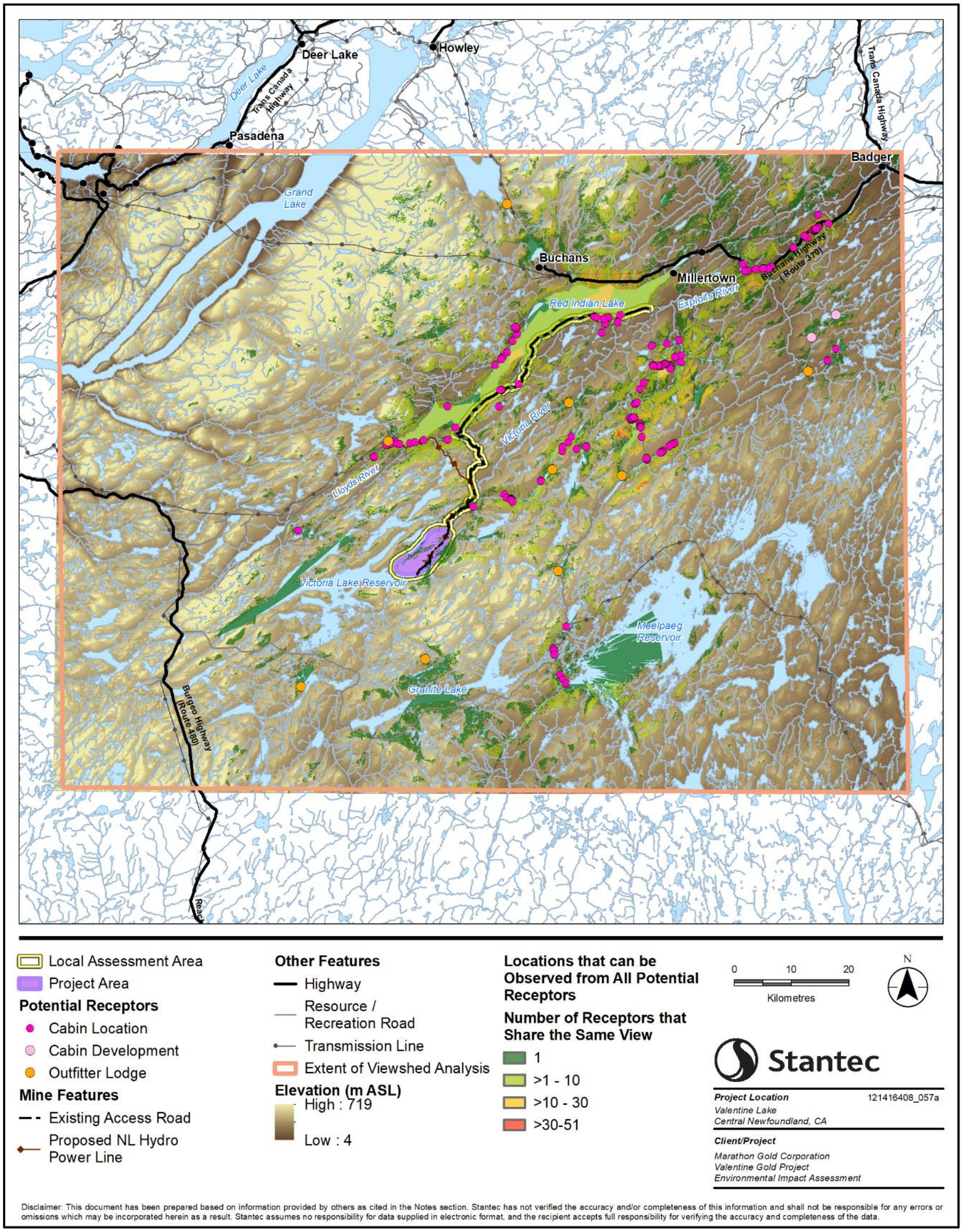
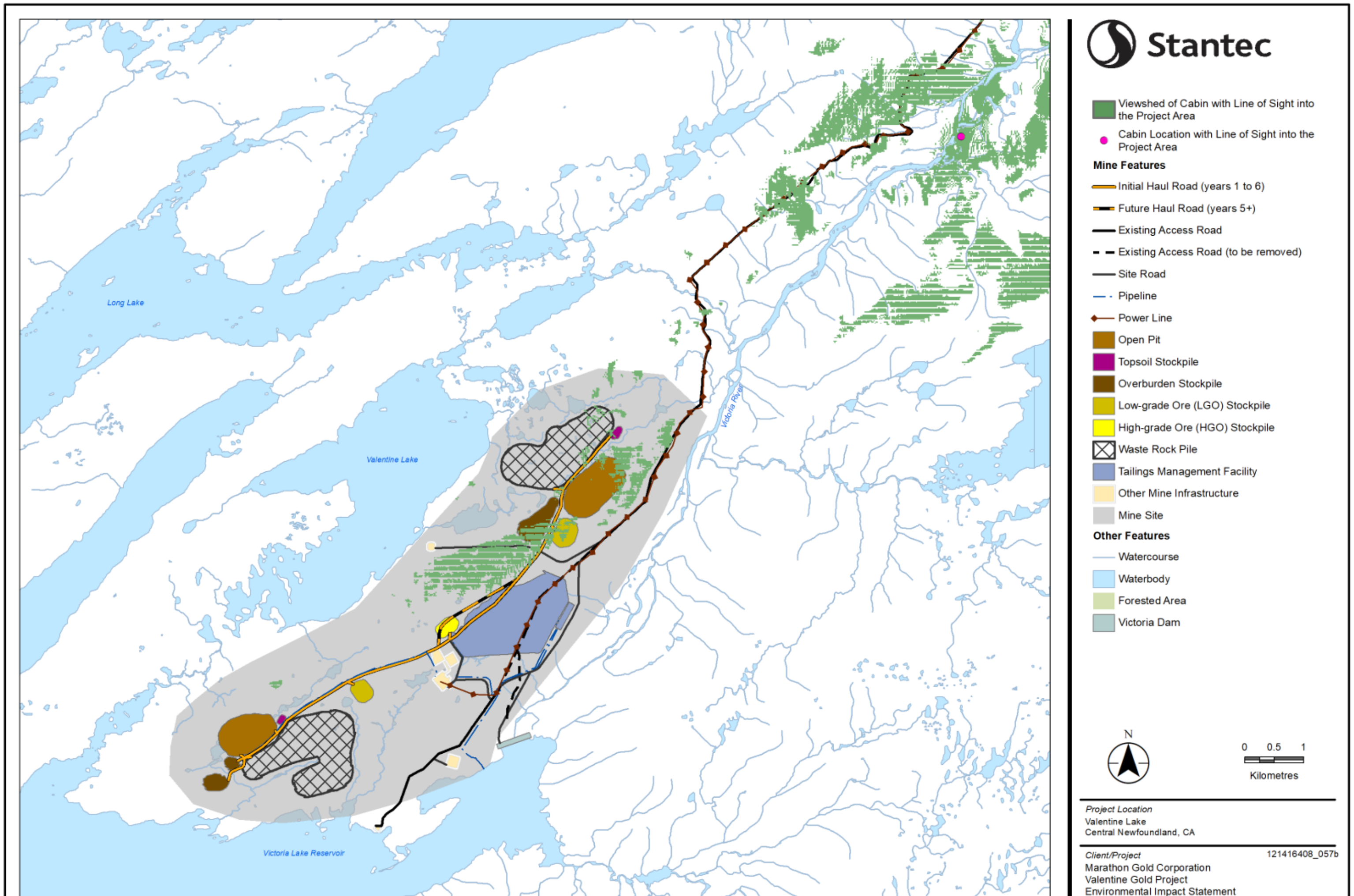


Figure 5-13 Estimated Viewshed of Nearby Receptor Locations (Scenario 2)



Disclaimer: This document has been prepared based on information provided by others as cited in the Notes section. Stantec has not verified the accuracy and/or completeness of this information and shall not be responsible for any errors or omissions which may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format, and the recipient accepts full responsibility for verifying the accuracy and completeness of the data.

Figure 5-14 Estimated Viewshed of Cabin with Line of Sight into Project Area (Scenario 3)

5.5.4.3 Summary

Construction

The residual environmental effects on light levels during construction are adverse, and are predicted to be low in magnitude, as Project construction results in a relatively small change in lighting to nearby sensitive receptors relative to baseline conditions. The geographic extent for change in light levels during construction is expected to be the LAA/RAA, the duration is short-term, and the frequency is irregular because lighting will not be required continuously during construction, rather, it will only be required during periods of darkness. The residual effect would be reversible, with the increase in lighting due to the Project construction ending once construction was complete. The LAA/RAA in which the changes in light levels are assessed is considered undisturbed; there has been little human development (anthropogenic sources of emissions) within the LAA/RAA prior to the Project.

Operation

The residual environmental effects on light levels during operation are adverse, and are predicted to be low in magnitude, as Project operation will result in a relatively small change in lighting to nearby sensitive receptors. The geographic extent for change in light levels during operation is expected to be the LAA/RAA, the duration is medium-term, and the frequency is continuous, as lighting will be used continuously overnight during operation. The residual effect on light levels will be reversible, with the increase in lighting due to the Project operation ending when mining ceases. The LAA/RAA in which the changes in light levels are assessed is considered undisturbed; there has been little human development (anthropogenic sources of emissions) within the LAA/RAA prior to the Project.

Decommissioning, Rehabilitation and Closure

The residual environmental effects on light levels during decommissioning, rehabilitation and closure are adverse, and are predicted to be low in magnitude. The quantities of lighting emissions during decommissioning, rehabilitation and closure are typically much less than construction and operation and can be effectively managed through the application of mitigation measures. The geographic extent for change in light levels during decommissioning, rehabilitation and closure is expected to be the LAA/RAA, the duration is short term, and the frequency is irregular, because lighting will not be required continuously, rather only when Project activities overlap with periods of darkness. The residual effect is reversible, with the increase in lighting due to decommissioning, rehabilitation and closure ending once closure is complete. The LAA/RAA in which the changes in light levels are assessed is considered undisturbed; there has been little human development (anthropogenic sources of emissions) within the LAA/RAA prior to the Project.

5.5.5 Summary of Project Residual Environmental Effects

Residual environmental effects that are likely to occur as a result of the Project are summarized in Table 5.30. The significance of residual adverse effects is considered in Section 5.6.

Table 5.30 Project Residual Effects on Atmospheric Environment

Residual Effect	Residual Effects Characterization							
	Project Phase	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Ecological and Socio-economic
Change in Air Quality	C	A	L-M	LAA/RAA	ST	C	R	U
	O	A	M	LAA/RAA	MT	C	R	U
	D	A	L	PA	ST	R	R	U
Change in GHGs	C	A	L	N/A	ST	C	I	D
	O	A	M	N/A	MT	C	I	D
	D	A	N	N/A	ST	IR	I	D
Change in Sound Quality	C	A	L	LAA/RAA	ST	C	R	U
	O	A	M	LAA/RAA	MT	C	R	U
	D	A	L	LAA/RAA	ST	R	R	U
Change in Light Levels	C	A	L	LAA/RAA	ST	IR	R	U
	O	A	L	LAA/RAA	MT	C	R	U
	D	A	L	LAA/RAA	ST	IR	R	U

KEY
See Table 5.8 for detailed definitions

Project Phase
C: Construction
O: Operation
D: Decommissioning

Direction:
P: Positive
A: Adverse
N: Neutral

Magnitude:
N: Negligible
L: Low
M: Moderate
H: High

Geographic Extent:
PA: Project Area
LAA: Local Assessment Area
RAA: Regional Assessment Area

Duration:
ST: Short term
MT: Medium term
LT: Long term
P: Permanent

N/A: Not applicable

Frequency:
S: Single event
IR: Irregular event
R: Regular event
C: Continuous

Reversibility:
R: Reversible
I: Irreversible

Ecological / Socio-Economic Context:
D: Disturbed
U: Undisturbed

5.6 DETERMINATION OF SIGNIFICANCE

Air Quality

The construction and operation phases of the Project will result in air contaminant emissions; however, the magnitudes of the releases will be limited and well managed.

Construction related emissions (primarily dust from site preparation and material handling as well as combustion gases from equipment) can decrease air quality; however, with the implementation of mitigation, the change in air quality is not expected to be substantive. Air contaminant releases during construction are expected to be lower in magnitude than those from operation. Therefore, based on the results of the dispersion modelling for operation activities, it is unlikely that air contaminant releases from construction would result in a frequent exceedance of the ambient air quality standards (<1% of the time). During operation, some exceedances of the PM_{10} 24-hour standard were predicted; however, the maximum concentrations are likely a result of fugitive releases from the TMF, which will have minimal emissions during construction.

The potential change to air quality in the LAA/RAA during operation was assessed by predicting ground-level concentrations from the modelling of Project-related releases combined with measured background concentrations and compared against ambient air quality criteria.

The combined concentrations for most air contaminants modelled (due to Project related air contaminant releases combined with measured ambient background concentrations) were below the adopted ambient air quality standards outside the Project Area, with the exception of the 24-hour PM_{10} predictions. However, the exceedances of the 24-hour PM_{10} standard are predicted to occur in a small area and are expected to be infrequent (<1% of the time) and of short duration. The combined air contaminant concentrations were also below the ambient air quality standards at the existing exploration camp, accommodations camp and cabin locations.

With the implementation of mitigation and environmental protection measures as described in this assessment and based on the results of the dispersion modelling (for operation) and characterization of residual effects in Section 5.5.1.2, residual environmental effects on air quality during the construction, operation, and decommissioning phases of the Project are predicted to be not significant.

Greenhouse Gases

Provincial and federal policies and regulations do not identify specific thresholds or standards for determining significance when assessing the residual effects of a single Project's GHG emissions. The primary criterion used to assess significant effects of Project-related changes in GHG emissions is magnitude. The GHG emissions from the Project are compared to provincial and national GHG inventories to establish a context for the magnitude of emissions following the Strategic Assessment of Climate Change (ECCC 2020a) guidance. As described in Section 5.3.2, the Project GHG emission contributions will be ranked as low, moderate or high as per the IAAC (formerly the Canadian Environmental Assessment Agency) guidance from the CEA Agency (2003) and as presented in the magnitude definition of Table 5.8

The Project GHG emissions during construction and operation represent a small contribution to provincial and national GHG emissions. On the maximum annual basis, the construction emissions contribute approximately 0.30% and 0.005% to provincial and national GHG emission totals, respectively. The operation contributes approximately 0.84% and 0.013% to the provincial and national emission totals, respectively. The Project emissions are ranked as low in magnitude during construction and moderate during operation. Based on these results and the characterization of residual effects in Section 5.5.2.2, the residual environmental effects from the Project on GHG emissions are predicted to be not significant.

Sound Quality

The construction, operation and decommissioning of the Project will result in noise emissions; however, the magnitude of the releases will be limited and well managed.

Construction and decommissioning-related emissions will occur through the operation of heavy machinery and from earth moving and material handling, site preparation and material handling. Emissions during Project operation are expected to be similar and would also include processing activities related to gold extraction and refinement.

Acoustic modelling was completed to predict sounds levels at nearby receptors due to Project activities. The predicted sound pressure levels were added to measured baseline data collected within the Project Area to estimate the change in sound quality.

As presented in Section 5.3.2, a significant residual adverse effect for sound quality is one where Project-related noise levels at noise-sensitive receptors are likely to exceed Health Canada's annoyance and sleep disturbance targets. The predicted sound pressure levels (existing sound levels plus Project sound levels) at the nearby receptors are expected to be well below Health Canada targets for annoyance (change in %HA < 6.5) and sleep disturbance (45 dBA partially open windows and 57 dBA for fully closed windows) during both construction and operation.

With the implementation of mitigation and environmental protection measures as described in this assessment, and based on the results of the acoustic modelling and characterization of residual effects in Section 5.5.3, residual environmental effects on sound quality during the construction, operation and decommissioning phases of the Project are predicted to be not significant.

Lighting

As defined in Section 5.3.2, a significant environmental effect on lighting is defined as an increase in Project related light emissions such that the CIE guidelines for light trespass and glare in a suburban environment are exceeded and sky glow levels would be altered toward those of an urban environment.

With the proposed mitigation (Section 5.4), an increase in Project-related light emissions (light trespass and glare) is not likely to exceed the criteria in Section 5.1.1.4 for a suburban environment. Based on this light assessment, the levels of light trespass and glare will be maintained at levels representative of a rural environment provided the Light Design for the Project incorporates guidance from IES and CIE. With proper design, existing levels of sky glow will also be maintained at levels representative of rural areas beyond the Project Area. Therefore, residual effects are predicted to be not significant.

A viewshed analysis was also conducted that considered nearby receptor locations with a direct line of sight to the Project. The results of the viewshed analysis indicated that there is one receptor location within the LAA/RAA that could have a direct line of sight to some Project components (considering existing topography and Project design, however trees and other vegetation are not considered), however, those components are not likely to contain permanent lighting structures. Therefore, the nighttime views from that viewpoint will not likely be affected by the Project components within the Project Area.

5.7 PREDICTION CONFIDENCE

Air Quality

The air quality assessment depends on air quality dispersion models to link emissions (the releases of air contaminants to the atmosphere) to changes in ambient air quality. The model predictions depend on the representativeness of the sources and the associated emissions inventory, the meteorological conditions used in the model, and the algorithms used to represent atmospheric physics and chemistry processes in the models.

The overall approach for the air quality assessment is considered conservative. This is because the assessment is a screening type of an analysis, meaning the targets of the assessment are worst case conditions (i.e., the conditions that cause the highest ambient concentrations, and the highest concentrations). The conditions are considered in the assessment to predict a conservative yet representative change in air quality as a result of the Project. Generally, dispersion model inputs are based on maximum quantities of air contaminants potentially released to the atmosphere from the Project. These are assumed to occur continuously over the period of the model run to identify / establish the potential maximum short-term concentrations that might occur. Therefore, the results of the assessment are considered to be conservative. However, there are uncertainties associated with the emissions estimates, the meteorological data, and the algorithms used to model plume dispersion. A description of these uncertainties is provided below.

Uncertainty in Emissions

Release estimates of air contaminant emissions from the processing plant sources are based on source characteristics and processing rates provided by Marathon, as well as published emission factors (for HCN and NH_3). Particulate matter and trace metal emissions were estimated using stack dust concentrations, exhaust gas flow rates (based on design information and manufacturer specifications) and ore specifications (provided by Marathon). Releases of HCN and NH_3 were estimated using processing rates and emissions factors. The level of confidence associated with the particulate matter and trace metals release estimates is higher than those for HCN and NH_3, since the particulate matter and metals are based on site-specific design information (stack dust concentrations and ore specifications) rather than on generic emission factors for gold mining.

