APPENDIX F
BEST AVAILABLE CONTROL TECHNOLOGY REPORT

Valentine Gold Project, Assessment of Best Available Control Technology (BACT)

Final Report

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Abbreviations

BACT	Best Available Control Technology
CH_4	Methane
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalents
ECCC	Environmental and Climate Change Canada
EIS	Environmental Impact Statement
GHG	Greenhouse Gases
GHGRP	Greenhouse Gas Reporting Program
IAAC	Impact Assessment Agency of Canada
kW	Kilowatt
kWh	Kilowatt-Hour
kt	Kilotonnes
LED	Light Emitting Diode
MAC	Mining Association of Canada
NL	Newfoundland and Labrador
N_2O	Nitrous Oxide
NIR	National Inventory Report
TMF	Tailings Management Facility

1.0 INTRODUCTION

Marathon Gold Corporation (Marathon) is planning to develop an open pit gold mine at Valentine Lake, located in the west-central region of the Island of Newfoundland, approximately 60 kilometres (km) southwest of the town of Millertown, Newfoundland and Labrador (NL) (refer to Figure 1-1).

Marathon submitted an environmental impact statement (EIS) for the Project to the federal Impact Assessment Agency of Canada (IAAC, the Agency) and the Newfoundland and Labrador Department of Environment and Climate Change (NLDECC) in September 2020 with the support of Stantec Consulting Ltd. (Stantec).

The predicted annual greenhouse gas (GHG) emissions from the Project are >25,000 t CO_2e/year during the first eight operational years, therefore, the Project is subject to the provincial Best Available Control Technology (BACT) requirements for activities inside the Project's boundaries, as outlined in section 12.1 of the *Management of Greenhouse Gas Regulations*.

This report outlines how BACT was considered in the design of the Project.

1.1 PROJECT OVERVIEW

Marathon is proposing to develop an open pit gold mine near Valentine Lake, located in the central region of the Island of Newfoundland, southwest of the Town of Millertown, Newfoundland and Labrador (NL). The Valentine Gold Project (the Project) will consist primarily of two open pits, waste rock piles, crushing and stockpiling areas, conventional milling and processing facilities (the mill), a tailings management facility (TMF), personnel accommodations, and supporting infrastructure including roads, on-site power lines, buildings, and water and effluent management facilities. The mine site is accessed by an existing gravel road, approximately 82 km in length, which extends south from Millertown. Approximately 73 km of this existing access road will be upgraded and maintained by Marathon as part of the Project.

The operational life of the Project is estimated to be 13 years with the anticipated total resource milled of 41,049 kilotonnes. The Project will operate 24 hours a day, seven days a week on a 12-hr shift basis and is anticipated to create nearly 11,000 full-time equivalents (FTE) in NL. The Project will generate $292 million in revenue to the federal government, and almost $400 million ($27 million annually) of incremental revenues to the treasury of NL (Strategic Concepts 2020).

Gold ore will be mined from the Marathon and Leprechaun open pits using the standard surface mining techniques, which include blasting, loading, hauling ore from the pit to the mill or to stockpiles, processing ore, tailings deposition, hauling and placement of waste rock on the waste rock piles, and phased development of the TMF dams. Both the Marathon pit and the Leprechaun pit will be mined simultaneously, with blasting occurring on alternating days.

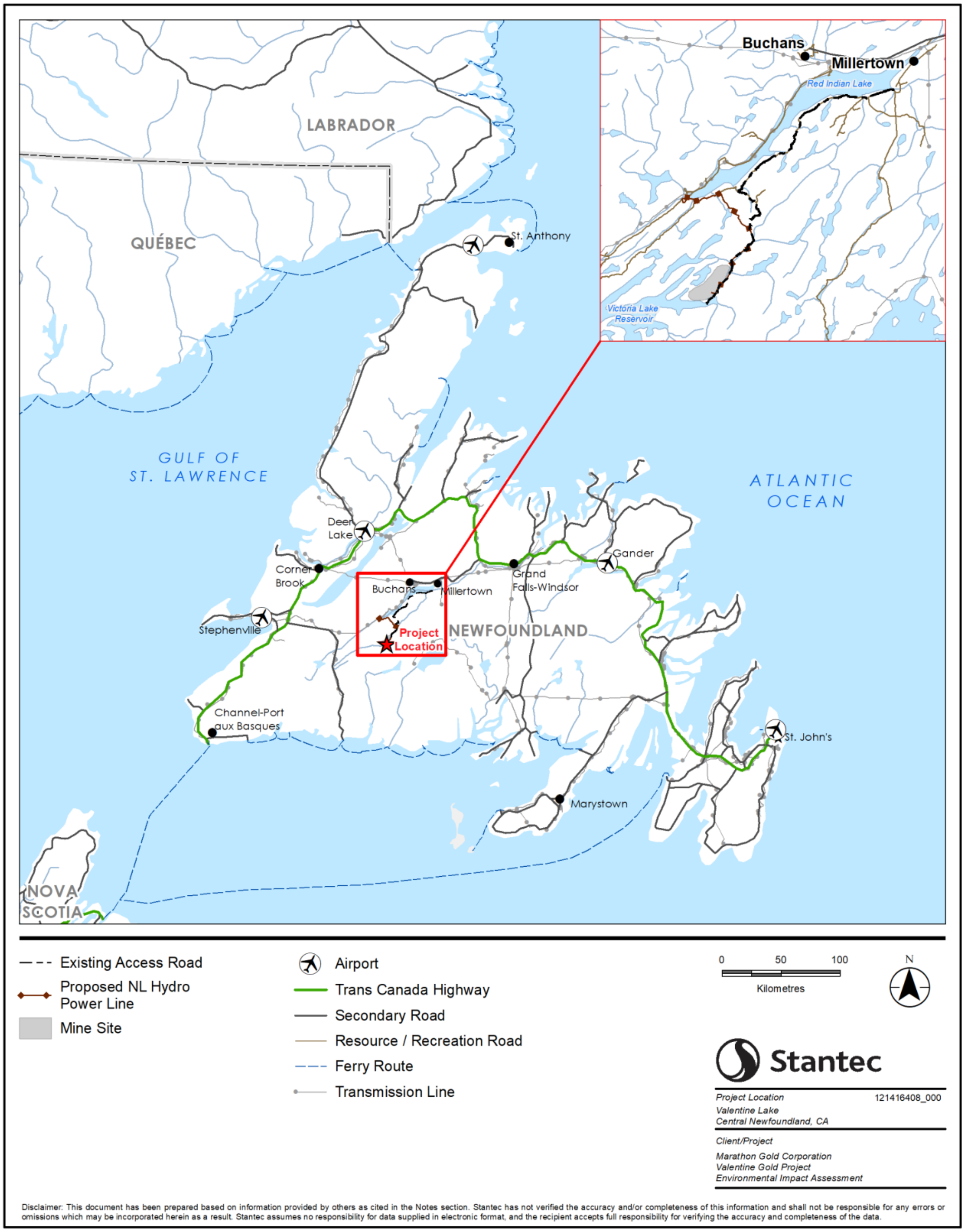

Figure 1-1 Location of the Valentine Gold Project

For the first three years of operation, ore will be processed through the mill on-site where it will be crushed, milled and processed through gravity and cyanidation processes to recover the gold. Initially, 6,800 t of ore will be processed daily, with this quantity anticipated to increase to 11,000 tonnes per day (tpd) in Year 4 through the addition of the flotation process. Tailings will be treated to remove cyanide prior to disposal in an engineered TMF. Gold doré will be shipped from site to market in secured trucks.

