12. Assessment of Potential Climate Effects

12.1 INTRODUCTION

This section pertains to the environmental assessment (EA) of the effects of the Brucejack Gold Mine Project (the Project) on climate, focusing on greenhouse gas (GHG) emissions. Anthropogenic climate change is a global issue that has implications for both human and natural systems and could lead to significant effects on resource use, production, and economic activity over the life of the Project. As stipulated in the Application for Information Requirements (AIR), the main guidance document for the assessment of climate change is *Incorporating Climate Change Considerations in Environmental Assessment* (CEA Agency 2003). Other applicable regulations and best practices documents are discussed in Section 12.2.

It is known that the Project will: 1) emit GHGs that contribute to climate change, and 2) be affected by climate change itself. Therefore, as recommended by the Canadian Environmental Assessment Agency (CEA Agency) 2003 guideline, the Brucejack environmental assessment covers the effect of GHG emissions by the Project as well as the risks of climate change impacts to the Project. The Project GHG emissions will be addressed in this chapter, and the risks of climate change impacts to the Project will be addressed in Chapter 32, Effects of the Environment on the Project. Rather than assessing the cumulative effects of the project on climate change, Project GHG emissions will be compared with provincial, federal, and international GHG emission levels, which represent relative effects at different scales. This comparative method is consistent with guidance by the CEA Agency (2003) and the majority of Canadian environmental assessments.

12.2 REGULATORY AND POLICY FRAMEWORK

Legislation is being implemented globally to mitigate the level of GHG emissions to the Earth's atmosphere. Many initiatives to adapt to the potential adverse effects of climate change are also being developed (CEA Agency 2003; IPCC 2007a; BC MOE 2010b), but there is some regulatory uncertainty as to what legislation will apply during the Project life due to changes in political influences. In British Columbia (BC), carbon management and carbon markets fall under both regulatory and voluntary domains, so organizations can implement carbon management strategies under several voluntary third-party programs that promote best practices in the measurement, reduction, and transparent reporting of GHG assessments and reductions.

The primary pieces of legislation pertaining to carbon management for major projects in BC, including taxation and market mechanisms, are listed in Table 12.2-1. In the absence of regulations, many organizations seek to minimize GHG emissions voluntarily to meet corporate sustainability reporting goals, procure financing, address liability, or improve public relations.

As a signatory of the 2009 Copenhagen Accord, Canada is committed to reduce its total GHG emissions by 17% from 2005 levels by 2020, mirroring the United States' targets. To demonstrate its reductions, Canada reports national GHG emissions annually to the United Nations Framework Convention on Climate Change (UNFCCC).

BC also has several climate change regulations in place provincially. Through the BC Climate Action Plan (Government of British Columbia 2008), the province has set more stringent targets than the national targets described above. BC currently also has a carbon tax, although the general *GHG Reduction (Cap and Trade) Act* (2008a) may become the major legislative arm to regulate emissions in BC.

Table 12.2-1. Greenhouse Gas Emission Legislation and Initiatives

Name	Year	Type	Level of Government	Description
Copenhagen Accord	2009	Agreement	International	Canada signed to a GHG[1] emissions target of 17% reduction from 2005 levels by 2020; national regulations, under the Clean Air Regulatory Agenda (below), are shaped to meet this target.
Canadian Environmental Protection Act	1999	Act	National	Act respecting pollution prevention and the protection of the environment and human health in order to contribute to sustainable development that provides authority for the collection of GHG emission data nationally by Statistics Canada and Environment Canada.
Clean Air Regulatory Agenda	2006	Agenda	National	Established in 2006 and administered by Environment Canada, this agenda supports national efforts to reduce GHG and other air pollutant emissions. Transport sector emissions regulations fall under this agenda.
Federal Sustainable Development Act	2008	Act	National	Purpose is to provide legal framework for a Federal Sustainable Development Strategy which has Climate Change as its Goal 1, to make environmental decision-making more transparent and accountable.
Federal Sustainable Development Strategy	2008	Strategy	National	Goal 1 of the Federal Sustainable Development Strategy is climate change, to "reduce greenhouse gas emission levels to mitigate the severity and unavoidable impacts of climate change."
On-road Vehicle and Engine Emission Regulations	2002	Regulation	National	This and newer regulations under the authority of the *Canadian Environmental Protection Act* (1999) and Clean Air Regulatory Agenda regulate the reduction of vehicle emissions and establish emission standards.
BC Climate Action Plan	2008	Plan	Provincial	Action plan under which provincial acts regulating emissions are being created to achieve specific targets, such as 33% GHG[2] reduction by 2020 compared to 2007 levels.
BC Air Action Plan	2008	Plan	Provincial	Comprises 28 actions that promote clean transportation and clean industry, including emissions reductions.
Carbon Tax	2007	Tax	Provincial	Revenue-neutral tax to incentivize emissions reductions.
Greenhouse Gas Reduction (Cap and Trade) Act	2008	Act	Provincial	Legislation to authorize hard caps on GHG emissions. Reporting underway, but caps currently being negotiated.
GHG Reduction (Vehicle Emissions Standards) Act	2008	Act	Provincial	Will increase automobile fuel efficiency thereby reducing transport sector GHG emissions.
Zero Net Deforestation Act	2010	Act	Provincial	Sets reporting on net deforestation to start in 2012 and achieve net zero deforestation by 2015.
Greenhouse Gas Reporting Regulation	2010	Regulation	Provincial	Under the *GHG Reduction (Cap and Trade) Act*, sets out GHG reporting requirements for facilities emitting 10,000 t/a CO_2e[2] or more.
Part 6 - Clean Air Provisions under *Environmental Management Act*	2004	Provision	Provincial	Provides general authority to make regulations on fuel emissions and motor vehicle/engine and burning emissions.

[1] GHG = greenhouse gas
[2] t/year CO_2e = tonnes per year of carbon dioxide equivalent

The *GHG Reduction (Cap and Trade) Act* also enabled BC to be the first Canadian province to join the Western Climate Initiative (WCI) in 2007, but BC has not yet implemented regulations through the WCI and still has the option to opt out prior to its slated implementation in 2015.

The *GHG Reduction (Vehicle Emissions Standards) Act* (2008b) is also slated to roll out in BC in the next few years, putting initial caps on transport emissions, which will likely be changed incrementally in future years to be in line with target reductions in BC: a total of 33% by 2020 compared to 2007 and 80% below 2007 levels by 2050 (Government of British Columbia 2008). In conjunction with national transport regulations, this act will regulate the reporting and mitigation of highway haul truck emissions for the Project.

Regarding land-use change, in support of the Climate Action Plan, BC has enacted the *Zero Net Deforestation Act* (2010), targeting net zero deforestation for BC by December 31, 2015, starting with government reporting on deforestation in 2012. The objectives of this act are to achieve net zero deforestation without "undermining economic development" and to use information and incentives to encourage voluntary action by industry to avoid and reduce deforestation and increase afforestation levels (BC MFML 2010).

The project lies within the boundaries of the Nass South Sustainable Resource Management Plan (BC MFLNRO 2012). This plan mentions addressing climate change risks to forests, but not preventative GHG mitigation. The Cassiar Iskut-Stikine Land and Resource Management Plan for land near the Project makes no mention of climate change or GHGs (BC MFLNRO 2000).

12.2.1 Greenhouse Gas Emission Reporting and Reduction Requirements

In support of national and provincial GHG mitigation targets, facilities in BC must report their GHG emissions to the BC and federal government, depending on the amount of annual emissions:

- Facilities emitting over 10,000 t CO_2e/year are required to report to the British Columbia Ministry of Environment (BC MOE).
- Facilities emitting over 25,000 t CO_2e/year are required to report to the BC MOE and have emissions verified by an independent and accredited third party.
- Facilities emitting over 50,000 t CO_2e/year are required to report to Environment Canada as well as the BC MOE and be verified by an independent and accredited third party.

Reporting for provincial compliance is done under the BC Reporting Regulation (BC Reg. 272/2009) of the *Greenhouse Gas Reduction (Cap and Trade) Act* (2008a), and national reporting is required as part the *Greenhouse Gas Emissions Reporting Program* (Environment Canada 2012), under the jurisdiction of the *Canadian Environmental Protection Act* (1999). Data from the reporting program are used in national inventory reports to supplement data from the annual Report on Energy Supply-Demand in Canada compiled by Statistics Canada in national inventory reports (NIRs) to the UNFCCC (Environment Canada 2013).

The above provincial and national reporting regulations only pertain to direct facility-level emissions, and so do not include indirect emissions or land-use changes. In years that the Project's direct facility-level GHG emissions surpass the BC and federal thresholds for annual GHG emissions, Project GHG emissions will need to be assessed, verified (if over 25,000 t CO_2e), and reported. If applicable, Project GHG emissions will be reported through Environment Canada's online Single Window reporting system, which was introduced in 2010 to align the needs of federal and provincial reporting, prevent duplication, and reduce the reporting burden on industry (BC MOE 2011).

There is no current cap on industrial GHG emissions mandating emission reductions for the Project; however, BC's carbon tax will also apply to purchases for the Project, and the *Greenhouse Gas Reduction (Cap and Trade) Act* (2008a) is designed to set the groundwork for a regulatory regime that was to be implemented through the tabled Emission Trading Regulation on January 1, 2012. The proposed Emission Trading Regulation would be applicable to facility operations that emit over 25,000 t CO_2e/year from "emissions from general stationary combustion of fuel or waste with the production of useful energy" (BC Climate Action Secretariat 2010).

12.3 BASELINE CHARACTERIZATION

12.3.1 Scientific Background

Weather and climate are related, but distinct. Weather relates to short-term meteorological conditions (e.g., temperature and precipitation), which, for the local Project area, are included in meteorological baseline studies reported in Chapter 7 and Appendix 7-A. Climate can be studied at local small scales, such as in boundary layer climatology (Oke and Rouse 1997), but climate is generally understood to be the long-term average (over 30 years) pattern of weather stemming from physical drivers (e.g., solar radiation levels and atmospheric composition). Long-term climate change is distinct from periodic fluctuations in climate such as the El Niño Southern Oscillation, and is caused by shifts in large-scale climate drivers that lead to long-term trends in annual climatic conditions in an area over time.