The Project-related mobile equipment exhaust emissions are based on expected fuel consumption and accepted industry emission factors. The estimate of fuel consumption is based on past experience, and the conversion of fuel quantities to combustion gases is well understood. Therefore, the level of confidence associated with the estimation of combustion gas (e.g., NO_X, SO_2, CO and CO_2) and particulate matter emissions is high.

Fugitive TSP (and associated PM_{10}, $PM_{2.5}$ and trace metals) emission rates depend on the properties of the surface material, the expected occurrence of surface disturbances, and meteorological conditions. While the air quality assessment uses emission algorithms developed by the US EPA and other sources, there is some uncertainty associated with estimating these emissions and ambient concentrations (i.e., for TSP, PM_{10} , $PM_{2.5}$ and metals). In response to the difficulty in estimating fugitive road dust emissions, the New York State Department of Environmental Conservation rates fugitive dust estimates using the US EPA approach as “indeterminate” (NYSDOEC 2013) with a number of shortcomings. Nonetheless, fugitive dust emissions using the US EPA approach were estimated for Project sources and used in the assessment to obtain a first order understanding of potential magnitude, geographic extent, and frequency of the maximum concentrations in the LAA due to the Project.

Uncertainty in Meteorology

The application of three years of hourly meteorological data includes a wide range of weather conditions in the modelling. This helps to reduce the uncertainty related to meteorology. The use of three years of meteorological data in the modelling is consistent with the recommendations provided in the Plume Dispersion Modelling Guideline (NLDMAE 2002). The level of confidence related to the meteorological data is rated as moderate to high.

Uncertainty on the Dispersion Model

The dispersion modelling is a screening analysis used to identify the highest concentrations of air contaminants caused by the Project on its own and cumulatively (i.e., when combined with other nearby sources and background). In terms of the air quality model algorithms, the US EPA (2005) states:

> *Models are reasonably reliable in estimating the magnitude of highest concentrations occurring sometime, somewhere within an area. For example, errors in highest estimated concentrations of ±10 to ±40% are found to be typical, i.e., certainly well within the often quoted factor-of-two accuracy that has long been recognized for these models.*

In addition, they also state, “*it is desirable to quantify the accuracy or uncertainty associated with concentration estimates used in decision-making. Communications between modelers and decision-makers must be fostered and further developed*.” This communication is being done as part of this assessment.

The US EPA (2005) indicates that the application of regulatory dispersion models is viewed as a best estimate approach and that this approach should be viewed as acceptable to the decision maker. The NLDMAE (2002) has issued the plume dispersion modelling guideline recognizing that the modelling is a best estimate approach and to provide consistency with respect to the application of models to assess projects in NL. The approach to the dispersion modelling that was used for this assessment is viewed as a best-practice approach. The level of confidence related to the air dispersion model is rated as moderate to high.

Overall Air Quality

The level of confidence is high for the estimated processing plant and combustion emissions, the representativeness of the meteorological data, the selected model approach, and the overall effectiveness of the proposed mitigation measures. There is some uncertainty and a lower confidence associated with the estimation of fugitive dust emissions. However, given the screening type analysis conducted for the dispersion modelling (as described above), the overall assessment of air quality is still considered to be conservative, meaning the modelling results are likely to be higher than those that would be measured when the Project is in operation.

GHG Emissions

The estimation of GHG emissions associated with construction, operation and decommissioning depends on the engineering design and on the estimated fuel consumption. The prediction confidence for GHG emissions is rated as high because published GHG emission factors and manufacturer specifications were used. The confidence in the effectiveness of the GHG mitigation measures is also high because most of the mitigation measures are known to effectively reduce the source of GHG emissions (e.g., lower fuel consumption is directly proportional to lower GHG emissions).

Sound Quality

The estimation of noise emissions associated with construction, operation and decommissioning depends on the final design, processing approach, intensity of mining activity and required supporting infrastructure. The prediction confidence for noise emissions is rated as high because the equipment noise emissions are well-understood and are based on equipment totals and published and measured sound power levels for similar equipment. Also, current sound quality conditions are based on sound pressure level monitoring data collected within the Project Area. Finally, the predicted sound pressure levels at nearby receptors were completed using industry-standard software that is routinely used for predicting environmental noise from industrial activities.

Lighting

Future levels of light trespass, glare and sky glow related to the construction, operation and decommissioning of the Project are directly related to the lighting plan for the Project which has yet to be designed. This lighting assessment was therefore qualitative and based on other similar projects, the Project components and their location, results of a viewshed analysis, and professional opinion. However, as the lighting plan will be designed to incorporate guidance and criteria published by the IES and CIE to limit offsite light trespass and glare and contributions to sky glow, the predictions and conclusions made in this assessment are based on a medium to high level of confidence.

5.8 PREDICTED FUTURE CONDITION OF THE ENVIRONMENT IF THE UNDERTAKING DOES NOT PROCEED

There are no large industrial emissions sources within the LAA; therefore, the air contaminant concentrations in the LAA are not likely to change substantially from those concentrations measured in June 2020 near the Project site. If the Project were not to proceed, air quality in the LAA would remain at the existing low background levels unless other developments with substantive emissions were brought into the area.

The federal and provincial governments have set targets to reduce emissions of GHGs. The federal target aims to reduce GHG emissions by 30% below 2005 levels by 2030, down to 513 MT annually, and to achieve a low carbon economy by 2050 (ECCC 2019a). The provincial targets aim to reduce GHG emissions by 35%-45% below 1980 levels by 2030 and to reduce by 30% below 2005 levels by 2030 down to 3.9 MT annually (Government of NL 2019). If the Project were not to proceed, federal and provincial GHG emissions would continue the current trend of decreasing GHG emissions due to efforts by the governments to meet specified targets and reduce the effects of climate change. This trend would continue regardless of Project implementation as the Project contributions to overall GHG emissions would not be substantial to the extent that Canada and NL would be unable to meet GHG reduction targets.

There are no large industrial emissions sources within the LAA and existing noise levels in the LAA/RAA are likely to be low and influenced predominantly by wildlife (e.g., bird and insects). If the Project were not to proceed, sound levels in the LAA/RAA would remain at the existing low background levels unless some other developments are planned for the area.

The predicted future condition of lighting if the Project does not proceed is anticipated to be consistent with the current existing condition within the LAA/RAA.

5.9 FOLLOW-UP AND MONITORING

Air Quality

An Air Quality Management Plan (AQMP) will be created for Project construction and operation, as part of the EPP. The AQMP will specify the mitigation measures for the management and reduction of air emissions during Project construction, operation and decommissioning, and the proposed ambient air quality monitoring program.

Ambient air and meteorology monitoring will be implemented in conjunction with emissions mitigation to provide an understanding of the meteorological conditions and offsite concentrations and evaluate the need for more rigorous mitigation. Monitoring will include meteorological monitoring (wind speed and wind direction) and monitoring of ambient TSP, PM_{10} and $PM_{2.5}$ concentrations.

The results of the ambient PM monitoring will be used to assess the effectiveness of the dust mitigation and to evaluate the potential need for more rigorous dust mitigation. If the monitoring program indicates that ground-level TSP, PM_{10} or $PM_{2.5}$ concentrations are greater than the NL AAQS, additional mitigation measures to reduce PM emissions will be implemented. Given that fugitive dust from the haul roads is the largest source of PM emissions, more frequent road watering or an application of a dust suppressant will be implemented.

Greenhouse Gases (GHGs)

The purpose of the Greenhouse Gas Management Plan will be to manage Project GHG emissions in accordance with relevant GHG emissions management legislation. The Plan will also include policy updates, emission source descriptions, data management framework, GHG emission intensity reduction strategies, effectiveness of mitigation, follow-up, monitoring and regulatory reporting of GHGs, and will be based on provincial and federal reporting requirements.

Sound Quality

With the implementation of mitigation measures, the Project will result in construction, operation and decommissioning noise effects that are not expected to exceed guidance levels. Sound pressure level monitoring programs are recommended near the most affected receptor locations, including the accommodations camp, to monitor the effectiveness of Project mitigation measures. An indoor sound monitoring program is also recommended at the accommodations camp to confirm daytime and nighttime noise levels.

Lighting

There is no follow-up monitoring recommended with respect to ambient lighting.

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6.0 GROUNDWATER RESOURCES

6.1 SCOPE OF ASSESSMENT

Groundwater is the water held beneath the earth's surface in the pores, fractures, crevices, and seams of bedrock and overlying surficial material. Groundwater originates from the percolation of rain, snowmelt, or surface water as it infiltrates ground surfaces. This infiltrating water fills voids between individual grains in unconsolidated materials and fills fractures developed in consolidated materials, such as bedrock. Groundwater generally flows from areas of high elevation (recharge areas) to areas of low elevation (discharge areas), where it exits the sub-surface as springs, wetlands, or as baseflow to streams and lakes. The upper surface of the saturated zone is called the water table. The water table intersects the surface environment at springs, lakes, streams, and wetlands, where interaction between the groundwater and surface water environment can occur. An aquifer is a saturated formation or group of formations that can store or yield useable volumes of groundwater to wells or springs. Natural groundwater quality is directly influenced by the geochemical composition of the geological material that forms the aquifer, and the time the water resides within that material.

For this assessment, the Groundwater Resources Valued Component (VC) is defined as the value and function of groundwater resources in maintaining baseflow to streams for ecological habitat, and in supplying fresh water for human and industrial / commercial uses.

The rationale for the selection of groundwater resources as a VC includes the following:

- Its importance to ecosystem function
- Concerns regarding potential for release of hazardous materials on-site, and potential contamination associated with mine and process water management
- Possible lowering of water table and effects of surface water and groundwater interactions (e.g., wetlands interacting with baseflow from headwaters of two major watersheds)
- Provisions of the Newfoundland and Labrador (NL) *Water Resources Act*

The Groundwater Resources VC is closely linked to other VCs including Surface Water Resources (Chapter 7), Fish and Fish Habitat (Chapter 8), and Vegetation, Wetlands, Terrain and Soils (Chapter 9). The potential environmental effects of changes to groundwater resources on these VCs are discussed in their respective sections.

6.1.1 Regulatory and Policy Setting

In addition to the *Canadian Environmental Assessment Act, 2012* (CEAA 2012) and the NL *Environmental Protection Act*, the Project is subject to other federal and provincial legislation, policies and guidance. This section identifies the primary regulatory requirements and policies of the federal and provincial authorities that influence the scope of the assessment on groundwater resources.

6.1.1.1 Federal Regulatory Requirements

Guidelines for Canadian Drinking Water Quality (2019)

Guidelines for potable water are established by Health Canada in collaboration with the Federal-Provincial-Territorial Committee on Drinking Water. *Guidelines for Canadian Drinking Water Quality* (GCDWQ) are applicable as aesthetic and health-based guidelines for a variety of chemical parameters for potable water sources at the site (e.g., accommodations camp).

Federal Fisheries Act (2019)

Metal and Diamond Mining Effluent Regulations (MDMER), pursuant to the federal *Fisheries Act*, sets allowable limits for specific metals as sampled by a prescribed schedule. The MDMER set out the maximum allowable limits for concentrations of specific metals and compounds in discharge resulting from the Project. The MDMER also sets forth the extensive Environmental Effects Monitoring criteria to be implemented during the operational phase of the Project.

6.1.1.2 Provincial Regulatory Requirements

Water Resources Act (2002)

The *Water Resources Act* gives the Water Resource Management Division of the NL Department of Environment, Climate Change and Municipalities (NLDECCM) the responsibility and legislative power for the management of water resources in the province.

The *Environmental Control Water and Sewer Regulations*, under the *Water Resources Act*, which incorporate the limits imposed by the MDMER, will also apply to discharge of water and effluent from the Project.

Water supply well construction for various Project components (e.g., accommodations camp) is regulated under the *Well Drilling Regulations* (2003), NLR 63/03 under the *Water Resources Act*.

Water well abandonment is regulated under section 18 (3) of the *Well Drilling Regulations*.

6.1.2 The Influence of Consultation and Engagement on the Assessment

As part of ongoing engagement and consultation activities, Marathon has documented interests and concerns about the Project received from communities, governments, Indigenous groups and stakeholders. An overview of Marathon's engagement activities is provided in Chapter 3. Documented interests and concerns have influenced the design and operational plans for the Project, and the development of the EIS, including the scope of assessment on the VCs. Interests and concerns noted that specifically relate to groundwater resources or routine Project activities that could affect groundwater resources are provided below. Issues and concerns related to effects of potential accidents or malfunctions are described in the assessment of accidental events (Chapter 21).

Questions and concerns raised by Qalipu through Marathon's engagement efforts include:

- Design and operation of the tailing management facility, including use of earthen dams, long-term plans for the tailings pond, nature of "detox tailings", use of a geo-membrane, and likelihood and consequences of a breach
- Processing onsite, including the use of cyanide and the heap leach process
- Water quality and water treatment

Questions and concerns raised by Miawpukek through Marathon's engagement efforts include:

- The need for treatment to protect water quality
- Tailings, including questions about treatment, accidental events, and rehabilitation and closure

Questions and concerns raised by communities and other stakeholders through Marathon's engagement efforts include:

- Project components and infrastructure including: if pits will be mined simultaneously; how many ponds there will be; if the mine will be open pit only or include underground; how ore will be transported to the mill and how and where it will be processed; use of cyanide; what will replace the heap leach process; whether other metals, like silver, are present; whether product will be tested at an on-site lab or externally; and what will happen to waste rock and overburden
- Tailings and potential risks, including how tailings will be managed, the treatment of effluent, understanding "detox tailings", the consideration of use of a geo-membrane liner, potential impact of the tailings pond and polishing pond on water resources, and the long-term plan [closure] for the tailings pond

Questions and concerns raised by fish and wildlife and civil society organizations through Marathon's engagement efforts include:

- Project description, including the size of the Project footprint, pit stability, the source of power for the Project, use of cyanide, the process that will replace the heap leach process, how tailings will be transported, and tailings management (and consideration of alternatives)
- Water quality including the potential for contamination, the potential for acid rock drainage, and the need for the protection of small ponds near the Project Area

6.1.3 Boundaries

The scope of the assessment is defined by spatial boundaries (i.e., geographic extent of potential effects) and temporal boundaries (i.e., timing of potential effects). Spatial boundaries for the Groundwater Resources VC were selected in consideration of the geographic extent over which Project activities, and their effects, are likely to occur to the VC. Temporal boundaries are based on the timing and duration of Project activities and the nature of the interactions with the VC. The spatial and temporal boundaries associated with the effects assessment for the Groundwater Resources VC are described in the following sections.

6.1.3.1 Spatial Boundaries

The following spatial boundaries were used to assess Project effects, including residual environmental effects, on groundwater resources in areas surrounding the mine site and access road (Figure 6-1):

Project Area: The Project Area encompasses the immediate area in which Project activities and components occur and is comprised of two distinct areas: the mine site and the access road. The mine site includes the area within which Project infrastructure will be located, and the access road is the existing road to the site, plus a 20-metre (m) wide buffer on either side. The Project Area is the anticipated area of direct physical disturbance associated with the construction, operation and decommissioning, rehabilitation and closure of the Project.

Local Assessment Area (LAA) / Regional Assessment Area (RAA): The LAA was delineated for the site, as shown on Figure 6-1. The LAA for groundwater is based on the likely extent of drawdown from open pit dewatering, and changes to flow or groundwater quality due to recharge from the tailings management facility (TMF) and waste rock piles. The LAA boundaries (Figure 6-1) are based on the study areas described in the baseline hydrogeology reports presented in Baseline Study Appendix 3: Water Resources (BSA.3) and results of groundwater flow modelling presented in Appendix 6A. The RAA is the same as the LAA because the aquifers that interact with the Project are limited in extent due to groundwater divides coinciding with surface water sub-watershed boundaries. The RAA is used to provide regional context for the determination of significance of residual effects and is the area within which accidental events are assessed (Chapter 21). The RAA also informs the assessment of cumulative effects (Chapter 20). The LAA and RAA are considered together as the LAA/RAA in the remainder of the assessment.

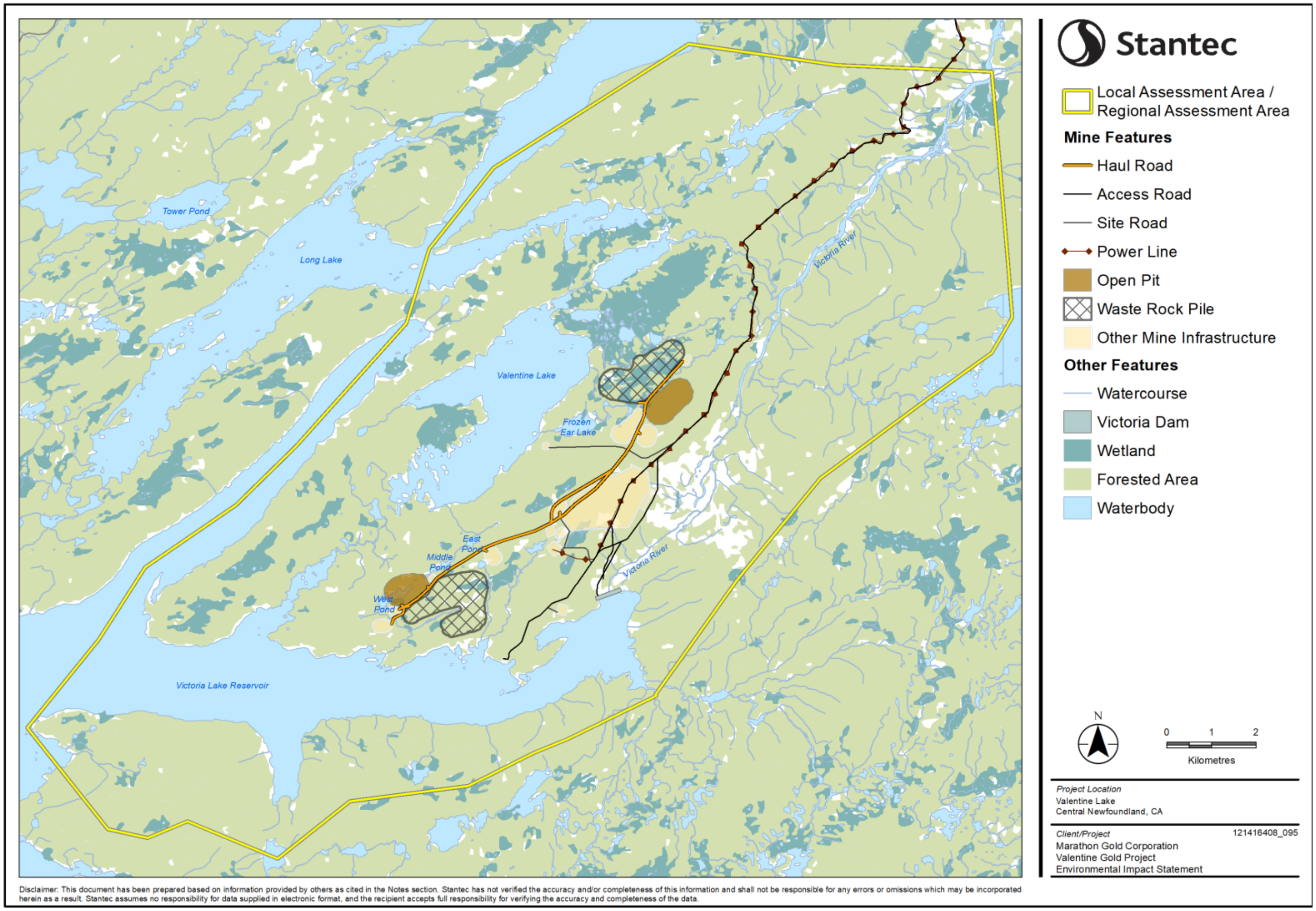

Figure 6-1 Local and Regional Assessment Areas

6.1.3.2 Temporal Boundaries

The temporal boundaries for the assessment of potential effects on the Groundwater Resources VC include:

- Construction Phase – 16 to 20 months, beginning in Q4 2021, with 90% of activities occurring in 2022
- Operation Phase – Estimated 12-year operation life, with commissioning / start-up and mine / mill operation slated to start Q2 2023
- Decommissioning, Rehabilitation and Closure Phase – Closure rehabilitation to occur once it is no longer economical to mine or resources are exhausted

6.2 EXISTING CONDITIONS FOR GROUNDWATER RESOURCES

A characterization of the existing conditions within the spatial boundaries defined in Section 6.1.3.1 is provided in the following sections. This includes a discussion of the influences of past and present physical activities on the VC, leading to current conditions. An understanding of the existing conditions for the VC within the spatial area being assessed is a key requirement in the prediction of potential Project effects provided in Section 6.5.