The maximum estimated annual GHG emissions from Project operation are presented in Table 1.1. The GHG emissions inventory for Project operation has been updated since the EIS (Marathon 2020) was prepared, to reflect changes to the Project based on updated Project design. These changes are reflected in the GHG estimates provided in Table 1.1. Details pertaining to how the GHG emissions inventory was prepared can be found in Section 5.5.2 and Appendix 5G of the EIS (Marathon 2020).

Table 1.1 Summary of Maximum Estimated Annual GHG Emissions During Project Operation

Activity	Units	CO_2	CH_4	N_2O	Total (expressed as CO_2e)
Blasting[A]	t/y	2,400	-	-	2,400
Stationary Combustion[B]	t/y	1,802	0.09	0.27	1,884
On-Road Transportation[C]	t/y	58,863	3.08	1.83	59,484
Off-Road Mobile Equipment[C]	t/y	29,986	0.82	0.22	30,073
Electricity Consumption (indirect)[D]	t/y	2,506	-	-	2,506
Shipping of Delivered Supplies (indirect)[C]	t/y	926	0.05	0.03	935
Total Direct Emissions	*t/y*	*93,051*	*3.98*	*2.32*	*93,842*
Total Indirect Emissions	*t/y*	*3,432*	*0.05*	*0.03*	*3,441*
Total (direct + indirect)	*t/y*	*96,483*	*4.03*	*2.35*	*97,283*

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)

1.2 REGULATORY CONTEXT

From a regulatory perspective, 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 target in the provincial Climate Change Action Plan (Government of NL 2019):

- 30% reduction in provincial GHG emissions below 2005 levels by 2030

The Government of NL has also passed a motion committing the province to achieve net zero carbon emissions by 2050 (Newfoundland and Labrador Oil and Gas Industrial Association 2020).

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

- 17% reduction of national GHG emissions below 2005 levels by 2020 (under the 2009 Copenhagen Accord)
- 40% to 45% reduction of national GHG emissions below 2005 levels by 2030 (2021 Earth Day Summit, ECCC 2021) replacing the former target of a 30% reduction of national GHG emissions below 2005 levels by 2030 (2015 submission to the United Nations Framework Convention on Climate Change, under the Paris Agreement)
- Legislation for 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 (NLDMAE 2018), which was approved by the federal government to meet the requirements of the Pan-Canadian Approach to Pricing Carbon Pollution in October 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:

- Emission reduction targets from a baseline emission intensity for industrial facilities emitting more than 25,000 tonnes CO_2e annually under NL's *Management of Greenhouse Gas Act* (NL Reg. 116/18). This requires the industrial facilities to reduce their GHG emissions under their baseline in the fourth year of production and to reduce the emissions by 12% under their baseline in year 8 of production and subsequent years.
- 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 2022, the price will increase to $50 per tonne of CO_2e.

In addition to the GHG reduction targets and carbon pricing, there are federal and provincial GHG emission reporting requirements. Federally, under the authority of the *Canadian Environmental Protection Act*, 1999 (CEPA), the GHG Emission Reporting Program (GHGRP) 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 also GHG emission reporting requirements. Provincially, there are three tiers for 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, with third-party emissions verification in compliance with ISO 14064-3 and ISO 14065
- Facilities emitting more than 25,000 tonnes of CO_2e are subject to mandatory annual GHG reduction targets and require third-party verification of emission reports in compliance with ISO 14064-3 and ISO 14065

New facilities that release 15,000 t CO_2e or more in a calendar year must notify the Minister of Environment and Climate Change by March 31 of the subsequent year.

Based on the above noted thresholds, the Project will likely be required to report annual GHG emissions to both the provincial and federal governments, depending on the annual quantity of GHG emissions released to the atmosphere once the Project is operational.

1.3 BACT ANALYSIS OBJECTIVE

As the GHG emissions resulting from the operation of the Project are expected to exceed 25,000 t CO_2e/year during the first eight years of the mine life, the *Management of Greenhouse Gas Regulations* (Newfoundland and Labrador Regulation 116/18, last amended 31/19) will apply to the operation of the Facility. Section 12.1 (1), 12.3 and 12.4 of the *Management of Greenhouse Gas Regulations* state the following:

Section 12.1(1) – “Where a person registers an industrial facility to which these regulations may apply, other than an offshore industrial facility or a mobile offshore industrial facility, in accordance with the *Environmental Protection Act*, the person shall, on the date the industrial facility is registered, provide information regarding best available control technology to the minister.”

Section 12.3 – “Where information is provided under subsection (1) or (2), the industrial facility is required to employ best available control technology in accordance with this Part in the operation of the industrial facility.”

Section 12.4 – “An industrial facility is considered to meet the best available control technology requirements where the Lieutenant-Governor in Council is satisfied that the combination of machinery and equipment in the industrial facility

(a) has the most effective greenhouse gas emissions control;

(b) has proven performance and reliability in comparable industrial facilities;

(c) is economically feasible, based on consultation with the operator; and

(d) complies with an Act or regulation relating to air pollution, occupational health and safety and fire and life safety.”

The objective of this BACT Assessment is to therefore illustrate how Marathon has considered the use of best available control technology in the design and planning of the Project and to demonstrate how the *Management of Greenhouse Gas Regulations* BACT requirements will be met. As the Regulation applies to operational facilities, this assessment focuses on operational activities and equipment.

2.0 PROJECT COMPONENTS AND TECHNOLOGIES CONSIDERED

A detailed description of the Project and its components is presented in Section 2.3, Project Components, of the EIS for the Valentine Gold Project (Marathon 2020). Marathon considered alternatives (e.g., locations, equipment, techniques, methods) for numerous Project components and activities. These are detailed in the alternative's analysis of the EIS (Section 2.11), which identifies and describes alternative means of carrying out the Project and Project components, with consideration of technical and economic feasibility, market conditions, regulatory factors, and socio-economic implications that could affect the selection of the preferred alternative.

The Project infrastructure that is considered to potentially have the biggest impact on GHG releases was considered in the BACT Assessment and includes:

- Power supply
- Mining equipment (stationary and mobile)
- Ore processing
- Other considerations (haul road design, lighting, blasting)

A description of each of these Project components and the technologies considered during the design of the Project are presented in the following sections.

2.1 POWER SUPPLY

2.1.1 Main Power

The Project's grinding mill and processing facility require 23 MW to process the ore and produce gold doré bars. Assuming continuous operation (8,760 hours per year), the electricity requirement for the grinding mill and processing facility is estimated at 201,480 MWh annually.

Two main scenarios for power supply exist: purchase and delivery of electricity generated by a third party or self-generation at the Valentine Gold Project site. These options could include one or a combination of:

- Grid connection
- Diesel generators for electrical base load
- Solar power
- Wind power

These options are each evaluated in the following subsections.

2.1.1.1 Grid Connection

Power in this area of the province is generated from a number of hydroelectric facilities owned and operated by NL Hydro. Marathon has consulted with NL Hydro, who has indicated that power for the Project can be provided via a direct connection to the existing power grid at a location near the Star Lake Hydroelectric Generation Station. The use of hydroelectric power at the Valentine Gold Project results in no on-site air contaminants or direct GHG emissions generated from power supply.