The aspect of climate that this assessment focuses on is pertaining to the greenhouse effect, which results from the properties of atmospheric greenhouse gases that absorb and then reradiate infrared radiation, raising average surface temperatures compared to what they would be in the absence of these gases. GHGs include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulphur hexafluoride (SF_6), water vapour (H_2O), ozone (O_3), hydrofluorocarbons, and perfluorocarbons.

GHGs from human activities contribute to the greenhouse effect, and have been identified—along with natural climate forcing factors (i.e., solar cycles, Milankovich cycles, and volcanic activity)—as a driver of climate change that has been scientifically observed and documented over the last several decades. The level of confidence in the science of climate change from anthropogenic GHGs is reflected in the recent Intergovernmental Panel on Climate Change (IPCC) compendium report, which states that warming of the global climate system is unequivocal, that anthropogenic GHGs are the dominant source of this warming, and that there is very high confidence that the analysis of human-caused climate change is correct (Hegerl et al. 2007; IPCC 2013). Global atmospheric concentrations of CO_2 have increased by about 95 ppm since 1780, and of this, about 84% is attributable to fossil fuel emissions, which now far exceed pre-industrial levels, while the rest is likely due to land-use changes such as vegetation clearing (BC MOE 2007; Hegerl et al. 2007). The Project will involve activities that both burn fossil fuel and convert forest land to industrial settlement land.

12.3.2 Historical Activities

Since the lifetime of CO_2 in the atmosphere is 50 to 200 years (IPCC 2001) and GHGs collect and fully mix in the global atmospheric pool, GHG emissions by definition are cumulative in nature, with new GHG emissions adding to historic ones to contribute to the greenhouse effect and climate change. BC and Canada evaluate and report on aggregated GHG inventories annually per UNFCCC reporting standards, which are then incorporated into global anthropogenic emission inventories by the UNFCCC. These inventories serve as the historic GHG emission setting for the Project climate assessment GHG indicator and also serve as a point of comparison for the assessment of significance for the Project in Section 12.7.

12.3.2.1 The International Greenhouse Gas Setting

International anthropogenic GHG emissions can provide an idea of the global context to compare Project GHG emissions to, as will be done further in this assessment in Section 12.6.2. As shown in Table 12.3-1, out of the total global estimate of anthropogenic CO_2 emissions to the atmosphere of 31,350,455 kt, Canada was the ninth largest GHG emitter in 2010 with 499,137 kt CO_2 (UN Statistics Division 2013). Note that total values reported in Table 12.3-1 are lower than those reported in the Canadian inventory report (Table 12.3-2) for the same year, as international data do not account for emissions from other GHGs besides CO_2 due to gaps in obtaining information from developing nations. Canadian self-reported emissions in 2010 were approximately 701,000 kt CO_2e with 554,000 kt from CO_2 (Environment Canada 2013). The GHG emissions listed in Table 12.3-1 also only include facility-level sources, and not land-use, land-use change, and forestry (LULUCF) GHG emissions relating to vegetation clearing and re-vegetating activities.

Table 12.3-1. Global Greenhouse Gas Emissions (2010; not counting LULUCF*)

Rank	Country	Annual CO_2 Emissions (kt)	% of World Emissions
1	China	8,286,892	26.43%
2	United States	5,433,057	17.33%
3	India	2,008,823	6.41%
4	Russian Federation	1,740,776	5.55%
5	Japan	1,170,715	3.73%
6	Germany	745,384	2.38%
7	Iran (Islamic Republic of)	571,612	1.82%
8	Korea, Republic of	567,567	1.81%
9	**Canada**	**499,137**	**1.59%**
10	United Kingdom	493,505	1.57%
Total	**World**	**31,350,455**	**100%**

Source: UN Statistics Division (2013)
** Data reported in this table do not account for LULUCF reporting requirements or GHGs besides CO_2 due to data gaps from developing nations.*

Of total world emissions, the energy sector accounted for 26%, the industrial sector for 17%, LULUCF for 17%, agriculture for 14%, transportation for 13%, commercial and residential buildings for 8%, and waste and wastewater (including landfill methane and incineration sources) for 3% in 2004 (IPCC 2007b).

12.3.2.2 The National and Provincial Greenhouse Gas Setting

Table 12.3-2 summarizes historic GHG emissions across BC and Canada, gathered from inventory reports. In BC, LULUCF emissions are reported as afforestation and deforestation and are based on land-use change data. As shown in Table 12.3-2, the 2011 total annual reported GHG emissions were 701,791 kt CO_2e nationally and 59,100 kt CO_2e in BC, and do not include CO_2e from LULUCF. This inventory is intended to serve as a general guide, rather than an exact comparison, since at the onset of inventory reporting in 1990, data sources were not as complete as they currently are, and reporting methods and standards have improved over the years.

Mining sector emissions include data from oil, gas, coal extraction, and non-energy mining such as iron ore, gold, diamonds, potash, and aggregates. Per UNFCCC reporting standards, in 2011, the national mining sector accounted for about 36,400 kt CO_2e and BC mining emissions contributed about 1,670 kt CO_2e, as shown in Table 12.3-2. Because the mining sector values reported provincially and nationally include aggregate metal and non-metal mining, alongside oil/gas extraction, which accounts for the majority of GHG emissions, supplementary data on gold mining and metal mining are also included in Table 12.3-2. These data were tracked separately by the Simon Fraser University Canadian Industrial Energy End-use Data and Analysis Centre for the Mining Association of Canada (Nyboer and Bennett 2013).

Table 12.3-2 shows that, in terms of relative growth, GHG emissions for the mining sector as a whole have increased more rapidly than any other subsector. Mining sector emissions for 2011 reported by the Canadian Industrial Energy End-use Data and Analysis Centre as 3,776 kt CO_2e for national metal mining and 482 kt CO_2e for national gold mining, show increases in GHG emissions compared to 2005, but the historical increasing/decreasing trend is more variable year-to-year compared to the mining sector as a whole. Of the facilities that have to report to Environment Canada under the federal reporting system, two BC metal ore mining facilities reported in 2011, totalling 235 kt CO_2e.

Reforestation/afforestation emissions are reported as negative values in Table 12.3-2 to represent carbon removals from the atmospheric GHG pool through photosynthetic sequestration of CO_2 into biomass pools. In BC, the difference between deforestation (2,922 kt CO_2e) and afforestation (-18 kt CO_2e) led to net deforestation emissions of 2,904 kt CO_2e in 2010. More recent data were not available, as the BC GHG inventory report is not produced annually. Deforestation in this context only counts anthropogenic deforestation that is not followed by regeneration, and does not include natural causes that emit very high levels of GHGs, such as damage by mountain pine beetle or forest fires; the latter alone caused emissions to jump by 43.4 Mt CO_2e in 2009 compared to 2008 (BC MOE 2010a). In this context, the largest contributors of anthropogenic deforestation in BC were agriculture and municipal settlement sectors, 1,777 and 1,420 ha, respectively, in 2010. Comparatively, the mining sector deforestation rate has been 615 ha/year on average, accounting for about 9% of the total deforestation in the province from 1990 to 2010 (BC MOE 2012b).

12.4 ESTABLISHING THE SCOPE OF THE EFFECTS ASSESSMENT FOR CLIMATE

This section includes a description of the scoping process used to identify potentially affected Valued Components (VCs), select assessment boundaries, and identify the potential effects of the Project that are likely to arise from the Project's interaction with an intermediate component or receptor VC. Scoping is fundamental to focusing the Application for an Environmental Assessment Certificate / Environmental Impact Statement (Application/EIS) on those issues where there is the greatest potential to cause significant adverse effects. The scoping process for the assessment of climate consisted of the following four steps:

- *Step 1:* undertaking an issues scoping process to select components, sub-components, and indicators based on a consideration of the Project's potential to interact with a subject area;
- *Step 2:* consideration of feedback on the results of the scoping process from technical experts and the EA Working Group[1];
- *Step 3:* definition of assessment boundaries for each subject area, and/or sub-component; and
- *Step 4:* identification of key potential effects on climate and/or sub-components.

These steps are described in detail below.

[1] The EA Working Group is a forum for discussion and resolution of technical issues associated with the proposed Project, as well as providing technical advice to the BC EAO and CEA Agency, who remain ultimately responsible for determining significance. It comprises representatives of provincial, federal, and local governments, and Aboriginal groups.