6.2.1 Methods

Information regarding existing conditions of groundwater resources in the Project Area and LAA/RAA are derived from data collected in support of the Project and existing, publicly available regional hydrogeological information. The data spans the period 2011 through 2020. The following data and reports were reviewed to characterize existing conditions for groundwater resources for the Project:

- Aquifer Test Analysis, Water Supply Well, Victoria Lake Exploration Camp. Prepared for Northeast Well Drilling Ltd. (Stantec 2011)
- Valentine Lake Project: Preliminary Baseline Hydrogeology Assessment completed in 2017 and 2019 (BSA.3, Attachments 3-A and 3-B)
- Pre-Feasibility Geotechnical Investigation: Marathon & Leprechaun Deposits (Terrane 2020; Appendix 2C)
- Hydrogeology Baseline Report, Marathon Valentine Gold Project, Central Newfoundland (GEMTEC 2020; BSA.3, Attachment 3-D)
- Valentine Lake Project: Hydrology and Surface Water Quality Monitoring Baseline Report (BSA.3; Attachment 3-C)

Additional information used in support of baseline water resource characterization was derived from:

- Geological / hydrogeological mapping information from GeoScience OnLine Atlas (Newfoundland and Labrador Department of Natural Resources [NLDNR] 2020)
- Historical Weather Data from Buchans Reference Climate Stations (Environment and Climate Change Canada [ECCC] 2020)

Historical information and existing groundwater data were used to characterize baseline groundwater conditions to assess potential changes in groundwater quantity and quality through measurable indicators described in Section 6.3.3. Physiographic setting, water levels, groundwater chemistry, hydraulic properties, groundwater flow directions, and groundwater users were considered to develop an understanding of how groundwater might interact with the Project, and how the Project might in turn interact with the natural hydrogeological-hydrologic cycle.

6.2.2 Overview

This section provides an overview of existing groundwater conditions for the Project. Detailed baseline environmental conditions for groundwater, including figures of borehole and monitoring well locations, are provided in the Hydrogeology Baseline Report in BSA.3, Attachment 3-D.

6.2.2.1 Physiographic Setting

An overview of the data and analysis used to characterize the existing conditions for the groundwater environment include climate, detailed in Chapter 5, Section 5.2.2.1, surficial geology detailed in Chapter 9, Section 9.2.2.5, and bedrock geology and regional hydrogeology, which are provided below. Further information is provided in Appendix 6A.

Bedrock Geology

Given the limited depth of overburden over much of the Project Area, the majority of groundwater flow is expected to occur within the three major lithological units underlying the Project Area. Lithological summaries below are based on descriptions by Tettelaar and Dunsworth (2016).

Bedrock underlying the Leprechaun and Marathon open pit areas and waste rock piles consists of the Valentine Lake Intrusive Complex, described as an elongate zoned intrusive body of Precambrian quartz porphyry monzonite, trondhjemite, gabbro, and diorite. A well-defined northeast trending thrust fault defines the southeast margin of the complex. The Valentine Lake Intrusive Complex is the major host of gold mineralization of the Project.

Bedrock underlying the TMF, plant and accommodations camp consists of mixed sedimentary units and lesser gabbroic and mafic volcanic rocks of the Victoria Lake Group, comprised of Cambrian to mid-Ordovician rocks. The group consists of dark grey to black shale and siltstone containing thin, felsic, tuffaceous beds. The black shale layers transform into a mélange with felsic volcanic blocks near major faults.

The Rogerson Lake Conglomerate lies along the southeastern margin of the Valentine Lake Intrusive Complex and occurs as a narrow, elongate contact between the Valentine Lake Intrusive Complex and the Victoria Lake Group. The Rogerson Lake Conglomerate consists of Silurian-aged siliciclastic conglomerate.

Regional Hydrogeology

Regional hydrogeological data was obtained from *The Hydrogeology of Central Newfoundland* (AMEC 2013). Most of the Leprechaun and Marathon deposits are located in what is referred to as hydrogeological Unit 5, which consists of plutonic strata and includes mostly major granites, granodiorite, diabase, and diorite intrusions. The Valentine Lake Intrusive Complex is contained wholly within Unit 5. Yields of wells drilled in Unit 5 are typically low to moderate with a median sustainable pumping rate of 9 litres per minute (L/min). The southeast portion of the Project Area is located in Hydrogeological Unit 3, primarily consisting of basic pillow lava flows, breccia and tuff, and corresponds to the Victoria Lake Group. Yields of wells drilled in Unit 3 are similar to wells in Unit 5 and also have a median sustainable pumping rate of 9 L/min. Hydrogeological Unit 2 lies along the southern boundary of the Leprechaun pit and consists largely of sandstone, conglomerate, breccia, greywacke, and minor volcanic flows and tuff. The Rogerson Lake Conglomerate is part of Unit 2. Yields of wells drilled in Unit 2 are also low to moderate with a median sustainable pumping rate of 7 L/min. The boundaries of Hydrostratigraphic Units 2, 3 and 5, with respect to site infrastructure, are shown on Figure 6-2.

It is expected that the shallow groundwater system in the area will be largely controlled by surface runoff and local recharge, while at moderate depths the flow system may be influenced by recharge at higher elevations (Tóth 2009). Groundwater levels are generally assumed to be close to ground surface and to be a subdued reflection of the topography (Tóth 2009). The movement of groundwater through the underlying bedrock can be expected to mainly occur within secondary openings, such as fractures and joints, and will be variable depending on the frequency and interconnection of these structural features. The underlying bedrock aquifer is likely to be under semi-confining conditions with recharge predominantly from lateral inflow of groundwater from adjacent upland areas.

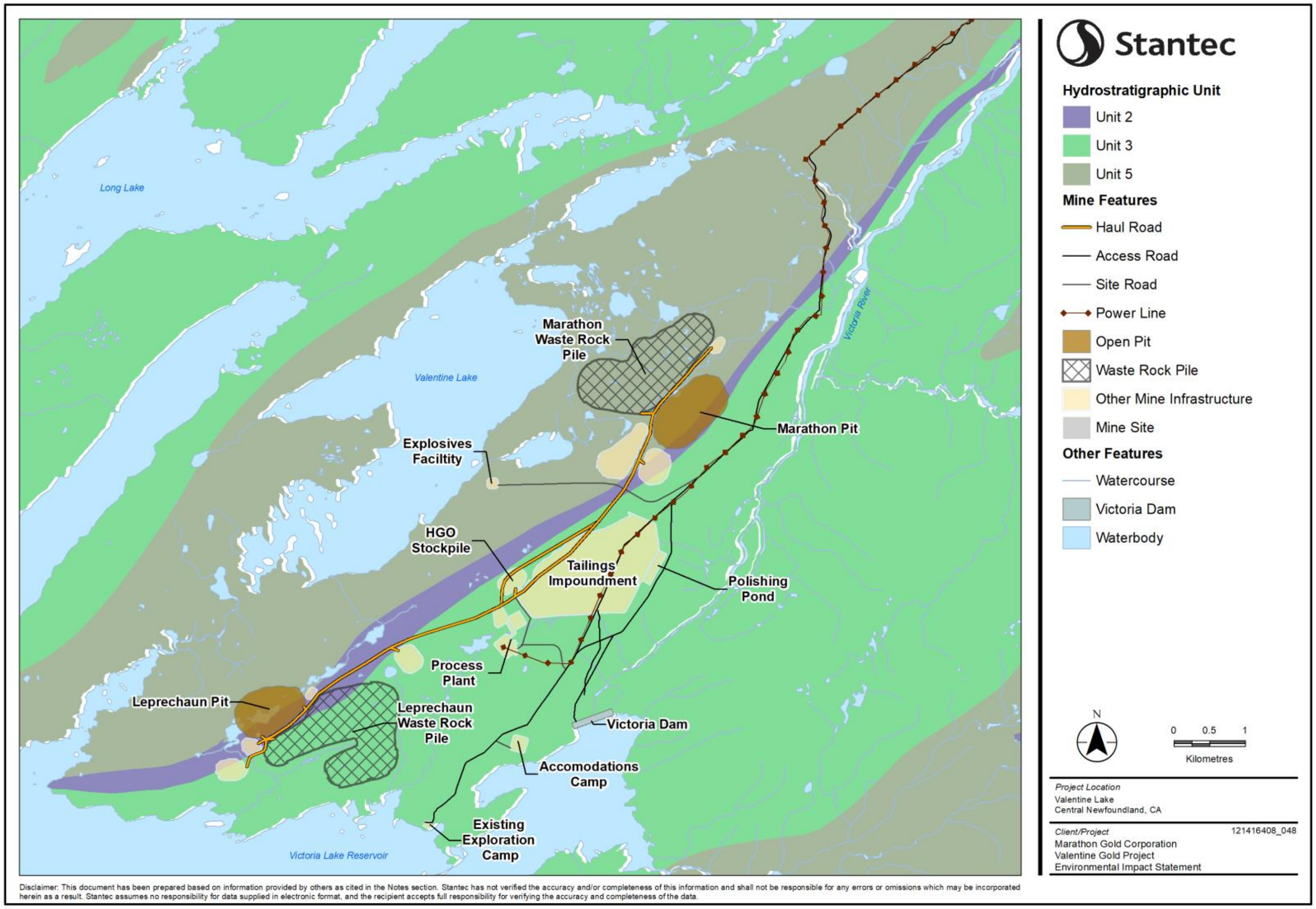

Figure 6-2 Regional Hydrogeology

6.2.2.2 Water Levels

Water levels collected manually from over 300 exploration boreholes and monitoring wells during several field programs for baseline assessment ranged from approximately -0.8 meters below ground surface (mbgs) (flowing artesian well) to 28.2 mbgs (BSA.3, Attachments 3-B and 3-D). Water levels were collected in the vicinity of the proposed Leprechaun and Marathon pits, and along the exploration corridor between the two pits. Groundwater elevations vary across the Project Area and generally reflect the topographic relief of the area, with higher groundwater elevations occurring in boreholes / wells located at higher topographic elevations (BSA.3, Attachment 3-B). A groundwater elevation change of 100 m was observed between the topographic highs of the exploration corridor connecting the two pits (maximum elevation of approximately 420 metres above sea level (masl)) down to Valentine Lake and Victoria Lake Reservoir (elevation of 320 masl) (BSA.3, Attachment 3-B).

Continuous water level monitoring by data loggers over a full calendar year (November 2017 to November 2018) in five exploration boreholes at the Leprechaun and Marathon pit areas do not indicate a seasonal trend or a strong correlation between precipitation and groundwater levels. Annual fluctuations of water levels in the five measured boreholes were less than 0.8 m (BSA.3, Attachment 3-A). There are currently eight loggers installed for continuous water level monitoring in monitoring wells near proposed site features (e.g., open pits, waste rock piles and the TMF) (BSA.3, Attachment 3-D).

6.2.2.3 Groundwater Chemistry

Groundwater chemistry in the Project Area was characterized with 19 samples collected from boreholes / wells during the baseline assessment (BSA.3, Attachments 3-A and 3-D). In general, it was found that groundwater comprised a slightly hard to very hard, calcium-sodium-bicarbonate-chloride-sulfate type water. Groundwater samples were predominantly slightly alkaline with moderate acid buffering potential and low conductivity, indicating fresh conditions. Langelier Saturation Index values for groundwater samples indicate groundwater is neither strongly corrosive nor scale-forming with respect to solid $CaCO_3$.

Metals parameters were generally low except for iron and manganese.

Analyzed parameters generally meet the GCDWQ (Health Canada 2019), except for pH (2 samples), true colour (3 samples), total dissolved solids (1 sample), turbidity (17 samples), arsenic (2 samples), iron (4 samples), and manganese (16 samples), which exceed either the aesthetic objective or maximum allowable concentration. Plots of minimum, maximum and mean concentrations of general chemistry parameters and metals for the 19 samples that were analyzed are shown in Figure 6-3 and Figure 6-4 respectively. Groundwater in the vicinity of the pits is not expected to be used as a potable source and is compared to the GCDWQ for descriptive purposes only.