Primary power will be delivered to the site substation, then stepped down and distributed throughout site to the various equipment and locations required, primarily via overhead power lines.

There is sufficient grid capacity to meet all the site's electrical needs through the grid connection. This includes both process needs and space/comfort heating needs.

The 2018 Newfoundland and Labrador provincial electrical grid had an average GHG emissions intensity of 27 g CO_2e/kWh (ECCC 2019), which is on the lower end of provincial intensities due to most of the electricity being generated by hydrogeneration. However, this does not consider that the majority of hydrogenerated electricity is exported to HydroQuebec. To meet the electricity demand in Newfoundland, the Holyrood Generating Station (HGS) acts as a peaking operation to supply the additional demand in excess of the remaining hydrogenerated electricity. The HGS generates electricity from the combustion of oil, which releases GHG emissions. The actual provincial electrical grid GHG intensity based on 2019 generation and emissions data from HGS is approximately 797 t CO_2e per GWh (or 797 g CO_2e/kWh). We understand that the HGS will be decommissioned before the Project is initiated (Pers. Comm. G. Crane, June 22, 2021) and replaced with additional hydrogeneration. The removal of the HGS will lower the provincial grid intensity to near zero GHGs per kilowatt-hour given the use of non-emitting hydroelectric power. As such, the use of electricity from the Newfoundland electrical grid would not generate direct GHG emissions.

Another broader perspective on GHG emissions from power supply is to consider emissions over the life cycle of a system such as a hydroelectric dam. A life cycle typically consists of the phases covering the cradle to grave of a project or product including: raw material extraction (e.g., iron ore mining); assembly in a factory; transportation to the end-user; commissioning, operation, decommissioning; and final disposal. The GHG emissions associated with each phase can be estimated and summed to give a life cycle GHG emissions intensity, typically with units of g CO_2e per kWh for an electricity generating project.

The life cycle GHG emissions associated with a hydroelectric generation facility would vary depending on details including construction approach, design, and location-specific characteristics but have been estimated at approximately 36 g CO_2e/kWh (BC Hydro 2013). Using this life cycle GHG intensity factor for the Project, the life cycle GHG emissions associated with the use of hydroelectric electricity are approximately 7,253 t CO_2e per year of operation, as shown below.

$$201{,}480 \text{ MWh/y} * 36 \text{ g } CO_2\text{e/kWh} * (1{,}000 \text{ kWh}) / (1 \text{ MWh}) * (1 \text{ tonne}/10^6 \text{ g}) = 7{,}253 \text{ t } CO_2\text{e/y}$$

2.1.1.2 Diesel Generator Set

A generator set generally includes two parts:

- A diesel engine system that uses air and diesel to produce power, usually via a crankshaft
- A generator that produces an electric current when the crankshaft rotates the rotor of the generator

Other supporting equipment is also present (e.g., diesel fuel tank, controls, exhaust system). The combustion of diesel in the engine emits air contaminants, steam, and GHGs.

Diesel generator sets are commonly used for base load power supply where grid electricity is not readily available, such as in remote communities and facilities, or when interruptions to power supply can be damaging or unsafe. In emergencies, when grid electricity is not available, diesel generator sets provide a reliable source of energy to safely run criteria loads and life safety systems.

A diesel generator efficiency of 50% was selected to represent large, well-maintained generator sets and is the upper end of diesel generator set efficiency (Engineering Facility 2019). The required volume of diesel to meet the full operational electricity needs of the Project would be approximately 38 million litres per year. Using the emission factors for diesel stationary combustion equipment from the ECCC's 2019 National Inventory Report (ECCC 2020b), the GHG emissions associated with the use of diesel for power generation are estimated to be 101,076 tonnes CO_2e per year. The calculation is provided below.

201,480 MWh/y * 3,600 MJ/MWh * (1 MJ input energy) / (0.5 MJ output energy) / (36.8 MJ diesel/L) = 37,581,762 L/y

37,581,762 L/y * (2,681 g CO_2/L + 0.078 g CH_4/L * 25 g CO_2e/g CH_4 + 0.022 g N_2O/L * 298 g CO_2e/g N_20) * 1 t $CO_2e/10^6$ g CO_2e = 101,076 t CO_2e/y

From a life cycle perspective, the vast majority (>95%) of energy use during the life cycle of a diesel generator set is during its operation phase (Benton et al. 2017). Since GHG emissions are directly correlated with diesel energy, the GHG emissions associated with the other phases are approximately 5% of the operation phase emissions. Using the energy output required (201,480 MWh per year) and the estimated GHG emissions from operation (101,076 t CO_2e per year), the estimated operation phase GHG intensity is 502 g CO_2e/kWh. The GHG emissions intensity of other phases would be approximately 5,054 t CO_2e per year, for a combined intensity of 527 g CO_2e/kWh (502 g CO_2e/kWh plus 25 g CO_2e/kWh).

In addition to the life cycle GHG emissions intensity of the diesel generator set, there is also the life cycle GHG emissions intensity of the diesel itself. That is, there are GHG emissions associated with the production of the diesel used by the Project. The diesel life cycle (cradle to tank prior to combustion) GHG emissions intensity from the Argonne National Laboratory is 13.4 g CO_2e/MJ (Argonne National Laboratory 2020). Using a higher heating value of diesel of 36.8 MJ/L, the life cycle diesel GHG intensity is approximately 493 g CO_2e/L. The estimated annual amount of diesel required over the Project is 37,581,762 L/y. As a result, the estimated annual life cycle GHG emissions from diesel during Project operation are 18,528 t CO_2e.

483 g CO_2e/L * 37,581,762 L/y * 1 t CO_2e/10^6 g CO_2e = 18,528 t CO_2e/y

2.1.1.3 Solar Power

A photovoltaic system using solar panels generates electricity from solar irradiance. The amount of solar irradiance at a given location varies daily depending on weather (e.g., cloud cover), season, and sun activity, but can be approximated based on historical weather conditions. The area where the Project is to be located could produce an average of 950 kWh/kW/year (Rylan Urban 2018). Therefore, to produce 201,480 MWh annually to supply the Project, a solar farm with an installed capacity of approximately 212 MW would be required:

201,280 MWh/year / 0.950 MWh/kW/year = 212 MW installed

Large scale solar farms are typically mounted on structures on the ground. The efficiency of the system's technology to convert sunlight to energy dictates the physical footprint required to generate a specified amount of power. Crystalline solar panels are approximately 18% efficient and thin-film solar panels are approximately 12% efficient. Depending on the technology selected, a solar farm designed to generate 212 MW would require between approximately 848 acres and 1,060 acres (3.4 km^2 to 4.3 km^2).

The terrain around the Project site is steep and includes wetlands, therefore the amount of land clearing and preparation to accommodate the minimum solar panel area would be substantially more than the 4.3 km^2 estimate. The mining of the aggregate needed to support the solar farm would, in effect, constitute its own small mine.