Table 12.3-2. National and Provincial Greenhouse Gas Emissions, including Mining Sector

Emission Source Greenhouse Gas	Greenhouse Gas Emissions (kt CO_2e) 1990	2000	2005	2007	2008	2009	2010	2011	2011 % Change from 1990†	2011 % Change from 2005†
United States Total*	6,169,592	7,045,346	7,169,899	7,225,934	7,021,569	6,566,198	6,790,642	6,665,701	8%	-7%
European Union Total*	5,574,424	5,066,464	5,129,156	5,059,034	4,952,412	4,593,442	4,705,200	4,550,212	-18%	-11%
Canada Total*	**591,079**	**717,581**	**737,457**	**748,840**	**730,916**	**689,030**	**700,849**	**701,791**	**19%**	**-5%**
Stationary Combustion Sources Subtotal**	281,000	346,000	341,000	352,000	336,000	315,000	316,000	313,000	11%	-8%
• Electricity and Heat Generation**	94,000	129,000	123,000	122,000	115,000	100,000	101,000	93,000	-1%	-24%
• Fossil Fuel Production and Refining**	51,000	67,000	71,000	72,000	67,000	67,000	65,000	62,000	22%	-13%
• *Mining Sector (Including Oil and Gas Extraction)***	*6,600*	*12,100*	*18,900*	*28,900*	*30,000*	*31,700*	*35,000*	*36,400*	*452%*	*93%*
• Manufacturing Industries**	55,800	55,600	48,600	47,600	45,100	40,300	41,100	42,700	-23%	-12%
• Agriculture and Forestry**	2,400	2,500	2,100	2,600	2,600	2,500	2,900	3,600	50%	71%
Land-use, Land-use Change, and Forestry**	-62,000	-52,000	63,000	52,000	-11,000	-10,000	100,000	87,000	-240%	38%
Canada Metal Mining Total §	***3,934***	***3,265***	***3,327***	***3,532***	***3,889***	***3,130***	***3,649***	***3,776***	***-4%***	***13%***
• *Canada Gold Mining §*	*356*	*340*	*319*	*309*	*303*	*249*	*396*	*482*	*35%*	*51%*
British Columbia Total**	**49,400**	**61,900**	**64,000**	**62,600**	**63,000**	**60,000**	**59,900**	**59,100**	**20%**	**-8%**
Stationary Combustion Sources Subtotal**	19,000	22,500	23,100	20,900	20,800	20,500	19,900	19,300	2%	-16%
• Electricity and Heat Generation**	803	1,810	1,320	1,130	1,470	1,320	1,210	637	-21%	-52%
• Fossil Fuel Industries**	3,600	3,800	7,300	6,200	6,000	6,300	6,400	5,200	44%	-29%
• *Mining Sector (Including Oil and Gas Extraction)***	*328*	*331*	*280*	*1,170*	*1,440*	*1,420*	*1,620*	*1,670*	*409%*	*496%*
• Manufacturing Industries**	6,460	8,060	6,340	4,660	4,070	4,040	4,060	3,990	-38%	-37%
• Agriculture and Forestry**	321	315	72.1	71.5	59.9	46.4	305	277	-14%	284%
Afforestation/Reforestation***	0	-3	-9	-13	-14	-16	-18	n/a	n/a	n/a
Deforestation***	6,146	3,863	3,341	3,520	3,089	2,996	2,922	n/a	n/a	n/a

Notes:
Data gathering and processing techniques have improved since 1990, so this table is intended to give general rather than precise indications of aggregate provincial and national GHG emissions.
Numbers in bold represent sum totals and values in italics specifically represent the mining sector.
n/a = not available
Negative values represent sequestered carbon and a withdrawing from rather than adding to atmospheric GHG pool.
United States, European Union, Canada, and British Columbia totals do not include LULUCF CO_2e.
† % change provided for 1990 and 2005 to represent reporting under Kyoto Protocol and new national targets respectively.
** UNFCCC Annex 1 GHG Data Sheet (UNFCCC 2013)*
*** NIR, National GHG Inventory Report (Environment Canada 2013)*
**** BC Greenhouse Gas Inventory Report 2010 (BC MOE 2012b)*
§ Direct emissions, measured and reported separately by the Canadian Industrial Energy End-use Data and Analysis Centre (Nyboer and Bennett 2013) with slightly different methods than the NIR; included to provide disaggregated values of metal mining and gold mining from Mining Sector reported for Canada and BC, the latter include high oil and gas extraction GHG emissions.

12.4.1 Selecting Valued Components and Indicators

Selecting receptor VCs for assessment is undertaken to focus the Application/EIS on the issues of highest concern. Receptor VCs are specific attributes of the biophysical and socio-economic environments that have environmental, social, economic, heritage, or health significance. Receptor VCs also have the potential to be indirectly affected by changes in the baseline condition of other environmental components thereby acting as receptors of that change. Indirect effects may, in turn, also affect the baseline condition of the receptor VC. To be considered for assessment, a component must be of recognized importance to society, the local community, or the environmental system, and there must be a perceived likelihood that the receptor VC will be affected by the proposed Project. Receptor VCs are scoped during consultation with key stakeholders, including Aboriginal communities and the EA Working Group. Consideration of certain receptor VCs may also be a legislated requirement, or known to be a concern because of previous project experience.

As described in Section 6.4.1.1, a scoping exercise was conducted during the development of the draft AIR to explore potential Project interactions with candidate receptor VCs, and to identify the key potential adverse effects associated with that interaction. The results of the scoping exercise were circulated for review and approval by the EA Working Group, and feedback from that process was integrated into the Application.

Subject areas are classified as either an intermediate component or receptor VC and are further refined into sub-components and indicators. Climate was identified as a receptor VC as a result of the scoping process, with GHG emissions as the indicator. No sub-components of climate were identified through the scoping process.

12.4.1.1 Potential Interactions between the Project and Climate

Table 12.4-1 provides an impact scoping matrix of the climate VC, which has a possible or likely interaction with Project components and projects and activities. A full impact scoping matrix for all intermediate and receptor VCs is provided in Table 6.4-1 of the methodology chapter.

Interactions between the Project and the climate were assigned a colour code as follows:

- not expected (white);
- possible (grey); and
- likely (black).

Table 12.4-1. Interaction of Project Components and Physical Activities with Climate

Construction Phase	
Activities at existing adit	
Air transport of personnel and goods	
Avalanche control	
Chemical and hazardous material storage, management, and handling	
Construction of back-up diesel power plant	
Construction of Bowser Aerodrome	
Construction of detonator storage area	

(continued)

Table 12.4-1. Interaction of Project Components and Physical Activities with Climate (continued)

Construction Phase (cont'd)	
Construction of electrical tie in to BC Hydro grid	
Construction of electrical substation at the Brucejack Mine Site	
Construction of equipment laydown areas	
Construction of helicopter pad(s)	
Construction of incinerators	
Construction of Knipple Transfer Area	
Construction of local site roads	
Construction of Mill Building (electrical induction furnace, backfill paste plant, warehouse, mill/ concentrator)	
Construction of mine portal and ventilation shafts	
Construction of Brucejack Operations Camp	
Construction of ore conveyer	
Construction of tailings pipeline	
Construction and decommissioning of Tide Staging Area construction camp	
Construction of truck shop	
Construction and use of sewage treatment plant and discharge	
Construction and use of surface water diversions	
Construction of water treatment plant	
Development of the underground portal and facilities	
Employment and labour	
Equipment maintenance/machinery and vehicle refuelling/fuel storage and handling	
Expansion of current exploration camps	
Explosives storage and handling	
Grading of the mine site area	
Helicopter use	
Installation and use of Project lighting	
Installation of surface and underground crushers	
Installation of the Brucejack Transmission Line and associated towers	
Machinery and vehicle emissions	
Potable water treatment and use	
Pre-production ore stockpile construction	
Procurement of goods and services	
Quarry construction	
Solid waste management	
Transportation of workers and materials	

(continued)

Table 12.4-1. Interaction of Project Components and Physical Activities with Climate (continued)

Construction Phase (cont'd)	
Underground water management	
Upgrade and use of exploration access road	
Use of Granduc Access Road	
Operation Phase	
Air transport of personnel and goods and use of aerodrome	
Avalanche control	
Backfill paste plant	
Back-up diesel power plant	
Bowser Aerodrome	
Brucejack Access Road use and maintenance	
Brucejack Operations Camp	
Chemical and hazardous material storage, management, and handling	
Concentrate storage and handling	
Contact water management	
Detonator storage	
Discharge from Brucejack Lake	
Electrical induction furnace	
Electrical substation	
Employment and Labour	
Equipment laydown areas	
Equipment maintenance/machine and vehicle refuelling/fuel storage and handling	
Explosives storage and handling	
Helicopter pad(s)	
Helicopter use	
Knipple Transfer Area	
Machine and vehicle emissions	
Mill building/concentrators	
Non-contact water management	
Ore conveyer	
Potable water treatment and use	
Pre-production ore storage	
Procurement of goods and services	
Project lighting	
Quarry operation	

(continued)

Table 12.4-1. Interaction of Project Components and Physical Activities with Climate (continued)

Operation Phase (cont'd)	
Sewage treatment and discharge	
Solid waste management/incinerators	
Subaqueous tailings disposal	
Subaqueous waste rock disposal	
Surface crushers	
Tailings pipeline	
Transmission line operation and maintenance	
Truck shop	
Underground backfill tailings storage	
Underground backfill waste rock storage	
Underground crushers	
Underground explosives storage	
Underground mine ventilation	
Underground water management	
Underground drilling, blasting, excavation	
Use of Brucejack Mine Site haul roads	
Use of portals	
Ventilation shafts	
Waste rock transfer pad	
Warehouse	
Water treatment plant	
Closure Phase	
Air transport of personnel and goods	
Avalanche control	
Chemical and hazardous material storage, management, and handling	
Closure of mine portals	
Closure of quarry	
Closure of subaqueous tailings and waste rock storage (Brucejack Lake)	
Decommissioning of Bowser Aerodrome	
Decommissioning of back-up diesel power plant	
Decommissioning of Brucejack Access Road	
Decommissioning of camps	
Decommissioning of diversion channels	
Decommissioning of equipment laydown	

(continued)

Table 12.4-1. Interaction of Project Components and Physical Activities with Climate (completed)

Closure Phase (cont'd)	
Decommissioning of fuel storage tanks	Grey
Decommissioning of helicopter pad(s)	Grey
Decommissioning of incinerator	Grey
Decommissioning of local site roads	Grey
Decommissioning of Mill Building	Grey
Decommissioning of surface crushers	Grey
Decommissioning of underground crushers	Grey
Decommissioning of ore conveyer	Grey
Decommissioning of Project lighting	Grey
Decommissioning of sewage treatment plant and discharge	Grey
Decommissioning of surface explosives storage	Grey
Decommissioning of transmission line and ancillary structures	Grey
Decommissioning of waste rock transfer pad	Grey
Decommissioning of water treatment plant	Grey
Decommissioning of tailings pipeline	Grey
Employment and labour	White
Helicopter use	Grey
Machine and vehicle emissions	Grey
Procurement of goods and services	White
Removal or treatment of contaminated soils	Grey
Solid waste management	Grey
Transportation of workers and materials (mine site and access roads)	Grey
Post-closure Phase	
Discharge from Brucejack Lake	White
Environmental monitoring	White
Employment and labour	White
Procurement of goods and services	White
Subaqueous tailings and waste rock storage	White
Underground mine	White

Notes:
White = unexpected interaction between Project components/physical activities and a receptor VC
Grey = possible interaction between Project components/Projects and Activities and a receptor VC
Black = likely interaction between Project components/Projects and Activities and a receptor VC

Interactions coded as not expected (white) are considered to have no potential for adverse effects on a receptor VC and are not considered further.

