34. Federal Cumulative Effects Assessment

34.1 INTRODUCTION

This chapter describes the methodology and outcome of the Cumulative Effects Assessment (CEA) for the Brucejack Gold Mine Project (the Project) Application for an Environmental Assessment Certificate/Environmental Impact Statement (Application/EIS). Summaries of the residual cumulative effects and significance determinations for each intermediate and receptor Valued Component (VC) are consolidated in this chapter to meet the requirements of the *Canadian Environmental Assessment Act, 2012* (CEAA; 2012) as directed by the Canadian Environmental Assessment Agency (CEA Agency). Cumulative effects assessment is also a requirement of the provincial Application for Information Requirements (AIR; BC EAO 2014) and the federal EIS Guidelines and it is thus necessary for the proponent, Pretium Resources Inc. (Pretivm), to comply with both the British Columbia (BC) *Environmental Assessment Act* (2002a) as well as the CEAA.

Cumulative effects are defined in this Application/EIS as "effects which are likely to result from the designated project in combination with other projects and activities that have been or will be carried out." This definition follows that in section 19(1) of the CEAA (2012) and is consistent with the International Finance Corporation Good Practice Note on Cumulative Impact Assessment (ESSA Technologies Ltd. and IFC 2012) which refers to consideration of other existing, planned, and/or reasonably foreseeable future projects and developments.

The potential for cumulative effects arises when the residual effects of a project affect (i.e., overlap and interact with) the same resource/receptor that is affected by the residual effects of other past, present, or reasonably foreseeable future projects or activities. The CEA considers the potential environmental, economic, health, social, and heritage cumulative effects of the Project on both intermediate components and receptor VCs. Intermediate components are specific attributes of the biophysical environment that, if affected (i.e., if there is a positive or negative change in the baseline condition), act as a pathway to pass on those changes to receptor components (thereby also having the potential to affect or change the baseline condition of a receptor component). Where a receptor component is perceived as important by the public, scientists, government agencies, Aboriginal groups, or other stakeholders, these are referred to as receptor VCs.

Full details of the assessments of cumulative effects for both intermediate components and receptor VCs are provided in Chapters 7 to 25 to address provincial requirements. A summary of these CEAs is provided in this chapter to address federal requirements.

34.2 METHODS

The CEA Agency issued an Operational Policy Statement in May 2013 entitled *Assessing Cumulative Environmental Effects under the Canadian Environmental Assessment Act 2012* (CEA Agency 2013) that provides a method for undertaking CEA. Recently the British Columbia Environmental Assessment Office (BC EAO) also released the updated *Guideline for the Selection of Valued Components and the Assessment of Potential Effects* (BC EAO 2013), which includes advice for determining the need for a cumulative impact assessment. The CEA methodology adopted in this Application/EIS therefore follows the guidance of the CEA Agency, as well as the selection criteria in BC EAO (2013).

The following documents are used to guide the CEA, where applicable:

- *BC EAO User Guide* (BC EAO 2010) for a cumulative effect assessment;
- *Guidelines for the Selection of Valued Components and Assessment of Potential Effects* (BC EAO 2013);
- *Operational Policy Statement: Addressing Cumulative Environmental Effects under the Canadian Environmental Assessment Act, 2012* (CEA Agency 2013);
- *Cumulative Effects Assessment Practitioners' Guide* (Hegmann et al. 1999);
- *A Reference Guide for the Canadian Environmental Assessment Act: Determining Whether a Project is Likely to Cause Significant Adverse Environmental Effects* (Federal Environmental Assessment Review Office 1994); and
- *A Reference Guide for the Canadian Environmental Assessment Act: Assessing Environmental Effects on Physical and Cultural Resources* (CEA Agency 1996).

The CEA methodology for each selected intermediate component and receptor VC follows the key steps laid out below and in Figure 34.2-1:

- scoping;
- analysis;
- identification of mitigation measures;
- identification of residual cumulative effects;
- determination of significance;
- risk assessment; and
- follow-up.

34.2.1 Identifying Intermediate or Receptor Valued Components for the Cumulative Effects Assessment

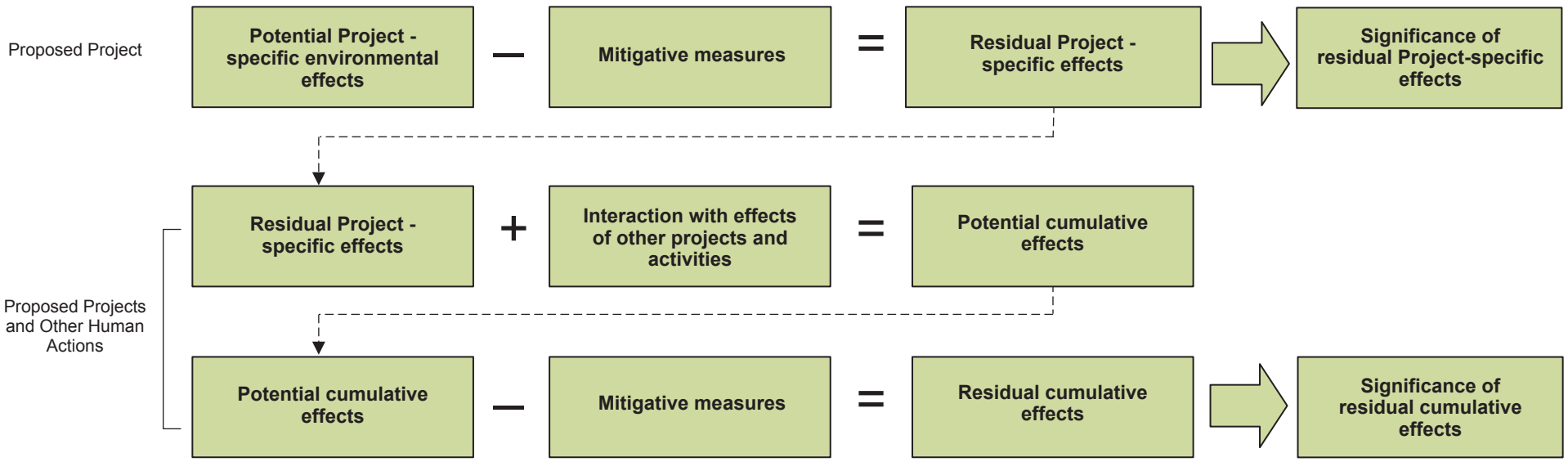
Intermediate or receptor VCs included in the CEA were selected using four criteria following BC EAO (2013):

- there must be a residual change or effect as a result of the Project;
- that the predicted change or effect must be demonstrated to interact cumulatively with residual environmental effects from other projects or activities;
- it must be known that the other projects or activities have been or will be carried out and are not hypothetical; and
- the cumulative environmental effect must be likely to occur.

The residual effects on each intermediate or receptor VC are described in their respective Application/EIS chapters (Chapters 7 to 25). All residual effects identified have been selected for the cumulative effects evaluation, as required under the AIR, and are summarized in this chapter.

Figure 34.2-1

Steps to Cumulative Effects Assessment



34.2.2 Cumulative Effects Assessment Boundaries

The CEA considers the spatial and temporal extent of Project-related predicted changes and residual effects on receptor VCs, combined with the anticipated residual effects from other projects and activities, to assist with analyzing the potential for a cumulative effect to occur.

Spatial Boundaries

Distinct CEA study areas were defined for intermediate components and receptor VCs based on the different spatial scales over which cumulative effects may occur. The spatial scale may be confined to the Project footprint, the assessment footprint, a Local Study Area (LSA), or a Regional Study Area (RSA). A linkage map for each assessment topic was developed, illustrating the areas where effects of the Project on a VC can reasonably be expected to occur. Linkage maps and tables for each assessment topic, where relevant, are presented in the respective Application/EIS chapters with summaries presented in this chapter. Final boundaries are the result of consultation with Aboriginal groups, the BC EAO and CEA Agency as well as other government agencies, and the public and stakeholders.

Temporal Boundaries

The expected timing and duration of Project-related residual effects was compared with the timing of the residual effects of other past, present, and future projects or activities to identify temporal overlap. This process included an assessment of whether past projects or activities affected the current baseline condition of each intermediate component and receptor VC. Figure 34.2-2 portrays the temporal category for each of the projects and/or activities that were considered in the CEA, while Tables 34.2-1 and 34.2-2 provide further details regarding the timing and duration of past, present, and future projects and activities, and which subject areas they potentially have a temporal interaction with.

The phases of the Project form the primary temporal boundaries for the Project-specific effects assessment and, combined with potential effects from other projects and activities, the CEA. The phases of the Project are:

- Construction phase: 2 years;
- Operation phase: 22 years;
- Closure phase: 2 years; and
- Post-closure phase: minimum of 3 years.

The following temporal phases were assessed in the CEA:

- **Past:** The year 1918 is the historical temporal boundary, representing a time when organized mining activity first started to occur in the regional area. Effects of past activities are captured in baseline studies.
- **Present:** This category includes existing projects and activities which are operating or undergoing construction, or those that will be operating concurrently with the Project.
- **Foreseeable Future:** Future temporal boundaries are VC-specific and are based on the predicted length of time it would take for the VC to recover to baseline conditions, if possible. The future boundaries are identified in each VC section below.

Figure 34.2-2
Temporal Overlap between All Other Projects and Activities and the Brucejack Gold Mine Project

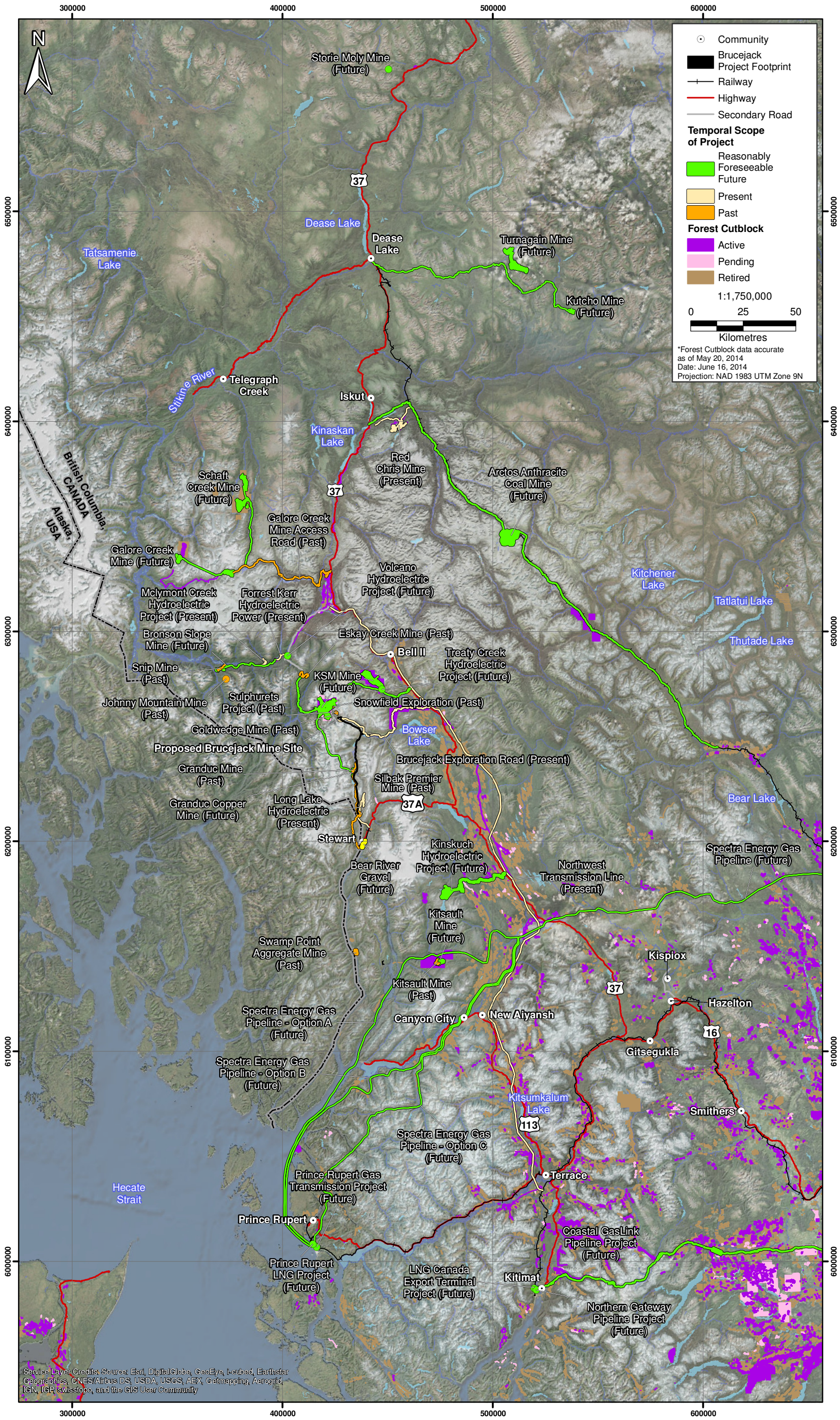


Table 34.2-1. Past, Present and Reasonably Foreseeable Future Projects with the Potential to Interact with the Brucejack Gold Mine Project

	Project Name	Development Type	Company / Organization	Location / Coordinates	Proximity to Project	Infrastructure	Operational Period	Current Regulatory Status
Past	Eskay Creek Mine	Underground mine	Barrick Gold Corporation	56º 39' N 130º 27' W	25 km	Underground works; waste rock and tailings storage in Albino Lake and Tom Mackay Lake; tailings pipeline and access road.	1995 to 2008	Post-closure restoration and monitoring
	Galore Creek Project - access road only	Access road	NovaGold	57° 5' N 131° 6' W	106 km	48-km access road	n/a	EA Certificate issued 2007
	Goldwedge Mine	Underground mine	Catear Resources Ltd.; ceased trading in 1990	56° 29' N 130° 12' W	2 km	Underground works; land and lake waste rock and tailings disposal.	1985 to 1989	Closed
	Granduc Mine	Underground mine	Newmont Mining Corporation Ltd. Esso Resources Canada	56° 12' N 130° 20' W	32 km	Underground works; tunnel; access road; 2,000 tpd mill; concentrator facility.	1971 to 1978 1980 to 1984	Closed; potential for redevelopment
	Johnny Mountain Mine	Underground mine	International Skyline Gold Corp.	56° 37' N 131° 04' W	56 km	Underground works; tailings impoundment; airstrip; road.	1988 to 1990 1993	Closed
	Kitsault Mine	Open pit mine	B.C. Molybdenum, a subsidiary of Kennco Exploration (Western) Ltd. from 1963 to 1972; Climax Molybdenum Company of British Columbia (CMC) and affiliates from 1973 to 1998	55° 25' N 129° 25' W	126 km	Open pit works; waste rock facilities; stockpiles; mill; concentrator; truck shop; haul roads.	1967 to 1972 1981 to 1982	Closed; reclamation completed in 2006; redevelopment being proposed by Avanti Mining Inc.
	Silbak Premier Mine	Open pit/ underground mine	Various companies from 1918 to1996; Westmin Resources Ltd. from 1998 to 1996	56° 03' N 130° 00' W	35 km	Open pit and underground workings; 2,000 tpd mill; buildings; cyanide plant; tailings pond.	1918 to 1953 1953 to 1996 1989 to 1996	Care and Maintenance since 1996; potential redevelopment may be proposed by Ascot Resources Ltd.
	Snip Mine	Mine	Cominco Ltd.; Homestake Canada Inc. (beginning in 1996); and acquired by Barrick Gold Corp. in 2001	56° 40' N 131° 06' W	56 km	Underground works; mill; tailings impoundment; ancillary facilities.	1991 to 1999	Closed and reclaimed in 1999

(continued)

Table 34.2-1. Past, Present and Reasonably Foreseeable Future Projects with the Potential to Interact with the Brucejack Gold Mine Project (continued)

	Project Name	Development Type	Company / Organization	Location / Coordinates	Proximity to Project	Infrastructure	Operational Period	Current Regulatory Status
Past *(cont'd)*	Snowfield Exploration Project	Exploration	Pretium Resources Inc.	56°28' N 130°11'W	7 km	Exploration access roads.	1980s to 2010	Exploration completed, no future activities proposed
	Sulphurets Advanced Exploration Project	Exploration; bulk sample	Newhawk Gold Mines Ltd.	56° 30' N 130° 12' W	0 km	Underground works; waste rock pad.	1986 to 1990	Care and maintenance since 1996; reclaimed in 1999
	Swamp Point Aggregate Mine	Open pit mine	Ascot Resources Ltd.	55° 28' N 130° 02' W	112 km	Sand and gravel pit; ship loading facility; lay down areas; haul roads.	Construction and operation between 2006 and 2008, closed in 2011	EA Certificate issued 2006; closed in 2011
Present	Brucejack Exploration and Bulk Sample Program	Exploration; bulk sample	Pretium Resources Inc.	56° 28' N 130° 11' W	0 km	Reactivation of Newhawk Gold Mines Inc. exploration access road and underground works.	2011-present	Exploration ongoing; Bulk Sample Program Completed
	Forrest Kerr Hydroelectric Power Facility	Hydro	AltaGas Renewable Energy Inc.	56°44' N 130°39' W	41 km	~37.3 km long transmission line; plant site; 8-km access road.	From mid-2014 for 60 years	Construction in progress
	Long Lake Hydroelectric Power Facility	Hydro	Regional Power/ Premier Power Corp	56° 6' N 129° 59' W	42 km	20 m high rock fill dam; 10-km 138 kV transmission line.	From mid-2013 for 80 years	Commenced operation in December 2013
	McLymont Creek Hydroelectric Power Facility	Hydro	AltaGas Renewable Energy Inc.	56° 41' N 130° 47' W	45 km	Access roads; powerhouse; 10-km transmission line.	From end of 2015 for 40 years	EA Certificate issued 2012; Construction in progress
	Northwest Transmission Line	Transmission Line	BC Hydro	Along Highway 37 from Terrace to Bob Quinn Lake	36 km	344-km 287 kV transmission line.	From mid-2014 for 50+ years	EA Certificate issued 2011; Construction in progress
	Red Chris Mine	Open pit mine	Imperial Metals Corp.	57° 42' N 129° 47' W	139 km	Open pit; process plant; waste rock dump; tailings pile; effluent treatment; 23-km access road; 30,000 tpd mill.	28-year mine life / 2014 to 2042	EA Certificate extended in 2010; Construction in progress

(continued)

Table 34.2-1. Past, Present and Reasonably Foreseeable Future Projects with the Potential to Interact with the Brucejack Gold Mine Project (continued)

	Project Name	Development Type	Company / Organization	Location / Coordinates	Proximity to Project	Infrastructure	Operational Period	Current Regulatory Status
Future	Arctos Anthracite Coal Project	Open pit mine	Fortune Coal Ltd.	between 57° 06' N and 57° 23' N; and 128°37' W and 129° 15' W	116 km	Four open pit areas; tailings storage facility; 150 km of new railway.	20-year mine life/ 2017 to 2037	Pre-application stage
	Bear River Gravel Project	Mine	Glacier Aggregates Inc.	55° 56' N 129° 38' W	63 km	Gravel extraction from the Bear River, expanded existing infrastructure; shipping.	20-year mine life / 2020 to 2045	No longer a requirement to complete an EA
	Bronson Slope Project	Open pit mine	Skyline Gold Corp.	56°39' N 131°05' W	60 km	Open pit mine, concentrator plant, tailings storage locations, access road, transmission line; waste storage; and plant site.	20-year mine life / 2019 to 2039	Withdrawn
	Coastal GasLink Pipeline Project	Pipeline	Coastal GasLink Pipeline Ltd.	Groundbirch to Kitimat 54° 1' N 128° 41' W	288 km	650-km long, 48-inch diameter natural gas pipeline; metering facilities, compressor stations, and possibly a natural gas liquid injection facility.	From 2018 for 30+ years	Pre-application stage
	Galore Creek Project	Open pit mine	Galore Creek Mining Corporation (NovaGold and Teck Resources)	57° 13' N 131° 26' W	106 km	Five open pits, waste rock facilities, process plant, 13-km conveyor tunnel, a 71-km slurry pipeline, and an 87-km access road.	18-year mine life / 2018 to 2036	Certified in 2007, re-drafting Project Description
	Granduc Copper-Mine	Underground mine	Castle Resources Inc.	56° 14' N 130° 20' W	32 km	New mill and Tailings Management Facility (TMF), upgrades to the existing 54 km haul road, a power transmission line, and ancillary facilities.	15-year mine life / 2016 to 2031	Not yet in Pre-application stage
	KSM Project	Open pit and Underground mine	Seabridge Gold Inc.	56° 33' N 130° 7' W	4 km	Open pit and underground works; ore processing facilities; TMF; water treatment plant and water storage; rock storage facilities; access roads; 23-km tunnel; transmission lines; hydro plants; permanent accommodations; and other ancillary facilities.	52.5-year mine life / 2020 to 2073	EA review stage

(continued)

Table 34.2-1. Past, Present and Reasonably Foreseeable Future Projects with the Potential to Interact with the Brucejack Gold Mine Project (continued)

	Project Name	Development Type	Company / Organization	Location / Coordinates	Proximity to Project	Infrastructure	Operational Period	Current Regulatory Status
Future *(cont'd)*	Kinskuch Hydroelectric Project	Hydro	Syntaris Power	55° 42' N 129° 19' W	102 km	40-km 138 kV transmission line.	50+ years	Pre-application stage
	Kitsault Mine	Open pit mine	Avanti Kitsault Mining Inc.	55º 25' N 129º 25' W	124 km	Kitsault Pit, a conveyor material handling system, ore stockpile, process plant and camp accommodations, and a TMF.	16-year mine life / 2016 to 2032	EA Certificate issued 2013
	Kutcho Project	Underground and open pit mine	Capstone Mining Corp.	58° 12' N 128° 22' W	223 km	Mostly underground works and some open pit works; underground backfill of tailings and waste.	12-year mine life / 2017 to 2029	Pre-application stage
	LNG Canada Export Terminal Project	LNG	LNG Canada Development Inc.	54° 1' N 128° 41' W	287 km	Natural gas liquefaction facility and marine terminal; supporting infrastructure and facilities.	25+ years / 2020 to 2045+	Pre-application stage
	Northern Gateway Pipeline Project	Pipeline	Enbridge Inc.	54° 1' N 128° 41' W	288 km	Two 1,172-km pipelines, a marine terminal, and associated facilities.	30+ years / 2017 to 2047	EA review stage (joint review panel)
	Prince Rupert Gas Transmission Project	Pipeline	Prince Rupert Gas Transmission Ltd.	54° 12' N 130° 17' W	252 km	750-km sweet natural gas pipeline; metering facilities; compressor stations; access roads; bridges.	40+ years / 2018 to 2058	Pre-application stage
	Prince Rupert LNG Project	LNG	Prince Rupert LNG Ltd.	54° 12' N 130° 18' W	251 km	Liquefied natural gas plant; port; shipping infrastructure.	30-60 years / 2021 to 2051	Pre-application stage
	Schaft Creek Project	Open pit mine	Copper Fox Metals Inc.	130° 58'N 57° W	111 km	Open pit, tailings/PAG waste rock storage facility, camp, and mill.	15-year mine life /2017 to 2032	Pre-application stage
	Spectra Energy Gas Pipeline Project	Pipeline	Spectra Energy Corp.	55° 43' N 126° 16' W	50 km	851 to 872-km pipeline(s); two metering stations; and up to five compressor stations.	2018 – undetermined	Pre-application stage
	Storie Moly Project	Open pit mine	Columbia Yukon Explorations	59°14' 30" N 129°51' 24" W	309 km	Use of existing infrastructure from the former Cassiar Mining camp; new open pit; waste rock and tailings storage facilities.	20-year mine life /2019 to 2039	Pre-application stage
	Treaty Creek Hydroelectric Project	Hydro	Northern Hydro Ltd.	Unknown	25 km	Intake, weir, penstock, powerhouse and tail race, transmission line, access road and laydown area(s).	2015 - undetermined	Unknown