The use of solar panels in a photovoltaic system to generate electricity does not result in direct GHG emissions to the atmosphere. However, GHGs are emitted throughout the life cycle of a photovoltaic system, as the greatest emissions occur during the manufacturing phase (approximately 97% of total life cycle GHG emissions) (Lima et al. 2021). In Lima et al. (2021), a life cycle assessment for a solar farm located in Brazil resulted in an estimate of 65.3 g CO_2e/kWh (the highest in the range of 42 g CO_2e/kWh to 65.3 g CO_2e/kWh). The authors of this study noted that the photovoltaic panel manufacturing location has a large impact on the life cycle GHG emissions intensity. Using the estimated electricity consumption for Marathon (201,280 MWh/year), an estimated equivalent 13,144 t CO_2 per year would be generated during the solar farm's lifetime. The solar farm life cycle GHG intensity is lower than the estimated GHG emissions intensity of a diesel generator set.

GHG Emissions (t CO_2/y) = estimated electricity usage (201,280 MWh/y) * solar farm life cycle intensity (65.3 g CO_2/kWh) * (1000 kWh/MWh) / (1,000,000 g/tonne) = 13,144 t CO_2e/y

This amount of GHGs is equivalent to the combustion of 4,902,648 L of diesel per year over the lifetime of the Project:

13,144 t CO_2/y / 2,681 kg CO_2/kL * 1000 kg / 1 t * 1000 L / kL = 4,902,648 L/y

2.1.1.4 Wind Power

Wind power is generated from the rotation of turbines by the wind to turn generators. Wind turbines for commercial electricity generation are typically 50 m to 105 m tall and can be rated between 1 MW and 3 MW per turbine (Bhandari et al. 2020). Turbine rotor diameters for a 2 MW turbine can be up to 132 m (GE Renewable Energy 2021).

As of December 2019, there were 27 wind turbines installed in Newfoundland and Labrador, for a total installed capacity of 55 MW (Canadian Wind Energy Association nd). This is approximately 2 MW per turbine.

Like solar power, wind power is intermittent and dependent on the wind speed over time at a given location. A back-up electricity generator, such as a diesel generator, and/or a connection to the electrical grid, would be required.

The area needed for a wind turbine farm is substantial. While the individual footprint of a wind turbine is small (approximately 0.25 m^2 [NREL nd]), the distance between wind turbines is required to be between 5 and 10 turbine diameters (660 m to 1,320 m for turbines with 132 m diameter rotors). Using basic assumptions on available wind power and turbine technology, approximately 10 to 12 wind turbines would be required to meet the Project's power needs.

There are no direct GHG emissions from the operation of a wind farm. GHGs are, however, emitted throughout the life cycle of a wind turbine installation. An average life-cycle GHG emissions intensity for an onshore windfarm of the size required for the Project is approximately 40 g CO_2e/kWh (Bhandari et al. 2020); meaning approximately 11,686 t CO_2e per year may be generated from the operation of the wind farm providing the electricity required for the Project. The windfarm life-cycle GHG intensity is lower than the operational GHG intensity of a diesel generator set and solar but higher than hydroelectric. The use of electricity from a wind farm is equivalent to the combustion of 4,168,324 L of diesel per year in a diesel generator over the lifetime of the Project.

11,686 t CO_2 / (2,681 kg CO_2/kL * 1 kg CO_2e/kg CO_2 + 0.133 kg CH_4/kL * 25 kg CO_2e/kg CH_4 + 0.4 kg N_2O/kL * 298 kg CO_2e/kg N_2O) * 1 kL/1000 L * 1 t CO_2e/1000 kg CO_2e = 4,168,324 L

2.1.2 Comparison of Power Supply Options

A comparison of the main power supply options is provided in Table 2.1.

Table 2.1 Comparison of Main Power Supply Options

Main Power Supply	Life Cycle GHG Emission Intensity During Project Lifetime (g CO_2e/kWh)	Operating/Direct GHG Emissions (t CO_2e/y)	Approximate Total Life Cycle GHG Emissions Over the Project Lifetime (t CO_2e)
Grid Electricity (Hydroelectricity)	36	Zero or negligible emissions	94,293
Diesel Generator Set	527	101,076	1,559,906
Solar Power	65.3	Zero or negligible emissions	170,872
Wind Power	40	Zero or negligible emissions	151,918

Notes:

Grid electricity intensity assumes the Holyrood Generating Station will be decommissioned and additional hydrogenerated electricity will be available.

Project lifetime is 13 years.

2.2 BACK-UP POWER

For safety reasons, it is necessary to have a back-up source of power available at the Project site. Typically, diesel-powered generator sets are used for back-up power as this is an economical and readily available solution in emergencies. The other forms of power supply assessed in this report are not suitable for an ‘always at-ready’ back-up power source.

In the event of a grid power outage, back-up generators are not intended to provide power to the entire Project site; rather, back-up generators will be sized to operate only the most critical systems needed to prevent damage to and safely shut down equipment and assist with personnel safety. Marathon plans to install four back-up diesel generators (one 40 kW and three 600 kW) at the Project site.

Back-up generators are typically tested (i.e., operated) at least quarterly to identify any issues that may be present prior to being called on in an emergency. Testing with diesel fuel is a necessary safety measure. The exhaust to atmosphere from the back-up generators will be controlled to meet the province’s air quality requirements. A preliminary review of the tier system set by the federal government suggests that the back-up generators may need to follow tier 4 requirements.

NL Power estimates that the area surrounding the Project (i.e., TL280 – Buchans to Star Lake) experiences approximately 62.4 power outage hours each year (Pers. Comm. R. Coish, July 13, 2021). Assuming that the back-up generators operate at their max capacity of 1,840 kW for 62.4 hours each year, an annual total of 115 MWh of electricity is produced during outages. The required volume of diesel to fuel the back-up generators during outages is approximately 21,416 litres per year. Using the emission factors for diesel stationary combustion equipment from the ECCC’s 2019 National Inventory Report (ECCC 2020b), the GHG emissions associated with the use of diesel for power generation are estimated to be 58 t CO_2e per year. The calculation is provided below.

115 MWh/y * 3,600 MJ/MWh * (1 MJ input energy) / (0.5 MJ output energy) / (36.8 MJ diesel/L) = 21,416 L/y

21,416 L/y * (2,681 g CO_2/L + 0.078 g CH_4/L * 25 g CO_2e/g CH_4 + 0.022 g N_2O/L * 298 g CO_2e/g N_2O) * 1 t CO_2e/10^6 g CO_2e = 58 t CO_2e/y

2.3 BACK-UP SPACE AND COMFORT HEATING

Space and comfort heating is a small energy requirement but is one that must not be interrupted due to health and safety requirements. Site buildings (e.g., accommodations camp, offices, processing areas) will be connected to the grid and electricity will be used for heating. However, a back-up system for space and comfort heating is essential. Similar to the diesel generators for back-up power supply for critical systems, Marathon has considered back-up space and comfort heating using diesel and propane fuel in stationary combustion equipment.

Propane is typically preferred over diesel for small heating loads. Although propane combustion releases GHG emissions, the quantities of GHG emissions released from propane combustion are less than those from combustion of an energy equivalent amount of diesel. For example, considering the energy-based emission factors for diesel and propane in Newfoundland and Labrador's "A Guidance Document for Reporting Greenhouse Gas Emissions for Large Industry in Newfoundland and Labrador" (2017), for every 1 GJ of energy, diesel releases approximately 70 kg of CO_2 and propane releases approximately 60 kg of CO_2. Therefore, the use of propane releases fewer GHGs than diesel, on an energy-equivalent basis.