The likely and possible interactions in Table 12.4-1 were identified based on the activities that involved release of GHGs to the atmosphere, including any equipment, machinery, or vehicles using petroleum-based fuel (diesel, gasoline, aviation fuel, etc.), and activities associated with fugitive GHG emissions such as refuelling. Potential effects on carbon sinks due to the Project include any potential land-use changes, primarily from construction and decommissioning of Project components.

12.4.1.2 Consultation Feedback on Receptor Valued Components

Through consultation, members of the Skii km Lax Ha have expressed that they have observed changes to the climate over the last 20 years, including an increase in temperatures and rainfall during the winter, which is making some smaller streams unsafe to cross as they no longer freeze over (Rescan 2013b).

There was a public comment asking for GHG accounting to be performed for all mine related activities.

EA Working Group comments during the AIR and EIS guidelines review phase did not further support the identification and selection of the climate VC.

12.4.1.3 Summary of Receptor Valued Components Included/Excluded in the Application for an Environmental Assessment Certificate/Environmental Impact Statement

Table 12.4-2 summarizes the results of the impact-matrix and consultation feedback. Climate was identified in the AIR as a receptor VC, indicating government interest. It was also identified in the impact matrix scoping exercise. The effects due to climate change were identified by the Skii km Lax Ha.

Table 12.4-2. Climate Receptor Valued Components Included in the Application for an Environmental Assessment / Environmental Impact Statement

Identified by*				
AG	G	P/S	IM	Rationale for Inclusion
X	X	X	X	GHGs emitted by the Project will incrementally add to global atmospheric GHG levels, which drive climate change. Also required by the CEA Agency guidance document (2003).

**AG = Aboriginal Group; G = Government; P/S = Public/Stakeholder; IM = Impact Matrix*

No receptor VCs related to climate or GHGs that were initially considered for the EA are excluded from this assessment.

12.4.2 Assessment Boundaries for Climate

Assessment boundaries define the maximum limit within which the effects assessment is conducted. They encompass the areas within, and times during which, the Project is expected to interact with the receptor VCs, as well as the constraints that may be placed on the assessment of those interactions due to political, social, and economic realities (administrative boundaries), and limitations in predicting or measuring changes (technical boundaries). The definition of these assessment boundaries is an integral part of the assessment process of climate, and encompasses possible direct, indirect, and induced effects of the Project on climate, inclusive of Project effects on relevant intermediate components, as well as the trends in processes that may be relevant.

12.4.2.1 Spatial Boundaries

The spatial boundary for the climate effects assessment is defined as the area subject to potential effects from Project emissions. As mentioned, GHGs emitted by the Project will enter an open atmospheric pool that is globally unbounded, therefore, as is standard for environmental assessments for mining projects (Rescan 2010; Teck Coal Limited 2011; Rescan 2013a), spatial boundaries for GHG emissions are defined by Project GHG sources for facility and land-use change emissions. The assessment considers all project-related emissions and land-use change associated with the Brucejack mine site, access road, and transmission line.

12.4.2.2 Temporal Boundaries

The temporal boundary for the climate effects assessment's GHG indicator is defined as the period of time that the Project GHG emissions will have an effect on the environment. Because GHGs in the atmosphere have a lifetime of 50 to 200 years, Project GHG emissions will continue to have an effect on the environment long after Project closure. The four temporal phases of the Project are:

- **Construction:** 2 years;
- **Operation:** 22-year run-of-mine life;
- **Closure:** 2 years (includes project decommissioning, abandonment, and reclamation activities); and
- **Post-closure:** minimum of 3 years (includes ongoing reclamation activities and post-closure monitoring).

The Project climate assessment will focus on GHGs emitted during the Construction and Operation phases as the majority of Project emissions will occur during this time. Potential facility-level contributions to GHG emissions during Closure and Post-closure are expected to be minimal and will not be assessed; however, net GHG emissions due to land-use change during reclamation will be assessed.

12.4.3 Identifying Potential Effects on Climate

There are two primary pathways through which activities taking place across Project areas are anticipated to lead to incremental increases in atmospheric GHG emissions, as illustrated in Figure 12.4-1 and described below:

1. Facility-level GHG sources defined by the GHG Protocol (2013):
   - Scope 1: Fuel burning by Project owned/operated equipment, trucks, incinerators, generators, and blasting, as well as Project fugitive GHG emissions such as during equipment refuelling.
   - Scope 2: Electricity used by the Project, which is purchased and imported into site.
   - Scope 3: Upstream and downstream third-party owned/operated activities such as employee travel and contracted material hauling.
2. Land-use change: Changing of net GHG sources and sinks from activities such as clearing and burning of vegetation of Project land components (net source), as well as restoration activities such as replanting, which will contribute to GHG sequestration (net sink) over time.

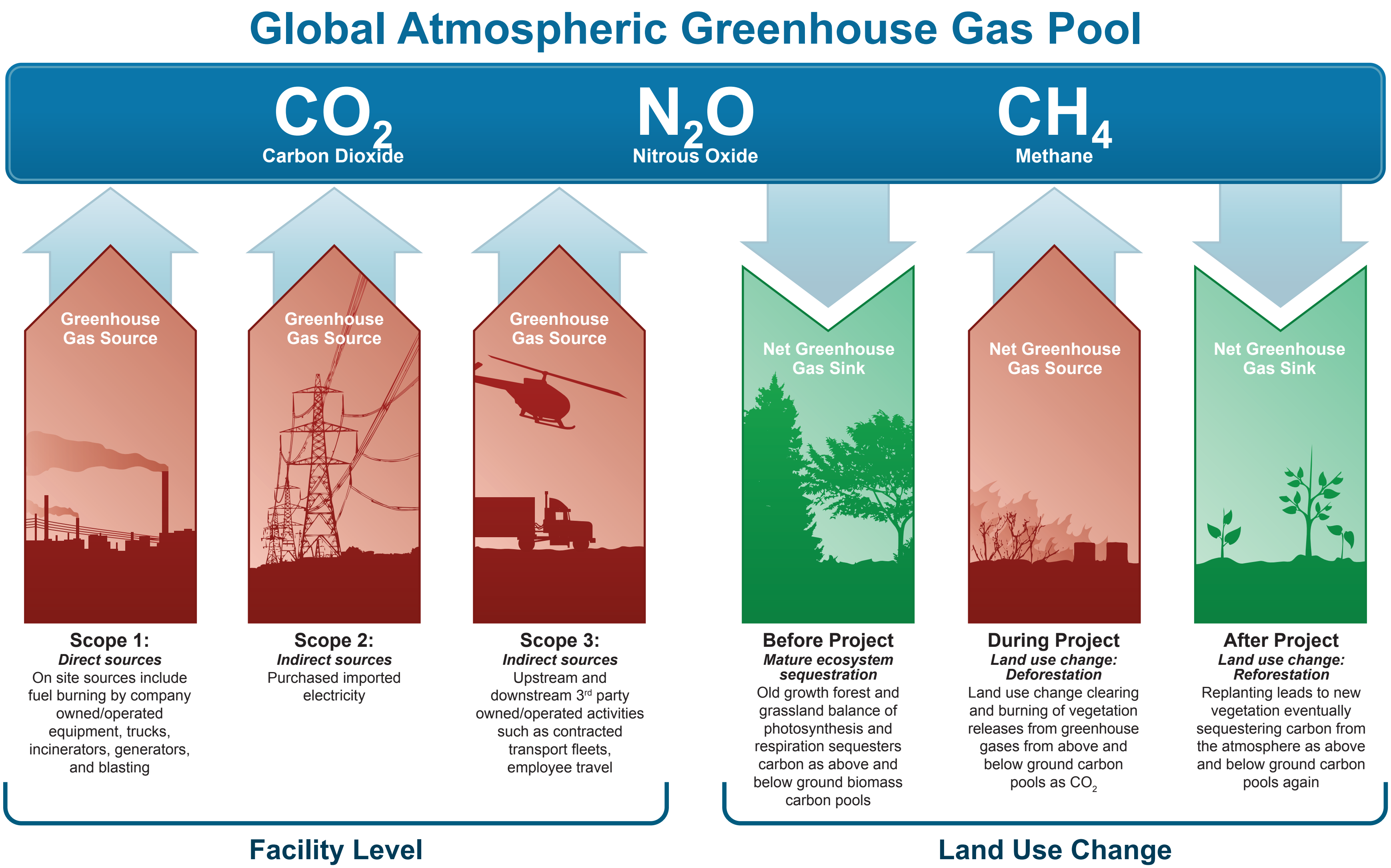
Because Project GHG emissions enter into a global atmospheric GHG pool, climate effects from GHG emissions will occur globally, over the atmospheric GHG lifetime of 50 to 200 years after emission. Project GHG emissions during different Project phases are described below. Facility-level GHG sources are only assessed during the Construction and Operation phases, as it is expected that facility-level GHG emissions during the Closure and Post-closure phases will be minimal.

12.4.3.1 Construction

During the Construction phase, the Project will emit GHGs though the use of equipment and machinery (both owned and contracted) that rely on petroleum-based fuels. The amount of GHG sinks created by the Project will be reduced by clearing vegetation during the construction of Project components such as those in the mine site area, the Knipple Transfer Area, the Tide Staging Area, the Bowser Aerodrome, and the Brucejack Transmission Line.