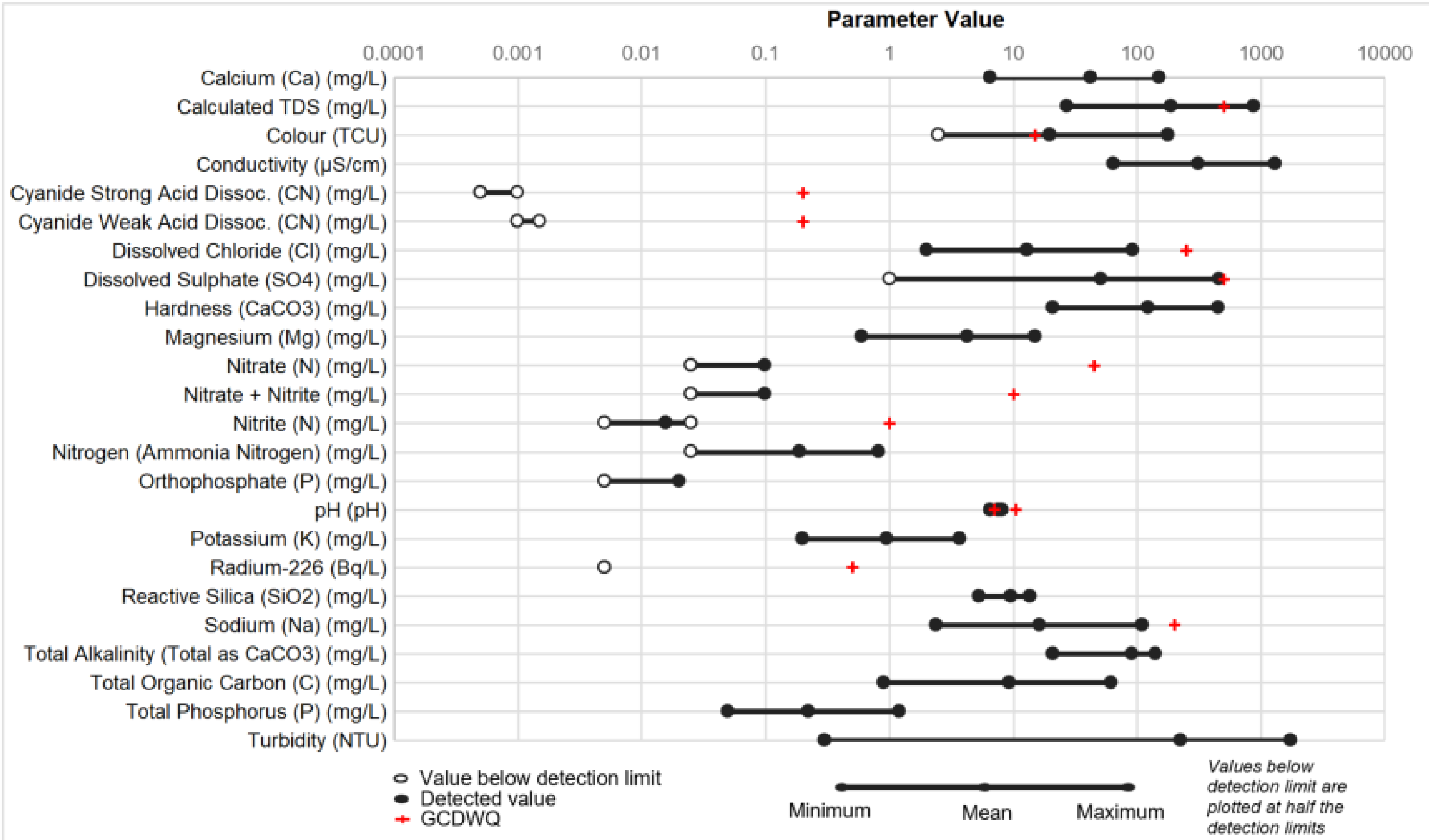

Figure 6-3 Baseline Groundwater General Chemistry

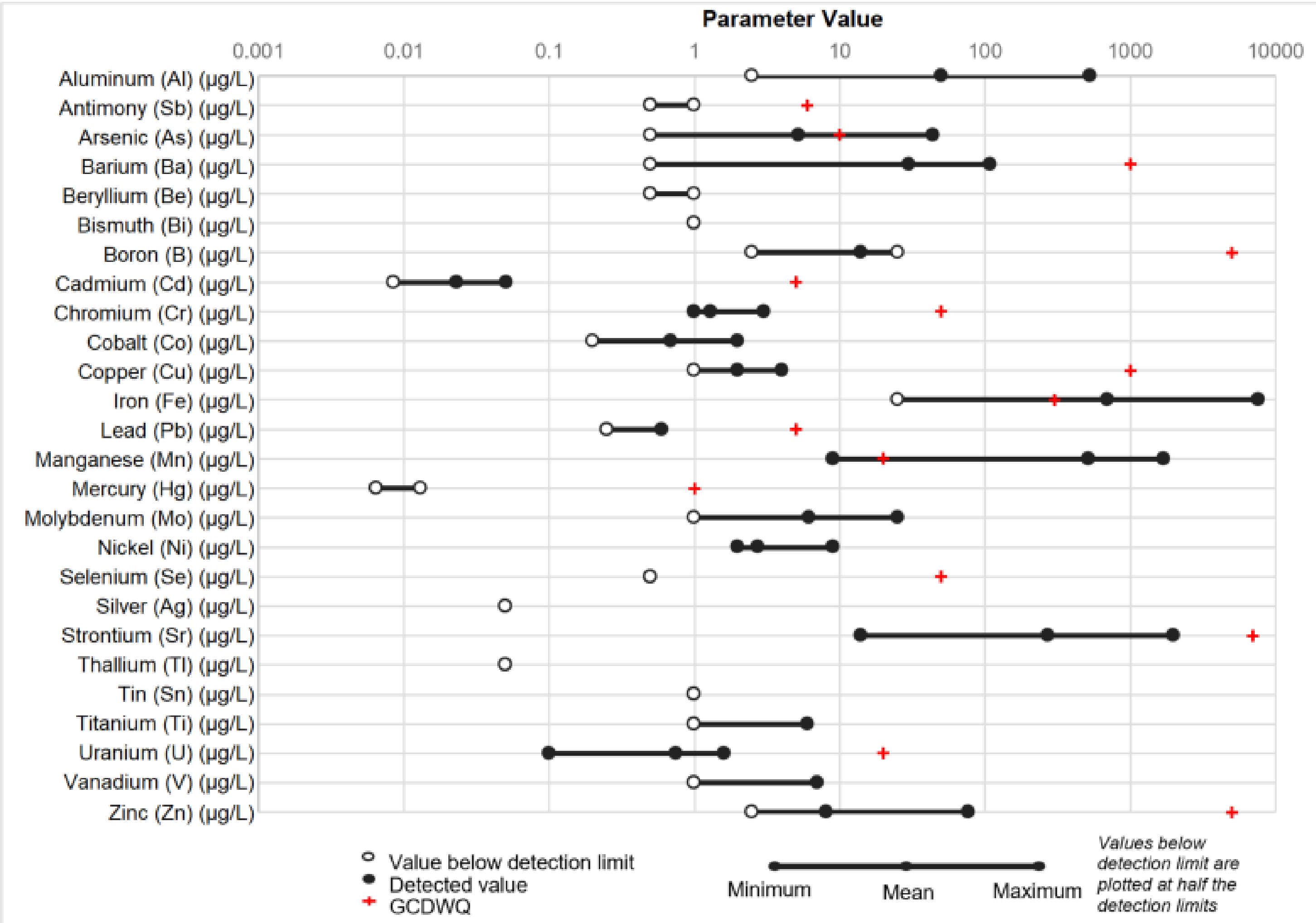

Figure 6-4 Baseline Groundwater Metals Chemistry

Where tested, radium-226, cyanide and dissolved mercury were below the reportable laboratory detection limit.

Continuous groundwater temperature monitoring by data loggers over a full calendar year (November 2017 to November 2018) in five exploration boreholes at the Leprechaun and Marathon pit areas does not indicate a strong seasonal variation of groundwater temperatures. Groundwater temperatures in the five measured boreholes fluctuated approximately 1.0°C over the year with an average groundwater temperature of 6.0°C (BSA.3, Attachment 3-A). There are currently eight loggers installed for continuous groundwater temperature monitoring (BSA.3, Attachment 3-D).

6.2.2.4 Hydraulic Properties

Rising and falling head tests in unconfined overburden and shallow bedrock resulted in hydraulic conductivity measurements ranging from 8×10^{-7} meters per second (m/s) to 9×10^{-5} m/s with a geometric mean of 5×10^{-6} m/s (BSA.3, Attachment 3-D).

Packer testing across a variety of depths in bedrock in the Valentine Lake Intrusive Complex and the Rogerson Lake Conglomerate resulted in hydraulic conductivity measurements ranging from 4×10^{-10} m/s to 6×10^{-6} m/s, with a geometric mean of approximately 5×10^{-8} m/s (Terrane 2020, Appendix 2C). Hydraulic conductivity values of shallow wells were generally higher than those observed in deep wells, consistent with a decreasing degree of fracturing and bulk hydraulic conductivity with depth. Results were similar to recovery testing completed in existing exploration boreholes at the Leprechaun (3.4×10^{-8} m/s) and Marathon (7.8×10^{-8} m/s) pits (BSA.3, Attachment 3-A).

Data collected to date does not indicate a correlation between hydraulic conductivity and lithological unit, supporting the assumption that permeability is likely controlled by fractures and joints. There is currently no indication of significantly increased hydraulic conductivity in areas tested along the thrust fault separating the Valentine Lake Intrusive Complex and the Rogerson Lake Conglomerate. However, hydraulic testing along the thrust fault is limited to one packer test at the Leprechaun pit and one packer test at the Marathon pit (Terrane 2020, Appendix 2C). Various faults, fractures and shear zones have been mapped in these areas that were not tested and localized areas of higher permeability may still be present. The measurement of hydraulic conductivity for the Victoria Lake Group is limited to a single pumping test, which returned a value of approximately 7.4×10^{-4} m/s (Stantec 2011).

6.2.2.5 Groundwater Flow Directions

Based on topography in the Project Area and water levels collected during baseline assessment, groundwater contours were generated as shown in Figure 6-5.

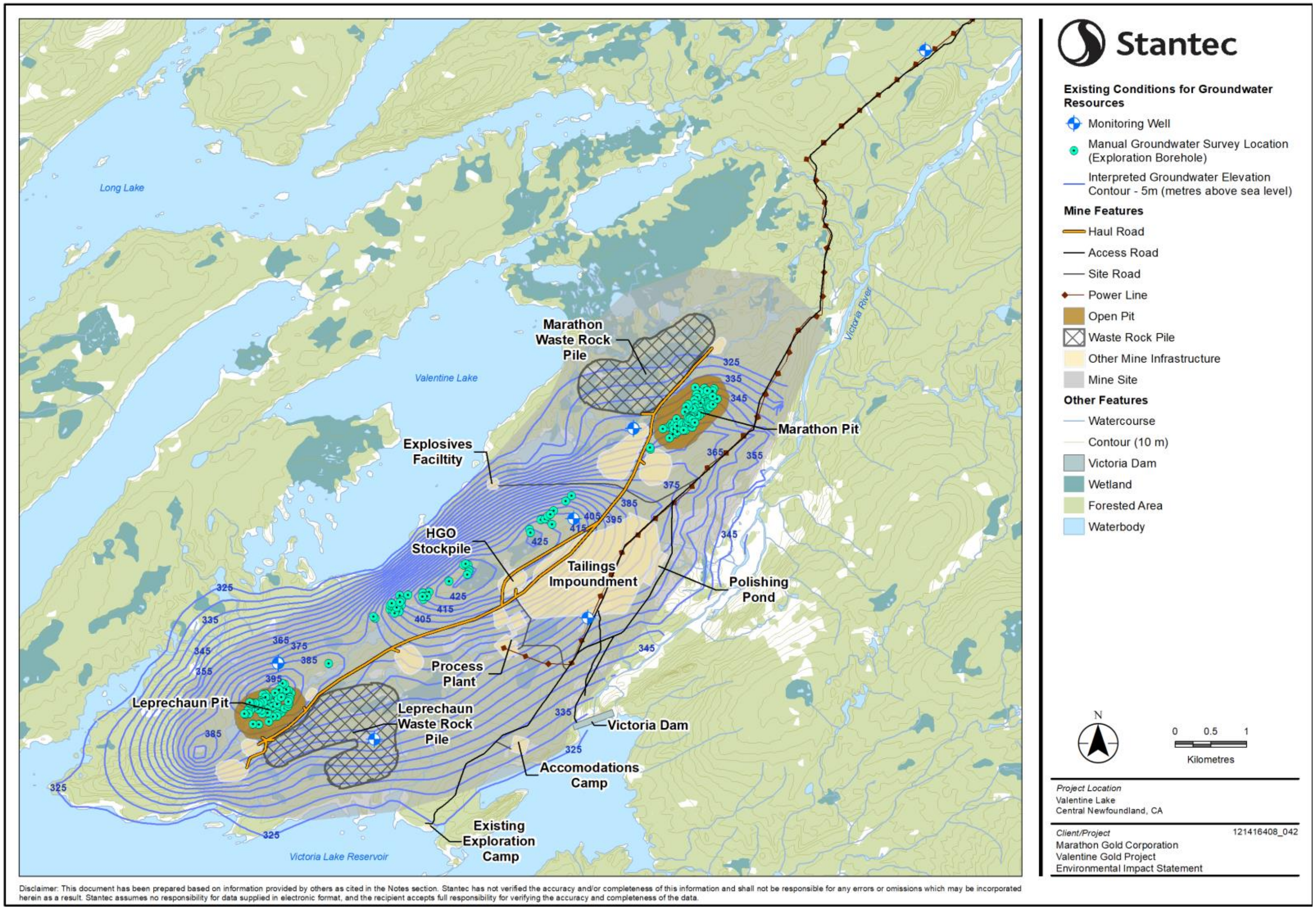

Figure 6-5 Groundwater Contour Map

Groundwater divides are typically expected to be near surface water divides, which define watersheds and sub-watersheds. These divides often coincide with topographic highs and act as areas of primary recharge (Freeze and Cherry 1979). In the Project Area, a groundwater divide is inferred to exist along the northeast-trending ridge (corresponding to the trend of the thrust fault) from the Leprechaun pit to the Marathon pit. Groundwater to the north and west of the divide is generally expected to flow into Valentine Lake to the northwest and groundwater to the east and south of the divide is generally expected to either flow into Victoria River to the east or into Victoria Lake Reservoir to the south. These bordering drainage features are primary areas of discharge for groundwater in the Project Area.

Groundwater flow velocity depends on the hydraulic conductivity of the aquifer material and the hydraulic gradient, and is a measure of the rate at which groundwater moves from point of recharge to point of discharge, and also how fast a contaminant of concern released from a mine-related activity may move toward a receptor, such as surface water or well. Horizontal groundwater gradients calculated in baseline assessment ranged from 1% along the low-lying area along the northwest side of the Marathon pit near the Marathon waste rock pile, to 8% along steeper topography in the vicinity of the exploration corridor between the two pits. Vertical hydraulic conductivity data calculated from two sets of paired wells ranged from 2.5% upward to 22% downward. Downward and upward vertical gradients appear to correspond to recharge and discharge areas respectively. This trend is also observed in the frequency of flowing artesian wells recorded in the vicinity of the northern slope of the Marathon pit. Although flowing artesian conditions were noted in some exploration boreholes along topographic highs along the groundwater divide, it is thought that these are localized and geologically controlled and do not reflect the overall groundwater flow regime (BSA.3, Attachment 3-D).

6.2.2.6 Groundwater Users

The only known active groundwater user in the Project Area is the existing exploration camp owned and operated by Marathon. Aquifer testing results indicate that the current 100-day continuous safe yield of the exploration camp well is approximately 60 L/min (Stantec 2011).

Based on a Drilled Well Location Request submitted to NLDECCM, the nearest known residences with domestic wells are located in the vicinity of Buchans and Millertown, approximately 49 km and 60 km from the mine site, respectively (NLDMAE 2020).

6.3 ASSESSMENT CRITERIA AND METHODS

This section describes the criteria and methods used to assess environmental effects on groundwater resources. Residual environmental effects (Section 6.5) are assessed and characterized using criteria defined in Section 6.3.1, including direction, magnitude, geographic extent, timing, frequency, duration, reversibility, and ecological or socio-economic context. The assessment also evaluates the significance of these effects using threshold criteria or standards beyond which a residual environmental effect is considered significant. The definition of a significant effect for the Groundwater Resources VC is provided in Section 6.3.2. Section 6.3.3 identifies the environmental effects to be assessed for groundwater resources, including effect pathway and measurable parameters. This is followed by the identification of potential Project interactions with this VC (Section 6.3.4). Analytical assessment techniques used for the assessment of groundwater resources are provided in Section 6.3.5.

6.3.1 Residual Effects Characterization

Table 6.1 presents definitions for the characterization of residual environmental effects on groundwater resources. The criteria are used to describe the potential residual effects that remain after mitigation measures have been implemented. Quantitative measures have been developed, where possible, to characterize residual effects. Qualitative considerations are used where quantitative measurement is not possible.

Table 6.1 Characterization of Residual Effects on Groundwater Resources

Characterization	Description	Quantitative Measure or Definition of Qualitative Categories
Direction	The long-term trend of the residual effect	**Neutral –** no net change in measurable parameters for groundwater resources relative to baseline **Positive –** a residual effect that moves measurable parameters in a direction beneficial to groundwater resources relative to baseline **Adverse –** a residual effect that moves measurable parameters in a direction detrimental to groundwater resources relative to baseline
Magnitude	The amount of change in measurable parameters of groundwater resources relative to existing conditions	**Negligible –** no measurable change to groundwater resources relative to baseline **Low –** a measurable change is detectable but within the normal variability that would be expected relative to baseline **Moderate –** measurable change occurs that is considered elevated above baseline or depressed below baseline but within acceptable limits **High –** measurable change occurs that is considered elevated above acceptable limits or regulatory objectives
Geographic Extent	The geographic area in which a residual effect occurs	**Project Area –** residual effects are restricted to the Project Area **LAA/RAA–** residual effects extend into the LAA/RAA
Frequency	Identifies how often the residual effect occurs and how often during the Project or in a specific phase	**Single event –** occurs only once **Multiple irregular event –** occurs at no set schedule **Multiple regular event –** occurs at regular intervals **Continuous –** occurs continuously
Duration	The period of time required until the measurable parameter or the VC returns to its existing (baseline) condition, or the residual effect can no longer be measured or otherwise perceived	**Short term –** residual effect restricted to construction or decommissioning, rehabilitation and closure phases **Medium term –** residual effect extends through project operations but is expected to subside when operations cease **Long term –** residual effect extends beyond the life of the project **Permanent –** recovery to baseline conditions unlikely

Table 6.1 Characterization of Residual Effects on Groundwater Resources

Characterization	Description	Quantitative Measure or Definition of Qualitative Categories
Reversibility	Describes whether a measurable parameter or the VC can return to its existing condition after the project activity ceases	**Reversible –** the residual effect is likely to be reversed after activity completion and rehabilitation **Irreversible –** the residual effect is unlikely to be reversed
Ecological and Socio-economic Context	Existing condition and trends in the area where residual effects occur	**Undisturbed –** area is relatively undisturbed or not adversely affected by human activity **Disturbed –** area has been substantially previously disturbed by human development or human development is still present

6.3.2 Significance Definition

Thresholds have been established to define significant adverse residual environmental effects on quantity and quality of groundwater. Thresholds consider the federal and provincial regulations, policies and guidelines identified in Section 6.1.1, the residual effects characterization criteria presented in Section 6.3.1, and measurable parameters listed in Section 6.3.3.

A significant adverse residual effect on the Groundwater Resources VC is defined as a measurable Project-related environmental effect that results in one of more of the following:

- Decrease in the yield from an existing and otherwise adequate groundwater supply well to the point where it is inadequate for its intended use
- Change in groundwater quality, such that the quality of groundwater from an otherwise adequate water supply well that meets applicable guidelines deteriorates to the point where it becomes non-potable or cannot meet the GCDWQ (Health Canada 2019) for a consecutive period exceeding 30 days
- Physical or chemical alteration to an aquifer to the extent that interaction with local surface water results in streamflow or surface water chemistry changes that adversely affect aquatic life or a down-stream surface water supply

6.3.3 Potential Effects, Pathways and Measurable Parameters

Table 6.2 lists the potential Project effects on groundwater resources and provides a summary of the Project effect pathways and measurable parameters and units of measurement to assess potential effects. Potential environmental effects and measurable parameters were selected based on review of recent environmental assessments for mining projects in NL and other parts of Canada, comments provided during engagement, and professional judgment.

Table 6.2 Potential Effects, Effect Pathways and Measurable Parameters for Groundwater Resources

Potential Environmental Effect	Effect Pathway	Measurable Parameter(s) and Units of Measurement
Change in groundwater quantity	• Direct loss or alteration of habitat arising from reduced baseflow to surface water features • Reduced groundwater availability for existing well users	• Reduction in baseflow (%) in surface water features supporting ecological habitat • Well yield (L/min) for existing well users in the Project Area
Change in groundwater quality	• Direct loss or alteration of habitat arising from chemistry of groundwater discharging to surface water features • Degradation of groundwater quality in potable water supplies	• Concentration of chemical parameters (various) in groundwater compared to applicable guidelines

6.3.4 Project Interactions with Groundwater Resources

Table 6.3 identifies the physical activities that might interact with the VC and result in the identified environmental effect. These interactions are indicated by checkmark and are discussed in detail in Section 6.5, in the context of effects pathways, standard and project-specific mitigation / enhancement, and residual effects. Following the table, justification is provided for where no interaction (and therefore no resulting effect) is predicted.