Although the design of the back-up space and comfort heating system has not been finalized, it is expected to include a furnace for combustion, a heat exchanger, and a thermal fluid for heat transfer. Both diesel and propane can be used for this purpose. Because diesel releases more energy (heat) when combusted, less diesel would be needed for heating than if propane were used.

Similar to the back-up diesel generators, the back-up space and comfort heating system would be regularly tested to ensure it is functioning properly. The GHG emissions from the testing would be negligible in comparison to other regularly operated stationary combustion sources.

A life cycle GHG emissions intensity for a propane heating system could not be located in the literature. However, such a system is likely to have a life cycle GHG emissions intensity that is heavily weighted in terms of percent contribution toward emissions from operation (emissions from combustion of propane), similar to the diesel generator set.

2.4 MINING EQUIPMENT

2.4.1 Dewatering Pumps

Dewatering of the pits is necessary for the safe operation of the mine and will be accomplished by in-pit pumping. Permanently installed pumps will be connected to the site grid whenever it is feasible. However, mobile dewatering pumps are also required where pumps are not permanently placed in one location. These are skid mounted and may be moved as frequently as weekly.

Based on expected dewatering needs, the temporary dewatering pumps will be rated for approximately 150 m^3/hour of water flow. The temporary dewatering pumps are expected to operate approximately 10,000 hours total in the maximum operation year (Year 3).

Both diesel engine driven and electric driven pumps were considered, during Project design and they are evaluated in the following subsections.

2.4.1.1 Diesel Engine Dewatering Pumps

A diesel engine was generally described in Section 2.1.1. For a dewatering pump, the crankshaft of the diesel engine rotates the impellor of a centrifugal pump, resulting in water movement. Diesel engines release air contaminants and GHGs to the atmosphere during regular operation.

Diesel engines are inefficient at converting the potential energy of diesel into kinetic energy for work. To meet the water flow and operational hours requirements, Marathon determined that diesel engines rated up to 100 kW (134 hp) would be required. These combust 45 L of diesel per hour, which, based on anticipated operational hours, would result in approximately 449,959 L of diesel combusted annually. Using the diesel stationary combustion emission factors in Canada's 2019 National Inventory Report (ECCC 2020b), approximately 1,261 t CO_2e per year would be generated from the use of diesel dewatering pumps.

449,959 L/y * (2,681 kg CO_2/kL * 1 kg CO_2e/kg CO_2 + 0.133 kg CH_4/kL * 25 kg CO_2e/kg CH_4 + 0.4 kg N_2O/kL * 298 kg CO_2e/kg N_2O) * 1 kL/1000 L * 1 t CO_2e/1000 kg CO_2e = 1,261 t CO_2e/y

In additional to the operational cost of the diesel fuel itself, diesel engines have regular maintenance requirements; this includes, but are not limited to, fuel and air filter replacements. Maintenance generally occurs every 6 months.

2.4.1.2 Electric Driven Dewatering Pumps

Mobility is key for the temporary dewatering pumps. To create a grid-connected dewatering pump, overhead powerlines would need to be connected from the main electricity system at the Project to transformers throughout the site. From there, a connection to the dewatering pump would be made via an "extension cord". There is a risk of mobile equipment making contact with overhead powerlines; therefore, this option increases the risk of unsafe operating conditions at the site.

The alternative to a wired connection is the use of batteries mounted next to the dewatering pump. The mining equipment manufacturer Epiroc has launched a series of battery-powered mobile mining equipment designed for underground mining (Quarry 2020). Dewatering solutions are not currently available from Epiroc. Their electric equipment can operate for up to five hours, with battery replacement taking 10-15 minutes. This means that battery replacements will halt operation temporarily, several times per 12-hour shift. Just like a diesel driven pump, operators must be cognizant of available power and keep the pump's energy source "topped up".

Sources of electricity were described in Section 2.1.

2.4.2 Light Towers

A light tower consists of one or more lights mounted to a telescopic mast and powered by an energy source connected at the base. In pit mining, the light tower is designed to be towed from place to place as needed for mining operations. Like temporary dewatering pumps, light towers must be mobile as they are moved from place to place on a regular basis.

Marathon has estimated that during peak operation, light towers rated at 20 kW are required for 27,997 hours per year (560 MWh per year).

Marathon considered diesel light towers, as these are commonly used and available from the manufacturers of mobile mining equipment. Other technologies are available, including solar, wind, and hybrid diesel/solar. Given the negligible energy, annual operational cost, and GHG emissions associated with light towers, Marathon did not pursue research into the solar, wind, and hybrid light tower technologies.

2.4.2.1 Diesel Engine Lighting Tower

The information related to diesel engines as presented in Section 2.4.1.1 for dewatering pumps also applies to light plants. Based on the required energy demand in the operation phase, generator set efficiency, and operating hours, the estimated diesel consumption is 2 L per hour, resulting in 41,999 L of diesel per year. The combustion of this diesel would release approximately 118 t CO_2e per year of GHGs:

41,999 L/y * (2,681 kg CO_2/kL * 1 kg CO_2e/kg CO_2 + 0.133 kg CH_4/kL * 25 kg CO_2e/kg CH_4 + 0.133 kg N_2O/kL * 298 kg CO_2e/kg N_2O) * 1 kL/1000 L * 1 t CO_2e/1000 kg CO_2e = 118 t CO_2e/y

2.4.3 Off-Road Mobile Mining Equipment

The Project will be operated using light and heavy mobile mining equipment to develop and extract ore from open pits, road maintenance and dust control, transporting operating supplies, relocating equipment, and snow removal.

Heavy equipment will include graders, production drilling units, dozers, front-end loaders, excavators, and haul trucks. Other, smaller, mobile equipment will include fuel and lube trucks, pickup trucks, shuttle buses, an on-highway dump truck, flatbed truck, emergency response vehicles, maintenance trucks, scissor lifts and other mobile lifts, and forklifts.

The capacities of the main hauling and excavating equipment and their roles are shown in Table 2.2.

Table 2.2 Hauling and Excavating Equipment

Hauling	
Rigid Frame Hauler, 91t payload	Hauling Ore and Waste
Articulated Hauler, 36 tonnes payload	Support Hauler, Till Hauling
Primary Pit Support	
Motor Grader, 4.9 m blade	Haul Road Maintenance
Track Dozer, 447 kW	Waste Dump Maintenance
Track Dozer, 325 kW	Pit Support
Wheel Loader, 4.5m^3 bucket	Pit Support
Hydraulic Excavator, 4.0 m^3 bucket (300-ton class)	Pit Support and Back Up Loading
Hydraulic Excavator, 3.0 m^3 bucket (200-ton class)	Pit Support, Ditching, Construction

Off-road mobile mining equipment is assumed to be owner-operated under a maintenance and repair contract. Fleet maintenance activities will be performed in the maintenance facilities located near the processing plant.

Three alternative engine technologies were considered during the design of the Project:

- Diesel-drive
- Electric-drive
- Hydrogen-drive

These alternatives are evaluated below.

2.4.3.1 Diesel-drive Off-Road Mobile Mining Equipment

Haul trucks fuelled with diesel are commonly used in mining operations around the world. These trucks can operate for hours before refuelling. Regulatory requirements and best operational practices for diesel storage and fuelling technologies are well defined in Canada and the mining industry. Diesel trucks sold for use in Canada are designed to meet the health and safety, fire and life safety, and air pollution control requirements in Canada, and would meet the standards set out in the Newfoundland and Labrador *Environmental Protection Act*.