(continued)

Table 34.2-1. Past, Present and Reasonably Foreseeable Future Projects with the Potential to Interact with the Brucejack Gold Mine Project (completed)

	Project Name	Development Type	Company / Organization	Location / Coordinates	Proximity to Project	Infrastructure	Operational Period	Current Regulatory Status
Future *(cont'd)*	Turnagain Project	Open pit mine	Hard Creek Nickel Corp.	58°30' N 128°45' W	235 km	Open pit; waste dumps; 23-km transmission line; process plant; mine service buildings; truck shop; explosives manufacturing facility; tailings and waste rock storage areas.	28-year mine life / 2017 to 2045	Not yet in Pre-application stage
	Volcano Creek Hydroelectric Project	Hydro	AltaGas Ltd.	56° 43' N 130° 35' W	38 km	2.35-km penstock, powerhouse, weir and water intake facilities, 1.2-km 287 kV transmission line interconnection, and short spur roads.	60+ years / 2015 - 2075	Feasibility Study in progress; EA not required

Table 34.2-2. Past, Present and Reasonably Foreseeable Future Activities with the Potential to Interact with the Brucejack Gold Mine Project

Activity Type	Land Users	Description
Parks and Protected Areas	Recreationists	There are four BC Parks facilities within 50 km of the Brucejack Mine Site, namely Bear Glacier, Border Lake, Lava Forks, and Ningunsaw Provincial Parks. The continued conservation and recreational use of these parks is expected to remain unaffected by the proposed Project.
Guide outfitting	Three registered guide outfitting licences	In the past and currently, guide outfitting occurs mostly between late spring and early fall. This activity is expected to continue. Species targeted include black bear, grizzly bear, caribou, deer, moose, mountain sheep, mountain goat, and wolf.
Aboriginal harvest	Skii km Lax Ha, Nisga'a Nation and Tahltan Nation	The traditional land use activities in the region include fishing, hunting, trapping and plant gathering, as carried out by Aboriginal groups in the greater area of the Project and collectively referred to as Aboriginal Harvest.
Hunting	BC residents	Four in-use Wildlife Management units (WMU) exist in the vicinity of the Project. Harvest levels and the number of hunters have fluctuated from year to year. These fluctuations are expected to continue.
Trapping	Six trapping licences	Three of the six traplines overlap the infrastructure of the proposed Project. One is leased and currently in use, another is inactive, and the third is owned by a member of the Ski km Lax ha. Species harvested on the leased trapline include marten, squirrel, beaver, lynx, weasel, mink, otter, and wolverine. Trapping activities occur twice per year, once in the spring and once in the fall. This activity is expected to continue into the future.
Commercial recreation (including fishing)	Eight commercial recreation licences	Two of the eight licences overlap the proposed Project infrastructure. These licences include heli-skiing, lodging, eco-tourism and fishing camps, guided freshwater recreation, guided backcountry expeditions, river rafting, a trapline cabin, angling, and other multiple use licenses. Activities occur during the winter and summer months and are expected to continue.
Forestry	Seven forest licences	The proposed Project overlaps the Cassiar and Nass Timber Supply Areas. There has been historical forest harvesting activities in the vicinity of the proposed Project, but there has been no recent logging activity in the Bob Quinn area. Two of the three licences overlap the proposed Project infrastructure. There is expected to be future forestry activity as a result of declining access costs.
Mineral exploration	Sixty-four entities holding mineral claims	Mineral exploration has occurred in the past and present and is expected to continue in the foreseeable future.
Agricultural Land Reserves	None	There are no known agricultural activities or Agricultural Land Reserves located near the proposed Project.
Oil and Gas	None	There are no known oil and gas tenures located near the proposed Project.
Transportation	Industrial, land users and general public	Transportation activities have occurred in the past and present and are expected to continue into the future. Transportation infrastructure in the vicinity of the proposed Project includes highways 37 and 37A, forest service roads, airstrips, and transmission lines.

34.2.3 Identification of Potential Cumulative Effects

An effect matrix approach was used to select candidate projects/activities, and a list of other historical, existing, and reasonably foreseeable future projects and activities was produced based on consultation comments received from Aboriginal groups, regulatory agencies, the public/stakeholders, and the BC EAO and CEA Agency. All Project-related residual effects were considered and analyzed for the potential to interact cumulatively with selected projects and/or activities. For each intermediate component and receptor VC, the analysis narrows the scope of the CEA to focus only on those projects and activities where there is an anticipated cumulative interaction with the predicted changes and residual effects from the Brucejack Gold Mine Project. A description of the type of cumulative effect that is expected is also provided. Additional mitigation measures to minimize cumulative effects were identified and discussed where applicable.

The design or implementation of future projects and activities may change due to their conceptual nature, leading to uncertainty in predicting the potential for cumulative effects.

34.2.4 Types of Cumulative Effects

Cumulative effects can manifest through a number of cause-effect pathways, including:

- **Physical-chemical transport**. A physical or chemical constituent is transported away from the action under review where it then interacts with another action (e.g., air emissions, waste water effluent, sediment).
- **Nibbling loss**. The gradual disturbance and loss of land and habitat (e.g., clearing of land for new roads into a forested area).
- **Spatial or temporal crowding**. Cumulative effects can occur when there are too many projects or activities within an area in too brief a period of time. A threshold may be exceeded and the environment may not be able to recover to pre-disturbance conditions. This can occur quickly or gradually over a long period of time before the effects become apparent. Spatial crowding results in an overlap of effects among actions (e.g., noise from a highway near multiple mines). Temporal crowding may occur if effects from different actions overlap or occur before a VC has had time to recover.
- **Growth-inducing potential**. Each new action can stimulate further actions to occur. The effects of these "spin-off" actions (e.g., increased vehicle access into a previously remote area lacking roads) may add to the cumulative effects already occurring in the vicinity of the proposed action, creating a "feedback" effect. Such actions may be considered "reasonably-foreseeable actions."

Interacting projects and activities may combine to affect VCs in the following three ways:

- **Additive effect**: increases the effect in a linear way (e.g., two projects both remove foraging habitat for the same moose population).
- **Synergistic effect**: may result in an effect greater than the sum of the two actions (e.g., two projects remove escape habitat for mountain goat, shifting their foraging activities to an area where they are susceptible to increased predation).
- **Induced effect**: may result when an effect stimulates another effect (e.g., construction of road access can stimulate "tie-in" roads for forestry or other projects which may result in additional environmental effects).

34.3 REGIONAL PROJECTS AND ACTIVITIES

Past, present, and reasonably foreseeable future projects and activities that overlap spatially or temporally and have the potential to interact with the Project were considered in the CEA. Table 34.2-1 summarizes

information on the past, present, and reasonably foreseeable future projects with the potential to interact with the Project. The past, present, and reasonably foreseeable future activities are presented separately in Table 34.2-2. These tables have been considered for each of the intermediate components and receptor VC CEAs. Figure 34.3-1 shows the spatial relationship between the Project and all past, present, and reasonably foreseeable future projects and activities. A detailed description of the project or activity including location, physical size, supporting infrastructure, operational period and other available information is provided in Chapter 6, Assessment Methodology.

Projects and activities considered in the CEA are identified as:

- past (closed) projects and activities within the CEA study areas;
- present (active and inactive) projects and activities within the CEA study areas; and
- reasonably foreseeable future projects (not hypothetical) and activities that are likely to occur within the CEA study areas.

Screening criteria were applied to determine whether projects and activities should be included or excluded from the CEA, including some or all of the following considerations:

- a project/activity is within an RSA;
- a project/activity is within a zone of influence of Project effects;
- a project/activity is currently under some type of regulatory review;
- a project/activity is within or the effects overlap with socio-economic influenced areas;
- the specific nature of an effect (i.e., present or potential impact on VC of local or regional concern);
- a project/activity has an effect on migratory species; and
- a high degree of confidence exists that the other project or activity would not interact with the residual effects of the Project.

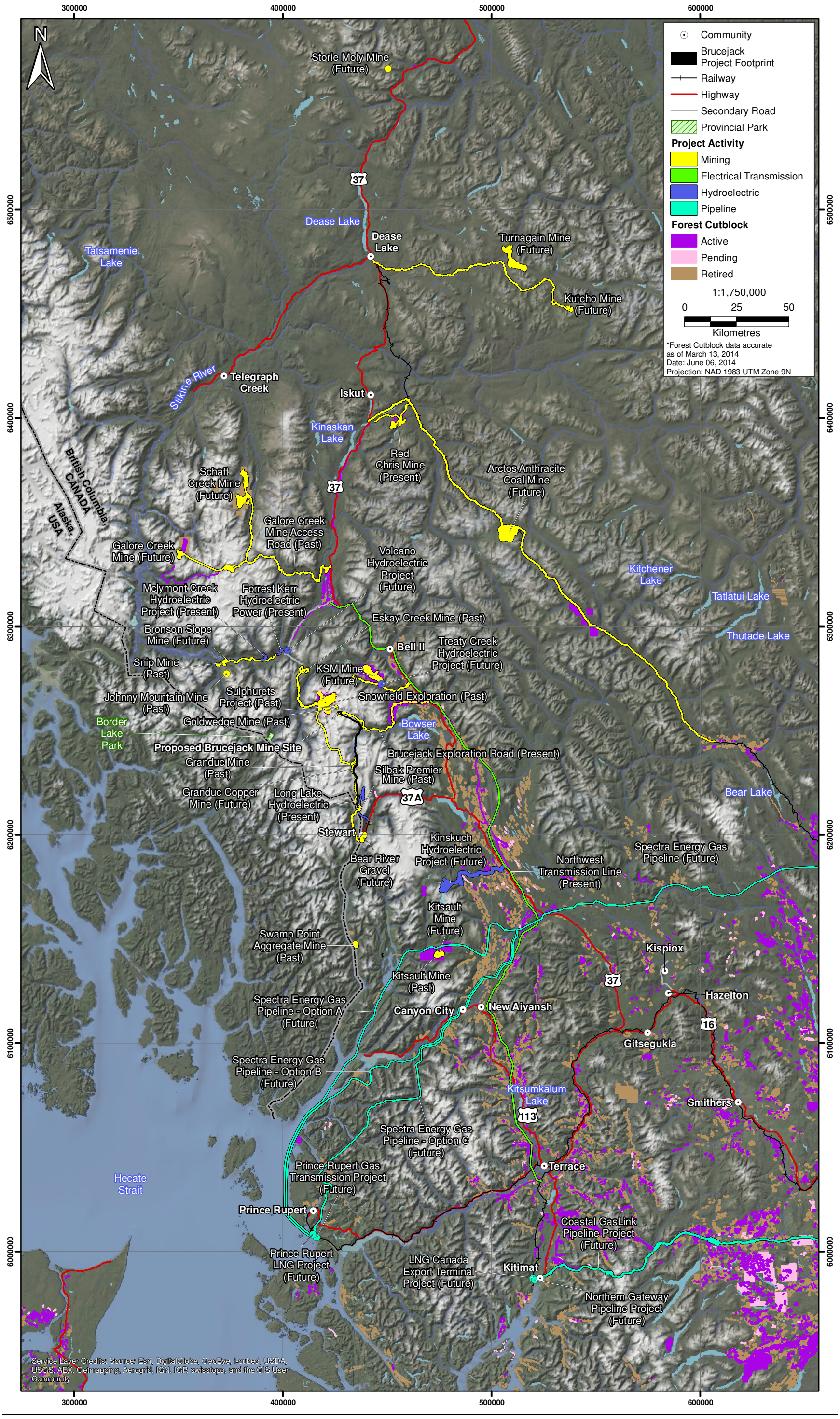
Past industrial projects within the Project CEA study areas are confined to mining and exploration activities.

With the suspension of construction for the Galore Creek Mine project in late 2007, and closure of the Eskay Creek Mine in March 2008, there are currently no operating mine projects close to the Project (BC Stats 2010). However, the Red Chris Mine is currently under construction, exploration for the Brucejack Gold Mine Project is ongoing, and closure and reclamation activities for Eskay Creek Mine are ongoing. There are also a number of hydroelectric developments in the region. The Northwest Transmission Line, and the Long Lake, McLymont Creek and Forrest Kerr hydroelectric projects are engaged in construction activities.

Reasonably foreseeable future projects are those within the CEA that have entered or completed the BC Environmental Assessment (EA) process, or are anticipated to enter the BC EA process during the review of the Project. There is uncertainty around the prediction of project effects from projects that are in the pre-application stage of the BC EAO process and have not yet completed the EA process. Potential effects and influences that can be predicted are based on publically available information and professional judgment. Assumptions are made considering typical projects of similar size and type where information is missing or lacking. Documentation and justification of these assumptions are included in the descriptions of each project in Chapter 6, Assessment Methodology (Section 6.9.2, Projects and Activities Considered).

Figure 34.3-1

Brucejack Gold Mine Project: Past, Present and Reasonably Foreseeable Projects within the Region



34.4 CUMULATIVE CHANGE ASSESSMENT ON INTERMEDIATE COMPONENTS

A review of the interaction between predicted changes on intermediate components from the Project and effects of other projects and activities was undertaken. The review assessed the projects and activities identified in Section 34.3, including:

- regional projects and activities that are likely to affect the intermediate component, even if they are located outside the direct zone of influence of the project;
- effects of past and present projects and activities that are expected to continue into the future (i.e., beyond the effects reflected in the existing conditions of the intermediate component);
- activities not limited to other reviewable projects, if those activities are likely to affect the intermediate component cumulatively (e.g., forestry, mineral exploration, commercial recreational activities).

A matrix identifying the potential cumulative effect interactions for intermediate components is provided in Table 34.4-1. Potential cumulative changes to intermediate components from the Brucejack Gold Mine Project, and other projects and activities, are summarized in Table 34.4-2.

34.4.1 Air Quality

34.4.1.1 Summary of Project-specific Predicted Changes on Air Quality

Air quality is an important environmental factor in ensuring the conservation of local vegetation, wildlife, and human health. Air quality was therefore identified as an intermediate component, with changes to the following criteria air contaminants (CACs) identified as air quality indicators:

- nitrogen dioxide (NO_2);
- sulphur dioxide (SO_2);
- carbon monoxide (CO);
- total suspended particulates (TSP);
- suspended particulates with diameter less than 10 micrometres (µm; PM_{10});
- suspended particulates with diameter less than 2.5 µm ($PM_{2.5}$);
- dustfall; and
- acid deposition.

Changes in air quality may directly result in changes in soil and vegetation quality and terrestrial ecology. Change in vegetation may affect wildlife and also consequently may change the quality of country foods. Dust deposition may alter water quality and wetlands. Degradation of air quality may also directly affect human health through inhalation.

According to the dispersion model results presented in Chapter 7, Air Quality Predictive Study, the Project will result in a change in air quality conditions. The changes in indicators are described in Table 34.4-3.

The effect on air quality during the Construction and Operation phases increases in concentrations and deposition of several CACs. Although exceedances were predicted for PM_{10} and dustfall, the frequency of exceedance for PM_{10} was small and the extent of exceedance for both was limited. The source of emissions will be continuous but the effect levels vary throughout the year and throughout the mine life; therefore, the frequency of the effect on air quality is considered regular. The change in ambient air quality is expected to be limited to up to 10 km for CACs and within 1 km for fugitive dust. The resilience of the area for change in air quality is considered medium. Although the change in ambient air quality is regular in frequency during the Construction

and Operation phases, ambient air quality will return to baseline conditions once the activities cease; therefore, the effects are reversible.

The potential impacts of air quality on receptor VCs are described in:

- Chapter 10, Surface Water Hydrology Predictive Study;
- Chapter 11, Terrain and Soils Predictive Study;
- Chapter 13, Assessment of Potential Surface Water Quality Effects;
- Chapter 16, Assessment of Potential Terrestrial Ecology Effects;
- Chapter 17, Assessment of Potential Wetlands Effects;
- Chapter 18, Assessment of Potential Wildlife Effects; and
- Chapter 21, Assessment of Potential Health Effects.

The following sections provide an examination of the relationship between the predicted changes as a result of the Project and those of other projects and activities. A matrix identifying the potential cumulative effect interactions of past, present and future projects and activities on air quality is provided in Table 34.4-1.

34.4.1.2 Cumulative Predicted Change Assessment Boundaries for Air Quality

Spatial Boundaries

The spatial linkages between the Project and other projects are shown in Figure 34.4-1. For air quality, spatial linkage is defined as any projects that have sources that may change air quality inside the Project's air quality RSA.

Temporal Boundaries

The temporal boundaries of the CEA are described in Section 34.2.2. Table 34.4-1 illustrates which past, present and future projects and activities will potentially have a temporal interaction with the air quality subject area.

34.4.1.3 Cumulative Predicted Change Assessment on Air Quality

Potential cumulative changes to air quality from the Project, and other projects and activities, are summarized in Table 34.4-2. The KSM Project has the potential to interact spatially and temporally with the Project. The change in air quality condition caused by the KSM Project thus needs to be considered in relation to the Project. The decrease in air quality due to the project activities was assessed for the KSM Project. The increase in pollutant concentrations or dust deposition levels predicted in the KSM Project effects assessment at the Brucejack Mine Site was obtained from the KSM Project dispersion model results (Rescan 2013). The incremental increases were applied to the maximum predicted concentrations or deposition predicted for the Project, together with the background levels, in order to determine the future predicted level when both the Brucejack Gold Mine Project and the KSM Project are in operation.

The calculation is shown as follows:

Future concentration = Background + Increment from Brucejack Gold Mine Project + Increment from KSM Project

The predicted increment from the KSM Project was obtained for the Brucejack Mine Site because the Mine Site is the closest facility to the KSM Project operation area and where the maximum cumulative change is expected.

Table 34.4-1. Potential Cumulative Effect Interactions for Intermediate and Receptor Valued Components

Projects and Activities	Biophysical																				Economic		Land Use	Social			Heritage	Human Health			Traditional Use	
														Wildlife							Labour Market										Traditional Lands and Resources	
	Air Quality	Climate[1]	Noise	Groundwater Quality	Groundwater Quantity	Surface Water Hydrology (Channel Morphology)	Surface Water Quality	Aquatic Resources - Primary and Secondary Producers	Fish	Fish Habitat	Terrain and Soils	Terrestrial Ecology	Wetlands	Moose	Mountain Goat	Grizzly Bear	American Marten	Western Toad	Increased Competition for Labour and Wage	Decrease in Employment at Closure	Commercial Land Use	Education, Skills Development, and Training	Community Infrastructure, Services and Housing	Family and Worker Well-being	Protected Archaeological Resources	Drinking Water	Air Quality	Noise	Hunting/Trapping Opportunities and Practices	
Historical																																
Eskay Creek Mine								■	■		■			■	■	■	■	■			■											
Galore Creek Project - Access Road Only											■	■		■	■	■					■											
Goldwedge Mine				■	■		■				■	■	■	■	■	■	■	■			■					■						
Granduc Mine							■	■	■		■	■	■	■	■	■	■	■			■					■						
Johnny Mountain Mine														■	■	■	■				■											
Kitsault Mine																■					■											
Silbak Premier Mine							■	■			■	■	■	■	■	■		■			■					■						
Snip Mine														■	■	■					■											
Snowfield Exploration Project				■	■		■	■			■	■		■	■	■	■	■			■											
Sulphurets Advanced Exploration Project				■	■	■	■	■	■		■	■	■	■	■	■		■			■					■						
Swamp Point Aggregate Mine																■																
Present																																
Brucejack Exploration and Bulk Sample Program	■			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			■					■					■
Forrest Kerr Hydroelectric Power Facility														■	■	■					■											
Long Lake Hydroelectric Power Facility											■	■	■	■	■	■	■	■			■					■						
McLymont Creek Hydroelectric Facility														■	■	■				■	■			■								
Northwest Transmission Line									■	■	■	■	■	■	■	■	■	■			■			■		■						■
Red Chris Mine																			■	■	■	■	■	■								■
Reasonably Foreseeable Future																																
Arctos Anthracite Coal Project														■	■	■				■	■	■	■	■								■
Bear River Gravel Project														■	■	■	■				■	■	■	■								
Bronson Slope Project														■	■	■				■	■	■		■								
Coastal GasLink Pipeline Project																■				■			■	■								
Galore Creek Project														■	■	■				■	■	■	■	■								
Granduc Copper Mine							■	■	■	■	■		■	■	■	■	■	■		■		■		■		■						■
KSM Project	■		■	■	■		■	■	■	■	■		■	■	■	■	■	■	■		■	■	■	■		■			■	■	■	■
Kinskuck Hydroelectric Project														■	■	■				■		■	■	■								
Kitsault Mine																■				■		■	■	■								■
Kutcho Project																				■			■	■								
LNG Canada Export Terminal Project																				■				■								
Northern Gateway Pipeline Project																				■				■								
Prince Rupert Gas Transmission Project																				■				■								
Prince Rupert LNG Project																				■												

(continued)

Table 34.4-1. Potential Cumulative Effect Interactions for Intermediate and Receptor Valued Components (completed)

Projects and Activities	Biophysical													Wildlife					Economic		Land Use	Social			Heritage	Human Health			Traditional Use
	Air Quality	Climate[1]	Noise	Groundwater Quality	Groundwater Quantity	Surface Water Hydrology (Channel Morphology)	Surface Water Quality	Aquatic Resources - Primary and Secondary Producers	Fish	Fish Habitat	Terrain and Soils	Terrestrial Ecology	Wetlands	Moose	Mountain Goat	Grizzly Bear	American Marten	Western Toad	Labour Market: Increased Competition for Labour and Wage	Labour Market: Decrease in Employment at Closure	Commercial Land Use	Education, Skills Development, and Training	Community Infrastructure, Services and Housing	Family and Worker Well-being	Protected Archaeological Resources	Drinking Water	Air Quality	Noise	Traditional Lands and Resources: Hunting/Trapping Opportunities and Practices
Reasonably Foreseeable Future (cont'd)																													
Schaft Creek Project														■	■	■			▒	▒	▒	■	■	■					
Spectra Energy Gas Pipeline Project																			▒		▒		▒	▒					
Storie Moly Project																			▒	▒		▒	▒	▒					
Treaty Creek Hydroelectric Project	▒										▒	▒	■	■	■	■	■	■			■					▒			▒
Turnagain Project																			▒		▒	▒	▒	▒					
Volcano Hydroelectric Project														■	■	■					▒								
Land Use Activities - All Stages (past, present future)																													
Parks and Protected Areas														■	■	■													
Guide Outfitting														■	■	■													▒
Aboriginal Harvest (fishing, hunting/trapping, plant gathering)									■			■		■	■	■	■												
Hunting														■	■	■	■												▒
Trapping																	■												▒
Commercial Recreation (including fishing)									■					■	■	■													
Forestry						■			■	■	■	■	▒	■	■	■	■	■											▒
Agricultural Land Reserves[2]																													
Oil and Gas[2]																													
Transportation													▒	■	■	■		■											▒

Black = likely interaction between Brucejack Gold Mine Project and other project or activity.