Table 6.3 Project-Environment Interactions with Groundwater Resources

Physical Activities	Environmental Effects to be Assessed	
	Change in Groundwater Quantity	Change in Groundwater Quality
CONSTRUCTION		
Access Road Upgrade / Realignment: Where required, road widening and replacement / upgrades of roads and culverts.	–	–
Construction related Transportation along Access Road	–	–
Mine Site Preparation and Earthworks: Clearing and cutting of vegetation and removal of organic materials, development of roads and excavation and preparation of excavation bases within the mine site, grading for infrastructure construction. For the open pits, earthworks include stripping, stockpiling of organic and overburden materials, and development of in-pit quarries to supply site development rock for infrastructure such as structural fill and road gravels. Also includes temporary surface water and groundwater management, and the presence of people and equipment on site.	✓	✓

Table 6.3 Project-Environment Interactions with Groundwater Resources

Physical Activities	Environmental Effects to be Assessed	
	Change in Groundwater Quantity	Change in Groundwater Quality
Construction / Installation of Infrastructure and Equipment: Placement of concrete foundations, and construction of buildings and infrastructure as required for the Project. Also includes: • Installation of water control structures (including earthworks) • Installation and commissioning of utilities on-site • Presence of people and equipment on-site	✓	–
Emissions, Discharges and Wastes[A]: Noise, air emissions / GHGs, water discharge, and hazardous and non-hazardous wastes.	–	–
Employment and Expenditures[B]	–	–
OPERATION		
Operation-related Transportation Along Access Road	–	–
Open Pit Mining: Blasting, excavation and haulage of rock from the open pits using conventional mining equipment.	✓	✓
Topsoil, Overburden and Rock Management: Five types of piles: • Topsoil • Overburden • Waste rock • Low-grade ore • High-grade ore Rock excavated from the open pits that will not be processed for gold will be used as engineered fill for site development, maintenance and rehabilitation, or will be deposited in waste rock piles.	✓	✓
Ore Milling and Processing: Ore extracted from the open pits will be moved to the processing area where it will either be stockpiled for future processing or crushed and milled, then processed for gold extraction via gravity, flotation and leach processes.	–	–
Tailings Management Facility: Following treating tails via cyanide destruction, tailings will be thickened and pumped to an engineered TMF in years 1 to 9, then pumped to the exhausted Leprechaun open pit in years 10 through 12.	✓	✓
Water Management (Intake, Use, Collection and Release): Recirculated process water and TMF decant water will serve as main process water supply, and raw water (for purposes requiring clean water) will be obtained from Victoria Lake Reservoir. Site contact water and process effluent will be managed on site and treated prior to discharge to the environment. Where possible, non-contact water will be diverted away from mine features and infrastructure, and site contact and process water will be recycled to the extent possible for use on site.	✓	✓

Table 6.3 Project-Environment Interactions with Groundwater Resources

Physical Activities	Environmental Effects to be Assessed	
	Change in Groundwater Quantity	Change in Groundwater Quality
Utilities, Infrastructure and Other Facilities • Accommodations camp and site buildings operation, including vehicle maintenance facilities • Explosives storage and mixing • Site road maintenance and site snow clearing • Access road maintenance and snow clearing • Power and telecom supply • Fuel supply	✓	–
Emissions, Discharges and Wastes[A]: Noise, air emissions / GHGs, water discharge, and hazardous and non-hazardous wastes.	–	–
Employment and Expenditure[B]	–	–
DECOMMISSIONING, REHABILITATION AND CLOSURE		
Decommissioning of Mine Features and Infrastructure	✓	✓
Decommissioning, Rehabilitation and Closure-related Transportation Along Access Road	–	–
Progressive Rehabilitation: Rehabilitating infrastructure or areas not required for ongoing operations (e.g., buildings, roads, laydown areas); covering and revegetating completed tailings areas, where practicable, including commencing closure of TMF beginning in Year 9 (when tailings deposition moves to Leprechaun open pit); erosion stabilization and re-vegetation of completed overburden and/or waste rock piles; infilling or flooding of exhausted mining areas; and completing revegetation studies and trials.	✓	✓
Closure Rehabilitation: Active rehabilitation based on successes of progressive rehabilitation activities. Includes: demolishing infrastructure (e.g., buildings, equipment, facilities, roads, laydown areas); grading and revegetating cleared areas, where practicable; breaching and regrading ponds to reestablish drainage patterns; completing closure of TMF (covering with overburden and revegetating); erosion stabilization and revegetation of completed overburden and/or waste rock piles; and infilling or flooding of open pits.	✓	✓
Post-Closure: Long-term monitoring	✓	✓
Emissions, Discharges and Wastes[A]	–	–
Employment and Expenditure[B]	–	–

Notes:

✓ = Potential interaction

– = No interaction

[A] Emissions, Discharges, and Wastes (e.g., air, waste, noise, light, liquid and solid effluents) are generated by many Project activities. Rather than acknowledging this by placing a checkmark against each of these activities, "Wastes and Emissions" is an additional component under each Project phase

[B] Project employment and expenditures are generated by most Project activities and components and are the main drivers of many socio-economic effects. Rather than acknowledging this by placing a checkmark against each of these activities, "Employment and Expenditures" is an additional component under each Project phase

The Project will interact with groundwater resources in the following ways:

- Potential loss of natural waterbodies as part of the Project
- Effects related to mine water management and effects on water quality from seepage
- Potential ammonia contamination from incomplete combustion of exploded materials (e.g., to groundwater via bedrock fractures)
- Dewatering of open pits during operation resulting in localized lowering of the water table, potentially reducing availability of groundwater for existing well users (if any are present) and reducing flow (and therefore habitat) in fish-bearing streams
- Sequestration of mine contact and process water within the tailings voids in the TMF during operation, filling of the open pits during closure, and evaporation from the tailings pond and eventual pit lake post-closure reducing the amount of surface water (and therefore groundwater) available for possible human consumption and ecological habitat
- Discharges of surplus water and seepage, through or beneath the TMF embankments, may affect groundwater quality if not adequately contained or treated to acceptable standards prior to entering the receiving environment

The primary Project-related effects on groundwater resources include changes to groundwater quantity through large-scale pumping and dewatering during operation of the open pits, and localized changes to groundwater quality in the vicinity of processing facilities, TMF and waste rock pile areas. Accidental releases of hazardous substances can also locally affect groundwater resources, as assessed in Accidental Events (Chapter 21).

The following activities will not interact in a substantive way with groundwater resources, and effects from these activities are not considered further in the EIS:

- The Access Road Upgrade / Realignment during construction will not substantively alter surface water flow patterns and will not interact with groundwater resources in a substantive way
- Transportation along the Access Road throughout the life of the Project will occur along defined corridors and will not interact in a substantive way with groundwater resources, except for accidental spills, which is assessed in Accidental Events (Chapter 21)
- Utilities, Infrastructure and Other Facilities (construction and operation phases) are not expected to interact with groundwater quality because there are no known sources of contamination associated with such construction and operational activities, except for accidental spills (Chapter 21)
- Employment and Expenditure (all phases) will not directly result in changes to the physical environment, including groundwater resources
- Ore Milling and Processing (operation phase) will require water and will result in mine waste. These processes are discussed under the water management activity; therefore, the ore processing activity as defined will not interact with groundwater resources
- Emissions, Discharges and Wastes (all phases) are limited to surface water discharge except in the case of an accidental spill, which are assessed separately in Accidental Events (Chapter 21)

6.3.5 Analytical Assessment Techniques

The environmental effects analysis for groundwater quantity and quality was carried out using analytical methods and tools, and includes laboratory analytical data, three-dimensional numerical groundwater flow modelling, water quality modelling, and mass balance loading calculations. The techniques are described in detail in the Hydrogeology Modelling Report (Appendix 6A) and the Water Quantity and Water Quality Modelling reports (Appendix 7A and 7B) with a summary provided below.

6.3.5.1 Assumptions and the Conservative Approach

The following assumptions were applied to the groundwater flow model and used in the assessment of change in groundwater quantity and/or flow, and identify the conservative approach used to address uncertainty in the analysis.

- The predictions of recharge rates and seepage from the TMF are based on the final (i.e., maximum) elevation of the TMF dams and tailings pond at the end of operation under steady-state conditions. This model approach imposes the highest vertical groundwater gradient from the tailings pond and results in a conservatively high prediction of seepage rates from the TMF over the operation phase of the Project.
- The predictions of recharge rates and seepage from the waste rock piles are based on the final (i.e., maximum) elevation of the waste rock piles at the end of operation under steady-state conditions, assuming an initially wet pile. This model approach results in a conservatively high prediction of seepage rates from the waste rock piles over the operation phase of the Project.

In addition to the above assumptions with respect to groundwater quantity, the following assumptions were applied in the assessment of change in groundwater quality.

- The water quality infiltrating to groundwater from beneath the waste rock piles, TMF, ore stockpiles, and overburden and topsoil stockpiles was assumed to be representative of the water quality at the predicted discharge location to the receiving environment. This approach provides a conservative estimate of groundwater quality discharging to surface water and does not consider physical or chemical attenuation processes along the groundwater flow path.
- Particle tracking was used in the groundwater flow model to provide a conservative estimate of groundwater discharge rates and travel times to surface water components based the groundwater velocity (i.e., advective flow processes). The effects of other physical flow processes, such as dispersion and diffusion, and chemical processes, such as adsorption and precipitation or dissolution, were not considered. These other processes will reduce parameter concentrations and arrival times.
- Loading predictions to downstream receptors do not consider groundwater travel times and are based on discharge rates at the end of operation and closure once the open pit is filled to its final water elevation. As a result, the loadings represent a conservative estimate under steady-state conditions during operation.

No reduction in loading due to precipitation reactions or reduction in oxidation kinetics are applied for the waste rock piles, ore stockpile and TMF beyond those estimated from the geochemical testing program and field data. Based on geochemical testing it has been demonstrated that loading rates will decline over time. As a result, by not including further decreases in loading rates, long-term water quality predictions and loading to the environment are overestimated and provides a conservative approach for the assessment.

6.3.5.2 Groundwater Modelling

The MODFLOW-NWT numerical groundwater flow code was used to simulate steady-state groundwater flow under baseline, operation and closure / post-closure scenarios. The groundwater flow model consists of 15 layers including: the TMF / waste rock pile (layers 1 to 2), overburden (layers 3 to 4), upper bedrock (layer 5), intermediate bedrock (layers 6 to 10), and deep bedrock (layers 11 to 15). The model grid is oriented 44°, with the long axis of the grid roughly parallel to the thrust fault that passes through the pits. The grid spacing is generally 250 × 250 m, with refinement to 25 × 25 m in the vicinity of Project components, as shown in Appendix 6A. The model boundaries generally correspond to subwatershed boundaries that are assumed to be no-flow boundaries, or surface water boundaries (e.g., Victoria Lake Reservoir and Valentine Lake), which are set at head-dependent flow boundaries. The upper boundary of the model is defined by the ground surface topography from the digital elevation model and the bottom boundary is set to follow topography, with a minimum depth of 150 m below the base of the open pits to the base of the groundwater model.

Calibration of the model was achieved by adjusting hydraulic conductivity, recharge, vertical anisotropy, and stream bed and lakebed leakage. The calibration process involved varying model parameters using PEST (Doherty 2009) until an acceptable match to water levels and baseflow targets was obtained. The model is calibrated to be within acceptable industry standards, and the model parameters fall within the observed ranges of hydraulic conductivity and estimated recharge rates. Details of the model development and calibration are presented in the Hydrogeology Modelling Report (Appendix 6A).

The three-dimensional finite difference groundwater flow model was developed to assist in the evaluation of potential effects of the Project on groundwater resources. The model provides quantitative predictions about changes in groundwater levels and flow during the operation, and closure / post-closure phases and the resulting changes in groundwater discharge for the following:

- Operation
  - Dewatering rates from staged development of the open pit, and associated changes to groundwater levels and baseflow to surrounding water features
  - Groundwater recharge originating from the waste rock piles and TMF during operation
  - Collection of groundwater in the subsurface seepage and contact water collection systems to be installed around site infrastructure
- Closure / Post-closure
  - Groundwater inflow rates to the open pit at progressive stages during filling with water to form a pit lake
  - Interactions of the pit lake at the final lake level with groundwater levels and baseflow to surrounding water features
  - Groundwater recharge originating from closure and rehabilitation of the waste rock piles and TMF, including the perimeter seepage collection ditches

Water quantity and water quality models were built using GoldSim™, coupling water quantity and mass transfer of selected parameters from different Project components for the Marathon Complex, and the Process Plant and TMF, and Leprechaun complexes. The results of the model are used to predict the water quality and recharge associated with the waste rock piles, ore stockpiles and TMF during construction, operation and closure (Water Quantity and Water Quality Model reports; Appendix 7B). The water quality source terms predicted from the Water Quantity and Water Quality Model reports were derived from the metal leaching and acid rock drainage assessment conducted at the site. The testing is summarized in Section 6.3.5.3.

The predicted water quality is then used, together with the groundwater discharge rates determined with the groundwater flow model, to estimate potential effects of Project activities on groundwater quality and loading to surface water receivers.

6.3.5.3 Acid Rock Drainage and Metal Leaching

An assessment of the potential for acid rock drainage and metal leaching (ARD/ML) was completed for the waste rock, ore, and tailings at the site (BSA.5, Attachments 5-A and 5-B). The assessment generally followed the methods outlined in the *Prediction Manual for Characterizing Drainage Chemistry from Sulphidic Geologic Materials* (Price 2009). This assessment of baseline geochemistry included:

- Static testing of approximately 350 samples of waste rock, ore, overburden and tailings for Acid-Base Accounting (ABA), Shake Flask Extraction, and total metals
- Characterization of composite samples using the static tests and a mineralogical method
- Kinetic testing of composite samples including 14 humidity cells, two ageing tests and two sub-aqueous columns tests

Acid Potential (AP) was calculated from sulphide sulphur hosted in pyrite and marcasite. Neutralization Potential (NP) was calculated from total inorganic carbon considering that calcite and dolomite are dominant acid neutralization minerals in the deposits. ARD classification is based on a Neutralization Potential Ratio (NPR=NP/AP) of samples compared to generic thresholds proposed by Price (2009). A sample is conservatively classified as Potentially Acid Generating (PAG) if NPR is below 2; otherwise, the sample is classified as non-PAG.

Metal leaching potentials were evaluated by comparing the concentrations of trace elements in the leachates from shake flask extraction and kinetic tests to the effluent quality limits prescribed in the MDMER and to the *Canadian Water Quality Guidelines for the Protection of Freshwater Aquatic Life* (CWQG-FAL). Concentrations exceeding MDMER and/or ten times the CWQG-FAL in kinetic tests indicate parameters with high leaching potential, while concentrations between the CWQG-FAL and ten times the CWQG-FAL value were arbitrarily assigned to moderate leaching potential.

The findings of this assessment are summarized below for each source of mine material. However, investigations of ARD/ML will continue, and will include field kinetic and laboratory kinetic testing, and additional sampling to develop an ARD block model.

Leprechaun Complex

Approximately 1.9 million cubic metres (Mm^3) of overburden will be excavated from the Leprechaun open pit. Overburden is classified as non-PAG material with moderate leaching potential for aluminum, iron, lead, and zinc, and no exceedances of the MDMER limits.

Less than 0.5% of the approximately 50 Mm^3 of Leprechaun waste rock is classified as PAG. Overall, the waste rock pile is not expected to generate ARD due to the small amount of PAG material and significant excess of NP. Therefore, it is not anticipated that specific ARD management of waste rock will be required.

There are no exceedances of MDMER limits observed in humidity cell leachates. The waste rock pile will be covered during rehabilitation reducing the already low risk of ARD/ML. Waste rock lithologies show moderate ML potential for aluminum, phosphorous, copper, selenium, and zinc.

About 10% of low-grade ore is estimated to be PAG, and overall is not expected to generate ARD. Kinetic testing suggests moderate leaching potential for aluminum and phosphorous. There are no exceedances of MDMER limits observed in these tests.

Marathon Complex

Approximately 4.4 Mm^3 of overburden will be generated from the Marathon open pit. Overburden is classified as non-PAG material, with moderate leaching potential for fluoride, aluminum, arsenic, cadmium, copper, iron, manganese, lead, selenium, and zinc based on shake flask extracts. There are no exceedances of MDMER limits observed in leachates from overburden. Most of the stockpiled overburden will be used during mine rehabilitation.

Approximately 14% of the 60 Mm^3 of waste rock is conservatively estimated to be PAG. Blending PAG and non-PAG rock with excess of neutralization potential and/or encapsulation of PAG waste by non-PAG rock will be conducted to neutralize acidity potentially generated in PAG pockets and as a result, the final drainage from waste rock is not expected to be acidic. The waste rock pile will be covered by growth medium / overburden during rehabilitation, further reducing the risk of ARD/ML. There are no exceedances of MDMER limits observed in leachates from the waste rock humidity cells. Overall, waste rock lithologies show moderate ML potential for aluminum, mercury, selenium, and zinc.

Approximately one-half of the low-grade ore is conservatively classified as PAG. The ARD onset time in PAG pockets of low-grade ore is approximately six years based on the highest laboratory leaching rates. The Marathon low-grade ore stockpile effluent has been segregated from other mine component flow streams in the overall mine design to facilitate collection and further ARD treatment, if required. There are no exceedances of MDMER limits observed in leachates from low-grade ore under neutral conditions. Based on kinetic testing, aluminum, phosphorous, and zinc have moderate leaching potential.

Processing Plant and Tailings Management Facility Complex

High-grade ore from the Leprechaun and Marathon deposits will be stockpiled together with 30% of the material originating from Leprechaun and the reminder from Marathon, on average. Approximately 13%

and 67% of ore samples from Leprechaun and Marathon pits, respectively are conservatively classified as PAG. The overall mixture of Leprechaun and Marathon high-grade ores is non-PAG and the high-grade ore stockpile is not expected to generate ARD. Drainage from the high-grade ore stockpile flows to the TMF by gravity and any potential acidity will be neutralized in the decant pond or in the mill during pH adjustment required as a part of the gold recovery by cyanide process. No exceedances of MDMER are observed in shake flask extracts. Moderate aluminum leaching was assigned for both Leprechaun and Marathon high-grade ores.

Approximately 41 Mt of tailings will be produced from both high-grade ore and low-grade ore with about 38% of the material originating from the Leprechaun pit and the remainder from the Marathon pit.

Composite samples of tailings from both deposits are classified as non-PAG and are not expected to generate ARD. During operation, tailings pond and pore water will likely exceed the MDMER limits for total cyanide, unionized ammonia, and copper sourced from process water. In addition, high leaching potential is also determined for total ammonia, weak acid dissociable cyanide (surrogate for free cyanide), fluoride, mercury, phosphorous, and iron. After closure, covered tailings beaches are not expected to produce acidic runoff and/or have high or moderate leaching except for phosphorous. Seepage from the TMF is conservatively predicted to exceed MDMER limits for total cyanide, unionized ammonia, and copper in the post-closure portion of the decommissioning, rehabilitation and closure phase, and further testing will be carried out to confirm this condition.

6.3.5.4 Groundwater Mass Loadings

The ARD/ML assessment summarized in Section 6.3.5.3 were scaled from laboratory tests to the full-sized features in the site by applying scale-up factors, as described in the Water Quantity and Water Quality Model reports (Appendix 7A and 7B). The scale up factors incorporated several assumptions that overestimate the mass loading terms from the laboratory testing. Groundwater mass loadings were calculated based on the geochemical source terms for the ore stockpiles, waste rock piles, and TMF seepage that leaves through the base of these facilities (i.e., basal seepage). The seepage rates are characterized by the groundwater flow model described in section 6.3.5.2.

6.4 MITIGATION AND MANAGEMENT MEASURES

A series of environmental management plans will be developed by Marathon to mitigate the effects of Project development on the environment. A full list of mitigation measures to be applied throughout Project construction, operation and decommissioning, rehabilitation and closure is provided in Section 2.7.4. Project planning and design and the application of proven mitigation measures will be used to reduce or avoid adverse effects of the Project on groundwater resources, as outlined in Table 6.4.