Figure 12.4-1

Greenhouse Gas Assessment:
Scoping Framework



12.4.3.2 Operation

During the Operation phase, the Project will emit GHGs though the use of equipment and machinery (both owned and contracted) that rely on petroleum-based fuels. There will also be indirect GHG emissions due to purchased imported electricity (Scope 2) from the provincial power grid.

12.4.3.3 Closure

During the Closure phase, the Project will emit GHGs though the use of equipment and machinery that rely on petroleum-based fuels; however, these emissions will be minimal compared to the Construction and Operation phases. At Closure, GHG sinks will be increased through restoring the land to its initial state by re-vegetating areas previously cleared in the Construction phase, which will help sequester atmospheric GHGs. Such sequestration will extend into the Post-closure phase.

12.5 EFFECTS ASSESSMENT AND MITIGATION FOR CLIMATE

12.5.1 Identifying Key Effects on Climate

The following section summarizes the Project components and activities that will have an adverse effect on climate by means of releasing GHG emissions or by reducing carbon sinks. Components and activities from Table 12.4-1, which were identified to have possible or likely interaction with climate, have been grouped into distinct categories, with their adverse effects on climate ranked in Table 12.5-1.

Components and activities that are expected to emit minimal or negligible amounts of GHGs were assigned an adverse effect rating of minor (green). The amount of GHG emission for these components and activities cannot be accurately quantified and therefore are not further assessed. All other activities were assigned a rating of moderate (yellow) and are quantitatively assessed further in Section 12.6. This table does not list the vegetation restoration activities during the Closure phase which will help return the amount of Project GHG emissions to baseline conditions by sequestration of atmospheric GHGs.

Table 12.5-1. Ranking Potential Effects on Climate

Construction Phase	
Activities at existing adit	● (green)
Air transport of personnel and goods	● (yellow)
Avalanche control	● (green)
Chemical and hazardous material storage, management, and handling	○
Construction of back-up diesel power plant	● (yellow)
Construction of Bowser Aerodrome	● (yellow)
Construction of detonator storage area	● (yellow)
Construction of electrical tie-in to BC Hydro grid	● (green)
Construction of electrical substation at the Brucejack Mine Site	● (yellow)
Construction of equipment laydown areas	● (yellow)
Construction of helicopter pad(s)	● (yellow)
Construction of incinerators	● (yellow)
Construction of Knipple Transfer Area	● (yellow)
Construction of local site roads	● (yellow)

(continued)

Table 12.5-1. Ranking Potential Effects on Climate (continued)

Construction Phase (cont'd)	
Construction of mill building (electrical induction furnace, backfill paste plant, warehouse, mill/concentrator)	🟡
Construction of mine portal and ventilation shafts	🟡
Construction of Brucejack Operations Camp	🟡
Construction of ore conveyer	🟡
Construction of tailings pipeline	🟡
Construction and decommissioning of Tide Staging Area construction camp	🟡
Construction of truck shop	🟡
Construction and use of sewage treatment plant and discharge	🟡
Construction and use of surface water diversions	🟡
Construction of water treatment plant	🟡
Development of the underground portal and facilities	🟡
Employment and labour	⚪
Equipment maintenance/machinery and vehicle refuelling/fuel storage and handling	🟢
Expansion of current exploration camps	🟡
Explosives storage and handling	⚪
Grading of the mine site area	🟡
Helicopter use	🟡
Installation and use of Project lighting	🟢
Installation of surface and underground crushers	🟢
Installation of the transmission line and associated towers	🟢
Machinery and vehicle emissions	🟡
Potable water treatment and use	⚪
Pre-production ore stockpile construction	🟡
Procurement of goods and services	⚪
Quarry construction	🟡
Solid waste management	🟢
Transportation of workers and materials	🟡
Underground water management	⚪
Upgrade and use of exploration access road	🟡
Use of Granduc Access Road	🟡
Air transport of personnel and goods and use of Bowser Aerodrome	🟡
Avalanche control	🟢
Backfill paste plant	⚪
Back-up diesel power plant	🟢
Bowser Aerodrome	⚪
Brucejack Access Road use and maintenance	🟡
Brucejack Operations Camp	⚪
Chemical and hazardous material storage, management, and handling	⚪

(continued)

Table 12.5-1. Ranking Potential Effects on Climate (continued)

Construction Phase (cont'd)	
Concentrate storage and handling	○
Contact water management	○
Detonator storage	○
Discharge from Brucejack Lake	○
Electrical induction furnace	○
Electrical substation	🟢
Employment and Labour	○
Equipment laydown areas	○
Equipment maintenance/machine and vehicle refuelling/fuel storage and handling	🟢
Explosives storage and handling	○
Helicopter pad(s)	○
Helicopter use	🟡
Knipple Transfer Area	🟡
Machine and vehicle emissions	🟡
Mill building/concentrators	○
Non-contact water management	○
Ore conveyer	○
Potable water treatment and use	○
Pre-production ore storage	○
Procurement of goods and services	○
Project lighting	○
Quarry operation	🟢
Sewage treatment and discharge	○
Solid waste management/incinerators	🟢
Subaqueous tailings disposal	○
Subaqueous waste rock disposal	○
Surface crushers	○
Tailings pipeline	○
Brucejack Transmission Line operation and maintenance	○
Truck shop	○
Underground backfill tailings storage	○
Underground backfill waste rock storage	○
Underground crushers	🟡
Underground explosives storage	○
Underground mine ventilation	🟡
Underground water management	○
Underground drilling, blasting, excavation	🟡
Use of Brucejack Mine Site haul roads	🟡
Use of portals	🟢

(continued)

Table 12.5-1. Ranking Potential Effects on Climate (continued)

Construction Phase (cont'd)	
Ventilation shafts	○
Waste rock transfer pad	○
Warehouse	○
Water treatment plant	○
Closure Phase	
Air transport of personnel and goods	●
Avalanche control	●
Chemical and hazardous material storage, management, and handling	○
Closure of mine portals	○
Closure of quarry	●
Closure of subaqueous tailings and waste rock storage (Brucejack Lake)	○
Decommissioning of Bowser Aerodrome	●
Decommissioning of back-up diesel power plant	●
Decommissioning of Brucejack Access Road	●
Decommissioning of camps	●
Decommissioning of diversion channels	●
Decommissioning of equipment laydown	●
Decommissioning of fuel storage tanks	●
Decommissioning of helicopter pad(s)	●
Decommissioning of incinerator	●
Decommissioning of local site roads	●
Decommissioning of mill building	●
Decommissioning of surface crushers	●
Decommissioning of underground crushers	●
Decommissioning of ore conveyer	●
Decommissioning of Project lighting	●
Decommissioning of sewage treatment plant and discharge	●
Decommissioning of surface explosives storage	●
Decommissioning of Brucejack Transmission Line and ancillary structures	●
Decommissioning of waste rock transfer pad	●
Decommissioning of water treatment plant	●
Decommissioning of tailings pipeline	●
Employment and labour	○
Helicopter use	●
Machine and vehicle emissions	●
Procurement of goods and services	○
Removal or treatment of contaminated soils	●
Solid waste management	●
Transportation of workers and materials (mine site and access roads)	●

(continued)

Table 12.5-1. Ranking Potential Effects on Climate (completed)

Post-closure Phase	
Discharge from Brucejack Lake	○
Environmental monitoring	○
Employment and labour	○
Procurement of goods and services	○
Subaqueous tailings and waste rock storage	○
Underground mine	○

Notes:
○ = *No interaction anticipated.*
● = *Negligible to minor adverse effect expected; implementation of best practices, standard mitigation, and management measures; no monitoring required, no further consideration warranted.*
● = *Potential moderate adverse effect requiring unique active management/monitoring/mitigation; warrants further consideration.*
● = *Key interaction resulting in potential significant major adverse effect or significant concern; warrants further consideration.*

12.5.2 Mitigation Measures for Climate

Project GHG emission mitigation includes ways to avoid, control, reduce, and offset facility-level and land-use change GHG emissions. The GHG mitigation hierarchy in Figure 12.5-1 illustrates the ideal approach to reduce GHG emissions starting with avoidance, then reduction, replacement, enhancement, and finally offsetting of GHG emissions. The actions at the bottom of the hierarchy are the most effective at reducing a project's GHG emission profile. Avoidance, reduction, and replacement activities involve reducing fuel and energy consumption and are also typically cost saving as well. Enhancement includes replanting activities to re-establish vegetation that will sequester carbon from the atmosphere. Offsetting remaining GHG emissions that cannot otherwise be mitigated is not currently required by law, but may be required in the future. Offsetting can involve either purchasing offsets or by creating them through development of additional offset projects. GHG emission management and mitigation measures are included as part of Section 29.2, Air Quality Management and Monitoring Plan.

The major source of GHG emissions associated with the Project will be from facility-level (Scope 1 to 3) emissions from the fuel/energy needs of the Project. The Mining Association of Canada (Stratos 2009b), states that over 95% of the GHG emissions generated directly by the mining industry are a result of fossil fuel use. Therefore, controlling fuel use will result in the most significant GHG emissions reductions, as well as reduced expenses. In addition, decreasing the variability of energy use and improving operating and maintenance practices can reduce energy costs and in most cases do not require a capital expenditure.

There will be zero net GHG emissions associated with land-use change because all Project-converted land, which was previously vegetated will be reclaimed via re-vegetation during the Closure phase, as described in Chapter 30, Closure and Reclamation. This re-vegetated land will return to its original GHG sequestering capability in the long term.

The Project's GHG mitigation strategies that will be used during each phase are summarized in Table 12.5-2 below. A more detailed description of GHG management and mitigation strategies is included as part of Section 29.2, Air Quality Management Plan.