Grey = possible interaction between Brucejack Gold Mine Project and other project or activity.

White = unlikely interaction between Brucejack Gold Mine Project and other project or activity.

[1] Climate is not anticipated to have any cumulative effect interactions with any past, current or future projects or activities.

[2] No known activities located near the proposed Project.

Table 34.4-2. Potential Cumulative Effects between the Proposed Brucejack Gold Mine Project and Other Projects and Activities

Intermediate or Receptor Valued Component	Residual Effect	Brucejack Gold Mine Project	Past Project or Activity	Existing Project or Activity	Reasonably Foreseeable Future Project or Activity	Type of Potential Cumulative Effect
Air Quality	Air quality	X	-	Brucejack Exploration	KSM Project	Additive
Climate	n/a					
Noise	Noise	X	-	-	KSM Project	Additive
Groundwater Quality	Change in groundwater quantity flowing to small creeks in LSA and Brucejack Lake	X	-	-	-	-
Groundwater Quantity	Change in groundwater quality from underground mine, mine-site cuts and fills or quarry	X	-	-	-	-
Surface Water Hydrology (Channel Morphology)	Change in channel morphology	X	Sulphurets Project (access road); Forestry	Brucejack Exploration and Bulk Sample Program (access road); Forestry	Forestry	Physical-chemical transport, nibbling loss, and spatial crowding
Surface Water Quality	Change in surface water quality	X	-	-	KSM Project	Additive
Aquatic Resources - Primary and Secondary Producers	Mine Site Area: Effects from erosion and sedimentation	X	-	-	KSM Project	Additive
	Mine Site Area: Changes in surface water quantity	X	-	-	KSM Project	Additive
	Changes of surface water quality due to ML/ARD and nutrient loading	X	-	-	KSM Project	Additive
	Mine Site Area: Changes in sediment quality	X	-	-	KSM Project	Additive
	Mine Site Area: Habitat loss	X	-	-	KSM Project	Additive
	Off-site Areas: Changes in surface water quality due to ML/ARD		-	Northwest Transmission Line		Additive
	Off-site areas: Changes in surface water quality due to ML/ARD		-	-	Granduc Mine	Additive
Fish	Blunt tissue trauma causing mortality to all fish life stages	X	Eskay Creek Mine, Granduc Mine, Fishing, Forestry	Northwest Transmission Line, Brucejack Exploration, Fishing	Granduc Mine, KSM Project, Fishing, Forestry	Additive effect decreasing population size
	Erosion and sedimentation causing smothering of eggs, decreased feeding efficiency, habitat avoidance	X	Eskay Creek Mine, Granduc Mine, Forestry	Northwest Transmission Line, Brucejack Exploration	Granduc Mine, KSM Project, Forestry	Additive effect decreasing population size and productive capacity
Fish Habitat	Erosion and sedimentation causing loss of fish habitat	X	Eskay Creek Mine, Granduc Mine, Forestry Activities	Northwest Transmission Line, Brucejack Exploration	Granduc Mine, KSM Project, Forestry	Additive effect decreasing available fish habitat
Terrain and Soils	Loss of soil quantity	X	Eskay Creek Mine, Goldwedge Mine, Granduc Mine, Silbak Premier Mine, Snowfields Exploration Project, Sulphurets Project	Long Lake, Brucejack Exploration, Northwest Transmission Line	KSM Project, Treaty Creek Hydroelectric Project, Granduc Mine	Nibbling loss; physical-chemical transport
	Loss of soil quality	X	Eskay Creek Mine, Goldwedge Mine, Granduc Mine, Silbak Premier Mine, Snowfields Exploration Project, Sulphurets Project	Long Lake, Northwest Transmission Line	KSM Project, Treaty Creek Hydroelectric Project, Granduc Mine	Nibbling loss; physical-chemical transport
Terrestrial Ecology	Loss of alpine, forest and/or floodplain ecosystem function and/or extent	X	Goldwedge Mine, Granduc Mine[1], Silbak Premier Mine, Sulphurets Project, Long Lake Hydroelectric, Brucejack Exploration Project, Forestry, Snowfield Exploration Project	None expected	KSM Project, Granduc Mine	Nibbling loss, synergistic, additive, physical-chemical transport, growth inducing[2]

(continued)

Table 34.4-2. Potential Cumulative Effects between the Proposed Brucejack Gold Mine Project and Other Projects and Activities (continued)

Intermediate or Receptor Valued Component	Residual Effect	Brucejack Gold Mine Project	Past Project or Activity	Existing Project or Activity	Reasonably Foreseeable Future Project or Activity	Type of Potential Cumulative Effect
Terrestrial Ecology *(cont'd)*	Alteration of alpine, forest and floodplain ecosystem function and/or extent	X	Goldwedge Mine, Granduc Mine, Silbak Premier Mine, Sulphurets Project, Long Lake Hydrelectric, Brucejack Exploration Project, Forestry, Snowfield Exploration Project	Forestry	KSM Project, Granduc Mine, Forestry	Nibbling loss, synergistic, additive, spatial and temporal crowding, physical-chemical transport[2]
	Loss of rare plants/lichens or associated habitat	X	Brucejack Exploration Project, information unavailable for other projects or activities	Information unavailable	KSM Project, information unavailable for other projects or activities	Nibbling loss, synergistic, additive, spatial and temporal crowding, physical-chemical transport[2]
	Alteration of rare plant or lichen habitat	X	Brucejack Exploration Project, information unavailable for other projects or activities	Information unavailable	KSM Project, information unavailable for other projects or activities	Nibbling loss, synergistic, additive, spatial and temporal crowding, physical-chemical transport[2]
Wetlands	Loss of wetland extent or altered function	X	Sulphurets Project, Silbak Premier Mine, Goldwedge Mine	Northwest Transmission Line, Long Lake Hydroelectric Project, Brucejack Exploration and Bulk Sample Program	KSM Project, Treaty Creek Hydroelectric Project	Additive
Moose	Disruption of movement	X	Eskay Creek Mine, Goldwedge Mine, Silback Premier Mine, Sulphurets Project, Granduc Mine	Brucejack Exploration and Bulk Sample, Forrest Kerr Hydroelectric Power Facility, Long Lake Hydroelectric Power Facility, McLymont Creek Hydroelectric Project, Northwest Transmission Line	Arctos Anthracite Coal Project, Bear River Gravel, Bronson Slope Mine, Galore Creek Mine, Granduc Mine, KSM Project, Kinskuch Hydroelectric Project, Schaft Creek Mine, Treaty Creek Hydroelectric, Volcano Hydroelectric Project	Spatial crowding of projects results in an additive effect of increased traffic volume, which causes barriers within moose movement routes. The additive effect of the nibbling loss of habitat also reduces connectivity along the landscape.
	Direct mortality	X	Eskay Creek Mine, Goldwedge Mine, Silback Premier Mine, Sulphurets Project, Granduc Mine	Brucejack Exploration and Bulk Sample, Forrest Kerr Hydroelectric Power Facility, Long Lake Hydroelectric Project, McLymont Creek Hydroelectric Project, Northwest Transmission Line	Arctos Anthracite Coal Project, Bear River Gravel, Bronson Slope Mine, Galore Creek Mine, Granduc Mine, KSM Project, Kinskuch Hydroelectric Project, Schaft Creek Mine, Treaty Creek Hydroelectric, Volcano Hydroelectric Project	With the potential for growth; inducing road development, the additive effect of spatial crowding of access roads results in greater exposure to traffic mortality. The growth potential of power projects support development of new projects, which increases traffic on highways and new access roads.
	Indirect mortality	X	Eskay Creek Mine, Granduc Mine	Brucejack Exploration and Bulk Sample, Forrest Kerr Hydroelectric Power Facility, Long Lake Hydroelectric Project, McLymont Creek Hydroelectric Project, Northwest Transmission Line	Arctos Anthracite Coal Project, Bronson Slope Mine, Galore Creek Mine, Granduc Mine, KSM Project, Kinskuch Hydroelectric Project, Treaty Creek Hydroelectric, Volcano Hydroelectric Project	Spatial crowding and growth; potential of access roads results in increased moose hunting opportunities and potential cumulative mortality from harvest.
Mountain Goat	Sensory disturbance	X	Johnny Mountain Mine, Sulphurets, Goldwedge Mine, Silbak Premier Mine, Eskay Creek Mine, Snip Mine	Brucejack Exploration and Bulk Sample, McLymont Creek Hydroelectric, Forest Kerr Hydroelectric, Long Lake Hydroelectric, Northwest Transmission Line	Bear River Gravel, Kinskuch Hydroelectric, Volcano Hydroelectric, Treaty Creek Hydroelectric, KSM Project, Galore Creek Mine, Schaft Creek Mine, Bronson Slope, Granduc Mine, Spectra Energy Gas Pipeline	The spatial crowding of disturbed areas and nibbling loss of habitat due to noise exposure from aircraft and helicopters.
	Indirect mortality	X	Johnny Mountain Mine, Sulphurets, Goldwedge Mine, Silbak Premier Mine, Eskay Creek Mine, Snip Mine	McLymont Creek Hydroelectric, Forest Kerr Hydroelectric, Long Lake Hydroelectric, Northwest Transmission Line	Bear River Gravel, Kinskuch Hydroelectric, Volcano Hydroelectric, Treaty Creek Hydroelectric, KSM Project, Galore Creek Mine, Schaft Creek Mine, Bronson Slope, Granduc Mine	Spatial crowding and growth-inducing potential of access roads results in increased mountain goat hunting opportunities and potential cumulative mortality from harvest.
Grizzly Bear	Disruption of movement	X	-	Brucejack Exploration and Bulk Sample, McLymont Creek Hydroelectric, Forest Kerr Hydroelectric, Long Lake Hydroelectric, Northwest Transmission Line, fishing, guide outfitting, resident and Aboriginal harvest, mineral and energy resource exploration, recreation and tourism, timber harvesting, traffic and roads	Kinskuch Hydroelectric, Volcano Hydroelectric, Treaty Creek Hydroelectric, KSM Project, Kitsault Mine, Galore Creek Mine, Schaft Creek Mine, Bronson Slope, [1]Granduc Mine, fishing, guide outfitting, resident and Aboriginal harvest, mineral and energy resource exploration, recreation and tourism, timber harvesting, traffic and roads	Spatial crowding. Nibbling loss of habitat resulting from the cumulative disturbance across the landscape from all projects or activities.

(continued)

Table 34.4-2. Potential Cumulative Effects between the Proposed Brucejack Gold Mine Project and Other Projects and Activities (continued)

Intermediate or Receptor Valued Component	Residual Effect	Brucejack Gold Mine Project	Past Project or Activity	Existing Project or Activity	Reasonably Foreseeable Future Project or Activity	Type of Potential Cumulative Effect
Grizzly Bear *(cont'd)*	Direct mortality	X	-	Brucejack Exploration and Bulk Sample, McLymont Creek Hydroelectric, Forest Kerr Hydroelectric, Long Lake Hydroelectric, Northwest Transmission Line, fishing, guide outfitting, resident and Aboriginal harvest, mineral and energy resource exploration, recreation and tourism, timber harvesting, traffic and roads	Bear River Gravel, Kinskuck Hydroelectric, Volcano Hydroelectric, Treaty Creek Hydroelectric, Arctos Anthracite Coal Mine, KSM Project, Kitsault Mine, Galore Creek Mine, Schaft Creek Mine, Bronson Slope, Granduc Mine[1], fishing, guide outfitting, resident and Aboriginal harvest, mineral and energy resource exploration, recreation and tourism, timber harvesting, traffic and roads	Spatial crowding of access roads and growth-inducing road development result in cumulative direct mortality across the Movement Area and CEA Area.
	Indirect mortality	X	Snowfields, Swamp Point Aggregate Mine, Johnny Mountain Mine, Sulphurets, Goldwedge Mine, Silbak Premier Mine, Eskay Creek Mine, Snip Mine, Kitsault Mine, Galore Creek Mine, Granduc Mine	Brucejack Bulk Sample and Exploration, McLymont Creek Hydroelectric, Forest Kerr Hydroelectric, Long Lake Hydroelectric, Northwest Transmission Line	Bear River Gravel, Kinskuch Hydroelectric, Volcano Hydroelectric, Treaty Creek Hydroelectric, Arctos Anthracite Coal Mine, KSM Project, Kitsault Mine[1], Galore Creek Mine, Schaft Creek Mine, Bronson Slope, Granduc Mine[1]	Spatial crowding and growth-inducing potential of access roads results in increased grizzly bear hunting opportunities.
	Attractants	X	Snowfields, Swamp Point Aggregate Mine, Johnny Mountain Mine, Sulphurets, Goldwedge Mine, Silbak Premier Mine, Eskay Creek Mine, Snip Mine, Kitsault Mine, Galore Creek Mine, Granduc Mine	Brucejack Bulk Sample and Exploration, McLymont Creek Hydroelectric, Forest Kerr Hydroelectric, Northwest Transmission Line, fishing, guide outfitting, resident and Aboriginal harvest, mineral and energy resource exploration, recreation and tourism, timber harvesting, traffic and roads	Bear River Gravel, Kinskuch Hydroelectric, Volcano Hydroelectric, Treaty Creek Hydroelectric, Arctos Anthracite Coal Mine, KSM Project, Kitsault Mine[1], Galore Creek Mine[1], Schaft Creek Mine, Bronson Slope, Granduc Mine[1], fishing, guide outfitting, resident and Aboriginal harvest, mineral and energy resource exploration, recreation and tourism, timber harvesting, traffic and roads	Spatial crowding of projects exposes grizzly bear individuals and populations to more attractants with a growth-inducing potential for habituation.
American Marten	Attractants	X	Goldwedge Mine, Snowfields exploration	Brucejack Bulk Sample and Exploration, Northwest Transmission Line, resident and Aboriginal harvest, and mineral and energy resource exploration	Bear River Gravel, Treaty Creek Hydroelectric, KSM Project, Granduc Mine, resident and Aboriginal harvest, Mineral and energy resource exploration	Spatial crowding of projects exposes American marten to more attractants with a growth-inducing potential for habituation resulting in additive population mortality rates.
Western Toad	Direct mortality	X	Goldwedge Mine, Silbak Premier Mine, Sulphurets Project, Granduc Mine	Brucejack Bulk Sample and Exploration, Long Lake, Northwest Transmission Line	KSM Project, Treaty Creek, Granduc Mine[1]	Nibbling loss resulting from the cumulative habitat loss of all Projects or activities.
Labour Market	Increased competition for labour and wage inflation	X	-	McLymont Creek Hydroelectric, Red Chris Mine	Arctos Anthracite Coal Mine, Bronson Slope Mine, Coastal GasLink Pipeline, Galore Creek Mine, Granduc Mine, KSM Project, Kinskuch Hydroelectric Project, Kitsault Mine, Kutcho Mine, LNG Canada Export Terminal, Northern Gateway Pipeline, Prince Rupert Gas Transmission, Prince Rupert LNG Project	Spatial and temporal crowding, additive and synergistic
	Decrease in employment at closure	X	-	McLymont Creek Hydroelectric, Red Chris Mine	Arctos Anthracite Coal Mine, Bronson Slope Mine, Coastal GasLink Pipeline, Galore Creek Mine, Granduc Mine, KSM Project, Kinskuch Hydroelectric Project, Kitsault Mine, Kutcho Mine, LNG Canada Export Terminal, Northern Gateway Pipeline, Prince Rupert Gas Transmission, Prince Rupert LNG Project	Spatial and temporal crowding; additive, synergistic and induced
Commercial Land Use	Access within commercial licence tenures will remain restricted.	X	N/A	Brucejack Exploration, Forest Kerr Hydro, Long Lake, Hydro, McLymont Creek Hydro, Northwest Transmission Line, Red Chris	Arctos Anthracite, Bear River Gravel, Bronson Slope, Galore Creek, Granduc, KSM Project, Kinskuch Hydro, Kitsault, Schaft Creek, Spectra Energy Transmission Line, Treaty Creek Hydro, Turnagain, Volcano Hydro	Nibbling loss
	Observation of multiple Project related infrastructure and vehicles may alter or reduce commercial licence holders (and their clients') experience of the natural environment.	X	N/A	Brucejack Exploration, Forest Kerr Hydro, Long Lake, McLymont Creek Hydro, Northwest Transmission Line	Bear River Gravel, Bronson Slope, Granduc, KSM, Treaty Creek Hydro, Volcano Hydro	Nibbling loss, additive

(continued)

Table 34.4-2. Potential Cumulative Effects between the Proposed Brucejack Gold Mine Project and Other Projects and Activities (completed)

Intermediate or Receptor Valued Component	Residual Effect	Brucejack Gold Mine Project	Past Project or Activity	Existing Project or Activity	Reasonably Foreseeable Future Project or Activity	Type of Potential Cumulative Effect
Commercial Land Use *(cont'd)*	Commercial licence holders, may experience reduced or altered wildlife (grizzly bear and moose) and fish resources in their licence areas as a result of direct and indirect mortality and disruption of wildlife movement.	X	Eskay Creek, Goldwedge, Granduc, Johnny Mountain, Kitsault, Silbak Premier, Snip, Sulphurets	Brucejack Exploration, Forest Kerr Hydro, Long Lake, Hydro, McLymont Creek Hydro, Northwest Transmission Line, Red Chris	Arctos Anthracite, Bear River Gravel, Bronson Slope, Galore Creek, Granduc, KSM, Kinskuch Hydro, Kitsault, Kutcho, Schaft Creek, Spectra Energy Transmission Line, Treaty Creek Hydro, Volcano Hydro	Nibbling loss, additive, growth-inducing
Education, Skills Development, and Training	Increased demand for educational programs in the LSA	X	Northwest Transmission Line	Red Chris Mine	All Reasonable Foreseeable Future Projects	Spatial and temporal crowding, additive and synergistic
Community Infrastructure, Services and Housing	Increased demand for infrastructure and housing	X	Northwest Transmission Line	Red Chris Mine	All Reasonable Foreseeable Future Projects	Spatial and temporal crowding, additive and synergistic
	Increased demand on health and social services	X	Northwest Transmission Line	Red Chris Mine	All Reasonable Foreseeable Future Projects	Spatial and temporal crowding, additive and synergistic
Family and Worker Wellbeing	Increase in transient workers coming into LSA communities	X	-	-	All Reasonable Foreseeable Future Projects	Spatial and Temporal crowding, additive
	Increased levels of stress and anxiety on families due to rotational work	X	-	-	All Reasonable Foreseeable Future Projects	Spatial and temporal crowding, additive and synergistic
	Increase in poor lifestyle choices	X	-	-	All Reasonable Foreseeable Future Projects	Spatial and temporal crowding, additive and synergistic
Protected Archaeological Resources	-	-	-	-	-	-
Drinking Water	Potential for health effects due to change in water quality	X	-	Brucejack Exploration and Bulk Sample Program, Long Lake Hydroelectric	Treaty Creek Hydroelectric Project, KSM Project, Granduc Mine	Additive
Air Quality	Potential for health effects due to change in air quality for worker camps and non-worker human receptor locations	X	-	-	KSM Project	Additive
Noise	Potential for health effects due to change in noise for worker camps and non-worker human receptor locations	X	-	-	KSM Project	Additive
Hunting/Trapping Opportunities and Practices	Change to the abundance and distribution of resources	X	-	Brucejack Exploration, Northwest Transmission Line, Red Chris, Guide Outfitting, Hunting, Trapping, Forestry, Transportation	Granduc Mine, KSM Project, Kitsault, Treaty Creek Hydro	Nibbling loss, growth-inducing, additive

Notes:
[1] Climate is not anticipated to have any cumulative effect interactions with any past, current or future projects or activities.
[2] See Table 16.10-2 for specific potential cumulative effects associated with each project or activity.

Figure 34.4-1

Air Quality CEA Boundary Showing All Other Projects and Activities Relevant to Air Quality in the Vicinity of the Brucejack Gold Mine Project

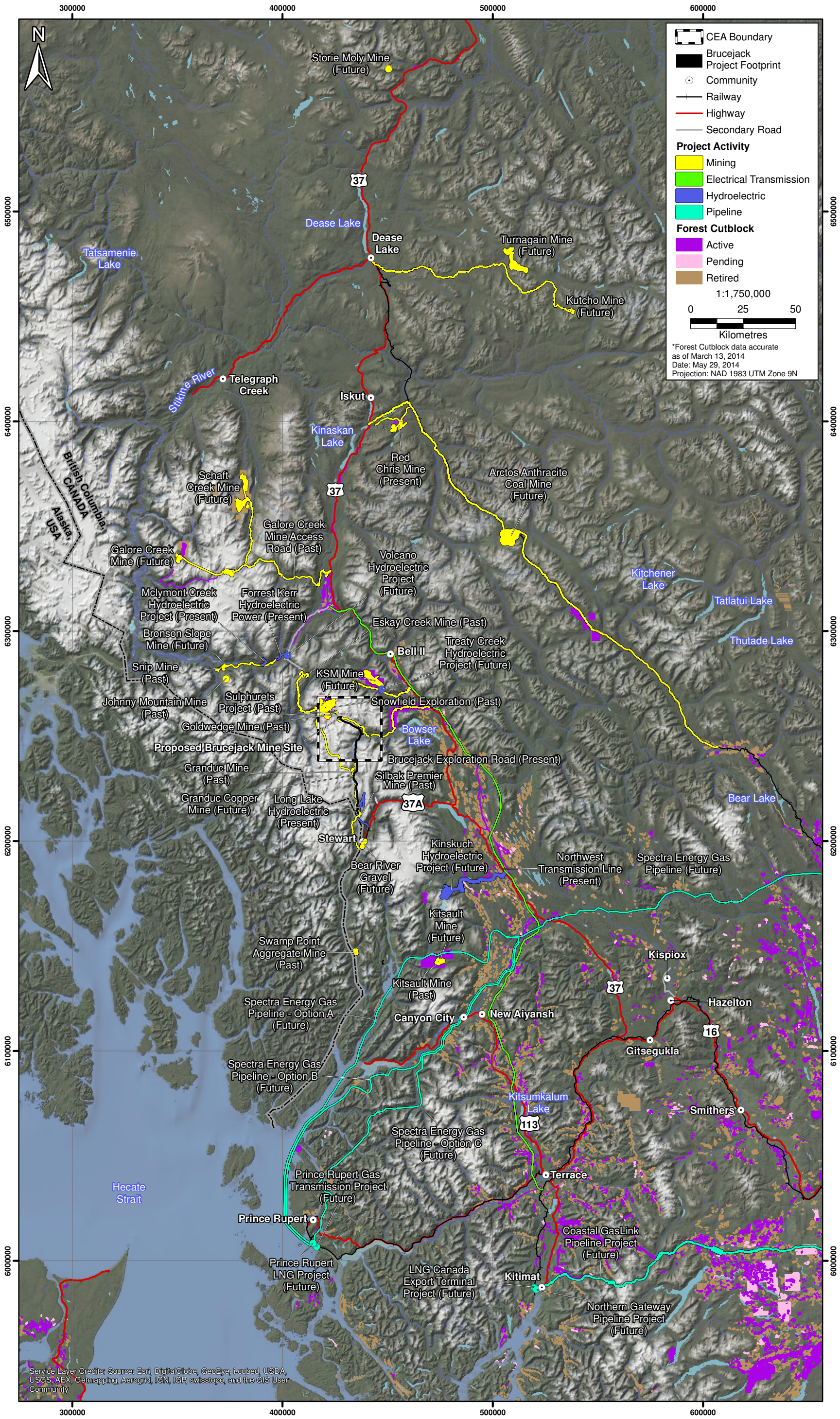


Table 34.4-3. Summary of Project-specific Predicted Changes after Mitigation for Air Quality

Indicators	Project Phase (timing of effect)	Project Component / Physical Activity	Description of Cause-Effect[1]	Description of Mitigation Measure(s)	Description of Predicted Change(s)
NO_2, SO_2, CO, TSP and $PM_{2.5}$	Construction and Operation	Construction and Operation activities	Project emissions that lead to increased concentrations of CACs	Maintaining equipment, installing scrubber, installing baghouses and watering the road	Increase in concentration but no exceedance was predicted
PM_{10}	Construction and Operation	Construction and Operation activities	Project emissions that lead to increased concentrations of CACs	Maintaining equipment, installing scrubber, installing baghouses and watering the road	Increase in concentration with infrequent exceedance and limited extent
Dustfall	Construction and Operation	Construction activities	Project emissions that lead to increased deposition of dust	Maintaining equipment, installing scrubber, installing baghouses and watering the road	Increase in deposition rate with but limited extent

[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.*

34.4.1.4 Mitigation Measures to Address Cumulative Predicted Change on Air Quality

Mitigation measures have been integrated into the design of the Project such as the use of baghouses and wetting of the access roads (Section 7.7, Mitigation Measures for Air Quality), and certain mitigation measures have been proposed by both the KSM Project and the Brucejack Gold Mine Project.