Table 6.4 Mitigation Measures: Groundwater Resources

Category	Mitigation	C	O	D
Site Clearing, Site Preparation and Erosion and Sediment Control	• Project footprint and disturbed areas will be limited to the extent practicable.	✓	-	-
Soil Management	• Sediment control fences will be installed in areas where topsoil is exposed to erosion and siltation, such as slopes and embankments and approaches to stream crossings or water bodies. Sediment control fences will be inspected and maintained over the course of the construction phase until the disturbed area has stabilized and natural revegetation has occurred. Non-biodegradable materials used for Sediment control fences will be removed following revegetation.	✓	✓	✓
Site Water Management	• Marathon will implement a Water Management Plan (Appendix 2A) for the site which will incorporate standard management practices, including drainage control, excavation and open pit dewatering which collectively comprise the water management infrastructure currently designed as part of the Project scope (Section 2.3.5). The Water Management Plan provides detail on runoff and seepage collection strategies and systems (e.g., local seepage collection ponds, berms, drainage ditches, pumps) to collect and contain surface water runoff and groundwater discharge from major Project components (open pit, waste rock piles, TMF, ore stockpile and overburden storage areas, process plant) during climate normal and extreme weather conditions.	✓	✓	✓
	• Standard construction methods, such as seepage cutoff collars, will be used where trenches extend below the water table to mitigate preferential flow paths.	✓	-	-
	• Contact water collection ditches will be installed around the overburden stockpiles, ore stockpiles and waste rock piles to collect toe seepage. Contact water collection ditches will be designed to convey the 1:100-year storm event, and with positive gradients to limit standing water and maintain positive flow.	✓	✓	✓
	• Groundwater quality and quantity will be monitored and adaptively managed, if required, using a network of groundwater monitoring wells to document Project effects on groundwater flow and quality. Monitoring locations will be maintained until the water levels and water quality have stabilized post-closure.	✓	✓	✓
Tailings Management	• Shallow groundwater seepage from the TMF will be intercepted by seepage collection ditches and pumped back to the TMF via sump pumps.	✓	✓	✓
	• Cyanide detoxification within the mill using the sulphur dioxide / air oxidation process will result in the degradation of cyanide and precipitation of metals prior to discharge to the TMF.	-	✓	-
Rehabilitation and Closure	• Progressive rehabilitation (e.g., placement of soil cover and vegetation over waste rock piles, erosion stabilization and temporary vegetation of completed organics, topsoil, and overburden stockpiles) will be implemented.	-	✓	✓
	• Open pit filling will be accelerated at closure, which will return groundwater levels to baseline conditions in a shorter timeframe.	-	-	✓
Notes: C – Construction Activities; O – Operation Activities; D – Decommissioning, Rehabilitation and Closure Activities				

6.5 ASSESSMENT OF ENVIRONMENTAL EFFECTS ON GROUNDWATER

For each potential effect identified in Section 6.3.3, specific Project activities that may interact with the VC and result in an environmental effect (i.e., a measurable change that may affect the VC) are identified and described. The following sections first describe the pathways by which a potential Project effect could result from Project activities in the absence of mitigation during each Project phase (i.e., construction, operation and decommissioning, rehabilitation and closure). Mitigation and management measures (Section 6.4) are applied to avoid or reduce these potential pathways and resulting environmental effects. Residual effects are those remaining following implementation of mitigation, which are then characterized using the criteria defined in Section 6.3.1. A summary of predicted residual effects is provided in Section 6.5.3.

6.5.1 Change in Groundwater Quantity

6.5.1.1 Project Pathways

Groundwater quantity effects can include potential lowering of local water levels, with consequent reduction in water levels in water supply wells drilled for the Project, reduction in domestic well yield in proximity to Project activities, and reduction in local streamflow. A related concern is the potential for diversion of surface water toward the open pits in the event that intervening permeable overburden or bedrock structures are encountered, with consequent increase in dewatering requirements, and possible reduction in streamflow during the summer period.

Construction

As indicated in Table 6.3, Project activities during construction that could affect groundwater quantity include mine site preparation and earthworks, and construction / installation of infrastructure and equipment. Stripping and initial development of the open pits during the construction phase is anticipated to result in the greatest degree of local groundwater disruption. Groundwater flow patterns may be altered by dewatering for the initial pit development and construction of the TMF and other site infrastructure. The resulting change in groundwater flow patterns and recharge rates may affect groundwater discharge to surface water features and wetlands. Potential effects to surface water features and wetlands from the lowering of groundwater levels and changes to baseflow are further assessed in Chapters 7 (Surface Water Resources) and 9 (Vegetation, Wetlands, Terrain and Soils), respectively.

The open pit mine areas will be isolated from overland drainage and shallow groundwater seepage through the overburden with trenches / ditches, sedimentation ponds and other water management measures. During the pre-stripping activities, particular care will be taken so that water collected within the open pits is pumped into settling basins, which will be built in advance of the construction work for the open pit mine areas. These basins (sedimentation ponds) will also be used during operation to receive water pumped from the open pits to allow for settling of suspended solids prior to discharge to the environment. A portion of this collected water will also be used for dust suppression, as required and where practicable. As mine development progresses, the degree of groundwater table decline within several hundred meters of the open pits will gradually increase in both overburden and bedrock; this effect is characterized for the operation phase below.

Operation

Similar to the construction phase, the main potential effect to groundwater quantity during mine operation is the potential dewatering of the overburden and bedrock aquifer surrounding the open pits. Groundwater quantity is also expected to be affected through reduced recharge in the vicinity of the waste rock piles and TMF. In the absence of identified domestic well users, surface water is the primary receptor of dewatering during operation.

The Project is not anticipated to interact with the nearest reported residential groundwater supplies in the vicinity of Buchans and Millertown. Given the distance between the Project and these well users, as the intervening lakes and watershed divides would act as hydraulic barriers.

Decommissioning, Rehabilitation and Closure

The main potential effects to groundwater quantity during decommissioning, rehabilitation and closure include rising groundwater levels immediately upon cessation of open pit mine dewatering as the open pits begin to flood with rainwater, runoff and groundwater seepage. During this period, the local groundwater movement would continue to be toward the open pits; however, as the water levels rise in the open pits, the degree of distant drawdown will gradually recover to near pre-mining levels.

Closure of water management infrastructure will result in the removal of contact water collection systems that may result in groundwater originating from the waste rock piles and TMF discharging to the natural environment. These changes will continue beyond the decommissioning, rehabilitation and closure phase and will reach a steady-state condition once the open pits are filled.

During progressive and closure rehabilitation, the removal and/or rehabilitation of the ore stockpiles, rehabilitation of the waste rock piles and TMF, and lowering of the water level in the tailings pond can change groundwater recharge rates (e.g., through re-vegetation). These changes will affect groundwater flow patterns and discharge to surface water features and wetlands. Potential effects to surface water features and wetlands are further assessed in Chapters 7 (Surface Water Resources) and 9 (Vegetation, Wetlands, Terrain and Soils), respectively.

During post-closure monitoring, interaction with groundwater quantity will be limited to monitoring of groundwater levels.

6.5.1.2 Residual Effects

Construction

During construction, the Project activities and components that might interact with groundwater quantity and result in an environmental effect (Table 6.3) include mine site preparation and earthworks, and construction / installation of infrastructure and equipment. These activities may interact through the temporary dewatering required for excavation of foundations and the installation of infrastructure.

Local changes in infiltration rates through compaction of ground surfaces or construction of infrastructure, such as buildings and overburden and topsoil storage areas, may result in reduced infiltration within the Project Area. Stripping of topsoil and removal of vegetation in the Project Area, specifically in the areas of the open pits, overburden stockpile, ore stockpiles, waste rock piles and TMF, will result in changes in evapotranspiration rates and runoff and may result in decreased infiltration rates where impervious surfaces remain, or increased infiltration rates where vegetation is removed. These changes are considered to have a limited effect on groundwater resources due to their limited extent of development (footprint) during construction.

Construction earthworks may encounter groundwater and require water management (i.e., localized dewatering to maintain dry working conditions and/or contact water collection). This could result in limited local changes to groundwater flow direction, and/or lowering of groundwater levels and a potential decrease in discharge to surface water features. With implementation of the construction mitigation measures presented in Section 6.4, these effects are expected to be low in magnitude. The temporary pumping for dewatering will be short-term and on an as-needed basis, and may be required for minor supporting infrastructure for equipment storage and maintenance, and preparation of foundations for the overburden stockpiles, ore stockpiles, waste rock piles and TMF.

With the implementation of the mitigation measures presented in Section 6.4 (e.g., limiting construction footprint, use of standard management practices including drainage control and excavation) changes to groundwater quantity and flow due to temporary construction dewatering are characterized as adverse, continuous, short-term (i.e., limited to the construction phase and on an as-needed basis), reversible, and confined to the Project Area. The magnitude is expected to be low, given that excavations for typical foundations is expected to be less than 1 m below ground surface. Timing (i.e., natural seasonal variations in precipitation) may affect dewatering rates, particularly during the spring when higher groundwater levels are expected; however, these variations would not be considered to be a Project-related effect. The ecological context within which effects to groundwater quantity would occur in the LAA/RAA is considered undisturbed as defined in Table 6.1.

Operation

During operation, the Project activities and components that might interact with groundwater quantity and result in an environmental effect (Table 6.3) include open pit mining, management of topsoil, overburden and waste rock, operation of the TMF, water management, and operation of utilities, infrastructure and other facilities. The primary Project effect on groundwater quantity and/or flow during operation is the lowering of water levels through continued dewatering of the open pits and the raising (or mounding) of the water table through operation of the waste rock piles and TMF.

Results of the groundwater flow modelling indicate that as dewatering progresses with development of the open pits, the average annual groundwater inflow rate to the open pits will increase, with a maximum rate of 1,350 m^3/d at the Leprechaun pit, and 1,846 m^3/d at the Marathon pit at the end of the operation phase. The change in water table elevation due to dewatering (e.g., drawdown) of the open pits at the end of mining in comparison to existing conditions is shown on Figure 6-6. Dewatering of the open pits is predicted to lower the water table by up to 1 m over an area extending up to 1.6 km from the Leprechaun pit and up to 1.3 km from the Marathon pit. The drawdown areas are extended to the north in the vicinity of the Leprechaun pit, and to the south in the vicinity of the Marathon pit. The induced infiltration of surface water to the shallow overburden and bedrock limits the extent of the drawdown. Increased infiltration in the waste rock piles results in some mounding within the waste rock piles, which also limits the drawdown in the direction of the waste rock piles.

Figure 6-6 also presents the predicted zone of influence of the TMF and waste rock piles on groundwater levels compared to existing conditions. As identified by the -1 m drawdown contour, mounding of the water table within the area of the TMF is predicted to extend up to 475 m north of the limits of the TMF, and is contained within the limits of the Leprechaun and Marathon waste rock piles. Drawdown due to the operation of the seepage collection ditches around the perimeter of the TMF and waste rock piles are predicted to lower the water table up to 1 m in the immediate vicinity of the collection ditches only.

Based on a review of the NL Water Well Database (NLDMAE 2020), as discussed in Section 6.2.2.6 there are no known groundwater well users located within the LAA/RAA. Therefore, no water supply wells or groundwater withdrawals that supply potable water are present within the extent of drawdown of the open pits (Figure 6-6). As a result, no adverse environmental effects to groundwater quantity and/or flow are predicted from the Project on existing water supply wells.

Groundwater drawdowns of up to 1 m are predicted to occur beneath wetlands located north of the Leprechaun pit, and south of the Marathon pit (Figure 6-6) from the effects of the pits and contact water collection ditches. A discussion of the effects of lowering the water table on wetlands is provided in the Vegetation, Wetlands, Terrain and Soils VC (Chapter 9).

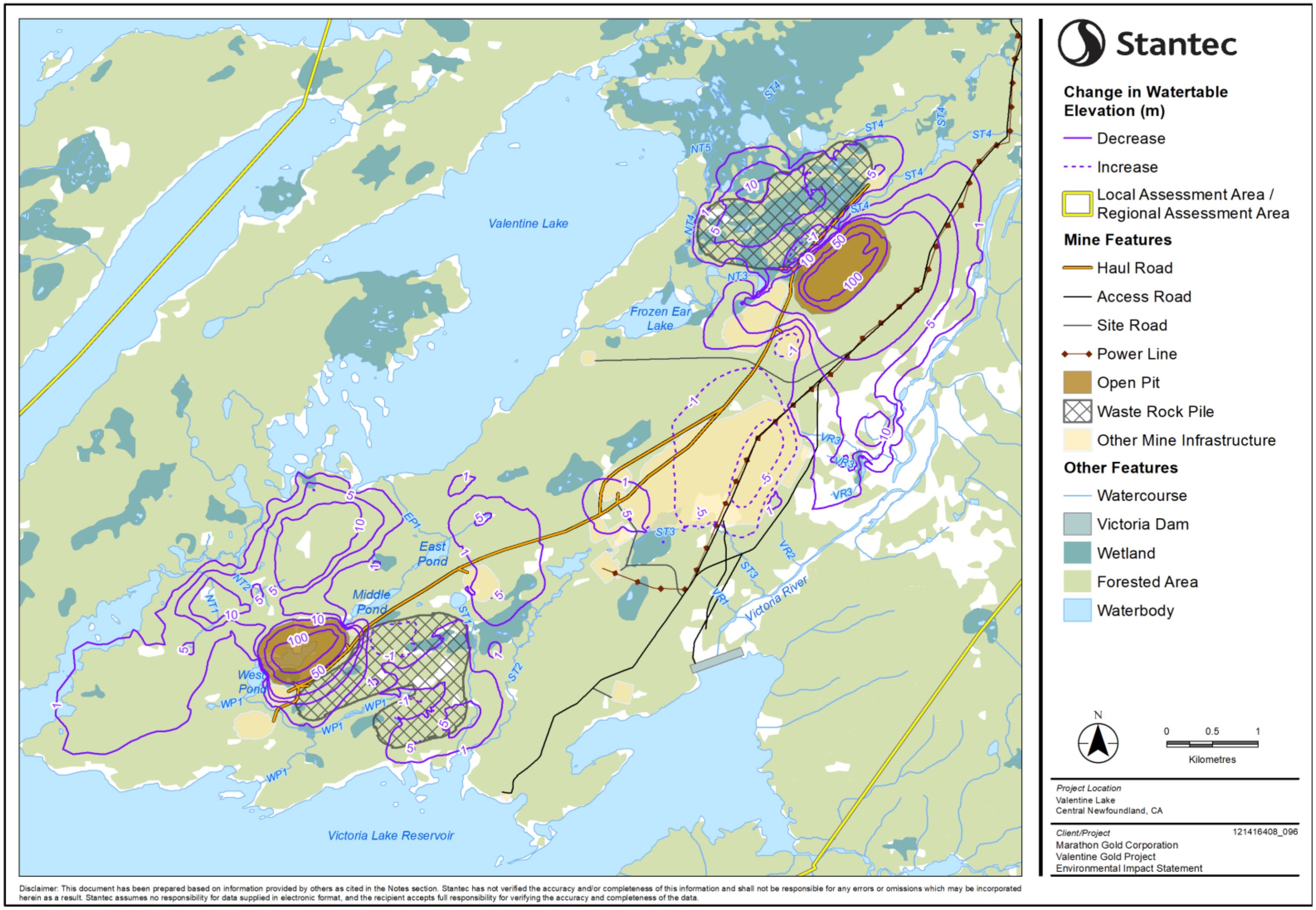

Figure 6-6 Change in Water Table Elevation at End of Project Operation

The effects of the open pits at their full extent, the waste rock piles and the TMF on the groundwater discharge to surface water features are assessed by comparing the predicted operation and baseline discharge rates presented in Table 6.5.

Table 6.5 Estimated Groundwater Discharge to Water Features near the Project Infrastructure under Baseline and Operational Conditions

Surface Water Feature	Baseline (m^3/d)	Operation (m^3/d)
Unnamed Tributary to Victoria Lake Reservoir NT1	332.6	623.7
Unnamed Tributary to Victoria Lake Reservoir NT2	61.2	768.6
Frozen Ear Lake and Tributaries NT3	2874.2	2349.8
Unnamed Tributary to Valentine Lake NT4	357.4	13
Unnamed Tributary to Valentine Lake NT5	408.4	367.6
Middle and East Pond and Tributaries EP1	919.9	547.4
West Pond and Tributaries WP1	2167.9	751.6
Unnamed Tributary to Victoria Lake Reservoir ST1	782.5	614.9
Unnamed Tributary to Victoria Lake Reservoir ST2	2872.6	2469.3
Unnamed Tributary to Victoria River ST3	1306.4	208.1
Unnamed Tributary to Victoria River ST4	5201.6	3113.4
Unnamed Tributary to Victoria River VR1	0.002	206.4
Unnamed Tributary to Victoria River VR2	0.2	387
Unnamed Tributary to Victoria River VR3	153.5	962.3
Unnamed Tributary to Victoria River VR4	12	1947.4

The direction of groundwater discharge to each surface water feature from baseline conditions to end of operation remains consistent with water features receiving groundwater. The rate of groundwater discharge is generally decreased for water features closest to the open pits, particularly for West Pond and tributaries, and Middle and East Ponds and tributaries, due to the removal of a portion of the ponds where they are overprinted by the Leprechaun pit. Similarly, the flows in the unnamed tributary to Victoria River (ST4) are also decreased due to the overprinting of a portion of the watercourse by the Marathon pit. Several small first or second-order watercourses (NT1, NT2, ST3) are predicted to not receive any groundwater inflows during operation either due to dewatering of the open pits, or to the interception of baseflow by ditches that collect seepage from the waste rock piles, stockpiles or the TMF. The main channel of the Victoria River is predicted to receive slightly more groundwater inflow during operation due to the increased seepage predicted from the TMF. The effect of changes in groundwater discharge on surface water levels and flow are generally offset by flows from seepage collection ditches. The effects of changes in predicted surface water flows are evaluated in the Surface Water Resources VC (Chapter 7).

The lowering of water levels through continued dewatering of the open pits, and the continued development of the waste rock piles and stockpiles and operation of the TMF (including seepage collection ditches) through the operational phase of the Project will result in a change in groundwater quantity and flow in the LAA. This change is characterized as adverse, long-term, continuous and irreversible, as the water levels are not expected to return to baseline levels during closure. The change will be confined to the LAA/RAA. The predicted change in groundwater level is less than 5 m in the Project Area and 1 m in the LAA/RAA; therefore, the magnitude is considered low to moderate. While the magnitude will be reduced during closure as the open pits fill to form pit lakes, some local drawdown will remain in the vicinity of the open pits as discussed below. Natural seasonal variations in precipitation may affect dewatering rates, particularly during spring when higher groundwater levels are expected; however, these variations would not be considered a Project-related effect. The ecological context within which effects to groundwater quantity would occur in the LAA/RAA is considered undisturbed as defined in Table 6.1.

Decommissioning, Rehabilitation and Closure

Following completion of the operation phase, dewatering of the open pits will cease and water levels will begin to rise within the open pits until an overflow elevation is reached. The water level will rise to a maximum water elevation of approximately 377 m above mean sea level (amsl) at Leprechaun pit, and approximately 330 m amsl at Marathon pit, and will represent the local water table elevation at closure.