The combustion of diesel fuel releases GHGs to the atmosphere. For the Project's needs, an estimated 30,073 t CO_2e per year would be released from off-road mining equipment combusting diesel. Details pertaining to how these emissions have been calculated can be found in Section 5.5.2 of the EIS (Marathon 2020).

2.4.3.2 Electric-drive Off-Road Mobile Mining Equipment

Rather than using a tank containing fuel such as diesel, electric-drive vehicles use batteries to store and provide energy. The length of operation depends on the activities undertaken and the capacity of the installed batteries and is expected to be in the order of hours, rather than days. The use of electric-drive equipment would result in no direct GHG emissions at the Project site and limited indirect GHGs if hydroelectric power is used to charge the batteries. Although life-cycle GHG emissions intensities for rechargeable batteries are available, they are dependent on battery chemistry, which is not known at this time.

The use of batteries requires charging spare batteries and replacing spent batteries as needed.

Marathon consulted the manufacturers Caterpillar, Komatsu, Hitachi, and Liebherr with regards to available electric-drive haul trucks and excavators. A brief summary of the findings is provided below.

- Electric-drive haul trucks are available from these manufacturers, but the trucks are either not available in North America (Liebherr) or do not meet the Project requirements with respect to capacity.
- Electric-drive hydraulic excavators are available from these manufacturers, but the excavators are either not available in North America (Liebherr, Komatsu) or not available as electric-drive in the 200- and 300-ton classes required for the Project.

An example of a mining operation that does use electric-drive mobile equipment (with batteries) in Canada is the underground Borden gold mine (Mining Technology 2021). This mine has been operating since October 2019 and presents a test case for using battery-operated mining equipment. The mine life is expected to be 7 to 15 years. The ore production capacity of the Borden gold mine is 4,000 tonnes per day (1.46 million tonnes per year); this is a smaller operation than the Project (4 million tonnes per year). The provincial and federal government provided a total of $10 million dollars to support electrification of the mine (Mining Global 2020).

2.4.3.3 Hydrogen-drive Off-Road Mobile Mining Equipment

Hydrogen is a potential fuel for mobile equipment that does not release GHGs when combusted, as there is no carbon present in the fuel. The technology to incorporate hydrogen fuel in mining equipment is still being tested and, as such, currently represents both a technological and a financial risk. It was therefore not considered further in the assessment.

2.5 ORE PROCESSING

For ore processing, Marathon considered alternative means for ore processing and locations of ore processing based on economic and technical feasibility, as well as environmental effects as outlined below.

2.5.1 General Ore Processing and Leaching Reagents

Marathon considered three options for ore processing: heap leach only; heap leach and milling; and milling only. For the first option (heap leach only), mined ore would be piled into heaps and a leaching solution will then pass through the ore heaps to dissolve the gold. For the second option (heap leach and milling), low grade ore would be heap leached and higher-grade ore would be processed by grinding, gravity concentration, and, optionally, flotation, as well as leaching. For the final option (milling only), mined ore is ground, gravity recovered, and leached in a mill.

There are no direct GHG emissions from the three options selected. Indirectly, the ore processing pathway would affect GHG releases based on the amount of electricity consumed.

Marathon considered several alternatives gold leaching reagents, which include cyanide, thiosulphate, thiourea, and halides. Of those leaching reagents, cyanide has been used on a commercial scale and safely and economically used by most gold producers.

2.5.2 Location

2.5.2.1 On-site mill processing

Marathon has considered various on-site mill processing locations based on health and safety requirements, geotechnical conditions, environmental receptors (e.g., caribou migration path), and locations of pits and TMF. The locations considered were termed the central site area, the eastern site area, and the western site area. The central site area was the best option because it is technically and regulatory feasible, economically feasible, and the best option for environmental considerations (less haulage and further from the caribou migration path).

The energy requirement to run the on-site mill would depend on the ore throughput rates. This was discussed in Section 6 above.

2.5.2.2 Off-site mill processing

Even if the ore is milled offsite by Marathon, the energy required to perform the milling is associated with the Project and would be considered an indirect GHG emission source. As the energy consumption for the milling process depends on the production rate (ore throughput), the same ore throughput requires the same amount of energy regardless of the location. Off-site milling would require additional energy for hauling and ore loading and unloading, which would result in higher GHG emission emissions during the operation phase than onsite processing.

Assuming a haul truck with 10 tonne loading capacity and the truck diesel fuel efficiency of 40 L/ 100 km, the GHG emissions from hauling 10 tonnes of ore would be approximately 0.1 t CO_2e for every 100 km travelled (one-way) as shown in the calculation below.

Haul Truck GHG emissions (t CO_2e) per 10 tonne hauled = 40 L of diesel/100 km * (2,681 g CO_2/L + 20.11 g CH_4/L * 25 kg CO_2e/kg CH_4 + 0.151 g N_2O/L * 298 kg CO_2e/kg N_2O) / 10^6 g/tonne = 0.1 t CO_2e/100 km.

The above estimate is based on emission factors for Heavy-duty Diesel Vehicles (HDDVs) - Advanced Control (ECCC 2020b).

These additional GHG emissions for off-site milling would consider number of hauling trips (based on hauling capacity and quantity of ore to be hauled) and empty trucks travelling back from the off-site milling location to pick up the next load. GHGs would also be associated with haul truck loading and unloading the ore, however this would be much lower compared to the emissions associated with transporting the ore.

2.6 OTHER CONSIDERATIONS

2.6.1 Haul Road Design

Haul roads are necessary for the movement of mobile equipment from the pits to locations around the Project site. Mining companies seek to optimize the length and profile (i.e., grade) of haul roads, to reduce to the extent practicable the amount of diesel consumed by heavy equipment. The optimization of haul roads can lower GHG emissions by reducing diesel usage and, therefore, haul road design was considered in this BACT assessment.

2.6.2 Lighting

Sufficient and appropriate interior and exterior lighting of Project spaces is necessary for the health and safety of Marathon personnel. Although electrical lighting does not directly emit GHGs, Marathon has considered the energy efficiency of available lighting technologies in this BACT assessment.

Three technologies were considered: incandescent bulbs, fluorescent tubes, and light-emitting diodes (LED). Incandescent bulbs are commonly found in residential applications due to the ease of replacement and low cost. They are available in a wide range of styles and wattages. However, these bulbs are not energy efficient (US Department of Energy nd) and result in a large portion of electrical energy being lost as heat. Fluorescent tube light fixtures are commonplace in commercial and industrial settings given the long lifespan of fluorescent tubes and the required ballasts. Fluorescent tubes are more efficient than incandescent bulbs (HowStuffWorks nd).

LED lights have an output of 90 to 150 lumens per watt (Lamp HQ nd), which is more efficient than the output of a comparable fluorescent tube at 50 to 100 lumens per watt (HowStuffWorks nd).

2.6.2.1 Blasting

The GHG emissions from the combustion of explosives are expected to be minimal (approximately 4% (Marathon (2020)) in comparison to GHG emissions from overall operation of the Project; however, these have been considered in the BACT assessment from the perspective of reducing explosive use as feasible.

3.0 EVALUATION OF TECHNICALLY FEASIBLE OPTIONS

In this section, the most technically feasible option for the components discussed are identified and summarized.