34.4.1.5 Summary of Predicted Cumulative Change on Air Quality

The increase in pollutant concentrations or dust deposition levels during Operation due to the KSM Project at the Project area, based on the combined dispersion model results, is summarized in Table 34.4-4.

Table 34.4-4. Predicted Pollutant Increment from KSM Project at Brucejack Gold Mine Project Area

		Concentrations (µg/m^3) or Deposition Rate (mg/dm^2/day)					
		Criteria					
Pollutant	Averaging Period	NAAQOs	BC Objective	Background	KSM Project Increment at Brucejack Gold Mine Project	Maximum at Brucejack Gold Mine Project	Cumulative Concentration
NO_2	1-hour	400	-	21	40	83	144
	24-hour	200	-	21	8	68	97
	Annual	60	-	5	0.4	19	24
SO_2	1-hour	450	450	4	2.0	6.1	12
	24-hour	150	160	4	0.4	1.6	6
	Annual	30	25	2	0.03	0.27	2.3
CO	1-hour	15,000	14,300	100	87	115	302
	8-hour	6,000	5,500	100	34	48	182
TSP	24-hour	120	150	10	13	69	92
	Annual	60	60	10	0.8	19	30

(continued)

Table 34.4-4. Predicted Pollutant Increment from KSM Project at Brucejack Gold Mine Project Area (completed)

		Concentrations (µg/m^3) or Deposition Rate (mg/dm^2/day)					
Pollutant	Averaging Period	Criteria		Background	KSM Project Increment at Brucejack Gold Mine Project	Maximum at Brucejack Gold Mine Project	Cumulative Concentration
PM_{10}	24-hour	-	50	3.4	6.2	**55**	**65**
$PM_{2.5}$	24-hour	30[a], 28[d] (2015) and 27[d] (2020)	25[b]	1.3	0.6	5.6	7.5
	Annual	10[d] (2015) and 8.8[d] (2020)	8[c]	1.3	0.06	2.9	4.3
Dust deposition	30-day	-	1.7 to 2.9	0.71	0.00017	**3**	**3.7**

Notes:
Dash (-) indicates information not available or applicable. Bold indicates exceedance over criteria. Numbers may not add up due to rounding.
[a] *Annual 98th percentile value, averaged over three consecutive years. Canada-wide standard published by CCME.*
[b] *Based on annual 98th percentile value.*
[c] *BC objective of 8 µg/m3 and planning goal of 6 µg/m3 was established in 2009.*
[d] *CAAQS adopted in 2013 and will be in effective in 2015 and 2020.*

The predicted NO_2 concentrations for 1-hour maximum are 144 µg/m^3, which is approximately 36% of the national ambient air quality objectives (NAAQO). The 24-hour and annual concentrations of 97 µg/m^3 and 24 µg/m^3, respectively, are approximately half of the NAAQO. The predicted 1-hour (12 µg/m^3), 24-hour (6 µg/m^3), and annual (2.3 µg/m^3) SO_2 concentrations are less than 10% of the most stringent criteria. The maximum predicted 1-hour and 8-hour CO concentrations are less than 4% of the BC objectives.

The highest 24-hour TSP maximum concentration of 92 µg/m^3 represents 77% of the NAAQO and 61% of the BC objectives. The maximum TSP annual concentration of 30 µg/m^3 represents 50% of the federal and provincial criteria. The highest 24-hour PM_{10} maximum concentration was predicted to be 65 µg/m^3, which exceeds the BC objective of 50 µg/m^3; however, the exceedances were only predicted within a short distance along certain sections of the access roads close to the Knipple Transfer Area. Exceedance at the Brucejack Mine Site is not expected. As mentioned in Section 7.2, the Canadian Ambient Air Quality Standards (CAAQs) for 24-hour and annual $PM_{2.5}$ will be in effect in 2015 and 2020; however, the BC objectives for 24-hour and annual $PM_{2.5}$ are more stringent than the CAAQs. The BC objectives are used here as thresholds. The highest 24-hour $PM_{2.5}$ maximum concentration was predicted to be 7.5 µg/m^3, which is 30% of the BC objective of 25 µg/m^3. The predicted highest annual concentration of 4.3 µg/m^3 represents 54% of the BC objective of 8 µg/m^3. Additionally, the highest annual concentration is also lower than the BC planning goal of 6 µg/m^3, established in 2009. The highest 30-day dust deposition at the Project is predicted to be 3.7 mg/dm^2/day with or without the presence of the KSM Project and therefore, there is no cumulative change for dust depositions between the Brucejack Gold Mine Project and the KSM Project. The highest dust deposition of 3.7 mg/dm^2/day exceeds the BC objective of 1.7 to 2.9 mg/dm^2/day; however, the extent of exceedance over the more stringent objective was only predicted within 170 m on either sides of the road and exceedance over the less stringent objective was predicted within 200 m on either side of the road and in a small area approximately 350 m south of the Knipple Transfer Area.

In summary, cumulative change was assessed assuming both the Brucejack Gold Mine Project and the KSM Project will be operating at the same time. Predicted cumulative changes are those changes remaining after the implementation of all mitigation measures and are summarized in Table 34.4-5. Increased CAC concentrations and dust deposition was predicted for the cumulative effect; however, only exceedances for PM_{10} and dust deposition were predicted, which is consistent with the Project-only changes.

Table 34.4-5. Summary of Predicted Cumulative Changes on Air Quality

Intermediate Component	Timing of Predicted Cumulative Change[1]	Description of Cause-Effect[2]	Description of Additional Mitigation (if any)	Description of Predicted Cumulative Change	VCs Affected
Air Quality	Operation	Project emissions that lead to increased concentrations of CACs and deposition of dust	Mitigation measures being implemented for both projects	Increase in CACs as summarized in Table 34.4-4	Surface water hydrology, terrain and soil, surface water quality, terrestrial ecology, wetlands, wildlife, and human health

[1] Refers to the Project phase or other timeframe during which the effect will be experienced by the intermediate component.
[2] "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.

34.4.2 Noise

34.4.2.1 Summary of Project-specific Predicted Changes for Noise

Noise has intrinsic importance to employees, local residents, and fauna as noise can directly affect the health of humans and wildlife. Noise may result in psychological and physiological effects in humans, as well as avoidance behaviour in wildlife populations that causes them to not access important habitats. As such, noise was identified as an intermediate component and was assessed in Chapter 8, Noise Predictive Study, for the following potential impacts on humans and wildlife:

- impact on humans:
  - sleep disturbance,
  - interference with speech communication,
  - complaints, and
  - high annoyance;
- impact on wildlife:
  - loss of wildlife habitat, and
  - wildlife disturbance.

The Project is predicted to increase noise levels at relevant human and wildlife receptors during the Construction and Operation phases. These changes are summarized in Table 34.4-6.

The impact for workers is that noise will have a maximum increase of 14 dBA above criteria, and will be medium in duration and sporadic in frequency. For humans other than the workers, the impact is considered high in magnitude, due to infrequent exceedance over the criteria, and medium in duration and regular in frequency. For wildlife, the impact is considered medium in

duration and sporadic in frequency. At times, there may be high noise levels due to construction and operation activities, when the occurrences are sporadic and each occurrence is short. Since the effects will cease once the Project activities cease, the effects are considered reversible short term. The Construction and Operation phases were assessed for the busiest year of construction and a year representing typical operations. If the effects of these years are predicted to be not significant on wildlife or human health then the potential effect of the entirety of the Project should also be not significant.

Table 34.4-6. Summary of Project-specific Predicted Changes after Mitigation for Noise

Intermediate Component	Project Phase (timing of effect)[1]	Project Component / Physical Activity	Description of Cause-Effect[2]	Description of Mitigation Measure(s)	Description of Predicted Change(s)
Noise	Construction and Operation	Construction and operational equipment, road activity	Project Construction and Operation noise sources are predicted to increase noise levels at Project workers' accommodation, existing off-site human receptors and to wildlife	Adequate maintenance, reducing vehicle speed, and avoid idling, construction design, site layout	Predicted exceedance of noise criteria limits at Project workers' accommodation by up to 7 dBA during Construction and up to 4 dBA during Operation. Predicted exceedance of noise criteria limits for sleep disturbance, complaints, and %HA at one existing human receptor. Predicted exceedances of noise criteria for habitat loss and disturbance for wildlife.

[1] *Refers to the Project phase or other timeframe during which the effect will be experienced by the intermediate component.*
[2] *"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.*

Noise modelling has predicted increases in noise levels due to noise generated by the Project at the Project workers' accommodation, at one existing human receptor, and at a number of wildlife receptors during both the Construction and Operation phases. Mitigation measures will reduce the noise generated from the Project; however, noise levels at relevant receptors are still expected to increase as a result of the Project.

The potential impacts of increased noise levels on wildlife and humans are assessed in Chapters 18 and 21, respectively. The following sections provide an examination of the relationship between the predicted changes as a result of the Project and those of other projects and activities. A matrix identifying the potential cumulative effect interactions of past, present and future projects and activities on noise is provided in Table 34.4-1.

34.4.2.2 Cumulative Effects Assessment Boundaries for Noise

Spatial Boundaries

Noise impacts are typically restricted to within 10 km of the noise source; therefore, the CEA focuses on projects within 10 km of the Project.

Temporal Boundaries

The temporal boundaries of the CEA are described in Section 34.2.2. Noise levels will immediately return to baseline levels after a project's noise sources are removed. Therefore, the CEA considers other projects with construction and/or operation phases that overlap with the Project phases. As such, the CEA for noise does not consider past projects or activities. Table 34.4-1 illustrates which present and future projects and activities will potentially have a temporal interaction with the noise subject area.

34.4.2.3 Cumulative Predicted Change Assessment for Noise

Since there are no current projects or major activities within 10 km of the Project, there are no potential noise interactions between the Project and other current projects or activities. There are potentially hunting, trapping, fishing, and other recreational activities in the area; however, these activities are not expected to generate appreciable noise levels that will cause an interaction with the Project noise. Therefore, no cumulative effect between the recreational activities and the Project is expected.

The only foreseeable future project or activity within 10 km of the Project is the proposed KSM Project (Tables 34.4-1 and 34.4-2). The KSM Project may impact noise levels at human or wildlife receptors which are affected by the Project, resulting in exceedances of relevant noise criteria.

The KSM Project Application/EIS (Rescan 2013) predicted that the project's noise effects on humans would be largely contained within the project boundary. Due to the logarithmic nature of reduction in noise levels with distance from a source, and the distance between the project sites, there are no expected measureable cumulative effects on noise levels at human receptors.

The main potential cumulative change is expected to occur at the wildlife receptors, especially those located between the Brucejack Gold Mine Project and the KSM Project. Blasting during the KSM Project operational phase was identified as one of the key sources of noise on the KSM Project. However, given that the KSM Project blasting only occurs for a few seconds once per day and that blasting only occurs during the Project's construction phase, the likelihood of both mines blasting simultaneously is negligible.

The main potential noise sources to consider are helicopters and aircraft, as these effects typically occur furthest from the Project footprint. If flight paths from the KSM Project and the Brucejack Gold Mine Project intersect then the frequency of exceedances of relevant noise criteria at nearby wildlife receptors may increase. Given that there will only be a few flights per day for each of the projects it is considered unlikely that two flights will occur simultaneously, i.e., it is unlikely that the magnitude of exceedances will increase or that new exceedances will occur.

These potential cumulative effects are discussed in greater details in Chapter 18, Assessment of Potential Wildlife Effects.

34.4.2.4 Mitigation Measures to Address Cumulative Predicted Change for Noise

There are no specific mitigation or management measures proposed to explicitly address potential cumulative changes. Mitigation measures provided in Chapters 18 and 21 and the associated management and monitoring plans are applicable to the potential cumulative changes.

34.4.2.5 Summary of Predicted Cumulative Changes for Noise

Predicted cumulative changes are those effects remaining after the implementation of all mitigation measures and are summarized in Table 34.4-7. Noise levels fall off rapidly with distance from the source and, as such, the noise levels across the Project area from any cumulative effects would be dominated by the Project. It is unlikely that there will be any cumulative effects from noise on human health. The cumulative effects of the Brucejack Gold Mine Project and the KSM Project may result in increased frequency of noise exceedances for wildlife receptors.

Table 34.4-7. Summary of Predicted Cumulative Changes on Noise

Intermediate Component	Timing of Predicted Cumulative Change[1]	Description of Cause-Effect[2]	Description of Additional Mitigation (if any)	Description of Predicted Cumulative Change	VCs Affected
Noise	Construction and Operation	Potential for loss of wildlife habitat and wildlife disturbance due to increased noise levels	None	Intersecting flight paths may increase the frequency of predicted exceedances	Wildlife

[1] Refers to the Project phase or other timeframe during which the effect will be experienced by the intermediate component.
[2] "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.

34.4.3 Hydrogeology

34.4.3.1 Summary of Project-specific Predicted Changes for Hydrogeology

Groundwater is valued as a source of water for human consumption and for its intrinsic links with surface water. Changes to groundwater fluxes can affect water levels and flows in surface water bodies, thereby influencing aquatic ecosystems, vegetation and wildlife. Groundwater is also a potable water resource when water quality is adequate. Groundwater was identified as an intermediated component and refined into two sub-components:

- groundwater quantity: changes to groundwater flow volume and movement assessed on the basis of increases or decreases in hydraulic heads as a result of the project; and
- groundwater quality: changes to concentrations of total and dissolved metals, nutrients, turbidity, total suspended solids, and groundwater temperature.

Residual effects related to groundwater quantity are predicted to be negligible post-closure of the Project. Residual effects for groundwater quality are predicted to include local discharge of low levels of ML/ARD affected groundwater for an extended period. Project-related residual effects for hydrogeology are not anticipated in areas extending more than two kilometres downgradient from the Project footprint. A summary of predicted changes on hydrogeology, for groundwater quantity and quality, is presented in Table 34.4-8.

The following sections provide an examination of the relationship between the predicted changes as a result of the Project and those of other projects and activities. A matrix identifying the potential cumulative effect interactions of past, present, and future projects and activities on surface water hydrology is provided in Table 34.4-1.

Table 34.4-8. Summary of Predicted Changes after Mitigation for Hydrogeology

Sub-Component	Project Phase (Timing of Effect)	Project Component / Physical Activity	Description of Cause-Effect[1]	Description of Mitigation Measure(s)	Description of Predicted Change(s)
Change in groundwater quantity flowing to small creeks in LSA and Brucejack Lake	Construction, Operation	Construction of mine portal and ventilation shafts, Development of underground portal and facilities, Underground water management, Underground: drilling, blasting, excavation	Dewatering of underground workings lowers water table, causing groundwater to be diverted to Underground Water Management System instead of baseflow.	Backfill underground workings with waste rock, paste tailings or other low permeability material.	Groundwater discharge will decrease or cease, resulting in decreased baseflow and discharge.
Change in groundwater quantity flowing to small creeks in LSA and Brucejack Lake	Closure and Reclamation, Post-closure	Closure of mine portals, Underground mine.	Cessation of pumping for dewatering leads to groundwater flow reverting to pre-disturbance conditions.	Backfill underground workings with waste rock, paste tailings or other low-permeability material; cease dewatering activities.	Groundwater discharge and baseflow will return to pre-disturbance rates.
Change in groundwater quality emanating from underground mine	Closure and Reclamation, Post-closure	Closure of mine portals, Underground mine.	Cessation of pumping for dewatering leads to groundwater flow reverting to pre-disturbance conditions. oxic or suboxic water in contact with PAG materials leads to ML/ARD reactions.	Backfill underground workings with waste rock, paste tailings or other low-permeability material; seal portals and ventilation shafts; cease dewatering activities.	Groundwater affected by ML/ARD reactions will migrate through the subsurface, discharging to creeks in the vicinity of the LSA.
Change in groundwater quality in mine-site cuts and fills or quarry	Construction, Operations, Closure and Reclamation, Post-closure	Construction, use and decommissioning of surface workings involving rock disturbance.	Possible contact of oxygenated water with PAG materials	Quarry site chosen to be non-PAG to minimize ML/ARD processes within quarry and mine-site fill areas. Drainage during construction and operations.	Limited amounts of groundwater affected by localized ML/ARD reactions.

[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 receptor VC.*

34.4.3.2 Cumulative Predicted Change Assessment Boundaries for Hydrogeology

Spatial Boundaries

The maximum spatial boundaries for the CEA are limited to the RSA for the Project; however, the changes and residual effects of the Project are localized to the headwaters of the watershed, within two kilometres of the Project footprint.

Temporal Boundaries

The temporal boundaries of the CEA are described in Section 34.2.2. Table 34.4-1 illustrates which past, present, and future projects and activities will potentially have a temporal interaction within the headwaters of the RSA watershed.

34.4.3.3 Cumulative Predicted Change Assessment for Hydrogeology

The current Brucejack Project is essentially an expansion of both the Sulphurets Advanced Exploration Project and the Brucejack Exploration Bulk Sample Program. Changes in hydrogeology from the current Project will be superimposed on the small changes that might remain from the previous projects. Any legacy effects from the prior projects have been accounted for in the baseline and predictive studies. Thus, there are no additional changes to consider and the cumulative changes to groundwater quantity and quality correspond to those of the Brucejack Project itself.

34.4.4 Surface Water Hydrology

34.4.4.1 Summary of Project-specific Predicted Changes for Surface Water Hydrology

Surface water hydrology is a key component of the physical and biological environment because it is linked to other ecosystem components, including surface water quality, fish and fish habitat, and aquatic resources. Surface water hydrology was identified as an intermediate component and refined to three sub-components:

- *Streamflows*: Based on the natural flow regime paradigm (Poff et al. 1997; Poff et al. 2010), flow indices are vital elements of aquatic environmental health. Annual runoff, monthly distribution of runoff, peak flow, and low flow were used as streamflow indices.
- *Channel morphology*: Channel morphology not only pertains to the long-term hydrology and sediment transport regime within a watershed, but it also reflects the aquatic habitat within the streams. Drainage morphology and stability were considered representative indicators of morphology.
- *Glaciers*: Since glaciers contribute to the hydrologic cycle, and are interrelated with streamflows and channel morphology, glaciers were considered as a sub-component of surface water hydrology in this EIS/Application. For effects assessment purposes, glacier ablation is of primary concern, and therefore was selected as an indicator for this sub-component.

The key changes to surface water hydrology that are predicted to remain after the implementation of mitigation measures are summarized in Table 34.4-9.

Table 34.4-9. Summary of Project-specific Predicted Changes after Mitigation for Surface Water Hydrology

Sub-component	Project Phase (Timing of Effect)	Project Component / Physical Activity	Description of Cause-Effect[1]	Description of Mitigation Measure(s)	Description of Predicted Change(s)
Streamflows	Closure	Brucejack Mine Site	During the Closure phase, underground seepage is not pumped into Brucejack Lake. This would reduce streamflows during the low-flow period when streamflows are dependent on the baseflow.	The Water Management Plan (Section 29.19) will be followed; natural flow drainages will be re-established during the Closure phase.	The 24% decrease in low flows has the potential to affect receptor VCs.
Channel Morphology	Construction, Operation, and Closure	Brucejack Access Road	Effects of culverts and bridges on channel morphology	Soils Management Plan (Section 29.13) and Transportation and Access Management Plan (Section 29.16) will be followed. If drainage stability issues are observed, design of hydraulic structures will be re-evaluated.	Culverts in the Wildfire Creek watershed can increase gully formation and downslope mass movement; channel morphology at the Wildfire Creek bridge and at bridges #18 to 21 are less stable than other bridges.
Glaciers	Construction and Operation	Brucejack Access Road	Dust generated by access road operations will fall on Knipple Glacier. The increased dustfall could change the albedo, and therefore the glacier ablation.	Unpaved access roads will be watered to mitigate road dust. Glacier monitoring program will assess glacier melt and additional road dust suppression measures will be taken if necessary.	A conservative estimate suggests a 34% increase in dustfall on the lower 3 km of Knipple Glacier

[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.*

The surface water hydrology sub-components with expected residual effects are:

- *Streamflows:* Estimated effects of the Project on streamflows are described in Section 10.6.1. Low flows at BJL-H1 are estimated to be reduced by up to 24% during the closure. These changes are confined to the LSA boundary. Downstream of the LSA boundary, where interactions with other projects are possible, low flow reductions beyond the reasonable range of data and modelling uncertainty are not expected. Thus, no interactions between the Brucejack Gold Mine Project and other projects are expected with regards to streamflow changes, and therefore no CEA regarding streamflows is undertaken;
- *Channel Morphology:* Effects of the Project on channel morphology are assessed in Section 10.6.2. Operation and maintenance of the access road and hydraulic structures can affect channel morphology within the LSA. Likewise, forestry activities and construction of the existing exploration road could affect the drainage morphology; and
- *Glaciers:* Predicted effects of the Project on glaciers are described in Section 10.6.3. Increased dustfall levels over a portion of Knipple Glacier are predicted. No other past, present, or foreseeable future project is expected to affect Knipple Glacier. Therefore, no CEA regarding glaciers is undertaken.

Based on the CEA criteria (following BC EAO 2013) and expected residual effects, channel morphology is the only sub-component for surface water hydrology that is included in the surface water hydrology CEA. The following sections provide an examination of the relationship between the predicted changes as a result of the Project and those of other projects and activities. A matrix identifying the potential cumulative effect interactions of past, present, and future projects and activities on surface water hydrology is provided in Table 34.4-1.