The simulated drawdown (relative to baseline conditions) after the pits have filled to their expected overflow levels (i.e., the minimum pit edge elevation) are presented on Figure 6-7. As shown, at the end of closure the water table is predicted to return to near baseline conditions except in the northwest corner of the Leprechaun pit. The northwest corner of the Leprechuan pit is expected to have an exposed rock wall approximately 30 m above the overflow elevation and will result in a permanently lowered water table elevation at this location following closure. This also has the effect of lowering the water table at the base of the cliff downgradient of the Leprechaun pit.

The mounding of the water table beneath the TMF and waste rock piles is limited by the seepage collection ditches around the perimeter of these features and nearby surface water features. Mounding of the water table is generally confined to the footprint of the TMF and waste rock piles. Drawdown due to the presence of the seepage collection ditches around the perimeter of the TMF, waste rock piles and ore stockpiles is predicted in the direct vicinity of the collection ditches. The drawdown shown on Figure 6-7 assumes that the seepage collection ditches have been decommissioned. Without the seepage collection ditches, the mounding of the water table extends to the surface water features around the base of the TMF. A discussion of the effects of the change in water table on wetlands is provided in Chapter 9 (Vegetation, Wetlands, Terrain and Soils).

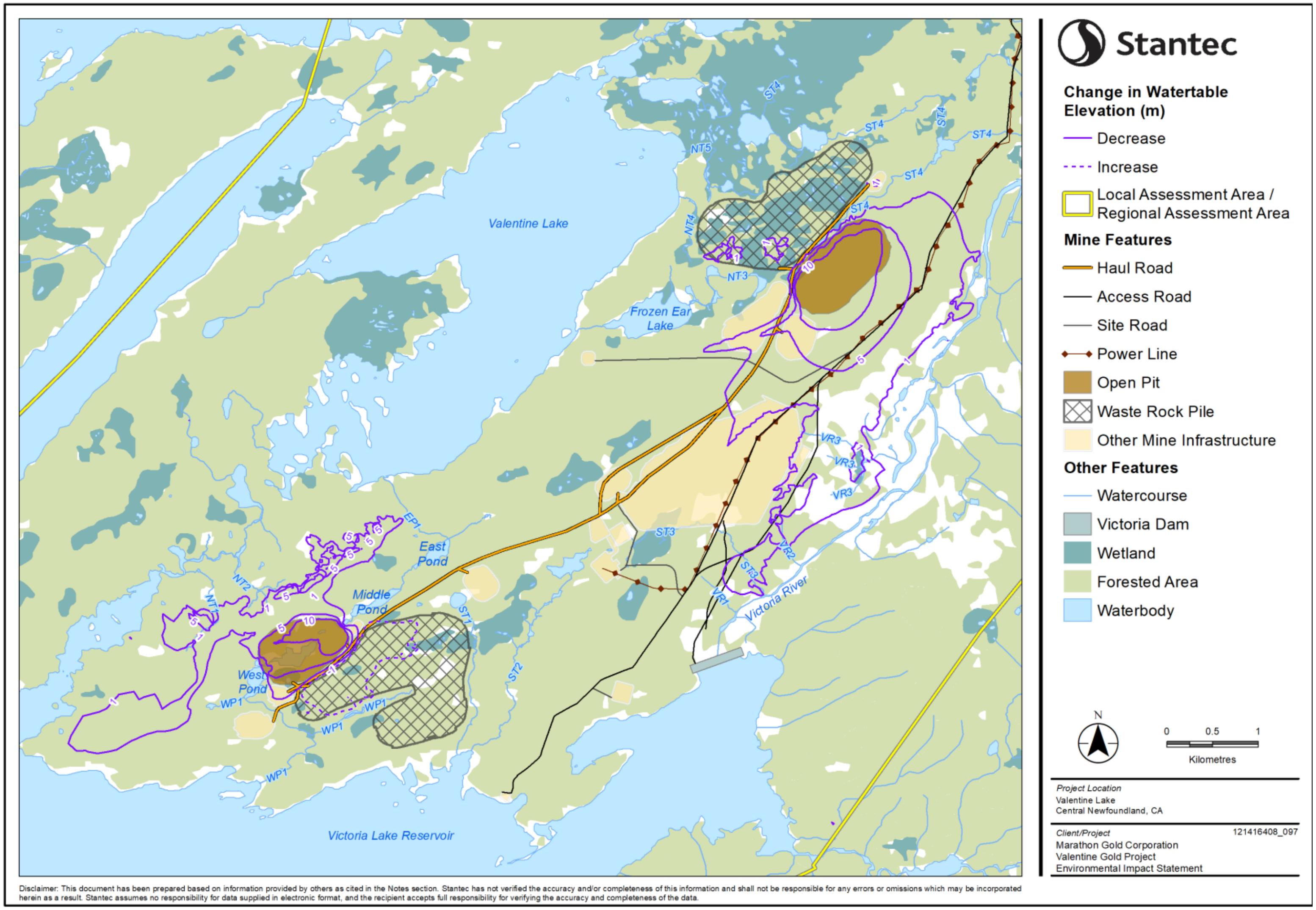

Figure 6-7 Change in Water Table Elevation Following Closure

Table 6.6 presents the comparison of baseline groundwater discharge rates to those at closure of the TMF and waste rock piles on the baseflow of watercourses and lakes at closure (i.e., after the pit lake is full). The operation and closure of the seepage collection ditches around the perimeter of the TMF and waste rock piles were simulated in the model because the seepage collection ditches will not be decommissioned until the water quality meets applicable regulatory discharge criteria. The seepage collection ditches are predicted to collect groundwater during closure and will have relatively minor changes to baseflows at water features compared to the operation simulation. The predicted effects of the removal of the ditches on baseflow rates are shown on Table 6.6, and result in flow rates in nearby water features that are similar to baseline conditions.

Table 6.6 Estimated Groundwater Discharge to Water Features under Baseline and Post-Closure Portion of Closure Phase (i.e., Pit-Full) Conditions (m^3/d)

Surface Water Feature	Baseline	End of Post-Closure (with ditches)	End of Post-Closure (without ditches)
Unnamed Tributary to Victoria Lake Reservoir NT1	332.6	625.8	623.8
Unnamed Tributary to Victoria Lake Reservoir NT2	61.2	769.5	769.5
Frozen Ear Lake and Tributaries NT3	2874.2	2330.4	2481.1
Unnamed Tributary to Valentine Lake NT4	357.4	173	327.1
Unnamed Tributary to Valentine Lake NT5	408.4	367.7	548.6
Middle and East Pond and Tributaries EP1	919.9	560.7	565.8
West Pond and Tributaries WP1	2167.9	953.5	1197
Unnamed Tributary to Victoria Lake Reservoir ST1	782.5	616.6	972.5
Unnamed Tributary to Victoria Lake Reservoir ST2	2872.6	2468.7	2525.8
Unnamed Tributary to Victoria River ST3	1306.4	139.5	852.6
Unnamed Tributary to Victoria River ST4	5201.6	3355	3691.9
Unnamed Tributary to Victoria River VR1	0.002	206.2	206.3
Unnamed Tributary to Victoria River VR2	0.2	348.7	361.4
Unnamed Tributary to Victoria River VR3	153.5	879.4	627.9
Unnamed Tributary to Victoria River VR4	12	2043.1	2050.4

The groundwater flow to the receptors are predicted to return to near baseline rates once the pits are full, except for Middle and East Pond and tributaries (EP1), West Pond and tributaries (WP1), and the unnamed tributary to Victoria River (ST4). These features are overprinted by open pit areas, permanently reducing the footprint of these streams. The predicted changes to the groundwater flow rates are relatively small compared to the overall anticipated flow rates in the surface water features. The presence of the TMF is predicted to change the baseflow to tributaries to Victoria River downgradient of the TMF. The larger unnamed tributary ST3 will recover some of the baseflow lost during operation once the drainage ditches around the TMF are removed. Several smaller tributaries, VR1, VR2, VR3 and VR4, are all expected to receive higher baseflow starting in operation due to the presence of the TMF, and these effects continue throughout closure. The effects of changes of groundwater discharge on surface water levels and flow are evaluated in the Surface Water Resources VC (Chapter 7).

The changes in groundwater levels during closure are characterized as adverse, long-term, continuous, irreversible, and confined to the LAA/RAA. The magnitude will be low in the LAA/RAA, as the change in groundwater level is predicted to be less than 1 m. Natural seasonal variations may affect water levels, particularly during spring when higher groundwater levels are expected, however, this is not considered a Project-related effect. The ecological context within which effects to groundwater quantity would occur in the LAA/RAA is considered undisturbed as defined in Table 6.1.

6.5.2 Change in Groundwater Quality

6.5.2.1 Project Pathways

Groundwater quality effects can include changes in groundwater chemistry near site infrastructure and may adversely affect groundwater quality in wells should they be located in proximity to Project activities, and contaminated discharge to local surface water.

Construction

As indicated in Table 6.3, Project activities during construction that could affect groundwater quality are mine site preparation and earthworks. Groundwater quality effects can include changes in groundwater chemistry from infiltrating water in exposed areas of overburden removal.

Operation

The main potential effect to groundwater quality during mine operation is the potential release of contaminated seepage from the waste rock piles and TMF. Seepage from the waste rock piles and TMF will migrate through overburden and shallow bedrock toward discharge points at the closest streams, lakes or wetlands. Based on the topography and drainage characteristics of the Project site, groundwater transport pathways from a source to a receptor stream or lake are likely to be short (i.e., less than a few hundred metres). In the absence of identified well users, surface water would be the primary receptor of contaminated seepages from the TMF or waste rock piles.

The Project is not anticipated to interact with the nearest reported residential groundwater supplies in the vicinity of Buchans and Millertown due to the distance between the Project and these well users. In addition, the intervening lakes and watershed divides would act as hydraulic barriers.

Decommissioning, Rehabilitation and Closure

The main potential effect to groundwater quality during decommissioning, rehabilitation and closure is the continued seepage from the waste rock piles and TMF through overburden and bedrock. Revegetation of the waste rock piles and TMF during progressive and closure rehabilitation will reduce seepage from operational levels. A short distance of travel is expected, with seepage ultimately discharging to adjacent surface water features and wetlands, which are further assessed in the Surface Water Resources VC (Chapter 7) and Vegetation, Wetlands, Terrain and Soils VC (Chapter 9), respectively.

During post-closure monitoring, interaction with groundwater quality will be limited to monitoring of groundwater chemistry.

6.5.2.2 Project Residual Effect

Construction

Groundwater quality effects can include changes in groundwater chemistry from infiltrating water in exposed areas of overburden removal. The short duration of the construction period is not anticipated to result in ARD/ML issues; therefore, groundwater quality effects are not anticipated during construction, with eventual changes to water quality, if any, observed during operation.

The residual effects on groundwater quality during construction are characterized as neutral, as groundwater quality is not anticipated to be changed. As there are no residual effects of construction on groundwater quality, no additional characterization is required.

Operation

During operation, the Project activities and components that might interact with groundwater quality and result in adverse environmental effects (Table 6.3) include open pit mining, management of topsoil, overburden and waste rock, TMF operation, and water management.

During operation, the waste rock piles, ore stockpiles and the TMF have the potential to affect groundwater quality. Table 6.7 provides a summary of mean concentrations predicted for groundwater recharge originating from these sources at the end of operation. The waste rock piles and ores stockpiles are conservatively assumed to be saturated at the start of operation, where the volume of water infiltrating into the waste rock piles, ore stockpiles and the TMF from precipitation will result in an equal amount of seepage or recharge out the base of the stockpiles.

Table 6.7 Predicted Water Quality from Source Areas during Operation

Parameter	Units	Leprechaun Waste Rock Pile	Leprechaun Low-Grade Ore Stockpile	Tailings Management Facility	Marathon Waste Rock Pile	Marathon Low-Grade Ore Stockpile
Aluminum	µg/L	600	600	570	600	600
Antimony	µg/L	32	23	17	36	21
Arsenic	µg/L	27	11	17	25.0	13.0
Barium	µg/L	350	47	48	120	66
Boron	µg/L	120	200	180	130	230
Cadmium	µg/L	0.11	0.12	0.09	0.21	0.18
Calcium	µg/L	220,000	120,000	180,000	300,000	150,000
Chromium	µg/L	8.5	4.2	2.6	8.3	3.5

Table 6.7 Predicted Water Quality from Source Areas during Operation

Parameter	Units	Leprechaun Waste Rock Pile	Leprechaun Low-Grade Ore Stockpile	Tailings Management Facility	Marathon Waste Rock Pile	Marathon Low-Grade Ore Stockpile
Copper	µg/L	37	5.3	200	75	13
Iron	µg/L	880	340	580	560	160
Lead	µg/L	2.6	0.48	0.31	2.1	0.92
Magnesium	µg/L	19,000	14,000	12,000	29,000	17,000
Manganese	µg/L	1,300	540	310	1,300	590
Mercury	µg/L	0.36	0.12	0.48	0.50	0.14
Molybdenum	µg/L	15	50	120	39	120
Nickel	µg/L	4.6	9.8	5.2	5.4	7.5
Phosphorus	µg/L	50	50	61	50	50
Potassium	µg/L	95,000	18,000	32,000	58,000	21,000
Selenium	µg/L	1.9	4.6	4.5	3.5	6.4
Silver	µg/L	1.8	0.62	0.60	2.0	0.73
Sodium	µg/L	90,000	74,000	670,000	130,000	96,000
Thallium	µg/L	0.29	0.20	0.10	0.30	0.32
Uranium	µg/L	34	12	5.4	43	34
Zinc	µg/L	75	27	9.6	81	30
Chloride	µg/L	3,000	3,200	46,000	2,300	2,300
Nitrate + Nitrite	µg/L	22,000	10,000	490	23,000	12,000
Nitrite	µg/L	510	240	220	530	270
Nitrate	µg/L	22,000	10,000	490	23,000	11,000
Ammonia	µg/L	2,800	1,300	19,000	2,900	1,500
Unionized Ammonia	µg/L	110	49	720	320	170
$\text{Cyanide}_{\text{Total}}$	µg/L	11	10	5,000	10	10
$\text{Cyanide}_{\text{WAD}}$	µg/L	1.1	1.0	170	1.0	1.0
Sulphate	µg/L	45,000	120,000	1,400,000	210,000	190,000
Fluoride	µg/L	1,600	750	1,300	1,600	1,200

The fate of seepage from the base of the waste rock piles, ore stockpiles, and TMF to groundwater is simulated as described in the Hydrogeology Modelling Report (Appendix 6A). There are no groundwater receivers located along the predicted groundwater flow paths. Therefore, the effects of the seepage from the Project infrastructure on groundwater are related to the predicted discharge of groundwater to surface water receivers. This discharge is characterized in the Hydrogeology Modelling Report as baseflow rates in the watercourses and waterbodies in the LAA. Groundwater discharging to seepage collection ditches has been characterized in the Water Quantity and Water Quality reports (Appendix 7A and 7B) and are not discussed further in this section. However, the mass loading to natural receivers from groundwater baseflow for the parameters of potential concern (POPC) listed in Table 6.7 are presented for the operation phase in Table 6.8.

As shown in Table 6.8, groundwater discharge as baseflow have been characterized for Victoria Lake Reservoir, Victoria River, and Valentine Lake, and tributaries to Victoria River and Valentine Lake. However, as these baseflow loadings will directly affect the surface water quality, the effects are further characterized in Chapter 7.

The changes in groundwater quality during operation are characterized as adverse, long-term, continuous, irreversible, and confined to the LAA/RAA. The magnitude will be low in the LAA/RAA, as the change in groundwater quality will not adversely affect any existing or reasonably foreseeable groundwater users. The ecological context within which effects to groundwater quality would occur in the LAA/RAA is considered undisturbed as defined in Table 6.1.

Table 6.8 Predicted Mass Loadings (kg/d) from Groundwater Baseflow to Surface Water Receivers during Operation

Parameter	Victoria Lake Reservoir	NT3	NT5	ST3	VR2	VR3	VR4	ST4	Victoria River (direct)
Aluminum	0.0011	0.00028	0.000064	0.000042	0.00002	0.000083	0.000045	0.00032	0.000024
Antimony	0.036	0.01	0.0023	0.00071	0.00034	0.0014	0.00093	0.012	0.0004
Arsenic	0.03	0.0069	0.0016	0.00071	0.00034	0.0014	0.00058	0.008	0.0004
Barium	0.39	0.033	0.0077	0.002	0.00097	0.004	0.0029	0.038	0.0011
Boron	0.14	0.038	0.0083	0.0075	0.0036	0.015	0.01	0.042	0.0042
Cadmium	0.00012	0.000059	0.000013	0.0000038	0.0000018	0.0000075	0.0000079	0.000067	0.0000021
Calcium	250	83	19	7.5	3.6	15	6.7	96	4.2
Chromium	0.0096	0.0023	0.00053	0.00011	0.000052	0.00022	0.00016	0.0027	0.000061
Copper	0.042	0.02	0.0048	0.0083	0.004	0.017	0.00071	0.024	0.0047
Iron	0.99	0.15	0.036	0.024	0.012	0.048	0.0074	0.18	0.014
Lead	0.0029	0.00058	0.00013	0.000013	0.0000063	0.000026	0.000041	0.00067	0.0000073
Magnesium	21	8.1	1.9	0.5	0.24	1	0.75	9.3	0.28
Manganese	1.5	0.36	0.083	0.013	0.0063	0.026	0.026	0.42	0.0073
Mercury	0.00041	0.00014	0.000032	0.00002	0.0000097	0.00004	0.0000065	0.00016	0.000011
Molybdenum	0.017	0.012	0.0025	0.005	0.0024	0.01	0.0053	0.012	0.0028
Nickel	0.0052	0.0016	0.00035	0.00022	0.0001	0.00043	0.00033	0.0017	0.00012
Phosphorus	0.056	0.014	0.0032	0.0025	0.0012	0.0051	0.0022	0.016	0.0014
Potassium	110	16	3.7	1.3	0.65	2.7	0.94	19	0.75
Selenium	0.0021	0.001	0.00022	0.00019	0.000091	0.00038	0.00028	0.0011	0.00011
Silver	0.002	0.00055	0.00013	0.000025	0.000012	0.00005	0.000032	0.00064	0.000014
Sodium	100	37	8.3	28	14	56	4.7	42	16
Thallium	0.00033	0.000086	0.000019	0.0000042	0.000002	0.0000083	0.000014	0.000096	0.0000024

Table 6.8 Predicted Mass Loadings (kg/d) from Groundwater Baseflow to Surface Water Receivers during Operation

Parameter	Victoria Lake Reservoir	NT3	NT5	ST3	VR2	VR3	VR4	ST4	Victoria River (direct)
Uranium	0.038	0.012	0.0027	0.00023	0.00011	0.00045	0.0015	0.014	0.00013
Zinc	0.085	0.022	0.0052	0.0004	0.00019	0.0008	0.0013	0.026	0.00023
Chloride	3.4	0.65	0.15	1.9	0.93	3.8	0.13	0.73	1.1
Nitrate + Nitrite	25	6.4	1.5	0.02	0.0099	0.041	0.53	7.3	0.012
Nitrite	0.58	0.15	0.034	0.0092	0.0044	0.018	0.012	0.17	0.0052
Nitrate	25	6.4	1.5	0.02	0.0099	0.041	0.48	7.3	0.012
Ammonia	3.2	0.81	0.19	0.79	0.38	1.6	0.079	0.93	0.45
Unionized Ammonia	0.12	0.089	0.02	0.03	0.015	0.06	0.008	0.1	0.017
$Cyanide_{Total}$	0.012	0.0028	0.00064	0.21	0.1	0.42	0.004	0.0032	0.12
$Cyanide_{WAD}$	0.0012	0.00028	0.000064	0.0071	0.0034	0.014	0.00016	0.00032	0.004
Sulphate	51	60	13	58	28	120	9.3	67	33
Fluoride	1.8	0.45	0.1	0.054	0.026	0.11	0.053	0.51	0.031

Decommissioning, Rehabilitation and Closure

During operation, the waste rock piles, and ore stockpiles have the potential to affect groundwater quality. Table 6.9 provides a summary of mean concentrations for groundwater recharge originating from these sources post-closure. The waste rock piles and TMF will be progressively rehabilitated throughout the Project, reducing the seepage from these areas. During this phase, the ore stockpiles are also depleted and rehabilitated, and should not act as source areas post-closure.