Figure 12.5-1

Conceptual Greenhouse Gas Mitigation Hierarchy

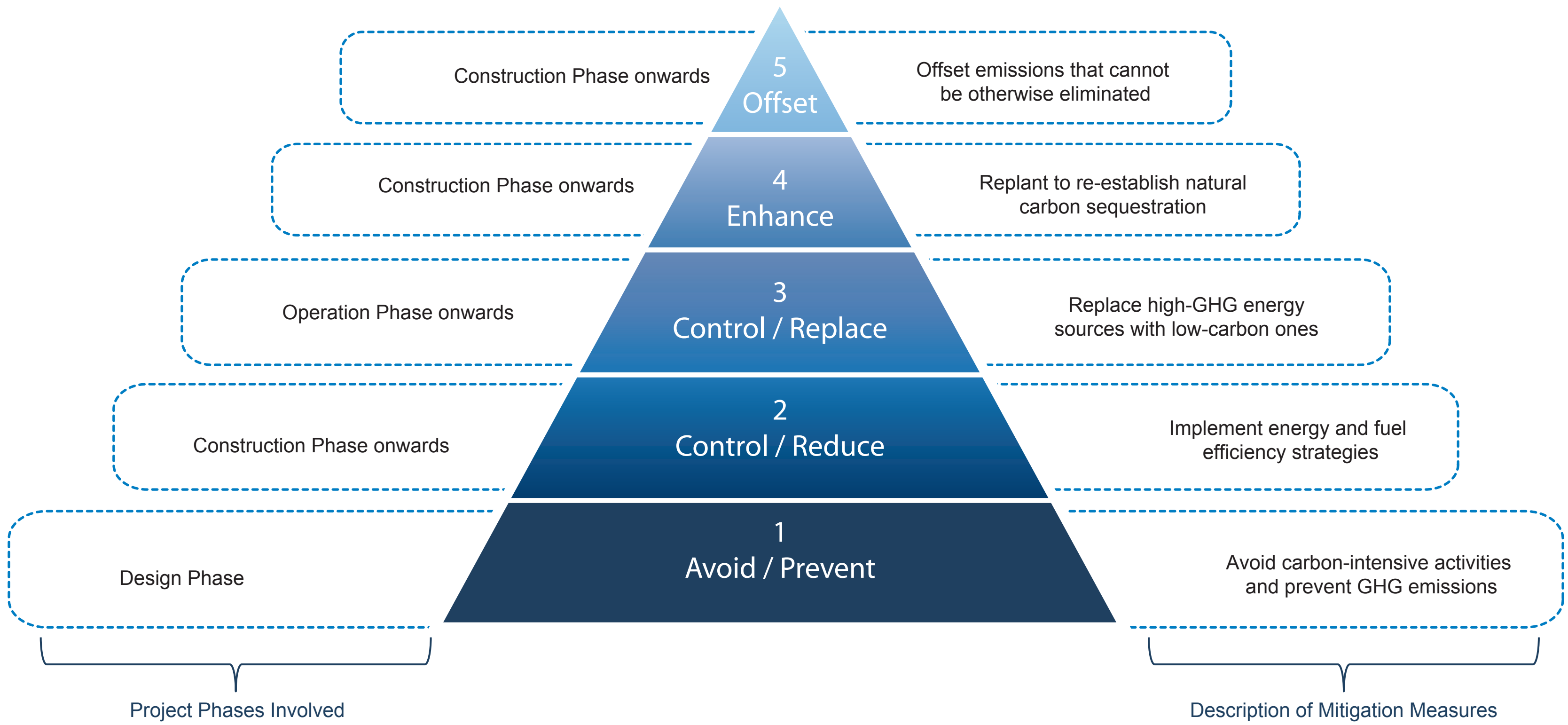


Table 12.5-2. Summary of Brucejack Gold Mine Project Greenhouse Gas Mitigation Strategies

Type of Mitigation	Mitigation Hierarchy	Strategies Used
Alternatives and Design Changes	Avoid/Prevent, Reduce	• Removal of the previously planned Wildfire leach plant site and tailings storage facility from the project design/plan. Results in reduced Scope 1, 2, and 3 emissions, and reduced land-use change. • Backfill of waste rock and tailings to the extent practical to reduce storage of waste material on surface. Results in reduced land-use change. • Subaqueous deposition of waste rock and tailings for waste material that cannot be stored in underground. Results in reduced land-use change. • Reuse of areas previously disturbed by historical activity including the Knipple Transfer Area and Bowser Aerodrome. Results in reduced land-use change. • Preference for non-local employees transportation to site by air (into Bowser Aerodrome) to reduce traffic along the access road. Results in reduced Scope 1 and 3 emissions. • Source majority of power requirements from BC Hydro grid rather than relying on diesel generators. Results in reduced Scope 1 emissions. • Transmission line design (tower/foundation type) that would limit the amount of ground-based access for construction and operations, limiting the need for new access roads. Results in reduced Scope 1 and 3 emissions, and reduced land-use change.
Management Practices	Avoid/Prevent, Control/Reduce	• Management practices that promote fuel and energy efficiency such as: • procuring fuel-efficient engine models; • performing regular equipment maintenance; • implementing operator/driver training; • reducing downtime power use where possible; and • designing buildings for energy efficiency and heat conservation.
Monitoring and Adaptive Management	Control/Reduce	• Conduct fuel and energy monitoring/audits. • Implement audit recommendations. • Conduct GHG assessments per provincial and federal reporting and verification requirements.
Enhancement	Enhance	Lower land-use change GHG emissions by: • minimizing land clearing; and • maximizing replanting.
Compensation	Offset	If a GHG cap and trade system is legislated during the life of the Project, and the Project does not meet the cap, the Project owner may: • meet caps directly through implementing GHG emissions reductions; • generate offsets to apply to its carbon footprint through implementing on-site carbon offset projects; and • purchase approved amounts of carbon offsets.

12.6 RESIDUAL EFFECTS ON CLIMATE

The following section contains the Project's GHG residual effects assessment on climate for facility-level GHG emission sources, after applying mitigation measures. As discussed in the previous section, all vegetated land used by the Project will be reclaimed to its original state in the long term, resulting in zero net land-use GHG emissions; therefore, land-use change GHG emissions will not be discussed further.

Table 12.6-1 summarizes the adverse residual effects on the climate, using the adverse effects ranked in Table 12.5-1, which were determined to have a moderate adverse residual effect.

Table 12.6-1. Summary of Residual Effects on Climate

Project Phase (timing of effect)	Project Component / Physical Activity	Description of Cause-Effect[1]	Description of Mitigation Measure(s)	Description of Residual Effect
Construction	Camp incinerators and generators	GHG emissions from each component/activity incrementally increases atmospheric GHG levels	Select generators and incinerators with lower emission rates	Net increase in atmospheric GHG levels
	Mobile transportation of workers and goods		Have GHG management as selection criteria to hire fleet contractors; driver training to minimize emissions	
	Stationary and mobile equipment/vehicles		Procure new equipment/ vehicles with monitoring capabilities when possible, conduct regular maintenance, use GHG mitigation as contractor hiring criteria, and inform operators of engine idling policies.	
Operation	Camp incinerators and generators		Select generators and incinerators with lower emission rates	
	Mobile transportation of workers and goods		Have GHG management as selection criteria to hire fleet contractors; driver training to minimize emissions	
	Purchased and imported electricity		Procure energy efficient equipment; use power-saving management practices to minimize use and maximize efficiency	
	Stationary and mobile equipment/vehicles		Procure new equipment/ vehicles with monitoring capabilities when possible, regular maintenance, use GHG mitigation as contractor hiring criteria, train operators	

[1] *"Cause-effect" refers to the relationship between the Project component/physical activity that is causing the change or effect in the condition of the intermediate component, and the actual change or effect that results.*

12.6.1 Facility-level Greenhouse Gas Emissions

12.6.1.1 Facility-level Greenhouse Gas Emissions Calculation Methodology

The GHG assessment for the Project uses facility-level activity data including stationary and mobile machinery/equipment use (Scope 1), imported electricity use (Scope 2) and third-party transportation of workers and goods (Scope 3).

The following subsections discuss facility-level GHG emissions, as well as a comparison of estimated Project GHG emission levels to that of other projects.

The number of pieces of on-site machinery and equipment as well as their GHG emission rates were sourced from the Chapter 7, Air Quality Predictive Study, which used the United States Environmental Protection Agency (US EPA) NONROAD model (US EPA 2010) along with information provided by Tetra Tech and AMC Consultants to determine the GHG emission rates. GHG emissions were also estimated for the generator at the Tide Staging Area during construction.

The amount of imported electricity was estimated from the Project's feasibility study to be 20 MW with an emissions factor of 25 t CO_2e per GWh. This emissions factor corresponds to a three-year average of BC Hydro's domestic supply GHG intensities from 2008 and 2010, and it is recommended for use in BC for public reporting (BC MOE 2012a).

The number of third-party transportation trips to and from the Project site using equipment such as various haul trucks and passenger vehicles was sourced from Chapter 5, Project Description. The emission factors for these vehicles were calculated from the US EPA MOVES model (US EPA 2012). The total amount of GHG emissions were calculated based on the number of annual trips per year, the distance travelled (estimated to be 55 km from the Knipple Transfer Area to Highway 37) and the emissions factor.

Global warming potential factors, defined as 1 for CO_2, 21 for CH_4, and 310 for N_2O, respectfully, were used to convert all individual GHGs emission factors to CO_2e.

12.6.1.2 Facility-level Greenhouse Gas Emission Calculation Results

Facility-level Scopes 1, 2, and 3 GHG emissions for the Project during Construction and Operation are presented in Table 12.6-2. As shown in the table, most of the estimated emissions are from direct sources (Scope 1) during both the Construction and Operation phases, 61,908 and 31,400 t CO_2e/year, respectively. This is in agreement with other reports, which indicate that over 95% of GHG emissions in the mining sector result from energy use, whether from fuel or electricity (Stratos 2009a). The majority of emissions occur during the Construction phase as that is when the majority of mobile and stationary equipment and machinery will operate, such as the electrical generators and all construction equipment.