34.4.4.2 Cumulative Predicted Change Assessment Boundaries for Surface Water Hydrology

Spatial Boundaries

The CEA boundaries (Figure 34.4-2) are aligned with the surface water hydrology RSA and encompass three major groups of watersheds. These are:

- Brucejack Mine Site watersheds — Brucejack Creek and its downstream watersheds (i.e., Sulphurets Creek and Unuk River);
- Brucejack Access Road watersheds — Bowser River (downstream of Knipple Lake), Scott Creek, Todedada Creek, and Wildfire Creek. The access road passes through these watersheds; and
- Brucejack Transmission Line watersheds — Salmon River and Bowser River (upstream of Knipple Lake).

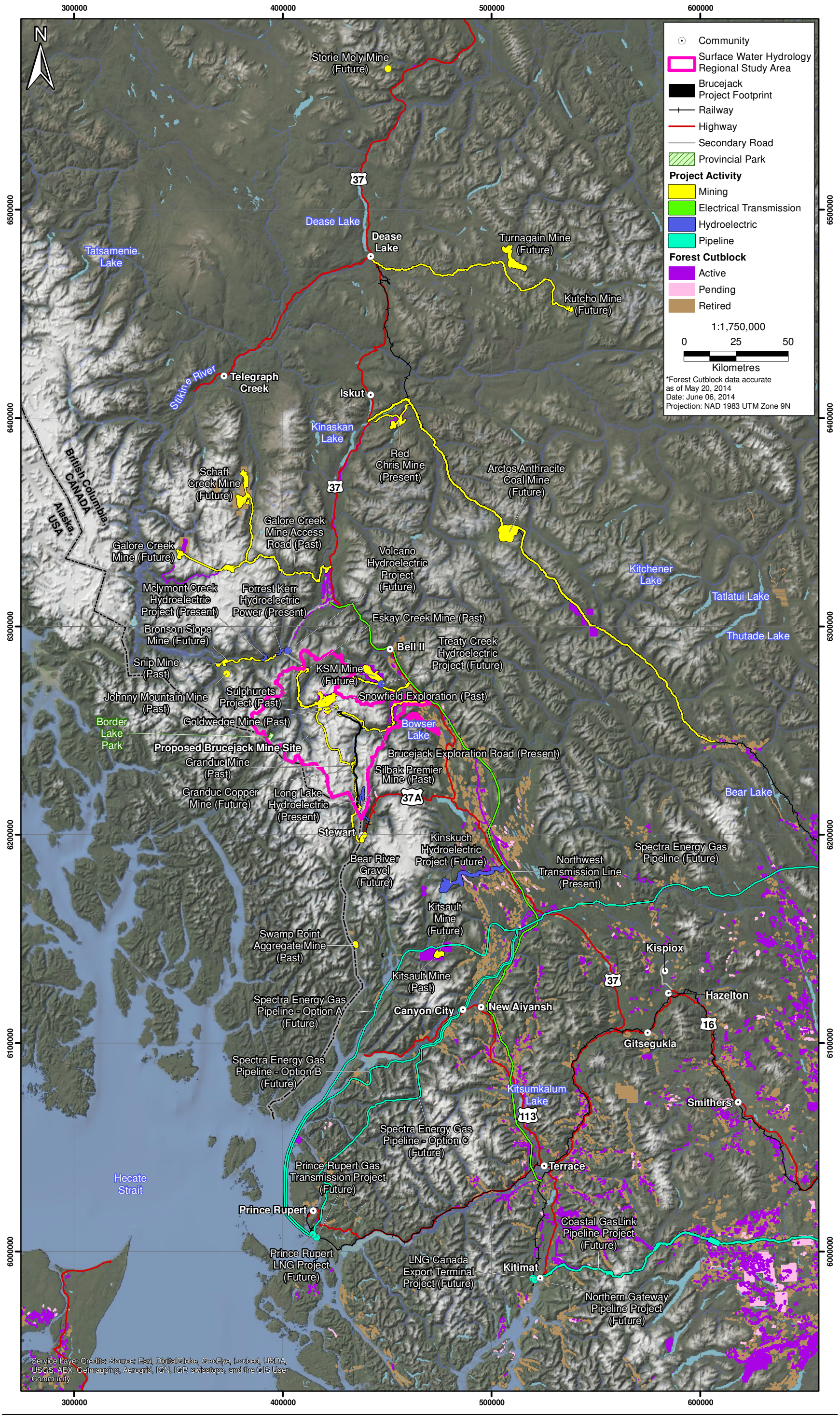
Among all projects in Figure 34.4-2, only the existing access road, which was built as part of the Sulphurets Project and Brucejack Exploration and Bulk Sample Program, and forestry activities along the access road have the potential to interact with the Project to affect channel morphology.

Temporal Boundaries

The temporal boundaries of the CEA are described in Section 34.2.2. Table 34.4-1 illustrates which past, present, and future projects and activities will potentially have a temporal interaction with the surface water hydrology RSA.

Figure 34.4-2

Surface Water Hydrology CEA Boundary Showing all Other Projects and Activities Relevant to Surface Water Hydrology in the Vicinity of the Brucejack Gold Mine Project



34.4.4.3 Cumulative Predicted Change Assessment for Surface Water Hydrology

Table 34.4-2 summarizes the relevant past, present, and future projects and/or land use activities with potential to cumulatively interact with the residual effects estimated for the Project. Morphologic changes (e.g., gully formation and increased mass transport on the down-drainage slope of a culvert) could be caused by a combination of forestry activities, access road construction, stream impairments associated with bridges and culverts, and operation/decommissioning of the access road. For example, a culvert could be built on a slope that is affected by forestry activities. Construction may include diversion ditches that divert runoff from the road to the culvert (i.e., increasing the natural drainage area of the culvert). In addition, poor operations and maintenance could lead to sediment transport issues (i.e., culvert blockage/overflow).

Given the spatial and temporal resolution of the preliminary channel morphology assessment (Chapter 10, Section 10.6.2), the morphologic changes due to individual activities (i.e., forestry, road construction, or road maintenance) could not be differentiated from each other. Rather, the assessment considered the collective effects of:

- the existing infrastructure (e.g., ditches that funnel the flow towards the culverts and alter the natural drainage area);
- forestry activities (e.g., land cover was considered in stability assessment); and
- operation, maintenance, and upgrade activities.

Therefore, the channel morphology assessment (Appendix 10-C, Potential Interactions between the Brucejack Gold Mine Project and Channel Morphology: Preliminary Results, and Section 10.6.2, Channel Morphology Alteration) may be considered as CEA for channel morphology. That is, due to the steep slopes, high culvert density, evidence of mass movements, and potential logging-related impacts, Wildfire Creek is the likeliest of the Project area watersheds to experience channel morphology changes associated with drainage by culverts. Channel morphology stability at Bridges #18 to 21 within the Bowser River watershed (with low gradient, unconfined, perennial streams) was estimated to be the lowest among all bridges. Likewise, channel morphology is not expected to be very stable at Wildfire Creek Bridge primarily due to bank stability issues.

34.4.4.4 Mitigation Measures to Address Cumulative Predicted Change for Surface Water Hydrology

Mitigation measures as described in Chapter 10 will also be applicable to the cumulative effects. Most relevant mitigation measures include:

- Culverts and adjacent slopes will be inspected as required, especially after high rainfall and/or melt events. Identified erosion and sediment concerns, such as blockages, siltation, gullying, or slope failure, will be addressed immediately to protect road infrastructure and the adjacent environment (see Sections 29.13, Soils Management Plan, and 29.16, Transportation and Access Management Plan);
- Channel morphology associated with bed and bank instability along the access road and at culvert and bridge crossing locations will be assessed regularly. Instability will be accessed for risk and addressed accordingly; and
- If drainage stability issues are observed, design of the hydraulic structures will be re-evaluated.

34.4.4.5 Summary of Predicted Cumulative Changes for Surface Water Hydrology

Predicted cumulative changes are those effects remaining after the implementation of all mitigation measures and are summarized in Table 34.4-10.

Table 34.4-10. Summary of Predicted Cumulative Changes on Surface Water Hydrology

Surface Water Hydrology Sub-component	Timing of Predicted Cumulative Change[1]	Description of Cause-Effect[2]	Description of Additional Mitigation (if any)	Description of Predicted Cumulative Change
Channel Morphology	Construction, Operation, Closure	Effects of culverts and bridges on channel morphology	n/a (mitigation measures as per Section 10.7)	Culverts in the Wildfire Creek watershed can increase gully formation and downslope mass movement; channel morphology at the Wildfire Creek bridge and at Bridges #18 to 21 are less stable than other bridges.

[1] *Refers to the Project phase or other timeframe during which the effect will be experienced by the intermediate component.*
[2] *"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.*

The channel morphology assessment (Appendix 10-C, Potential Interactions between the Brucejack Gold Mine Project and Channel Morphology: Preliminary Results, and Section 10.6.2, Channel Morphology Alteration) considered the collective effects of the existing road, forestry activities, and maintenance and upgrade of the access road. Therefore, the channel morphology assessment may be considered as the CEA for channel morphology.

Culverts in the Wildfire Creek watershed are expected to affect the morphology of their down-drainage slopes by increasing gully formation and potentially downslope mass movements. Channel morphology at the Wildfire Creek Bridge, and at low gradient unconfined bridges (i.e., bridges #18 to 21), are less stable than other access road bridges. That is, the channel morphology could be sensitive to maintenance and decommission activities at these bridges.

34.4.5 Terrain and Soils

34.4.5.1 Summary of Project-specific Predicted Changes for Terrain and Soils

Terrain and soils were selected as an intermediate component and assessed for potential effects in Chapter 11, Terrain and Soils Predictive Study, because of their intrinsic link with vegetation, wildlife habitat, water quality, and a broad spectrum of ecosystem functions. Terrain and soils were further refined into sub-components and indicators such as soil quality, soil quantity, and terrain stability, which were used when determining potential effects. The implications of these effects are summarized in Chapter 11, Terrain and Soils Predictive Study; Chapter 16, Assessment of Potential Terrestrial Ecology Effects; and Chapter 18, Assessment of Potential Wildlife Effects. As well, changes to soil quality and quantity can have indirect effects on human health, fish and fish habitat, and surface water quality. These are also discussed in Chapter 11.

Development of the Project will be associated with a residual loss of approximately 61.9 ha of ecologically functional soil. The loss of soils under the footprints of retained mine components will extend into the foreseeable future. An additional 19.8 ha of non-soils fall within the area lost within infrastructure footprints for all of the Sub-areas (the Brucejack Access Road Sub-area, the Brucejack Mine Site Sub-area, and the Brucejack Transmission Line Sub-area); however, these are not considered to be ecologically functional soils because they consist of glaciers, water, or material which has not yet

undergone sufficient weathering to meet soil classification criteria. Total losses of both soils and reclamation material are 24.0 ha within the Brucejack Mine Site, 33.2 ha within the Brucejack Access Road, and 4.7 ha within the Brucejack Transmission Line.

Despite dedication of resources and effort to monitoring and application of mitigation measures, some aspects of soil degradation within the 100-m buffers are expected. Examples of such effects include alteration of the soil moisture regime, changes in flora and fauna communities, erosion of the most fertile fractions of soil, and loss of soil structure. It is predicted that degradation of up to 958.8 ha of ecologically valuable soil could occur within the 100-m buffer around remaining infrastructure. Of this degradation of 187.3 ha of ecologically functional soil could occur within the Mine Site Sub-Area, up to 715.5 ha along the Brucejack Access Road Sub-Area, and up to 56.0 within the Transmission Line Sub-Area. While it is expected that a considerable portion of reclaimed areas will recover over time, the harsh local climate and demanding site topography could limit the success of the planned reclamation efforts.

Therefore, the sub-components for terrain and soils that are carried forward and included in this CEA are:

- soil quantity; and
- soil quality.

The terrain stability sub-component is not carried forward into the CEA for terrain and soils as there are no residual effects for terrain stability. The Project will not result in an increase in residual terrain instability or geohazards, as all potential geohazard scenarios will be mitigated through engineering and Project design.

The following sections provide an examination of the relationship between the predicted changes as a result of the Project and those of other projects and activities. A matrix identifying the potential cumulative effect interactions of past, present and future projects and activities on terrain and soils is provided in Table 34.4-1.

34.4.5.2 Cumulative Predicted Change Assessment Boundaries for Terrain and Soils

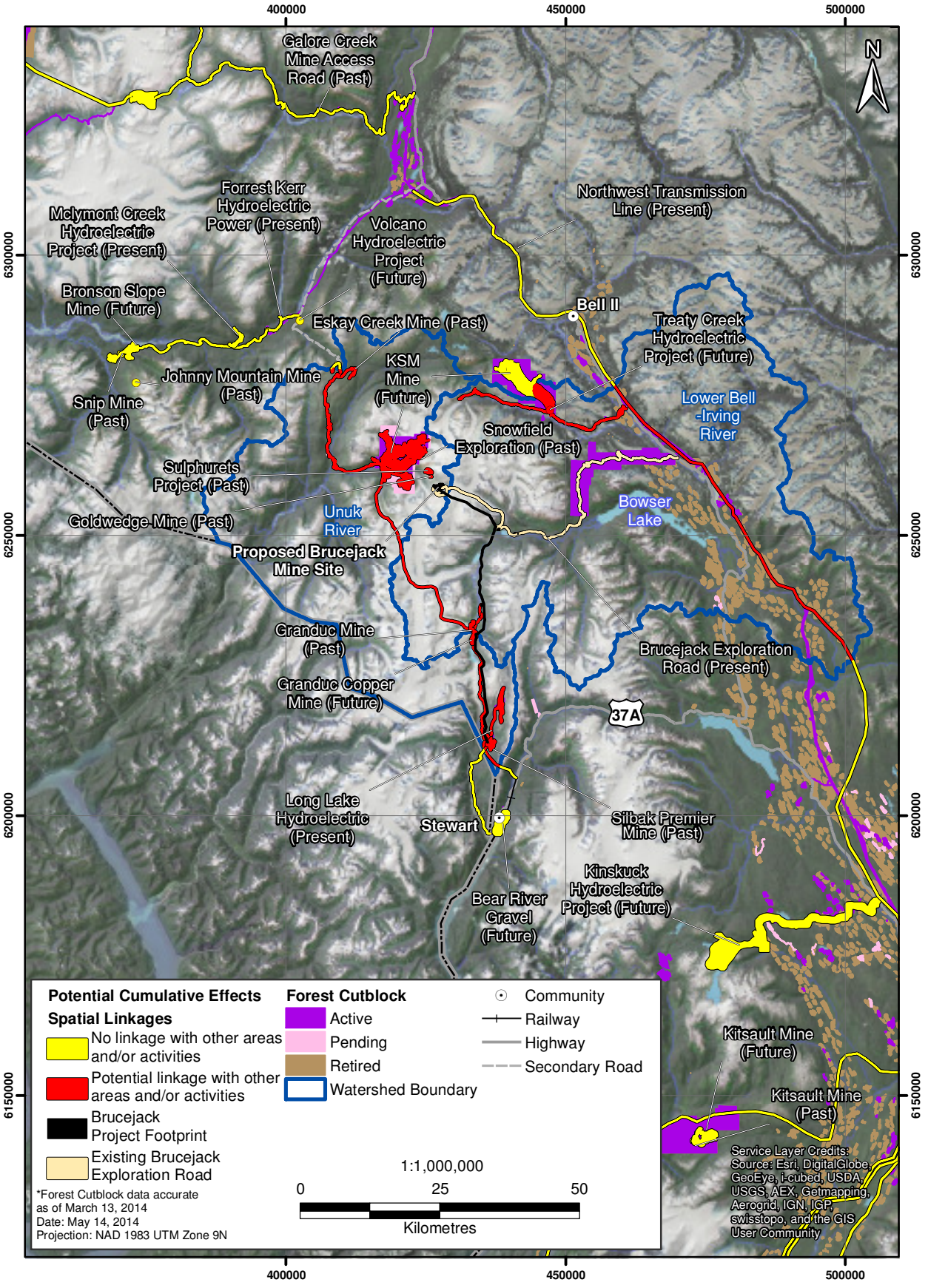
Spatial Boundaries

Due to the important role of water in soil erosion and pollutant transfer, watersheds are a natural unit within which distribution of most erosion and contamination takes place. Scientific evidence suggests that the most important long-term environmental impacts associated with soil disturbance are related to soil erosion and subsequent sedimentation of streams (Forman et al. 1997; Seiler 2001). Due to the confinement of most effects on a watershed basis, this natural boundary was used to define the CEA spatial boundary for terrain and soils.

The Project footprint extends into two watersheds: the Lower Bell-Irving River watershed, occupying 353,718 ha, and the Unuk River watershed, covering an additional 196,912 ha. Together, these comprise the terrain and soils CEA area, which occupies approximately 550,630 ha (Figure 34.4-3). A portion of the Project does extend into the Salmon River Watershed; however, this is confined to 3.15 km of the Brucejack Transmission Line. As the CEA study area is based upon watershed boundaries, the inclusion of this portion of the Transmission Line in the CEA would have added the 24,380 ha of the Salmon River watershed to the CEA study area. Given that the nature of the disturbance associated with the Brucejack Transmission Line, disturbance is mostly confined to tower pad installation.

Figure 34.4-3

Spatial Distribution of Human Activities within the Brucejack Cumulative Effects Assessment Area



Temporal Boundaries

The temporal boundaries of the CEA are described in Section 34.2.2. Table 34.4-1 illustrates which past, present, and future projects and activities will potentially have a temporal interaction with the terrain and soils study area.

34.4.5.3 Cumulative Predicted Change Assessment for Terrain and Soils

Loss of soil quantity and quality is expected to result from the removal of soil due to clearing for infrastructure footprints; erosion due to exposure of mineral soil and alteration of local hydrology from ground clearing activities associated with the mine and road; and power transportation development. Development of these Project components will result in disturbances that may or may not be reclaimed. Permanent access roads and non-reclaimed, disturbed areas such as landings, laydown areas, and the quarry contribute to a direct loss of soil quantity otherwise available to perform a number of ecological functions, and constitute a fundamental change in land use (Bulmer et al. 2008).

Table 34.4-2 summarizes the relevant past, present, and future projects and/or land use activities with potential to cumulatively interact with the residual effects estimated for the Project. Cumulative loss of soil quality and quantity was determined for each footprint of past, present, and future projects within the terrain and soils CEA area. This information is summarized per project footprint in Table 34.4-11. The footprints represent the worst-case scenario for loss of soil quantity, as the project effects applied to these areas do not necessarily result in soil loss. For example, the Northwest Transmission Line footprint includes the entire linear corridor, within which very little soil loss will occur, being confined to the access road, laydown areas, and other areas of infrastructure development. As well, a certain percentage of the disturbed land base will undergo reclamation, which will be carried out with varying degrees of success.

Table 34.4-11. Footprints of Projects Included in the Cumulative Effects Assessment

CEA Temporal Project Status	Projects within the Terrain and Soils CEA Area	Project Footprint (ha)
Past Project or Activity	Eskay Creek Mine	93
	Goldwedge Mine	6
	Granduc Mine	84
	Silbak Premier Mine	123
	Snowfields Exploration	6
	Sulphurets Project	85
Present Projects	Long Lake Hydroelectric	430
	Northwest Transmission Line	2,766
	Brucejack Exploration Phase	184
Reasonably Foreseeable Future Project or Activity	KSM Project	5,224
	Treaty Creek Hydroelectric	Not available
	Granduc Mine	1,956
Total		**10,872**

The footprints of all past, present and reasonably foreseeable future projects and activities cumulatively add up to 10,733 ha, representing about 1.95% of the terrain and soils CEA area.

There is potential for changes to soil quality to occur within the footprints of the project-related infrastructure, as well as in areas that are spatially linked to project activities. Soil compaction will occur due to the establishment of laydown areas and vehicular traffic. Foot traffic around project sites may also result in soil compaction. Linkages such as hydrological connectivity and air movement provide means for alterations of soil quality to occur away from the project footprint. Hydrological

linkage can result in the transfer of contaminants and sediments off site, while aerial deposition of metals away from the project footprint can occur through air movement. Within each project footprint some level of soil contamination can occur due to metal leaching from waste rock storage areas, from road cuts through acid generating rock, and from fluid leaks. Soil degradation will also occur during salvage, long-term storage, and redistribution. Landslides and other forms of soil erosion associated with roads have been shown to decrease the productivity of surrounding areas (Smith, Commandeur, and Ryan 1986; Bulmer et al. 2008).

Consequently, as the proportion of developed land increases, the cumulative spatial extent of soil degradation is expected to rise. Soil degradation associated with the other projects considered in this CEA is expected to spatially and temporarily interact with soil degradation associated with the Project.

34.4.5.4 Mitigation Measures to Address Cumulative Predicted Change for Terrain and Soils

Soils environmental management and monitoring plans are designed to avoid and minimize adverse effects to soil quality and soil quantity resulting from project activities within the feasible limits of project design and activities. Each past, present, and future project would have had or will have different mitigation measures and management practices for soil quality and soil quantity; however, it is generally assumed that any present and future projects will take into consideration the goals and requirements/objectives outlined in the relevant management plans.

Project-specific Cumulative Effects Mitigation for Loss of Soil Quantity

Project-specific cumulative effects mitigation for loss of soil quantity involves following the objectives and targets as outlined in the Soils Management Plan (Section 29.13). No additional mitigation measures are proposed.

Other Project/Activity Mitigation to Address Loss of Soil Quantity

In order to mitigate impacts to the soil resource, current and future projects must follow project-specific management plans designed to minimize both loss and degradation of soil. These plans should have similar objectives and targets as presented in Section 29.13, Soils Management Plan. However, the cumulative effects of soil loss are best addressed by early review of alternative design options and introduction of changes leading to reduction of the area on which ecological function of soil will be lost to soil excavation, burial, or erosion.

While the above strategies require participation of each of the involved projects, proactive and comprehensive regional planning will also provide effective mitigation of the cumulative effects of soil loss. Whenever feasible, resource sharing (e.g., highways, power lines, water, and fuel stations) and data sharing (e.g., assessment of the effectiveness of the monitoring methodologies and actions taken to improve the program if relevant, as well as the identification of any emerging negative trends) could be considered.

Project-specific Cumulative Effects Mitigation for Loss of Soil Quality

Project-specific cumulative effects mitigation for loss of soil quality involves following the objectives and targets as outlined in Section 29.13, Soils Management Plan. No additional mitigation measures are proposed. The Soil Management Plan will entail implementation of mitigation measures.

34.4.5.5 Summary of Predicted Cumulative Changes for Terrain and Soils

Predicted cumulative changes are those effects remaining after the implementation of all mitigation measures and are summarized in Table 34.4-12.

Table 34.4-12. Summary of Predicted Cumulative Changes on Terrain and Soils

Intermediate Component	Timing of Predicted Cumulative Change[1]	Description of Cause-Effect[2]	Description of Additional Mitigation (if any)	Description of Predicted Cumulative Change	VCs Affected
Soil quantity	Construction – beyond Post-closure	Removal of soil due to clearing for infrastructure footprints, mass wasting, and alteration of local hydrology.	No additional measures beyond Project specific BMPs as outlined in Soil Management Plant (Section 29.13)	Loss of soil quantity	Terrestrial ecosystems, human health, fish and fish habitat, surface water quality
Soil quality	Construction – beyond Post-closure	Degradation of soil due to metal loading via dust, contamination due to spills, alteration of physical characteristics due to compaction, surface erosion.	No additional measures beyond Project specific BMPs as outlined in Soil Management Plant (Section 29.13)	Loss of soil quality, including reductions in productivity and increases in contamination	Terrestrial ecosystems, human health, fish and fish habitat, surface water quality

[1] Refers to the Project phase or other timeframe during which the effect will be experienced by the intermediate component.
[2] "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.