Table 6.9 Predicted Water Quality from Source Areas Post-Closure

Parameter	Units	Leprechaun Waste Rock Pile	Tailings Management Facility	Marathon Waste Rock Pile
Aluminum	µg/L	600	91	600
Antimony	µg/L	18	0.98	20
Arsenic	µg/L	5.2	4.6	8.8
Barium	µg/L	200	5.3	92
Boron	µg/L	66	31	94
Cadmium	µg/L	0.07	0.016	0.20
Calcium	µg/L	99,000	16,000	230,000
Chromium	µg/L	6.1	1.3	7.9
Copper	µg/L	16	96	48
Iron	µg/L	470	230	180
Lead	µg/L	0.62	0.25	2.1
Magnesium	µg/L	7,500	1,900	22,000
Manganese	µg/L	690	190	940
Mercury	µg/L	0.21	0.035	0.29
Molybdenum	µg/L	7.7	8.9	19
Nickel	µg/L	3.0	1.4	4.4
Phosphorus	µg/L	50	62	50
Potassium	µg/L	7,900	2,500	12,000
Selenium	µg/L	1.3	0.49	1.8
Silver	µg/L	1.0	0.16	1.8
Sodium	µg/L	4,900	46,000	12,000
Thallium	µg/L	0.19	0.058	0.19
Uranium	µg/L	14	0.42	13
Zinc	µg/L	44	5.3	71
Chloride	µg/L	3,100	5,300	2,300
Nitrate + Nitrite (as N)	µg/L	89	94	83
Nitrite (as N)	µg/L	8.7	20	10
Nitrate (as N)	µg/L	86	91	71

Table 6.9 Predicted Water Quality from Source Areas Post-Closure

Parameter	Units	Leprechaun Waste Rock Pile	Tailings Management Facility	Marathon Waste Rock Pile
Ammonia	µg/L	59	2,400	32
Unionized Ammonia	µg/L	2.2	91	3.5
$Cyanide_{Total}$	µg/L	11	81	10
$Cyanide_{WAD}$	µg/L	1.1	64	1.0
Sulphate	µg/L	6,000	94,000	170,000
Fluoride	µg/L	1,600	190	1,600

The fate of seepage from the base of the waste rock piles and TMF to groundwater for this phase of the Project is simulated as described in the Hydrogeology Modelling Report (Appendix 6A). As there are no groundwater receivers located along the predicted groundwater flow paths, the effects of the seepage from the Project infrastructure from groundwater are predicted discharge of groundwater to surface water receivers. This discharge is characterized in the Hydrogeology Modelling Report as baseflow rates in the watercourses and waterbodies in the LAA. Groundwater discharging to seepage collection ditches has been characterized in the Water Quantity and Water Quality Modelling reports (Appendix 7B) and are not discussed further in this section. However, the mass loading to natural receivers from groundwater baseflow for the POPC listed on Table 6.9 are presented for the operation phase on Table 6.10.

As shown on Table 6.10, groundwater discharge as baseflow have been characterized for Victoria Lake Reservoir, Victoria River, and Valentine Lake, and tributaries to Victoria River. However, as these baseflow loadings will directly affect the surface water quality, the effects are further characterized in Chapter 7.

The changes in groundwater quality during decommissioning, rehabilitation and closure are characterized as adverse, long-term, continuous, irreversible, and confined to the LAA/RAA. The magnitude will be low in the LAA/RAA, as the change in groundwater quality will not adversely affect any existing or reasonably foreseeable groundwater users. The ecological context within which effects to groundwater quality would occur in the LAA/RAA is considered undisturbed as defined in Table 6.1.

Table 6.10 Predicted Mass Loadings (kg/d) from Groundwater Baseflow to Surface Water Receivers Post-Closure

Parameter	Victoria Lake Reservoir	NT3	NT4	NT5	ST3	VR2	VR3	VR4	ST4	Victoria River (direct)
Aluminum	0.00013	0.000011	0.0000019	0.0000095	0.0002	0.000078	0.00037	0.000088	0.000015	0.00067
Antimony	0.08	0.0068	0.0011	0.0057	0.018	0.0071	0.034	0.008	0.0091	0.061
Arsenic	0.0024	0.00023	0.000038	0.00019	0.00019	0.000076	0.00037	0.000086	0.0003	0.00065
Barium	0.00069	0.0001	0.000017	0.000083	0.0009	0.00036	0.0017	0.0004	0.00013	0.0031
Boron	0.027	0.001	0.00017	0.00087	0.001	0.00041	0.002	0.00047	0.0014	0.0035
Cadmium	0.0088	0.0011	0.00018	0.00089	0.0061	0.0024	0.012	0.0027	0.0014	0.021
Calcium	0.0000093	0.0000023	0.00000038	0.0000019	0.0000031	0.0000012	0.000006	0.0000014	0.000003	0.000011
Chromium	13	2.6	0.43	2.2	3.1	1.2	6	1.4	3.5	11
Copper	0.00081	0.00009	0.000015	0.000075	0.00025	0.0001	0.00049	0.00011	0.00012	0.00087
Iron	0.0021	0.00054	0.000091	0.00045	0.019	0.0074	0.036	0.0084	0.00073	0.064
Lead	0.063	0.002	0.00034	0.0017	0.045	0.018	0.086	0.02	0.0027	0.15
Magnesium	0.000083	0.000024	0.000004	0.00002	0.000049	0.000019	0.000093	0.000022	0.000032	0.00017
Manganese	1	0.25	0.042	0.21	0.37	0.15	0.71	0.17	0.33	1.3
Mercury	0.092	0.011	0.0018	0.0089	0.037	0.015	0.071	0.017	0.014	0.13
Molybdenum	0.000028	0.0000033	0.00000055	0.0000027	0.0000069	0.0000027	0.000013	0.0000031	0.0000044	0.000023
Nickel	0.001	0.00022	0.000036	0.00018	0.0017	0.00069	0.0033	0.00078	0.00029	0.0059
Phosphorus	0.0004	0.00005	0.0000083	0.000042	0.00027	0.00011	0.00052	0.00012	0.000067	0.00093
Potassium	0.0067	0.00057	0.000095	0.00047	0.012	0.0048	0.023	0.0055	0.00076	0.041
Selenium	1.1	0.14	0.023	0.11	0.49	0.19	0.93	0.22	0.18	1.7
Silver	0.00017	0.00002	0.0000034	0.000017	0.000096	0.000038	0.00018	0.000043	0.000027	0.00033
Sodium	0.00013	0.00002	0.0000034	0.000017	0.000031	0.000012	0.00006	0.000014	0.000027	0.00011
Thallium	0.65	0.14	0.023	0.11	9	3.6	17	4	0.18	31
Uranium	0.000025	0.0000022	0.00000036	0.0000018	0.000011	0.0000045	0.000022	0.0000051	0.0000029	0.000039

Table 6.10 Predicted Mass Loadings (kg/d) from Groundwater Baseflow to Surface Water Receivers Post-Closure

Parameter	Victoria Lake Reservoir	NT3	NT4	NT5	ST3	VR2	VR3	VR4	ST4	Victoria River (direct)
Zinc	0.0019	0.00015	0.000025	0.00012	0.000082	0.000033	0.00016	0.000037	0.0002	0.00028
Chloride	0.0059	0.00081	0.00013	0.00067	0.001	0.00041	0.002	0.00047	0.0011	0.0035
Nitrate + Nitrite	0.41	0.026	0.0043	0.022	1	0.41	2	0.47	0.035	3.5
Nitrite	0.012	0.00094	0.00016	0.00078	0.018	0.0073	0.035	0.0083	0.0013	0.063
Nitrate	0.0012	0.00011	0.000019	0.000095	0.0039	0.0016	0.0075	0.0018	0.00015	0.013
Ammonia	0.011	0.00081	0.00013	0.00067	0.018	0.0071	0.034	0.008	0.0011	0.061
Unionized Ammonia	0.0079	0.00036	0.00006	0.0003	0.47	0.19	0.9	0.21	0.00048	1.6
$Cyanide_{Total}$	0.00029	0.00004	0.0000066	0.000033	0.018	0.0071	0.034	0.008	0.000053	0.061
$Cyanide_{WAD}$	0.0015	0.00011	0.000019	0.000095	0.016	0.0063	0.03	0.0071	0.00015	0.054
Sulphate	0.00015	0.000011	0.0000019	0.0000095	0.013	0.005	0.024	0.0056	0.000015	0.043
Fluoride	0.8	1.9	0.32	1.6	18	7.3	35	8.3	2.6	63

6.5.3 Summary of Project Residual Environmental Effects

Residual environmental effects that are likely to occur as a result of the Project are summarized in Table 6.11. The significance of residual adverse effects is considered in Section 6.6.

Table 6.11 Project Residual Effects on Groundwater Resources

Residual Effect	Residual Effects Characterization							
	Project Phase	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Ecological and Socio-economic Context
Change in Groundwater Quantity	C	A	L	PA	ST	C	R	U
	O	A	M	LAA/RAA	LT	C	I	U
	D	A	L	LAA/RAA	LT	C	I	U
Change in Groundwater Quality	C	N	-	-	-	-	-	-
	O	A	L	LAA/RAA	LT	C	I	U
	D	A	L	LAA/RAA	LT	C	I	U

KEY
See Table 6.1 for detailed definitions
Project Phase
C: Construction
O: Operation
D: Decommissioning

Direction:
P: Positive
A: Adverse
N: Neutral

Magnitude:
N: Negligible
L: Low
M: Moderate
H: High

Geographic Extent:
PA: Project Area
LAA: Local Assessment Area
RAA: Regional Assessment Area

Duration:
ST: Short term
MT: Medium term
LT: Long term
P: Permanent

N/A: Not applicable

Frequency:
S: Single event
IR: Irregular event
R: Regular event
C: Continuous

Reversibility:
R: Reversible
I: Irreversible

Ecological / Socio-Economic Context:
D: Disturbed
U: Undisturbed

6.6 DETERMINATION OF SIGNIFICANCE

With the application of the identified mitigation and environmental protection measures, adverse residual environmental effects on groundwater quantity and groundwater quality are predicted to be not significant.

The main adverse residual environmental effect on groundwater quantity and flow identified in this assessment is the lowering of the water table as a consequence of dewatering the open pits. This effect will be most notable during the operation phase, and to a lesser extent during closure as the open pits fill and groundwater levels recover. Additional information on the duration and effects of accelerated open pit filling are included the Surface Water Resources VC (Chapter 7).

The threshold for significance defined in Section 6.3.2 for groundwater quantity relates to a reduction in the groundwater level of an existing water supply well located within the LAA/RAA, yet beyond the Project Area such that, following the application of mitigation, the water supply well no longer meets the needs of the current user(s). There are no known third-party groundwater users located within the LAA/RAA, and no new groundwater users will be permitted within the Project Area or within lands leased by Marathon within the LAA/RAA. Groundwater discharge to surface water features will be affected by the dewatering of the open pits and the mounding of the water table in and around the TMF and waste rock piles. Potential effects to surface water features and wetlands as a result of a reduction in groundwater discharge and/or levels are further assessed in the Surface Water Resources VC (Chapter 7) and Vegetation, Wetlands, Terrain and Soils VC (Chapter 9), respectively.

The main residual environmental effect on groundwater quality identified in this assessment is the increase in concentration of indicator parameters relative to baseline conditions above the drinking water guidelines along the groundwater flow path from the waste rock piles and TMF to the end receptor. This effect will be most notable later in mine life and post-closure because the predicted mean advective travel times of seepage from the Project components through the aquifer are generally decades to centuries. This effect will be mainly confined to the Project Area, with a portion of the groundwater flow paths from the waste rock piles and TMF extending into the LAA/RAA.

The significance threshold for groundwater quality is a change in groundwater quality such that the quality of groundwater from an otherwise adequate water supply well that meets applicable guidelines deteriorates to the point where it becomes non-potable or cannot meet the GCDWQ (Health Canada 2019) for a consecutive period exceeding 30 days. Typical for the Island of Newfoundland, groundwater naturally exceeds a number of water quality guidelines (see Figures 6-3 and 6-4). For parameters with baseline concentrations that naturally exceed the health-based standards specified in the GCDWQ, the determination of significance for groundwater quality reflects that the Project will not further impair the quality of these parameters for any existing water supply wells. No groundwater users are known within the area of influence of Project components, with the groundwater recharge from the waste rock piles and TMF discharging to surface water. Therefore, the adverse residual environmental effects of the Project on a change in groundwater quality during each Project phase are not significant. The effect of the groundwater quality discharging to surface water features is evaluated in Chapter 7.

6.7 PREDICTION CONFIDENCE

The assessment of baseline conditions and the conceptual model representing groundwater processes are based on industry standards and practices for quality assurance and control, which were applied to both field and laboratory procedures.

The predicted effects to groundwater levels and baseflow from the Project are based on a steady-state groundwater flow model. Prediction confidence is high because the groundwater flow model was calibrated within an acceptable range of error for groundwater levels and groundwater discharge to surface water features. As discussed in Section 6.3.5.1, predictions made using the model are based on several conservative assumptions to reduce the influence of uncertainty in the predictions, including the assumption of saturated waste rock piles, no attenuation of water quality along the flow paths, and that all mass of leached parameters from the piles will arrive simultaneously at the receptor. These assumptions result in a conservative prediction of the mass loading in the early phases of the Project (i.e., operation) and provide a better (while still conservative) representation of long-term water quality through closure.

6.8 PREDICTED FUTURE CONDITION OF THE ENVIRONMENT IF THE UNDERTAKING DOES NOT PROCEED

The Project is in an area with a long history of mining and mineral exploration, and it is likely that other mining projects would occur in this area if this Project were not to proceed. Future projects are anticipated to have similar effects on groundwater resources. Should mineral reserves associated with the Project remain undeveloped, the predicted future condition of groundwater resources would be relatively unchanged from what is discussed in the existing environment portion of this assessment, although groundwater resources could change over time as a result of climate change.

6.9 FOLLOW-UP AND MONITORING

6.9.1 Management and Monitoring Program Basis and Objectives

The main effect on groundwater quantity and flow is a lowering of the water table resulting from dewatering the open pits during construction and operation and, to a lesser extent, during closure when the open pits refill. The main effect on groundwater quality is the increase in concentrations of parameters in seepage (as noted in Section 6.5.2) from the waste rock piles and TMF to groundwater, although the effect is likely limited given the decades to centuries advective groundwater travel time, and potential for natural attenuation of the parameters along the groundwater flow paths.

Although there are no groundwater well users within the LAA/RAA, where effects on groundwater are anticipated, Marathon will develop a follow-up and monitoring program to monitor groundwater levels and groundwater quality at key Project locations. Monitoring data from these locations will be used to verify and confirm the anticipated effects identified in the groundwater flow model and to meet regulatory requirements related to specific permits and conditions of approval.

6.9.2 Monitoring Methods

During Project development, a detailed groundwater monitoring program will be implemented for main Project components, building on the baseline monitoring program, to confirm potential changes in groundwater associated with Project activities. A groundwater monitoring program will be developed based on regulatory requirements for both quantity and quality. The groundwater monitoring program will be continued during closure and will document water quality across the Project area and recovery in groundwater levels as the open pits fill.

The type of monitoring equipment, selection of monitoring stations, frequency of sample collection and duration of the program will be determined based on consultation with government agencies. However, it is expected that the monitoring program will be comprised of the following key elements:

- Monitoring wells will be established at select locations around the open pits to monitor groundwater levels during each Project phase as the open pits are dewatered during construction and operation, and subsequently recovered during closure.
- Monitoring wells and/or drive point piezometers will be installed in the vicinity of (but not limited to) Valentine Lake, Victoria Lake Reservoir and Victoria River. The monitoring wells and/or drive point piezometers will be used to record groundwater levels during construction, operation and closure, and to monitor the effects on groundwater levels due to open pit dewatering and recovery during closure.
- Monitoring wells upgradient, cross gradient and downgradient of the TMF and waste rock piles will be established to collect groundwater levels and water quality data during construction, operation and closure to document changes to groundwater levels and flow, and groundwater quality.
- Groundwater quality samples from monitoring wells will be monitored in spring, summer and fall during construction, operation and closure with the frequency progressively reduced based on monitoring results and Project phase. Winter groundwater sampling is not feasible, as baseline data indicates the monitoring wells are generally frozen such that sampling will not be possible. Groundwater quality samples will be analyzed for general chemistry and select dissolved metals.
- Follow-up monitoring results will be compared with applicable regulatory standards set out in GCDWQ, CWQG-FAL, and Project-specific regulatory approvals.

6.9.3 Monitoring Locations and Frequencies

Groundwater monitoring locations will be reviewed at regular intervals. Monitoring locations / stations may be added or removed from the monitoring program in accordance with their utility in monitoring the effects of the Project on the environment.

Monitoring locations will be maintained until the location is no longer required. If a monitoring location / station is no longer required but is identified as part of a regulatory approval, it will only be removed from the monitoring program once the required amendments are approved. Chapter 23 provides additional information on Environmental Management and Monitoring Programs.

6.10 REFERENCES

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