3.1 POWER SUPPLY

3.1.1 Main Power

Base load diesel generators of the size and capacity required to supply the power required for the Project may be technically feasible; however, these would require considerable initial investment and substantial operating and maintenance costs (fuel) and would result in substantial GHG emissions over the life of the Project.

Solar power supply for the Project is not considered technically feasible due to climate conditions (i.e., the amount of solar irradiance available). The installation of solar panels would also require a substantial physical footprint to generate the amount of power required to make installation / operation economically feasible. In addition, solar power has a higher life-cycle emission intensity (i.e., 715 g CO_2e/kWh) than hydroelectric (i.e., 36 g CO_2e/kWh) (BC Hydro 2013) and wind power generation (i.e., 40 g CO_2e/kWh). Life-cycle emission intensity estimates consider all stages of the life cycle of a product, activity or process.

Wind power has greater potential for success for a project in this region relative to solar power; however, wind power is considered to be an intermittent power supply source due to variable wind conditions over short periods of time (days / weeks). As a result, wind power requires a sizeable and reliable back-up or secondary power supply to provide the consistent supply of power required. For this Project, wind power could be used to augment a connection to the power grid (hydroelectric power) or on-site diesel generators. As the life-cycle emission intensity for wind power is similar to hydroelectric power generation, and construction and operation of 10 to 12 large turbines would result in adverse environmental effects including increased footprint, noise, hazard to birds and bats, and aesthetic effects (viewscape), wind power is not considered a suitable alternative (Marathon 2020).

Marathon has selected electrical power supplied by NL Hydro as the preferred alternative based on the adverse implications of using alternate power sources as indicated above and below. The failure or malfunction considerations are similar for power grid connection, and solar and wind power, in that failure within the system would mean a loss of production for the Project and could affect the health and safety of workers. On-site generated power would require more than one generator in parallel, so it is unlikely that the generators would fail all at once; however, it could result in similar issues depending on how many generators are employed, and the capacity of each generator. Diesel generations rely on substantial quantities of fuel, and therefore carry an inherent increase in risk due to failures or malfunctions in the transportation, storage, and handling of fuel.

3.1.2 Back-up Power

Marathon plans to use diesel engines for emergency back-up power supply. Given the specific requirements associated with a back-up system, other technologies were not considered technically feasible. With only one option being technically feasible, an economic assessment was not conducted. A discussion of GHG emissions controls can be found in Section 22.

3.1.3 Back-up Space and Comfort Heating

On the basis that propane and diesel heating systems are both technically feasible, but that propane results in few GHG emissions during operation, Marathon selected propane as the energy source for the back-up space and comfort heating system.

3.2 MINING EQUIPMENT

3.2.1 Dewatering Pumps

Due to the need for relocating pumps frequently and their high energy demand, a diesel engine is the preferred technology. Diesel engines can be moved with the dewatering pumps. Electric technology would pose safety risks for operators.

3.2.2 Light Towers

Similarly, to the dewatering pumps, due to the need for relocating the lighting towers frequently and given the negligible energy requirement on an annual basis, a diesel engine is the preferred technology to power the lighting towers.

3.2.3 Off-Road Mining Equipment

Marathon considered the use of electric trucks over diesel trucks because electric vehicles do not release GHGs during operation. However, electric haul trucks of the size required for the Project are not yet available in Canada. Similarly, Marathon considered electric-drive excavators, but found that these are not available in Canada in the size required for the Project. Hydrogen-drive equipment currently poses unacceptable technological and financial risks.

Based on a review of the options, Marathon has selected diesel engines as the technology for haul trucks and excavators. Marathon has not yet selected a manufacturer for the haul trucks or other equipment; however, fuel efficiency (i.e., the amount of energy available to do work per unit of diesel combusted) will be a major consideration in the manufacturer selection.

3.3 ORE PROCESSING

3.3.1 General Ore Processing and Leaching Reagents

For energy use and GHG perspective, the milling only option would be the highest energy intensive among the three options considered. However, when weighing with the overall environmental footprint associated with heap leach pads, storage ponds, solution / water handling ponds and the associated environmental and technical issues, milling only is the preferred ore processing pathway. The detailed studies on alternatives are presented in Section 2.11, Project Components, of the EIS for the Valentine Gold Project (Marathon 2020). The milling only option will be carried forward in this assessment.

3.3.2 On-site versus Off-site Milling Locations

Because on-site milling results in lower energy intensity compared to off-site, Marathon selected on-site milling.

3.4 OTHER CONSIDERATIONS

3.4.1 Haul Road Design

Although it is technically feasible to not optimize the haul roads, this would not be considered BACT. From an economic perspective, haul road optimization results in less diesel consumption, which leads to lower operational costs and fewer GHG emissions.

3.4.2 Lighting

The selected lighting technology proposed for the Project building's interiors and for stationary outdoor lighting is LED. LED lights are the more energy efficient option.

3.4.3 Blasting

Marathon will conduct blasting operations with consideration to reducing the amount of explosive used to achieve the desired results.

3.5 SUMMARY OF SELECTED OPTIONS

The selected component options are:

- Main power: grid electricity use (using hydroelectric generated power)
- Back-up power: diesel generator set
- Back-up space and comfort heating: propane heat exchanger system
- Dewatering pumps: diesel engine
- Light towers: diesel engine
- Off-road mining equipment: diesel engine
- Ore processing: milling only
- Leaching reagents: cyanide
- Location: on-site milling
- Haul road design: included in the estimation of GHG emissions
- Lighting: LED
- Blasting: use of computer-designed detonation sequencing

4.0 ANALYSIS AND RATIONALE FOR THE SELECTED CONTROL TECHNOLOGIES

In this section, any GHG reduction or control technologies that are applicable for the selected component options are identified.

4.1 POWER SUPPLY

4.1.1 Main Power

The use of grid electricity from a hydroelectric generation fleet is the BACT for the Project's power supply. There are no relevant control technologies on GHGs related to hydroelectricity that could be employed by Marathon.

4.1.2 Back-up Power

Marathon plans to use diesel engines for emergency back-up generators. In 2006, the federal Canadian government introduced into legislation emission standards and engine test methods that aligned with the those of the United States in the US Code of Federal Regulation (ECCC 2019d). The *Off-road Compression-Ignition (Mobile and Stationary) and Large Spark-Ignition Engine Emissions Regulations* (SOR/2020-258), under the *Canadian Environmental Protection Act*, apply to diesel-fuel engines. These Regulations use the tier system of classification, where each tier corresponds to air contaminant emission limits. Tier 4 represents the most stringent emission limits.

Marathon will follow the US Code of Federal Regulation (CFR) 60, subpart III (with respect to emergency generators) for the use of emergency back-up generators for the Project.

4.1.3 Back-up Space and Comfort Heating

Marathon will design the propane space and comfort heating system in accordance with provincial and federal requirements, including those regarding control of air contaminants.

4.2 MINING EQUIPMENT

4.2.1 Dewatering Pumps, Light Towers, and Off-Road Mobile Mining Equipment

Marathon will select diesel engines that can meet the province's requirements for health and safety and air contaminant emissions, including meeting the tier requirements specified by ECCC.

4.3 ORE PROCESSING

4.3.1 General Ore Processing On-site and Leaching Reagents

Marathon will seek to reduce GHG emissions by selecting energy efficient equipment and systems where practicable.