The other projects included in the CEA combine for a total project footprint of 10,688 ha. This represents about 1.94% of the terrain and soils CEA study area (550,630 ha). The Project will result in loss of 61.9 ha of ecologically valuable soil and the degradation of 958.8 ha of ecologically valuable soil. Therefore, in total, all past, present, and future projects as well as the Project have a combined footprint of 10,749.9 ha. This represents 1.95% of the terrain and soils CEA area. Therefore, the inclusion of the Project with the list of future projects results in an increase of approximately 0.01% of the area within the terrain and soils CEA area occupied by industrial footprint. This is the worst-case scenario for soil loss, as no reclamation activity is taken into consideration with this calculation.

Cumulative Residual Change Characterization for Soil Quantity

The probability of soil loss due to cumulative project development is high, while the confidence in the predicted outcome is medium due to potential interactions with natural slope instability, seismic activity, and other projects. While the spatial extent of this effect is expected to remain local on a project-by-project basis, the duration of the land loss will extend into the far future. The losses will occur with sporadic frequency throughout and beyond the life of the projects. The effect is irreversible, as the soils in some areas of the projects (e.g., quarry and/or some roads) will be permanently lost, while other areas will take decades to recover. Due to the scarcity of quality soils and the high degrees of acidity in those present, the resilience of the receiving environment is considered low. The overall ecological context is neutral.

Cumulative Residual Change Characterization for Soil Quality

The probability of loss of soil quality due to cumulative project development is medium, while the confidence in the predicted outcome is also medium due to potential interactions with natural slope instability, seismic activity, other projects, variability of contamination sources and pathways, and success of mitigation measures. While the spatial extent of this effect is expected to remain local on a project-by-project basis, the duration of the land loss will extend into the far future. The losses of soil quality will occur with sporadic frequency throughout and beyond the life of the projects. Soil

degradation is considered irreversible because many of the causal agents will not be removed, and recovery takes decades. There is a high incidence of natural slope erosion and sporadically high soil metal concentrations; however, the high degree of acidity present in the soils means that they have limited capacity to buffer further chemical inputs. Therefore, the resilience of the receiving environment is considered low. The overall ecological context is neutral.

34.5 CUMULATIVE EFFECTS ASSESSMENT ON RECEPTOR VALUED COMPONENTS

A review of the interaction between potential Project effects and effects of other projects and activities on receptor VCs was undertaken. The review assessed the projects and activities identified in Section 34.3, including:

- regional projects and activities that are likely to affect the receptor VC, even if they are located outside the direct zone of influence of the project;
- effects of past and present projects and activities that are expected to continue into the future (i.e., beyond the effects reflected in the existing conditions of the receptor VC); and
- activities not limited to other reviewable projects, if those activities are likely to affect the receptor VC cumulatively (e.g., forestry, mineral exploration, and commercial recreational activities).

A matrix identifying the potential cumulative effect interactions for receptor VCs is provided in Table 34.4-1. Potential cumulative changes to intermediate components from the Brucejack Gold Mine Project, and other projects and activities, are summarized in Table 34.4-2.

34.5.1 Climate

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. It is known that the Project will: 1) emit greenhouse gases (GHG) that contribute to climate change; and 2) be affected by climate change itself. However, as determined by the assessment for both facility and land-use change GHG emissions as outlined in Chapter 12, Assessment of Potential Climate Effects, the total average annual GHG emissions from the Project over the combined Construction and Operation phases is rated as **not significant** (Table 34.5-1). 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, the 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 34.5-1. Summary of Project-specific 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

A CEA 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.

34.5.2 Surface Water Quality

34.5.2.1 Summary of Project-specific Residual Effects on Surface Water Quality

Water quality is a critical component of the biological and physical environment and is protected under both provincial (e.g., *Environmental Management Act* [2003], *Mines Act* [1996]) and federal (e.g., Metal Mining Effluent Regulations [MMER; SOR/2002-2222] under the *Fisheries Act* [1985a]) legislation. Further, surface water quality of the Project has international transboundary implications, as the proposed mine location is situated within the Sulphurets Creek watershed, a tributary of the Unuk River which transverses Alaska and drains into the Pacific Ocean at Burroughs Bay.

Chapter 13, Assessment of Potential Surface Water Quality Effects, details the assessment of potential residual effects of the Project on surface water quality. Project-related residual effects for surface water quality are anticipated at Brucejack Creek (mine site area) due to localized increases in metal concentrations (contaminant of potential concern [COPCs]; arsenic, chromium, zinc), increases in nitrogen as nitrate, nitrite, ammonia (leaching of blasting residues), and due to erosion and sedimentation (Table 34.5-2). Project-related residual effects are anticipated in off-site areas (ancillary Project infrastructure) due to localized increases in metal leaching and acid rock drainage (ML/ARD), increases in nitrogen as nitrate, nitrite, ammonia (leaching of blasting residues), and due to erosion and sedimentation (Table 34.5-2). As a result of design changes and planned implementation of mitigation and monitoring programs, residual surface water quality effects associated with the Project are assessed as **not significant** (Table 34.5-2).

Table 34.5-2. Summary of Project-specific Residual Effects, Mitigation, and Significance on Surface Water Quality

Residual Effects	Project Phase(s)	Mitigation Measures	Significance
Mine Site Area and Receiving Environment			
Change in water quality of receiving environment due to localized increases in sulphate and metal concentrations (COPCs: arsenic).	Construction, Operation, Closure, Post-closure	Implementation of ML/ARD Management Plan (Section 29.10), Waste Rock Management Plan (Section 29.18), Tailings Management Plan (Section 29.15), Water Management Plan (Section 29.19), Aquatic Effects Monitoring Plan (Section 29.3); collection and treatment of seepage from underground workings.	Not significant
Change of water quality due to localized increases in sulphate and metal concentrations (COPCs: chromium, zinc)	Operation, Closure	Implementation of ML/ARD Management Plan (Section 29.10), Waste Rock Management Plan (Section 29.18), Tailings Management Plan (Section 29.15), Water Management Plan (Section 29.19), Aquatic Effects Monitoring Plan (Section 29.3); collection and treatment of seepage from underground workings.	Not significant
Change of water quality due to localized increases in nitrogen as nitrate, nitrite, ammonia (leaching of blasting residues).	Construction, Operation, Closure, Post-closure	Waste Rock Management Plan (Section 29.18), Tailings Management Plan (Section 29.15), Water Management Plan (Section 29.19), Aquatic Effects Monitoring Plan (Section 29.3); collection and treatment of seepage from underground workings.	Not significant

(continued)

Table 34.5-2. Summary of Project-specific Residual Effects, Mitigation, and Significance on Surface Water Quality (completed)

Residual Effects	Project Phase(s)	Mitigation Measures	Significance
Mine Site Area and Receiving Environment (cont'd)			
Change of water quality of receiving environment due erosion and sedimentation	Construction, Operation, Closure, Post-closure	Use of best management practices to minimize sediment entry to waterbodies; Dust suppression on roads; implementation of Soils Management Plan (Section 29.13), Water Management Plan (Section 29.19), Aquatic Effects Monitoring Plan (Section 29.3).	Not significant
Off-site Areas (Ancillary Project Infrastructure)			
Change in water quality of receiving environment	Construction, Operation, Closure, Post-closure	Implementation of ML/ARD Management Plan (Section 29.10), Soils Management Plan (Section 29.13), Transportation and Access Management Plan, BMPs	Not significant

The following sections provide an examination of the relationship between the residual effects of the Project and those of other projects and activities. A matrix identifying the potential cumulative effect interactions of past, present and future projects and activities on surface water quality is provided in Table 34.4-1.

34.5.2.2 Cumulative Effects Assessment Boundaries for Surface Water Quality

Spatial Boundaries

Cumulative effects scoping considered past, present, and future actions for watersheds downstream of the Project (Figure 34.5-1). Watersheds with the potential to be affected by Project activities include the Unuk River, Sulphurets Creek, Bell-Irving River, and Bowser River watersheds. Past, present, and/or potential future activities may combine to affect surface water quality in the LSA and RSA, in CEA boundaries, or in downstream watersheds. The surface water quality CEA boundary is the same as the RSA. The RSA was selected based upon watersheds within, upstream, and downstream of the Project with a potential for direct effects. Projects that are located outside of the identified watershed boundaries were excluded from the CEA.

Temporal Boundaries

The temporal boundaries of the CEA are described in Section 34.2.2. Effects to surface water quality from past projects and human activities may temporally overlap with potential effects from the Project, if discharge from the activities persists in the aquatic environment or if habitat has not had sufficient time to recover from past effects. Table 34.4-1 illustrates which past, present and future projects and activities will potentially have a temporal interaction with the surface water quality study area.

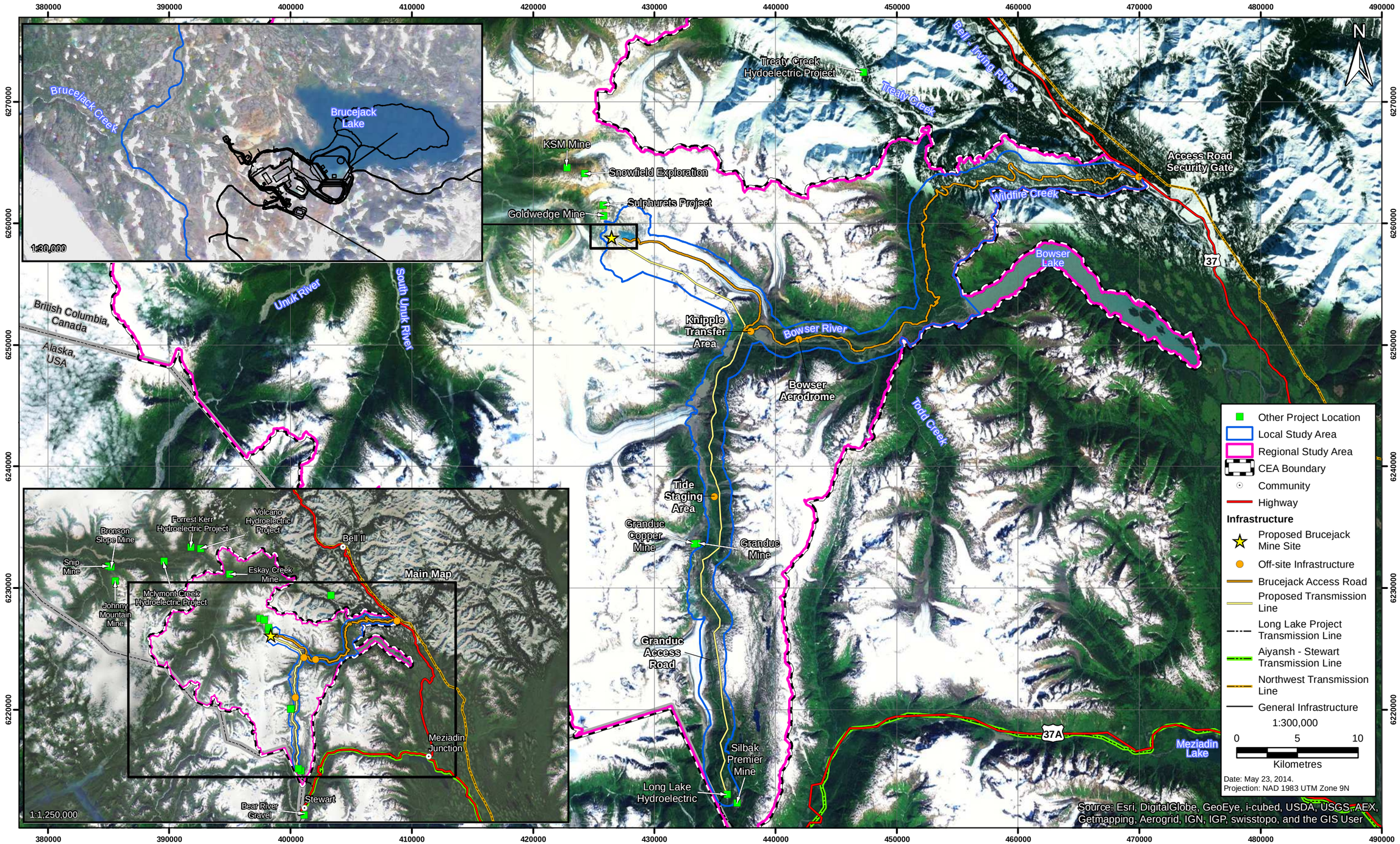
34.5.2.3 Cumulative Effects Assessment on Surface Water Quality

Cumulative effects from past, present, or foreseeable future activities, together with the Project, were assessed to determine the overall effect to surface water quality in the LSA and RSA and downstream watersheds (Table 34.4-2).

The surface water quality cumulative effects boundaries are based upon the watersheds in which the proposed Brucejack Gold Mine Project is located. As such, the mine area of the KSM Project is located within the cumulative effects boundary (Sulphurets Creek and Unuk River watersheds), while the processing and tailings management area of the KSM Project is located outside of the cumulative effects boundary (Teigen Creek, Treaty Creek). Therefore, the mine area of the KSM Project was only included in the CEA.

Figure 34.5-1

Surface Water Quality CEA Boundary Showing All Other Projects and Activities Relevant to Surface Water Quality in the Vicinity of the Brucejack Gold Mine Project



The KSM Project identified residual cumulative effects on surface water quality due to increased selenium concentrations downstream of the mine site. No other residual effects were identified.

Increased selenium loading from the Project has the potential to increase concentrations of selenium downstream in Sulphurets Creek and the Unuk River, which could result in a cumulative effect of a greater magnitude in the Unuk River at the BC-Alaska border. However, no guideline exceedances of selenium were predicted for the Project and selenium was not identified as a COPC (Section 13.6.1.2). Further dilution from the assessment point to Sulphurets Glacier, as well as substantial natural change in water chemistry observed as Brucejack Creek passes under Sulphurets Glacier and joins the existing sub-glacial flow of Sulphurets Creek results in any potential incremental increase in water quality parameters due to chemical loading upstream at Brucejack creek and lake to be negligible/undetectable in Sulphurets Creek Therefore there are no expected measureable cumulative effects on surface water quality due to selenium concentrations in the Sulphurets and Unuk watersheds. Similarly, as incremental increase in water quality parameters due to chemical loading upstream at Brucejack creek are expected to be negligible/undetectable (Section 13.6.1.2), there are no expected measureable cumulative effects on surface water quality due to identified COPCs for the Project (As, Cr, Zn) in the Sulphurets and Unuk watersheds.

No potential cumulative surface water quality effects were identified for off-site areas and will not be considered further in this assessment.

34.5.2.4 Mitigation Measures to Address Cumulative Effects on Surface Water Quality

Extensive mitigation to avoid degradation of surface water quality was included in the design for the proposed Project. Mitigation includes measures to avoid, reduce, and monitor adverse effects to surface water quality and specific mitigation measures that were developed for the various pathways that Project components can potentially interact with surface water quality. There are no additional specific mitigation or management measures proposed since no cumulative surface water quality effects were identified. Mitigation measures provided in Chapter 13, Assessment of Potential Surface Water Quality Effects (Section 13.5.2) and the associated management plans are applicable to the potential cumulative changes. In summary, water quality effects for the Project will be primarily mitigated through water management including diversion of non-contact water and collection and treatment of contact water as well as subaqueous deposition of tailings and waste rock into Brucejack Lake.

Water quality monitoring and adaptive management are expected to minimize water quality effects throughout the Construction, Operation, Closure, and Post-closure phases.

34.5.2.5 Summary of Residual Cumulative Effects on Surface Water Quality

Cumulative residual effects are those effects remaining after the implementation of all mitigation measures and are summarized in Table 34.5-3. No residual effects were identified and characterization of cumulative effects was assessed **as not applicable (N/A**) in Table 34.5-3.

Table 34.5-3. Summary of Cumulative Residual Effects on Surface Water Quality: Mine Site Area

Sub-component	Timing of Cumulative Residual Effect[1]	Description of Cause-Effect[2]	Description of Additional Mitigation (if any)	Description of Cumulative Residual Effect
Change in water quality of receiving environment due to localized increases in sulphate and metal concentrations (COPCs: arsenic).	N/A	N/A	N/A	N/A

(continued)

Table 34.5-3. Summary of Cumulative Residual Effects on Surface Water Quality: Mine Site Area (completed)

Sub-component	Timing of Cumulative Residual Effect[1]	Description of Cause-Effect[2]	Description of Additional Mitigation (if any)	Description of Cumulative Residual Effect
Change of water quality due to localized increases in sulphate and metal concentrations (COPCs: chromium, zinc)	N/A	N/A	N/A	N/A
Change of water quality due to localized increases in nitrogen as nitrate, nitrite, ammonia (leaching of blasting residues).	N/A	N/A	N/A	N/A
Change of water quality of receiving environment due erosion and sedimentation	N/A	N/A	N/A	N/A

[1] *Refers to the Project phase or other timeframe during which the effect will be experienced by the intermediate receptor or VC.*
[2] *"Cause-effect" refers to the relationship between the Project component/physical activity that is causing the change or effect in the condition of the receptor VC, and the actual change or effect that results.*

34.5.3 Aquatic Resources

34.5.3.1 Summary of Project-specific Residual Effects on Aquatic Resources

Aquatic resources refer to the biological communities residing within water column and sedimentary system compartments of the freshwater environment. Changes of water and sediment quality can affect the diversity, abundance, and activities of primary and secondary producer communities. Such effects to aquatic resources may cascade to higher trophic levels that depend directly or indirectly on primary and secondary producer communities to survive, including birds, amphibians, and fish. Other roles served by aquatic resources include nutrient and organic matter cycling, photosynthesis, the stabilization of substrata, and providing habitat for other organisms.

Chapter 14, Assessment of Potential Aquatic Resources Effects, details the assessment of potential residual effects of the Project on aquatic resources. The residual effects on aquatic resources included in this CEA are:

- erosion and sedimentation in the Mine Site Area;
- changes in surface water quantity in the Mine Site Area;
- changes in surface water quality, due to ML/ARD and nutrient loading in the Mine Site Area;
- changes in sediment quality in the Mine Site Area;
- habitat loss in the Mine Site Area; and
- changes in surface water quality due to ML/ARD in the off-site infrastructure areas.

The residual effects on aquatic resources are predicted to result from increased erosion and transport of suspended material in the aquatic environment, water management, the operation of the sewage treatment plant and mine water treatment plant, and the deposition of tailings and waste rock in Brucejack Lake (Section 14.6, Residual Effects on Aquatic Resources). The analysis of residual effects in the Mine Site Area are supported by predictive modeling studies for air quality (Chapter 7, Air Quality Predictive Study), hydrology and the site water balance (Chapter 10, Surface Water Hydrology Predictive

Study), and surface water quality (Chapter 13, Assessment of Potential Surface Water Quality Effects). The residual effects to surface water quality in the off-site infrastructure areas are predicted to result from ML/ARD processes related to the development, operation, and decommissioning of infrastructure at the transfer areas, the Bowser aerodrome, and along the access road (Section 14.6.2.1). As a result of design changes and planned implementation of mitigation and monitoring programs, residual aquatic resources effects associated with the Project are assessed as **not significant** (Table 34.5-4).

Table 34.5-4 presents a summary of residual effects, mitigation, and significance on the aquatic resources VC. All identified residual effects in Table 34.5-4 will be carried forward to the CEA.

Table 34.5-4. Summary of Residual Effects, Mitigation, and Significance on Aquatic Resources

Residual Effects	Project Phase(s)	Mitigation Measures	Significance
Mine Site Area			
Erosion and Sedimentation	Construction, Operation, Closure, Post-closure	• Use of best management practices to minimize sediment entry to waterbodies; • dust suppression on roads; and • implementation of Soils Management Plan (Section 29.13), Water Management Plan (Section 29.19), Aquatic Effects Monitoring Plan (Section 29.3).	Not significant
Changes in Surface Water Quantity	Closure	• Use of best management practices and engineered water management structures to maintain natural drainage networks, as much as feasible; • diversion of non-contact water into existing water courses; and • implementation of Water Management Plan (Section 29.19).	Not significant
Changes in Surface Water Quality	Construction, Operation, Closure, Post-closure	• Implementation of ML/ARD Management Plan (Section 29.10), Waste Rock Management Plan (Section 29.18), Tailings Management Plan (Section 29.15), Water Management Plan (Section 29.19), Aquatic Effects Monitoring Plan (Section 29.3); and • collection and treatment of seepage from underground workings.	Not significant
Changes in Sediment Quality	Construction, Operation, Closure, Post-closure	• Use of best management practices to minimize sediment entry to waterbodies; • dust suppression on roads; • collection and treatment of seepage from underground workings; and • implementation of ML/ARD Management Plan (Section 29.10), Waste Rock Management Plan (Section 29.18), Soils Management Plan (Section 29.13), Water Management Plan (Section 29.19), Aquatic Effects Monitoring Plan (Section 29.3).	Not significant
Habitat loss	Construction, Operation, Closure, Post-closure	• Tailings deposition to the deepest section of Brucejack Lake (eastern portion of lake), with subaquaeous discharged designed to add tailings to the deepest area.	Not significant
Off-site Project Infrastructure Areas			
Changes in surface water quality	Construction, Operation, Closure, Post-closure	• Implementation of ML/ARD Management Plan (Section 29.10), Waste Rock Management Plan (Section 29.18), Tailings Management Plan (Section 29.15), Water Management Plan (Section 29.19), and Aquatic Effects Monitoring Plan (Section 29.3)	Not significant

34.5.3.2 Cumulative Effects Assessment Boundaries for Aquatic Resources

Spatial Boundaries

Cumulative effects scoping considered past, present, and future actions for watersheds downstream of the Project (Figure 34.5-2). Watersheds with the potential to be affected by the Project activities include the Unuk River, Sulphurets Creek, Bell-Irving River, and Bowser River watersheds. Past, present, and/or potential future activities may combine to affect aquatic resources in the LSA and RSA, in CEA boundaries, or in downstream watersheds. The aquatic resources CEA boundary is the same as the RSA. The RSA was selected based upon watersheds within, upstream, and downstream of the Project with a potential for direct effects. Projects that are located outside of the identified watershed boundaries were excluded from the CEA.

Temporal Boundaries

The temporal boundaries of the CEA are described in Section 34.2.2. Effects to aquatic resources from past projects and human activities may temporally overlap with potential effects from the Project, if the effects from past activities persists in the aquatic environment or if the aquatic organisms or sediment quality have not recovered from past effects. Table 34.4-1 illustrates which past, present, and future projects and activities will potentially have a temporal interaction with the aquatic resources RSA.

34.5.3.3 Cumulative Effects Assessment on Aquatic Resources

Cumulative effects from past, present, or foreseeable future activities, together with the Project, were assessed to determine the overall effect to aquatic resources in the LSA and RSA and downstream watersheds (Table 34.4-2).

Cumulative Effects on Erosion and Sedimentation in the Mine Site Area

The mine area of the KSM Project is located within the cumulative effects boundary (Sulphurets Creek and Unuk River watersheds), while the processing and tailings management area of the KSM Project is located outside of the cumulative effects boundary (Teigen Creek, Treaty Creek). Therefore, only the mine area of the KSM Project is included in the CEA, since identified potential effects within processing and tailings management area watersheds would not have an interaction with the proposed Brucejack Gold Mine Project. No significant effects from erosion and sedimentation from the KSM Project site in the Sulphurets/Unuk watersheds were predicted because of the application of mitigation and management measures. However, the potential for some erosion and sedimentation was predicted, with the subsequent potential for non-significant effects to aquatic resources.