Table 12.6-2. Brucejack Gold Mine Project Facility-level Greenhouse Gas Emissions

Phase	Averaging Period (Years)	GHG Emissions Source	Average GHG Emissions (t CO_2e/year)
Construction	2	Scope 1	61,908
		Scope 2	0
		Scope 3	201
		Total	**62,109**
Operation	22	Scope 1	31,400
		Scope 2	4,380
		Scope 3	313
		Total	**36,093**
Total Annual Average	**24**	Scope 1	33,943
		Scope 2	4,015
		Scope 3	303
		Total	**38,261**

Note: values may not add up due to rounding.

Scope 2 GHG emission sources are expected to generate 4,380 t CO_2e/year, due to electricity production during the Operation phase. Although the Brucejack Transmission Line will be commissioned at some point during the Construction phase, Scope 2 emissions were not included in the Construction phase GHG emission calculations. For calculation purposes it was assumed that only the Construction phase would be powered by on-site diesel generators, resulting in a more conservative GHG emission estimate as on-site generators produce more emissions per kWh compared to imported electricity from the provincial grid.

Scope 3 GHG emission sources are expected to generate 201 and 313 t CO_2e/year during the Construction and Operation phases, respectively. It is expected that there will be more GHG emissions during the Operation phase compared to the Construction phase due to the higher traffic volumes, primarily related to concentrate hauling during operations.

Averaged over the combined 24-year construction and operation period, it is estimated that the Project will emit 38,261 t CO_2e/year. Provincial and national reporting requirements (discussed in Section 12.2.1) state that Scope 1 annual GHG emissions over 10,000 t CO_2e/year be reported to the BC MOE, GHG emissions over 25,000 t CO_2e/year be verified by a third party and reported to the BC MOE, and that GHG emissions over 50,000 t CO_2e/year be verified by a third party and be reported to the BC MOE as well as Environment Canada (see Section 12.2.1 for more details). During the Construction phase, it is expected that Scope 1 Project GHG emissions will need to be verified by a third party and reported to the BC MOE and Environment Canada. During the Operation phase, it is expected that Scope 1 Project GHG emissions will need to be verified by a third party and be reported to the BC MOE.

12.6.2 Comparison of Project Greenhouse Gas Emission Levels

The following section compares the estimated Project GHG emissions to provincial, national, and international GHG emission totals, as well as to other mines, as a proxy for assessing the level of effect the Project GHG emissions will have on the atmosphere. This is commonly done against provincial, national, and sector profiles in environmental assessments as recommended by guidance documentation (CEA Agency 2003); however, this assessment also includes an international inventory comparison, as this is considered to be more representative of the actual global GHG atmospheric scale involved.

12.6.2.1 Provincial, National, and International Comparison of Project Greenhouse Gas Emissions

A comparison of estimated Project emissions to the latest publically available year totals for provincial, national, and international emissions is presented in Table 12.6-3. Provincial, national, and international GHG emissions were previously discussed in Section 12.3.2.

Table 12.6-3. Comparison of Brucejack Gold Mine Project to Provincial, National, and International Direct Facility-level Greenhouse Gas Emissions

Comparison Source of GHG Emissions	Annual Direct Facility-level GHG Emissions (t CO_2e)		Brucejack Gold Mine Project Emission Comparison (%)
	Comparison	Brucejack Gold Mine Project	
International Total (2010)	31,350,455,000[a]	33,943	0.0001
Canadian Total (2011)	614,791,000	33,943	0.006
BC Total (2011)	59,100,000	33,943	0.06

[a] *Emissions from CO_2 only*

Project GHG emissions are considered to be negligible compared to global GHG emissions. The Project's estimated average annual emissions of 38,261 t CO_2e are roughly 0.0001% of the most recent global total estimate of anthropogenic CO_2 emissions. The comparison to international totals is considered to be conservative, as the international GHG totals account only for CO_2, while the Project total accounts for methane and nitrous oxide emissions as well as Scope 2 and 3 emissions.

Also shown in Table 12.6-3, the anticipated average annual Scope 1 GHG emissions of the Project are about 0.006% of the total national emissions and about 0.06% of the total provincial emissions.

12.6.2.2 Sector Comparison

GHG emission intensities measured against ore production provide a relatively standardized way to compare GHG emissions from projects with different production rates. The total average annual Scope 1 facility-level GHG emissions from the Project over the combined Construction and Operation phases, is anticipated to be about 33,943 t CO_2e/year, and the ore production rate is expected to be 2,700 t/d, resulting in an emissions intensity of 34.4 t CO_2e/kt ore to mill. Table 12.6-4 provides an industry comparison of the Project's facility-level emissions against those reported or estimated by other BC mines.

The estimated Project GHG emissions are the second lowest out of any compared project; however, the emission intensity is one of the highest due to the relatively low ore production rate compared to the other projects. Underground mining requires relatively higher energy consumption than open pit mining. If the Project's GHG emission intensity were based on valuable metal production instead of raw ore production, its intensity would be much lower compared to other mine projects. In general, emission intensities for the coal mining sector are much higher than metal mining, 39 to 242 t CO_2e/kt raw coal (Teck Coal Limited 2011), compared to metal mines; therefore, the Project's estimated GHG emission intensities are considered to be in the range of the industry norm for the mining sector.

Table 12.6-4. Brucejack Gold Mine Project and other British Columbia Metal Mining Project Greenhouse Gases

Project Name	Project Type	Mining Technique	Status	Production Rate (t/d)	Direct Facility Emissions (t CO_2e/year)	Emission Intensity (t CO_2e/kt Ore to Mill)
Red Chris	Copper/Gold/Silver	Open pit	In construction	27,500	297,172[1]	29.6
Teck Highland Valley Copper Partnership	Copper/Molybdenum	Open pit	Operating	115,847	180,396[2]	4.3
KSM Project	Copper/Gold/ Molybdenum/Silver	Open pit and underground	Under EA review	130,000	164,725[3]	3.5
Galore Creek	Copper/Gold/Silver	Open pit	Care and maintenance	65,000	121,300[4]	5.6
Mt. Milligan	Copper/Gold	Open pit	In construction	60,000	85,556[5]	3.9
Gibraltar Mine	Copper/Molybdenum	Open pit	Operating	50,000	54,687[2]	3.0
Mount Polley Mine	Copper/Gold	Open pit and underground	Operating	20,000	45,291[2]	6.2
Kitsault	Molybdenum	Open pit	Under EA review	45,000	35,845[6]	2.2
Brucejack Gold Mine Project	**Gold/Silver**	**Underground**	**Future proposed**	**2,700**	**33,943**	**34.4**
Myra Falls	Zinc/Lead/Copper	Underground	Operating	46.6 (concentrate)	13,606[7]	800 (t CO_2e/kt concentrate)

Sources: [1] Red Chris Development Company Ltd. (2004); [2] Environment Canada (2012); [3] Rescan (2013a); [4] Rescan (2006); [5] AMEC (2008); [6] AMEC (2012); [7] Nyrstar (2011)
Notes: '-' = not available; PD = Project Description

12.7 CHARACTERIZING RESIDUAL EFFECTS, SIGNIFICANCE, LIKELIHOOD, AND CONFIDENCE ON CLIMATE

Due to the global scale involved with GHGs, in order to determine a more useful proxy to assign significance to the residual effects of GHGs emitted by the Project on climate, various descriptors are used to rank the level of effects of the Project on atmospheric GHGs, which are presented in Table 12.7-1. These descriptors specifically pertain to the direct, measureable effect on atmospheric GHG levels by comparing to international, national, provincial, and industry sector profiles as a proxy for assessing climate effects.

12.7.1 Residual Effects Characterization for Climate

Using the residual effects characterization definitions in Table 12.7-1, the residual effect of the Project on climate has been characterized in Table 12.7-2 along with the likelihood, significance, and confidence. This residual effect of increasing atmospheric GHG levels includes the facility-level components and activities during the Project Construction and Operation phases.

Table 12.7-1. Definitions of Characterization Criteria for Residual Effects on Climate

<table>
<tr><td>Magnitude</td><td>Minor:
The magnitude of effect differs from baseline conditions such that GHG emissions increase by less than the Environment Canada reporting requirement threshold (50,000 t CO_2e/year) and are less than the 75th percentile of other BC metal mining project emissions (about 170,000 t CO_2e/year)[1].
Moderate:
The magnitude of effect differs from baseline conditions such that GHG emissions increase by less than the Environment Canada reporting requirement threshold (50,000 t CO_2e/year) and are greater than the 75th percentile of other BC metal mining project emissions (about 170,000 t CO_2e/year)[1].
OR
The magnitude of effect differs from baseline conditions such that GHG emissions increase by greater than the Environment Canada reporting requirement threshold (50,000 t CO_2e/year) and are less than the 75th percentile of other BC metal mining project emissions (about 170,000 t CO_2e/year)[1].
Major:
The magnitude of effect differs from baseline conditions such that GHG emissions increase by greater than the Environment Canada reporting requirement threshold (50,000 t CO_2e/year) and are greater than the 75th percentile of other BC metal mining project emissions (about 170,000 t CO_2e/year)[1].
<table>
<tr><td></td><td colspan="4">Project’s Annual Direct Facility-level GHG Emissions</td></tr>
<tr><td>Environment Canada reporting requirement threshold (50,000 t CO_2e/year)</td><td>Project less than</td><td>Project less than</td><td>Project greater than</td><td>Project greater than</td></tr>
<tr><td></td><td>and</td><td>and</td><td>and</td><td>and</td></tr>
<tr><td>75th percentile of other BC metal mining project emissions (about 170,000 t CO_2e/year)[1]</td><td>Project less than</td><td>Project greater than</td><td>Project less than</td><td>Project greater than</td></tr>
<tr><td>Magnitude Rank:</td><td>Minor</td><td>Moderate</td><td>Moderate</td><td>Major</td></tr>
</table>
[1] Assuming a normal distribution of the annual GHG emissions from the projects listed in Table 12.6-4, excluding the Brucejack Gold Mine Project.</td></tr>
<tr><td>Duration</td><td>Short term: An effect that lasts approximately 1 to 5 years.
Medium term: An effect that lasts between 6 to 25 years.
Long term: An effect that lasts between 26 and 50 years.
Far Future: An effect that lasts more than 50 years.</td></tr>
<tr><td>Frequency</td><td>Once: An effect that occurs once during any phase of the Project.
Sporadic: An effect that occurs at sporadic or intermittent intervals during any phase of the Project.
Regular: An effect that occurs regularly during any phase of the Project.
Continuous: An effect that occurs constantly during any phase of the Project.</td></tr>
<tr><td>Geographic Extent</td><td>Local: An effect that is limited to the immediate air column directly above the Project footprint (i.e., within about a 100 m buffer).
Landscape: An effect that extends beyond the Project footprint to a broader watershed area.
Regional: An effect that extends across the regional study area.
Beyond Regional: An effect that extends possibly across or beyond the province of BC.</td></tr>
</table>