4.4 OTHER CONSIDERATIONS

4.4.1 Haul Road Design

Marathon is implementing haul road optimization in the mine design and planned development sequence. This practice has been reflected in the information used to quantify the GHG emissions as stated in the EIS (Section 5.5.2). For example, the footprint of the TMF intersects with what would be the most direct route for the haul trucks to the process plant and the route that would, therefore, equate to the least fuel usage and air emissions (including GHGs) by the haul trucks (i.e., the shortest and least steep route). However, the TMF will not reach the full extent of its footprint until later in operations. Therefore, rather than designing and building the haul road to circumvent the ultimate TMF footprint, the haul road will initially be constructed along the most direct, least steep path, and then realigned in Year 5 to accommodate the ultimate TMF footprint. This approach reduces the Project's overall fuel usage and associated air emissions and GHGs.

4.4.2 Lighting

Lighting systems using LEDs can be designed to minimize electricity use to the extent practicable, such as through the use of motion sensors or timers. Otherwise, there are no direct control technologies applicable to lighting.

4.4.3 Blasting

Marathon is planning to achieve highly accurate blast hole drilling and increasing the rock fragmentation efficiency per unit of explosive used by employing techniques and technologies such as computer-designed detonation sequencing. By increasing blasting efficiency and accuracy, fewer explosives will be needed, reducing associated GHG emissions to the extent practicable.

5.0 SUMMARY

Marathon is proposing the construction, operation and decommissioning of the Valentine Gold Project in the central region of the Island of Newfoundland.

As the predicted annual GHG emissions for the Project are >25,000 CO_2e/year during the first eight operational years, the Project is subject to the provincial 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 is required to implement BACT to reduce overall GHG emissions during operation.

The design of the Project has considered BACT with respect to GHG emissions and these considerations were included in the calculations of GHG emissions presented in the EIS (Marathon 2020) and in this report. During Project planning and design, a wide variety of alternative approaches were reviewed and considered based on their technical, economic and environmental feasibility. This included Project components and activities that could result in GHG emissions, such as Project power supply, lighting, use of mobile and stationary equipment, and blasting.

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 operation emissions over the lifetime of the Project are estimated to be approximately 680,816 t CO_2e (Marathon 2020; Ausenco 2021). Note this this estimate does not include life-cycle GHG emissions from equipment or fuels.

The annual GHG emissions (direct and indirect) from Project operations range from 5,824 t CO_2e to 97,283 t CO_2e (Marathon 2020; Ausenco 2021). On an annual basis, the projected Project operation contribution to provincial and national GHG emissions totals range from 0.05% to 0.89%, and 0.001% to 0.013%, respectively. The Project's GHG intensity was determined to be comparable to other gold and silver mines in Canada.

To provide context for the GHG emissions from the Project against other mining operations in Canada, Table 5.1 compares operational GHG emissions from the Project to GHG emissions reported by existing gold and silver mining operations in Canada (for 2018). The reported emissions represent direct GHG emissions from stationary combustion and mobile combustion. For some facilities inTable 5.1, emissions of refrigerants from cooling processes are included, although this is a negligible source. Facilities are required to follow the quantification requirements set out by ECCC (2019c) for reporting to GHGRP. The projected Valentine Gold Project information is in **bold**.

Table 5.1 2018 Annual GHG Emissions

Facility	2018 Annual GHG Emissions[A] (t CO_2e)
Kirkland Lake Gold Ltd - Macassa Mine	10,322
McEwen Ontario - Black Fox Mine	10,419
Iamgold Corporation - La mine Doyon	11,736
SGO Mining Inc. - Seabee	11,850
Island Gold Mines - Island Gold Mine	12,955
Agnico-Eagle Mines Lted - Division Goldex	13,201
Lake Shore Gold - Timmins West Mine	14,415
Lake Shore Gold - Bell Creek Complex	15,556
Atlantic Mining NS Corp - Touquoy Mine	17,000
Pretium Resources Inc. - Brucejack Gold Mine	17,890
Goldcorp Canada Limited - Red Lake Gold Mines	24,833
Hecla Québec Inc. - Casa Berardi	27,857
Les mines Opinaca ltée - Mine Éléonore	28,246
Alamos Gold Incorporated - Young-Davidson	30,453
Les Mines Agnico Eagle Limitée - Division Laronde	35,350
Goldcorp Canada Ltd - Musselwhite Mine	39,484
Project – Valentine Gold Project (projected direct emissions)	**47,736** [C]
TMAC Resources Inc.[B] - Hope Bay Site	49,205
Goldcorp Canada Ltd - Porcupine Gold Mines	54,156
Agnico Eagle Mines Ltd Meliadine Division - Meliadine Gold Project	66,620
New Gold Inc. - Rainy River Mine	135,062
Agnico Eagle Mines Limited - Division Meadowbank	185,529
Canadian Malartic GP - Mine Canadian Malartic GP	198,813
Detour Gold Corporation[D] - Detour Lake Project	224,756

Notes:
[A] 2018 emissions as reported to GHGRP (Government of Canada 2020).
[B] Now owned by Agnico Eagle.
[C] Represents the annual average direct GHG emissions over life of mine.
[D] Now owned by Kirkland Lake Gold.

To establish a GHG intensity for gold and silver mines, the production for a sample of mines was found from publicly available information. The estimated GHG emissions intensity for the Project and reported emissions intensities for existing mines (in 2018) are presented in Table 5.2.

Table 5.2 GHG Emissions Intensity

Facility	2018 Annual GHG Emissions[A] (t CO_2e)	Annual Production (ounces)	GHG Emissions per Ounce (t CO_2e/ounce)
TMAC Resources Inc.[C] - Hope Bay Site	49,205	111,000	0.44
Detour Gold Corporation[D] - Detour Lake Project	224,756	621,000	0.36
Project – Valentine Gold (projected direct emissions)	**47,736[B]**	**145,833**	**0.33**
Hecla Québec Inc. - Casa Berardi	27,857	162,743	0.17
Canadian Malartic GP - Mine Canadian Malartic GP[E]	198,813	1,570,620	0.13

Notes:

[A] 2018 emissions as reported to GHGRP (Government of Canada 2020), representing direct GHG emissions from stationary combustion and mobile combustion. For some facilities, emissions of refrigerants from cooling processes are included, although this is a negligible source.

[B] Represents the annual average direct GHG emissions over life of mine. Corresponding production is average over life of mine.

[C] Now owned by Agnico Eagle.

[D] Now owned by Kirkland Lake Gold.

[E] Annual production data is a combination of gold and silver product

Production information:

Hecla Québec Inc. - Casa Berardi (Hecla Québec 2021)

TMAC Resources Inc. - Hope Bay Site (Mining Data Solutions nd)

Canadian Malartic GP - Mine Canadian Malartic GP (Canadian Malartic 2020)

Detour Gold Corporation - Detour Lake Project (Kirkland Lake Gold 2021)

The Project's GHG intensity is comparable to other gold and silver mines in Canada. It is noted that GHG intensity is dependent on a variety of factors, including estimation methods, power types (e.g., degree of electrification and power plant type), and the concentration of gold in the ore body. In addition, a mature mine that has been running consistently is likely to have lower GHG emissions intensity than a newer mine that is still finetuning the production process.

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