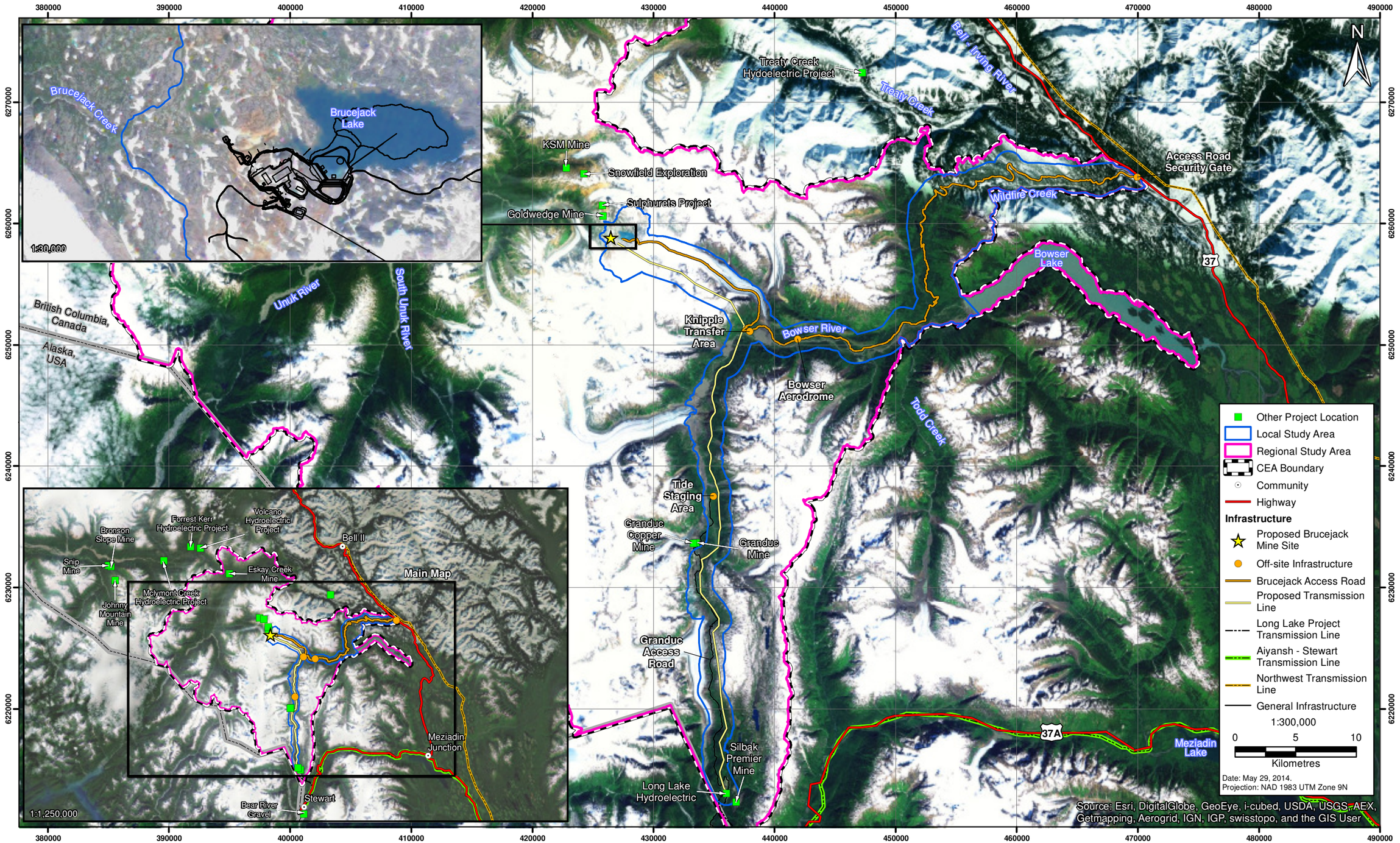
The residual effects from erosion and sedimentation from the Project are predicted to be restricted to the Brucejack watershed (Section 14.7.1.1). Therefore, there is no spatial or temporal overlap between the Brucejack Gold Mine Project and KSM Project, and no potential for cumulative effects is predicted and no further analysis is required.

Cumulative Effects on Surface Water Quantity in the Mine Site Area

The KSM Project was predicted to have no significant effects on water quantity in the Sulphurets/Unuk watersheds. However, no spatial or temporal overlap between the Brucejack Gold Mine Project and the KSM Project is predicted because the residual effects from changes in water quantity for the Brucejack Gold Mine Project are restricted to the Brucejack watershed. Therefore, no potential for cumulative effects from changes in surface water quantity are predicted, and no further analysis is required.

Figure 34.5-2

Aquatic Resources CEA Boundary Showing All Other Projects and Activities Potentially Affecting Aquatic Resources in the Vicinity of the Brucejack Gold Mine Projet



Cumulative Effects on Surface Water Quality in the Mine Site Area

The KSM Project identified residual cumulative effects on surface water quality as changes in metal concentrations (selenium) downstream of the mine area, but it was not expected to be significant due to the mitigation plan. However, no spatial or temporal overlap between the Brucejack Gold Mine Project and the KSM Project is predicted because the residual effects from changes in water quality for the Brucejack Gold Mine Project are restricted to the Brucejack watershed. Therefore, no potential for cumulative effects from changes in surface water quality are predicted, and no further analysis is required.

Cumulative Effects on Sediment Quality in the Mine Site Area

No spatial or temporal overlap between the Brucejack and KSM projects for sediment, surface water quantity, or surface water quality have been identified (Sections 14.9.2.1 to 14.9.2.3). Therefore, no overlap exists between potential residual effects to sedimentation, and no cumulative effects are predicted. No further analysis is conducted for potential cumulative effects to sediment quality.

Cumulative Effects on Habitat Loss in the Mine Site Area

The residual effects of habitat loss are restricted to Brucejack Lake (Section 14.7.1.5). There is no expected biological connectivity for aquatic resources between Brucejack Lake and waterbodies potentially affected by the KSM Project because Brucejack Lake is the headwaters for Brucejack Creek. Primary and secondary producers are not expected to travel the long distances (over 10 km; Figure 34.5-2) between waterbodies. Therefore, there is no spatial or temporal overlap for the potential cumulative effects of habitat loss, and no further analysis is conducted.

Cumulative Effects on Surface Water Quality in the Off-site Infrastructure Areas

The residual effects in the off-site infrastructure areas from ML/ARD are predicted to be short-term effects related to the disturbance of ground cover and the exposure of potential ML/ARD sources on the landscape (Section 14.7.2.1). There will be no potential cumulative effect from interactions between the Project activities in the Bowser River watershed and the activities at the Granduc mine because it is unlikely that there will be any temporal overlap because the Project residual effects in the Bowser watershed are predicted to be fully reversible and short-term (Section 14.7.2.1). The Granduc project, which is still in the early planning stages, would only be starting activities in 2016, which is after the completion of significant ground disturbance activities related to Brucejack Gold Mine Project activities in the Bowser watershed. Furthermore, details on the scope and extent of Granduc project activities are not available.

The potential residual effects from the Northwest Transmission Line (NTL) project are not predicted to have any temporal interaction with Project-related effects associated with off-site Project infrastructure. The NTL project occurs at the far eastern edge of the cumulative effects RSA, and no biophysical association with the local and sporadic residual effects from Project activities is expected to reach the edge of the RSA (Section 14.7.2.1). Based on the absence of temporal or spatial overlap with the NTL and Granduc projects, no cumulative effects are predicted for changes in surface water quality in the off-site infrastructure areas, and no further analysis is conducted.

34.5.3.4 Mitigation Measures to Address Cumulative Effects on Aquatic Resources

Extensive mitigation and management measures to eliminate, manage, or minimize Project effects on aquatic resources are detailed in Section 14.5.3, Mitigation Measures for Aquatic Resources. Furthermore, the Aquatic Effects Management Plan (Section 29.3) will be used to detect un-anticipated effects on aquatic resources and implement additional mitigation and management measures as necessary. No overlap

between Project-related residual effects and any other human activities has been predicted and therefore additional cumulative effects mitigation and management measures are not required.

34.5.3.5 Summary of Residual Cumulative Effects on Aquatic Resources

Cumulative residual effects are those effects remaining after the implementation of all mitigation measures and are summarized in Table 34.5-5. No residual effects were identified and characterization of cumulative effects was assessed **as not applicable (N/A**).

Table 34.5-5. Summary of Cumulative Residual Effects on Aquatic Resources

Aquatic Resources	Timing of Cumulative Residual Effect[1]	Description of Cause-Effect[2]	Description of Additional Mitigation	Description of Cumulative Residual Effect
Erosion and sedimentation in the mine site area	N/A	N/A	N/A	N/A
Changes in surface water quantity in the mine site area	N/A	N/A	N/A	N/A
Changes in surface water quality in the mine site area	N/A	N/A	N/A	N/A
Changes in sediment quality in the mine site area	N/A	N/A	N/A	N/A
Habitat loss in the mine site area	N/A	N/A	N/A	N/A
Changes in surface water quality in the off-site Project infrastructure area	N/A	N/A	N/A	N/A

[1] Refers to the Project phase or other timeframe during which the effect will be experienced by aquatic resources.
[2] "Cause-effect" refers to the relationship between the Project component/physical activity that is causing the change or effect in the condition of aquatic resources, and the actual change or effect that results.

34.5.4 Fish and Fish Habitat

34.5.4.1 Summary of Project-specific Residual Effects on Fish and Fish Habitat

Fish and fish habitat is a critical component of the aquatic environment and is protected under the *Fisheries Act* (1985a). Fish and fish habitat is linked to important identified valued components (or sub-components) including surface water quality, surface water quantity, primary and secondary producers, as well as human health. Fish are also important to Canadians from an economic, recreational, and cultural perspective.

Chapter 15, Assessment of Potential Fish and Fish Habitat Effects, details the assessment of potential residual effects of the Project on two receptor VC subcomponents:

- fish; and
- fish habitat.

Project-related residual effects are anticipated for direct mortality, erosion and sedimentation, and change in water quality (i.e., contamination by petroleum products) for the fish and fish habitat receptor VC sub-components. These potential residual effects are rated as **not significant** and are outlined in Table 34.5-6. The residual effects on fish and fish habitat are carried through the CEA where they are expected to have cumulative interactions with other projects and activities. A matrix identifying the potential cumulative effect interactions of past, present and future projects and activities on fish and fish habitat is provided in Table 34.4-1.

Table 34.5-6. Summary of Project-specific Residual Effects, Mitigation, and Significance on Fish and Fish Habitat

Residual Effects	Project Phase(s)	Mitigation Measures	Significance
Fish			
Blunt tissue trauma causing mortality to all fish life stages	Construction, Operation, Closure	Use of best management practices to minimize fish mortality with construction machinery; Adhere to Fisheries and Oceans Canada (DFO) operational statements; Adhere to appropriate construction operating window for instream work; Site isolation; Controlled access; Implement no-fishing policy for employees	Not significant
Erosion and sedimentation causing smothering of eggs, decreased feeding efficiency, habitat avoidance	Construction, Operation, Closure	Use of best management practices to minimize sediment entry to waterbodies; Adhere to DFO's operational statements; Adhere to appropriate construction operating window for instream work and the Soils Management Plan (Section 29.13); Riparian re-vegetation; Dust suppression on roads; Site isolation; Water quality maintenance	Not significant
Fish Habitat			
Erosion and sedimentation causing habitat loss	Construction, Operation, Closure	Use of best management practices to minimize sediment entry to waterbodies; Adhere to DFO's operational statements; Adhere to appropriate construction operating window for instream work and the Soils Management Plan (Section 29.13); Riparian re-vegetation; Dust suppression on roads; Site isolation; Water quality maintenance	Not significant

34.5.4.2 Cumulative Effects Assessment Boundaries for Fish Habitat

Spatial Boundaries

Watersheds with the potential to be affected by the Project activities include the Unuk River, Sulphurets Creek, Bell-Irving River, and Bowser River watersheds. Past, present, and/or foreseeable future activities may combine to affect fish and fish habitat in the LSA and RSA, within CEA boundaries, or in downstream watersheds. The fish and fish habitat CEA boundary is the same as the RSA (Figure 34.5-3). The RSA was selected based upon watersheds within, upstream, and downstream of the Project with a potential for direct effects. Since fish distribution and habitat utilization is related to watersheds, the same principles were applied to defining the CEA boundary. Projects that are located outside of the identified watershed boundaries were excluded from the CEA.

Temporal Boundaries

The temporal boundaries of the CEA are described in Section 34.2.2. Effects to fish and fish habitat from past projects and human activities may temporally overlap with potential effects from the Project, if discharge from the activities persists in the aquatic environment or if habitat has not had sufficient time to recover from past effects. Table 34.4-1 illustrates which past, present, and future projects and activities will potentially have a temporal interaction with the fish and fish habitat RSA.

34.5.4.3 Cumulative Effects Assessment on Fish Habitat

The past projects and human activities that may affect fish and fish habitat and spatially overlap potential effects from the Project are outlined in Table 34.4-1 and illustrated in Figure 34.5-3.

Cumulative effects from past, present, or foreseeable future activities, together with the Project, were assessed to determine the overall effect to fish and fish habitat in the LSA and RSA and downstream watersheds (Table 34.4-2).

No fish and fish habitat information was available for the Sulphurets Project. However, this project was located within the Sulphurets Creek watershed and close to the proposed Brucejack Gold Mine Project and the KSM Project. Fish and fish habitat are not present in the Sulphurets Creek watershed (except the lower reach) based upon baseline studies (Rescan 2009, 2010a, 2011, 2012a, 2012b, 2012c); therefore, potential impacts on downstream fish and fish habitat were likely similar to the impacts from the proposed Brucejack Gold Mine Project and are considered minor.

No fish and fish habitat information is available for past, present, or future forestry activities (e.g., access roads), fishing harvest, and mineral resource exploration. Therefore, potential effects were considered by their known cause and effect relationships (e.g., fishing increases direct mortality).

The NTL occurs along Highway 37 and runs parallel to the eastern fish and fish habitat cumulative effects boundary. For the clearing of the right-of-way (ROW) and construction of the transmission line, numerous fish bearing stream crossings were surveyed (Rescan 2008). Of these stream crossings, only two fish bearing stream crossings are located along the eastern cumulative effects boundary. These crossings occur outside the cumulative effects boundary; however, as the NTL project occurs within 1 km of the boundary, all effects on fish and fish habitat were reviewed.

The fish and fish habitat cumulative effects boundaries are based upon the watersheds in which the proposed Project is located. As such, the mine area of the KSM Project is located within the cumulative effects boundary (Sulphurets Creek and Unuk River watersheds), while the processing and tailings management area of the KSM Project is located outside of the cumulative effects boundary (Teigen Creek, Treaty Creek). Therefore, only the mine area of the KSM Project was included in the CEA, as identified potential effects within processing and tailings management area watersheds would not have an interaction with the proposed Brucejack Gold Mine Project. The KSM Project identified residual cumulative effect on fish and fish habitat due to changes in water quality (i.e., metals) downstream of the mine area, but it was not expected to be significant due to the mitigation plans. The KSM Project identified residual cumulative effect on fish and fish habitat due to habitat loss and alteration along the Coulter Creek Access Road, but it was not expected to be significant due to the fish habitat compensation and mitigation plans.

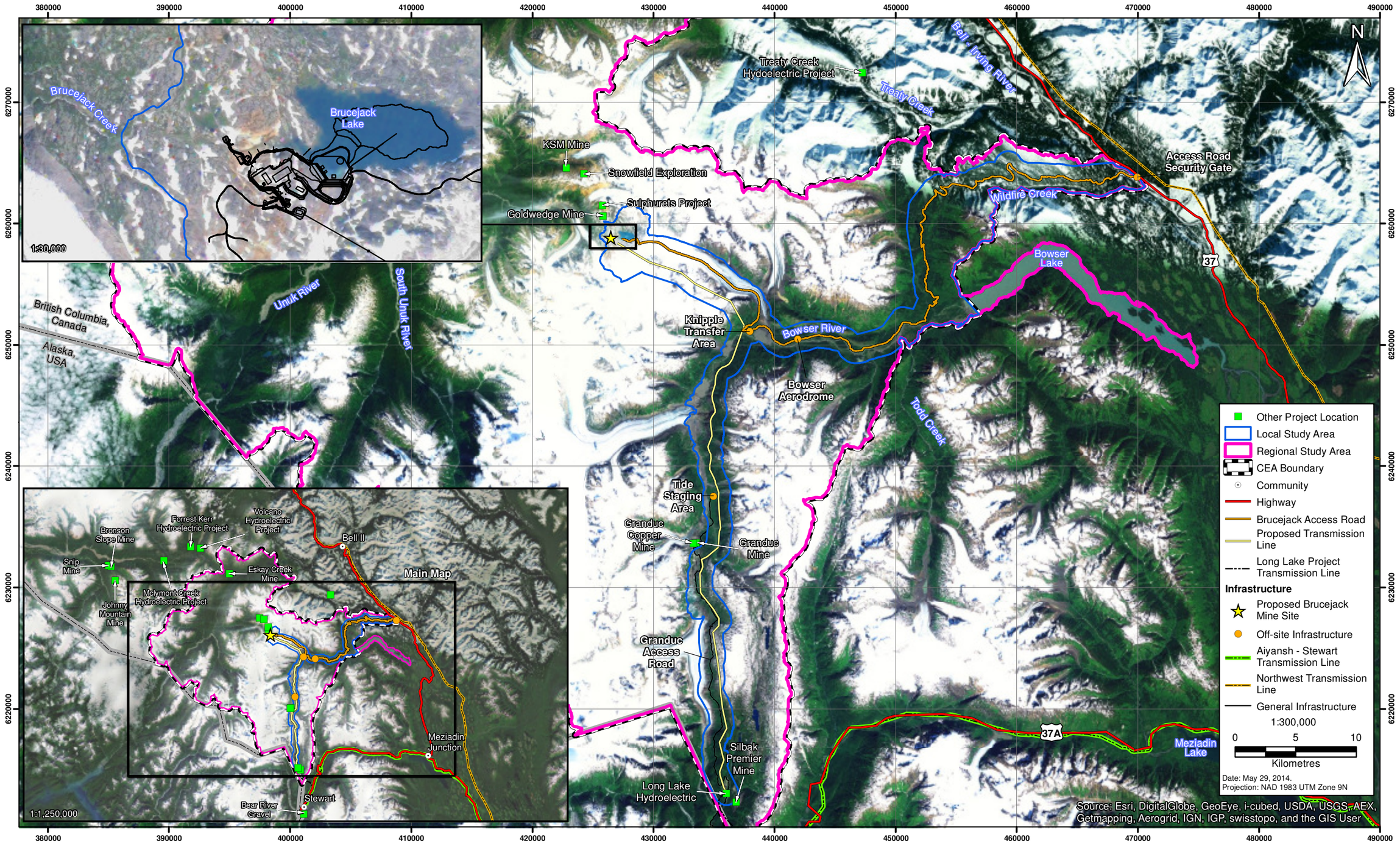
There was a total of 14 fish-bearing stream crossings identified during the construction of the exploration access road for the Brucejack Exploration Project (Cambria Gordon 2012; FINS Consulting 2011; Pretivm 2012). There was no fish habitat loss associated with the construction of the stream crossings (Cambria Gordon 2012; Pretivm 2012). Fish species were not affected during the construction of the exploration access road. Ongoing effects of road maintenance are addressed in this assessment.

Cumulative Effects of Direct Mortality

Fishing and the use of heavy equipment in and around waterbodies may affect fish in a cumulative manner, if the activities were to drastically increase or spatially extend across a broad area. Increased fishing pressure on Bull Trout, Rainbow Trout/Steelhead, and Pacific Salmon may occur due to improved access to waterbodies near the LSA and RSA. Increased fishing pressure may occur because of all identified relevant projects and activities. The majority of past, present, and future projects may cumulatively increase fish mortality; however, the potential for increased mortality is low because there are no fish present within most project infrastructure areas. Fish are not present within the mine footprint areas of the Eskay Creek Mine, Granduc Mine (past project), Sulphurets Project, KSM Project, and Granduc Copper Mine (potential future project).

Figure 34.5-3

Cumulative Effects Assessment Boundary Showing All Other Projects and Activities Relevant to Fish and Fish Habitat near the Brucejack Gold Mine Project



However, there are fish present within watercourses at past, present, and future access roads. The use of heavy equipment required by the construction and maintenance of access roads may contribute cumulatively to direct mortality effects; however, fish mortality is not known to have occurred as a result of the exploration access road development.

Cumulative Effects of Erosion and Sedimentation

The geographic scope of erosion and sedimentation can range from localized to far-reaching events depending on the amount and type (e.g., particle size) of sediment that is introduced into the aquatic environment. In addition, sedimentation effects can occur throughout the Project's Construction, Operation, and Closure phases. These spatial and temporal properties of erosion and sedimentation are likely similar for other projects and activities that may act cumulatively with potential Project-related erosion and sedimentation effects.

The majority of past, present, and future projects may cumulatively affect fish from increased sedimentation. The potential for increased sedimentation is low because there are no fish present within most project infrastructure, and fish are located a considerable distance (20 km) downstream from most project infrastructure. Fish are not present within the mine footprints of Eskay Creek Mine, Granduc Mine, Sulphurets Project, KSM Project, and Granduc Copper Mine. The nearest fish-bearing watercourse downstream of these projects are as follows: Eskay Creek Mine – Unuk River; Granduc Mine – Bowser River; Sulphurets Project – lower reach of Sulphurets Creek/Unuk River; KSM Project – lower reach of Sulphurets Creek/Unuk River; and Granduc Copper Mine – Bowser River.

However, there are fish present within watercourses at past, present, and future access roads, in which erosion events could occur. The use of heavy equipment required by the construction and maintenance of access roads may contribute cumulatively to sedimentation effects on fish; however, sedimentation events are not known to have occurred as a result of exploration access road development.

Cumulative Effects of Habitat Loss

Cumulative effects associated with fish habitat loss and alterations are expected to occur in the cumulative effects study area. There are no fish present within most areas with project infrastructure, such as the Eskay Creek, Granduc, Sulphurets, KSM Project, and Granduc Copper mines. The Northwest Transmission Line Project has caused the loss of fish habitat through the removal of riparian habitat due to the installation of the transmission line infrastructure. Construction of the exploration access road did not result in the loss of fish habitat within fish bearing stream crossings.

Lost and altered fish habitat will be compensated for as per federal project-specific Fish Habitat/Fisheries Offset Compensation plans. These compensation plans must be approved by DFO and must achieve no net loss of fish habitat/fisheries; therefore, cumulative effects associated with past, present, and future projects are minimal.

34.5.4.4 Mitigation Measures to Address Cumulative Effects on Fish and Fish Habitat

Cumulative Effects Mitigation for Direct Mortality

The effects of direct mortality are generally spatially and temporally isolated. Thus, effects are unlikely to become cumulative if the mitigation and management plans pertaining to fishing and the use of equipment in and around water are applied. Project-specific cumulative effect mitigations are the same as previously mentioned in Section 15.5.1.2, Mitigation Measures for Fish and Fish Habitat.