(continued)

Table 12.7-1. Definitions of Characterization Criteria for Residual Effects on Climate (completed)

Reversibility	Reversible Short term: An effect that can be reversed relatively quickly. Reversible Long term: An effect that can be reversed after many years after activities cease. Irreversible: An effect that cannot be reversed (i.e., is permanent).
Resiliency	Low: The receptor is considered to be of low resiliency following disturbances. Neutral: The receptor is considered to be moderately resilient following disturbances. High: The receptor is considered to be highly resilient following disturbances.
Ecological Context	Low: The receptor is considered to have little to no unique attributes. Neutral: The receptor is considered to have some unique attributes. High: The receptor is considered to be unique.

As indicated in Section 12.6.2, the expected Project GHG emissions are below most other comparable mining sector projects in BC, indicating that it is below the mining sector norm. Project GHG emissions are also far below international, national, and provincial emissions. Therefore, the magnitude of the residual effect is ranked as minor.

Once emitted, the life-span of atmospheric CO_2 in the global GHG pool is 50 to 200 years; therefore, Project GHG emissions will continue to contribute to the global atmospheric GHG pool long after Project emissions have stopped, and thus the duration of the residual effect is ranked as far future. Because GHG emissions collect in an unbound global pool, the geographic extent of the residual effect is ranked as beyond regional.

Although some GHG emissions will be sporadic or relatively instantaneous from some Project activities, other emissions will be relatively constant such as for electricity generation. Therefore, the residual effect frequency has been ranked as continuous.

Natural carbon sinks will eventually remove the Project GHG emissions over a long time; hence, the reversibility of the residual effect was ranked as reversible long term. Note that Project emissions can be reversed in a relatively shorter time through the implementation of carbon offset projects involving sequestration.

The climate and atmosphere will not be substantially affected by the increase in Project GHG emissions due to the very large atmospheric GHG pool; therefore, the resiliency and context of the climate VC was ranked as neutral.

12.7.1.1 Likelihood for Residual Effects on Climate

The likelihood of a residual effect occurring is calculated as a measure of probability, to determine the potential for the Project to cause effects. The likelihood of a residual effect does not influence the determination of significance, rather it influences the risk of an effect occurring. Likelihood has been considered here in keeping with the most recent guidance issued in September 2013 by the BC EAO (2013): *Guideline for the Selection of Valued Components and Assessment of Potential Effects.*

The assessment chapter only assesses GHG emissions and not their impacts on climate. The likelihood that there will be a rise in atmospheric GHG levels due to Project emissions is definite: GHGs will be emitted through fuel burning and land-use change activities of the Project, adding to the global atmospheric pool. Therefore, the likelihood ranking is rated as high for both the Construction and Operation phases.

Table 12.7-2. Characterization of Residual Effects, Significance, Confidence, and Likelihood on Climate

Residual Effects	Evaluation Criteria							Likelihood *(low, medium, high)*	Significance of Adverse Residual Effects *(not significant; significant)*	Confidence *(low, medium, high)*
	Magnitude *(low, moderate, high)*	**Duration** *(short-term, medium-term, long-term, far future)*	**Frequency** *(once, sporadic, regular, continuous)*	**Geographic Extent** *(local, landscape, regional, beyond regional)*	**Reversibility** *(reversible short-term; reversible long-term; irreversible)*	**Resiliency** *(low, neutral, high)*	**Context** *(low, neutral, high)*			
Rise in atmospheric GHG levels	Low	Far future	Continuous	Beyond regional	Reversible long term	Neutral	Neutral	High	Not significant	High

12.7.1.2 Significance of Residual Effects on Climate

Based on the residual effects characterization performed in the previous section, a significance conclusion of not significant has been assigned to the residual effect (rise in atmospheric GHG levels) on climate. The rationale for this significance determination is due to the low magnitude of Project GHG emissions, which will not cause a detectable change within the global atmospheric GHG pool. Also, the amount of expected Project GHG emissions will be small compared to GHG emissions from other mining projects in the province.

12.7.1.3 Characterization of Confidence for Residual Effects on Climate

Confidence, which can also be thought of as scientific uncertainty, is a measure of how well residual effects are understood. The predicted residual effects were assessed for their reliability to portray the certainty in the predicted outcome, based on the acceptability of the data inputs and analytical methods used in the characterization.

The assessment chapter only assesses GHG emissions and not their impacts on climate. The confidence ranking for the atmospheric rise in GHGs levels is rated as high for both the Construction and Operation phase, because the cause-effect relationship is well understood (as described in Section 12.3).

12.8 SUMMARY OF RESIDUAL EFFECTS AND SIGNIFICANCE FOR CLIMATE

As determined by the assessment for both facility and land-use change GHG emissions, the total average annual GHG emissions from the Project over the combined Construction and Operation phases is rated as **not significant**. Emissions during the Closure and Post-closure phases were deemed negligible and screened out during the scoping process. The rating of not significant for the Construction and Operation phases is due to the Project's annual average GHG emissions over both phases not exceeding the national reporting requirement threshold and being relatively low compared to other mining projects in the province. Project GHG emissions are also considered to be negligible when compared to global, national, and provincial anthropogenic GHG emissions; however, Project GHG emissions will be additive with those across the globe, incrementally contributing to elevated GHG levels in the atmosphere and consequent amplification of the greenhouse effect. Table 12.8-1 summarizes the residual effects, mitigation, and significance on climate.

Table 12.8-1. Summary of Residual Effects, Mitigation, and Significance on Climate

Residual Effects	Project Phases	Mitigation Measures	Significance
Rise in atmospheric GHG levels	Construction	Fuel efficiency	Not Significant
Rise in atmospheric GHG levels	Operation	Fuel and energy efficiency	Not Significant

12.9 CUMULATIVE EFFECTS ASSESSMENT FOR CLIMATE

Project GHG emissions will be cumulative to the global atmospheric pool, along with provincial, national, and international GHG emissions; however, a cumulative effects assessment was not conducted due to the negligible value of Project GHG emissions compared to aggregate world emissions and the difficulty in apportioning sources that contribute to climate change at the global scale.

12.10 EFFECTS ASSESSMENT CONCLUSIONS FOR CLIMATE

The Project will emit GHG emissions throughout its lifetime due to fuel and energy requirements as well as land-use change. GHG emissions will primarily occur during the Construction and Operation phases and will be negligible during the Closure and Post-closure phases. Construction and Operation emissions have been compared against the national and provincial reporting thresholds, as well as against mining sector norms in BC, in order to determine the significance of the effects of a rise in global atmospheric GHG levels on the climate due to Project GHG emissions. This comparative method is consistent with guidance by the CEA Agency (2003) and the majority of Canadian environmental assessments as an alternative to assessing the cumulative effects of project GHG emissions.

The result of this assessment is that the Project is estimated to emit an annual average of about 62 kt CO_2e/year during the Construction phase and about 36 kt CO_2e/year during the Operation phase at the facility-level (Scopes 1 to 3). Land-use change is estimated to result in zero net GHG emissions after mitigation is applied. The estimated facility-level residual GHG emissions are considered to be negligible when compared to international, national, and provincial anthropogenic GHG emission levels, and are considered to be low when compared to industry norms for metal mining. Therefore, the residual effect on climate of increasing atmospheric GHG levels is rated as **not significant** for the Construction and Operation phases, as summarized in Table 12.10-1.

Table 12.10-1. Summary of Project Residual Effects, Mitigation, and Significance for Climate

Residual Effects	Project Phases	Mitigation Measures	Significance of Residual Effects	
			Project	Cumulative
Rise in atmospheric GHG levels	Construction	Fuel and energy efficiency. Complete re-vegetation during closure, for any area cleared of vegetation.	Not significant	n/a
Rise in atmospheric GHG levels	Operation	Fuel and energy efficiency. Complete re-vegetation during closure, for any area cleared of vegetation.	Not significant	n/a

n/a = not applicable: cumulative effects assessment is not possible for Project level GHG emissions (CEA Agency 2003)

Although Project GHG emissions have been assessed as minor compared to the global atmospheric pool, it is expected that the Project will emit enough Scope 1 facility-level GHGs during the Construction phase (62 kt CO_2e/year) to require reporting to Environment Canada and the BC MOE, as well as having them verified by a third party. During the Operation phase, it is expected that the Scope 1 facility-level GHG emissions (31 kt CO_2e/year) will only need to be reported to the BC MOE and verified by a third party. GHG emissions can be reported to both Environment Canada and the BC MOE through the online Single Window reporting system (BC MOE 2011).

The Proponent will continue to monitor and mitigate the Project GHG footprint over the Project life through implementing fuel and energy efficiency improvements and other measures as outlined in Section 29.2, Air Quality Management Plan.

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