It is anticipated that other projects will adopt the same mitigation strategies as the Project. Mitigation measures proposed for the Project are in accordance with standards stated in federal and provincial guidelines (e.g., *Land Development Guidelines for the Protection of Aquatic Habitat* [DFO 1993],

Standards and Best Practices for Instream Works [BC MWLAP 2004], and Pacific Region Operational Statements [DFO 2007]), to which all projects are subject.

Cumulative Effects Mitigation for Erosion and Sedimentation

Project-specific cumulative effect mitigations are the same as those that are outlined for the Project in Chapter 15 (Section 15.5.1.2, Mitigation Measures for Fish and Fish Habitat).

It is anticipated that other projects will adopt the same mitigation strategies as the Project. Mitigation measures proposed for the KSM Project are in accordance with standards stated in federal and provincial guidelines (e.g., *Land Development Guidelines for the Protection of Aquatic Habitat* [DFO 1993], *Standards and Best Practices for Instream Works* [BC MWLAP 2004], *Fish-Stream Crossing Guidebook* [BC MOF 2002], and Pacific Region Operational Statements [DFO 2007]), to which all projects are subject.

Cumulative Effects Mitigation for Habitat Loss

Mitigation measures to prevent the loss and alteration of fish habitat will be implemented to minimize cumulative effects associated with habitat loss. Guidelines, BMPs, and DFO operational statements must be followed for each project and their activities to minimize the cumulative effect of habitat loss in the cumulative effects study area. Detailed and functional fish habitat compensation plans must also be developed and approved by DFO. Thus, additional mitigation to address potential habitat loss cumulative effects is not required.

34.5.4.5 Summary of Residual Cumulative Effect on Fish Habitat

Cumulative residual effects are those effects remaining after the implementation of all mitigation measures, as presented in Table 34.5-7. Cumulative residual effects are summarized as:

- direct mortality: blunt tissue trauma causing mortality to early life history stages, fishing harvest causing mortality to adult life stages;
- erosion and sedimentation: smothering of eggs, decreased feeding efficiency, habitat avoidance;
- petroleum product spill: sub-lethal toxic effects on fish; and
- fish habitat: physical loss of fish habitat.

Tables 34.5-8 and 34.5-9 characterize the cumulative residual effects, likelihood, determination of significance, and level of confidence in the assessment of significance for fish and fish habitat, respectively.

Direct Mortality

The magnitude of residual cumulative effects associated with direct mortality will be minor because events will be localized and geographically isolated. In addition, direct mortality events will be of short duration and will occur sporadically. Since the timing and duration of direct mortality is short, this effect can be reversed relatively quickly at the population level (not individual level), and the VC will be able to respond and adapt (i.e., resiliency is high).

Erosion and Sedimentation

The magnitude of residual cumulative effects associated with erosion and sedimentation will be minor because events will be localized and geographically isolated. Erosion events, should they occur, will be of medium-term duration (effect lasts from one to five years) and will occur sporadically during Project phases. The effects of erosion and sedimentation cannot be easily reversed, thus reversal will occur over several years (reversible medium term). Furthermore, fish and fish habitat may not be able to fully respond or adapt to the effects of erosion and sedimentation, thus resiliency was assessed as neutral.

Table 34.5-7. Summary of Cumulative Residual Effects on Fish and Fish Habitat

Fish and Fish Habitat	Timing of Cumulative Residual Effect	Description of Cause-Effect	Description of Additional Mitigation (if any)	Description of Cumulative Residual Effect	Significance of Residual Effects
Fish					
Blunt tissue trauma	Construction, Operation, Closure	Impact with construction machinery causing fish mortality; Increased fishing access causing increased harvest of game fish species	Use of best management practices to minimize fish mortality with construction machinery; Adhere to DFO's operational statements; Adhere to appropriate construction operating window for instream work; Site isolation; Controlled access; Implement no fishing policy for employees/contractors	Blunt tissue trauma causing mortality to early life history stages; Fishing harvest causing mortality to adult life stages	Not significant
Erosion and sedimentation	Construction, Operation, Closure	Entry of sediment to water bodies during instream construction and bridge/culvert removal; Entry of sediment to water bodies from road runoff and dust during operation and maintenance; Entry of sediment to water bodies during removal of riparian vegetation; Altered riparian vegetation causing smothering of eggs, decreased feeding efficiency, habitat avoidance	Use of best management practices to minimize sediment entry to water bodies; Adhere to DFO's operational statements; Adhere to appropriate construction operating window for instream work and the Soil Environmental Management Plan; Riparian re-vegetation; Dust suppression on roads; Site isolation; Water quality maintenance	Smothering of eggs, decreased feeding efficiency, habitat avoidance	Not significant
Fish Habitat					
Erosion and sedimentation	Construction, Operation, Closure	Entry of sediment to water bodies during instream construction and bridge/culvert removal; Entry of sediment to water bodies from road runoff and dust during operation and maintenance; Entry of sediment to water bodies during removal of riparian vegetation; Altered riparian vegetation causing habitat loss	Use of best management practices to minimize sediment entry to water bodies; Adhere to DFO's operational statements; Adhere to appropriate construction operating window for instream work and the Soil Environmental Management Plan; Riparian re-vegetation; Dust suppression on roads; Site isolation; Water quality maintenance	Physical loss of fish habitat	Not significant

The potential cumulative residual effects on fish and fish habitat were associated with direct mortality, erosion, and sedimentation. These effects can possibly interact, creating additive or synergistic effects that have a different extent for the local fish population as a whole. Considering these potential effects on fish and fish habitat in combination with Project infrastructure in the LSA and RSA, and mitigation to minimize effects, the overall potential cumulative residual effect on local fish populations and habitat is not likely to affect the viability of fish and fish habitat VC sub-components and is assessed as **not significant** for all residual cumulative effects.

34.5.5 Terrestrial Ecology

34.5.5.1 Summary of Project-specific Residual Effects on Terrestrial Ecology

Terrestrial ecosystems consist of living and non-living components interacting through the exchange of energy, nutrients, and waste. In addition to providing timber resources, non-timber botanical resources, and habitat for fish and wildlife species, they also serve important roles in the regulation of ground and surface water; the enrichment and stability of soils and terrain; the cycling of nutrients; and the sequestering, storage, and release of carbon. Furthermore, they provide a wide array of cultural, commercial and personal recreation, and non-material aesthetic benefits.

Chapter 16, Assessment of Potential Terrestrial Ecology Effects, details the assessment of potential residual effects on terrestrial ecology receptor VCs. The receptor VCs included in this terrestrial ecology CEA are:

- alpine ecosystems;
- parkland ecosystems;
- forested ecosystems;
- riparian and floodplain ecosystems;
- culturally/economically important plants; and
- rare plants and lichens and associated habitat.

The residual effects of loss and/ or alteration of ecosystem function or extent will result in not significant effects on alpine, parkland, forested, and floodplain ecosystems and culturally/economically important plant habitat. The Project-related residual effects of loss and/ or alteration of rare plant and lichen species or associated habitat will result in a not significant effect. The residual effects, mitigation, and significance on terrestrial ecology receptor VCs are summarized in Table 34.5-10.

The following sections provide an examination of the relationship between the residual effects of the Project and those of other projects and activities. A matrix identifying the potential cumulative effect interactions of past, present and future projects and activities on terrestrial ecology is provided in Table 34.4-1.

34.5.5.2 Cumulative Effects Assessment Boundaries for Terrestrial Ecology

Spatial Boundaries

The CEA spatial boundary for terrestrial ecology is the same as the regional study area and represents the area beyond which effects of the Project are not expected to cumulatively interact with effects of other projects. It is also intended to be ecologically relevant based on the ecosystems that provide habitat within the home range of key wildlife species known to inhabit the region. This boundary is 374,433 ha and is depicted in Figure 34.5-4.

Table 34.5-8. Significance Determination of Cumulative Residual Effects for Fish

Cumulative Residual Effects	Project Component	Timing of Effect	Cumulative Residual Effects Characterization Criteria							Likelihood *(low, medium, high)*	Significance of Adverse Cumulative 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 medium-term, reversible long-term, irreversible)*	**Resiliency** *(low, neutral, high)*	**Context** *(low, neutral, high)*			
Blunt tissue trauma causing mortality to all fish life stages	Upgrade and use of exploration access road	Construction	Low	Short-term	Sporadic	Local	Reversible short-term	High	High	Low	Not significant	High
	Brucejack Access Road use and maintenance	Operation	Low	Short-term	Sporadic	Local	Reversible short-term	High	High	Low	Not significant	High
	Decommissioning of Brucejack Access Road	Closure	Low	Short-term	Sporadic	Local	Reversible short-term	High	High	Low	Not significant	High
Erosion and sedimentation causing smothering of eggs, decreased feeding efficiency, habitat avoidance	Upgrade and use of exploration access road	Construction	Low	Medium-term	Sporadic	Local	Reversible medium-term	Neutral	Neutral	Medium	Not significant	High
	Brucejack Access Road use and	Operation	Low	Medium-term	Sporadic	Local	Reversible medium-term	Neutral	Neutral	Medium	Not significant	High
	Decommissioning of Brucejack Access Road	Closure	Low	Medium-term	Sporadic	Local	Reversible medium-term	Neutral	Neutral	Medium	Not significant	High
Overall Effect			Low	Short-term	Sporadic	Landscape	Reversible medium-term	Neutral	Neutral	Medium	Not significant	High

Table 34.5-9. Significance Determination of Cumulative Residual Effects for Fish Habitat

Cumulative Residual Effects	Project Component	Timing of Effect	Cumulative Residual Effects Characterization Criteria							Likelihood *(low, medium, high)*	Significance of Adverse Cumulative 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 medium-term, reversible long-term, irreversible)*	**Resiliency** *(low, neutral, high)*	**Context** *(low, neutral, high)*			
Erosion and sedimentation causing loss of fish habitat	Upgrade and use of exploration access road	Construction	Low	Short-term	Sporadic	Local	Reversible medium-term	Neutral	Neutral	Medium	Not significant	High
	Brucejack Access Road use and maintenance	Operation	Low	Short-term	Sporadic	Local	Reversible medium-term	Neutral	Neutral	Medium	Not significant	High
	Decommissioning of Brucejack Access Road	Closure	Low	Short-term	Sporadic	Local	Reversible medium-term	Neutral	Neutral	Medium	Not significant	High
Overall Effect			Low	Short-term	Sporadic	Local	Reversible medium-term	Neutral	Neutral	Medium	Not significant	High

Figure 34.5-4

Cumulative Effects Scoping: Projects and Activities Interacting with the Brucejack Gold Mine Project for Terrestrial Ecology

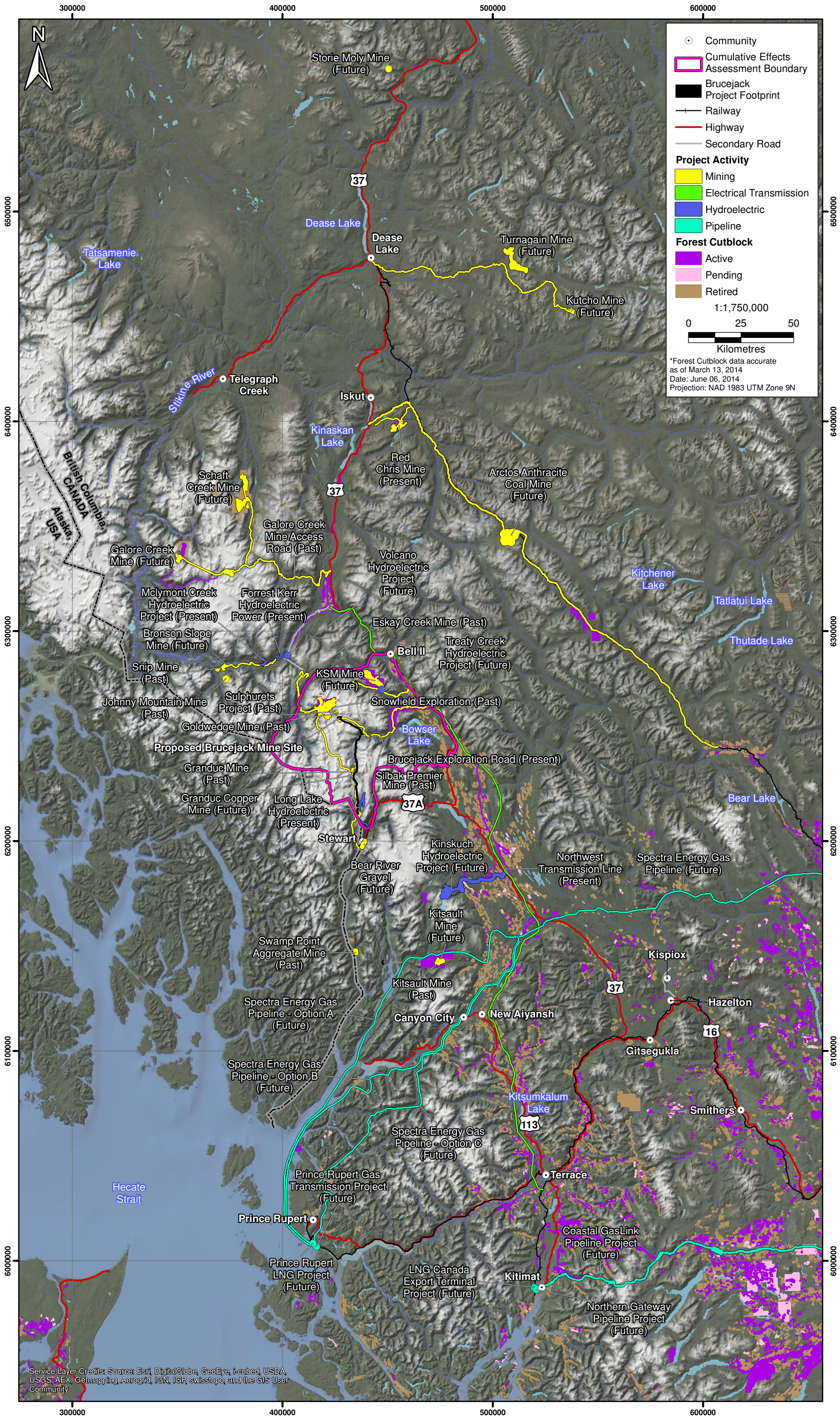


Table 34.5-10. Summary of Project-specific Residual Effects, Mitigation, and Significance on Terrestrial Ecology Receptor Valued Components

Residual Effect and Terrestrial Ecology Receptor Valued Components	Project Phase(s)	Mitigation Measures	Significance
Alpine Ecosystems			
Loss and/or alteration of ecosystem function and extent	Construction and Operation	Avoidance; restoration; adherence to management procedures for alpine ecosystems; enforcement of travel on designated road surfaces only; inspections for target invasive plants; education and training for the environmental monitor; clear communication between environmental monitor and employees / contractors; coordination with other management plans; effective internal reporting of environmental incidents and concerns.	Not significant
Parkland Ecosystems			
Alteration of ecosystem function and extent	Construction and Operation	Minimize loss and adaptively manage effects through an ecosystem based approach, including, managing for hydrological connectivity wherever possible; adherence to best management practices for forested ecosystems; dust suppression; vehicle inspections for target invasive plants; clear communication between environmental monitor and employees / contractors; coordination with other management plans; effective internal reporting of environmental incidents and concerns.	Not significant
Forested Ecosystems			
Alteration of ecosystem function and extent	Construction and Operation	Minimize loss and adaptively manage effects through an ecosystem based approach	Not significant
Floodplain Ecosystems			
Alteration of ecosystem function and extent	Construction and Operation	Minimize loss and adaptively manage effects through an ecosystem based approach including, managing for hydrological connectivity wherever possible; adherence to best management practices for riparian ecosystems; dust suppression; vehicle inspections for target invasive plants; clear communication between environmental monitor and employees / contractors; coordination with other management plans; effective internal reporting of environmental incidents and concerns.	Not significant
Culturally or Economically Important Plants			
Loss of habitat	Construction and Operation	Minimize clearing areas; dust suppression; effective internal reporting of environmental incidents and concerns.	Not significant
Rare Plants and Lichen			
Loss of Species and/ or Loss or Alteration of Habitat	Construction and/ or Operation	Avoidance; minimize clearing areas; dust suppression; creation of exclusion areas; effective internal reporting of environmental incidents and concerns.	Not Significant

Temporal Boundaries

The temporal boundaries of the CEA are described in Section 34.2.2. Table 34.4-1 illustrates which past, present, and future projects and activities will potentially have a temporal interaction with the terrestrial ecology subject area.

Ecological Boundaries

Nine Biogeoclimatic Ecosystem Classification (BEC) units occur within the CEA boundary, including both coastal and interior units. Six of the nine BEC units are forested and cover approximately 42% of the CEA study area, while the three alpine and parkland BEC zones collectively contribute approximately 58% of the CEA boundary.

34.5.5.3 Cumulative Effects Assessment on Terrestrial Ecology

Table 34.4-1 summarizes the relevant past, present, and future projects and/or land use activities with potential to cumulatively interact with the residual effects estimated for the Project. Cumulative loss of terrestrial ecosystems was determined by overlaying the footprint of each past, present, and future project on the baseline Predictive Ecosystem Mapping (PEM) data within the CEA boundary. This information is summarized per terrestrial ecology receptor VC in Table 34.4-2.

The cumulative loss of terrestrial ecosystems within the CEA boundary (excluding the Project) is 5,358 ha (1.7 %). The Project may result in the loss of 217 ha (0.1%) of alpine ecosystems, 178 ha (0.12%) of forested ecosystems, and 15 ha (0.19%) of floodplain ecosystems. The cumulative loss of terrestrial ecosystems within the CEA boundary (including the Project) is 5,769 ha (1.9%), including 1,706 ha (1.1%) of alpine ecosystems, 4,051 ha (2.8%) of forested ecosystems, and 225 ha (2.8%) of floodplain ecosystems. The Project contributes approximately 7.1% of the total cumulative loss of ecosystems expected within the CEA boundary.

The cumulative alteration of terrestrial ecosystems within the CEA boundary (excluding the Project) is 20,582 ha (6.6 %). The Project may result in the alteration of 196 ha (0.1%) of alpine ecosystems, 983 ha (0.68%) of forested ecosystems, and 102 ha (1.25%) of floodplain ecosystems. The cumulative alteration of terrestrial ecosystems within the CEA boundary (including the Project) is 21,806 ha (7.0%), including 3,442 ha (2.1%) of alpine ecosystems, 17,654 ha (12.16%) of forested ecosystems, and 710 ha (8.69%) of floodplain ecosystems. The Project contributes approximately 5.88% of the total cumulative alteration of ecosystems expected within the CEA boundary.

The cumulative loss of rare plants and lichens within the CEA, summarized by project, effect type, and species, is presented in Chapter 16, Assessment of Potential Terrestrial Ecology Effects (Table 16.10-5). Known rare plant or lichen locations were assigned a 100- to 200-m buffer to broadly define their associated habitat. During construction of the KSM Project, six rare plants and lichens will be lost, mostly due to the construction of the operational haul road. During operation, 34 plants and/or lichens will be removed within the Kerr Pit and 25 rare plants and lichens will be lost due to pit development, including six vascular plants, three mosses, and 16 lichens. No rare plants are expected to be directly affected by the current Brucejack Project design.

Nineteen rare plants and lichens may be degraded/altered in areas adjacent to the KSM Project and 25 lichens, 2 mosses and 7 vascular plants may be altered due to the Project activities.

34.5.5.4 Mitigation Measures to Address Cumulative Effects on Terrestrial Ecology

Ecosystem management and mitigation plans are designed to avoid and minimize adverse effects to ecosystems and plants resulting from project activities within the feasible limits of project design and activities. Each past, present, and future project would have had or will have different mitigation and management for terrestrial ecosystems and plants; however, it is assumed any present and future projects will take into consideration the goals and objectives outlined in the Cassiar Iskut-Stikine Land and Resource Management Plan (CIS LRMP; BC ILMB 2000) and the Nass South Sustainable Resource Management Plan (SRMP; BC MFLNRO 2012). It is also assumed that the following general mitigation measures will be common amongst any present and future projects or activities:

- avoid and/or minimize detrimental effects to terrestrial ecosystems and wetlands through strategic planning;
- minimize all clearing dimensions during any construction activities;
- minimize soil loss and degradation (i.e., compaction, erosion, and soil horizon mixing);
- avoid the introduction and spread of invasive plants;
- avoid and minimize detrimental effects to rare plants and lichens, including rare plant and lichen habitat;
- avoid and/or minimize loss or alteration of ecosystem functions due to clearing activities, dust deposition, fragmentation, edge effects, windthrow, and altered hydrology;
- ensure clearing activities are coordinated with other management plans; and
- maintain natural levels of plant and lichen biodiversity through avoidance, offsetting, and other mitigation strategies.

Collaborative approaches to address cumulative effects to the terrestrial ecology receptor VC should primarily involve the following:

- continuation of existing data sharing agreements, including identification of any emerging negative population and biodiversity trends likely attributable to the relevant project.

34.5.5.5 Summary of Residual Cumulative Effects on Terrestrial Ecology

Cumulative residual effects are anticipated for alpine, forested, and riparian ecosystems, as well as for rare plants and lichens (Table 34.5-11).

Table 34.5-11. Summary of Cumulative Residual Effects on Terrestrial Ecology Receptor Valued Components

Receptor Valued Component	Timing of Cumulative Residual Effect[1]	Description of Cause-Effect	Description of Additional Mitigation (if any)	Description of Cumulative Residual Effect	Significance of Residual Effects
Alpine ecosystems	Construction – beyond Post-closure	Surface clearing activities and continued use; reclamation disturbance	None anticipated	Loss and alteration of ecosystem function and/ or extent.	Not significant
Forested ecosystems	Construction and Operation	Surface clearing activities and continued use	None anticipated	Loss and alteration of ecosystem function and/ or extent.	Not significant
Floodplain ecosystems	Construction – Post-closure (depending on the type of riparian ecosystem)	Surface clearing activities and continued use	None anticipated	Loss and alteration of ecosystem function and/ or extent.	Not significant
Rare plants and lichens	Construction – beyond Post-closure	Surface clearing activities and continued use; reclamation disturbance	None anticipated	Loss of rare plants and lichens; loss and alteration of rare plant and lichen habitat.	Cannot be determined from available information

[1] *Refers to the Project phase or other timeframe during which the effect will be experienced by the intermediate component or receptor VC.*

Loss of alpine ecosystems is expected to be a cumulative residual effect because reclamation efforts within the Sulphurets Project, Snowfield Project, Granduc Mine, Goldwedge Project, and KSM Project footprints were either limited, or there is low confidence that reclamation efforts will restore ecosystem function and extent to a level similar to that of baseline conditions. The restoration success of each alpine ecosystem is influenced by the level of effort invested in the reclamation initiatives, as well as the scale, frequency, and intensity of the disturbance, together with the local edaphic conditions, which in alpine environments are a limiting factor (Chapin III and Shaver 1985; Forbes, Ebersole, and Strandberg 2001; Urbanska and Chambers 2002).

Alteration of forested ecosystem function and extent, as well as loss and alteration of floodplain ecosystem function and extent, is expected to be a cumulative residual effect because windthrow, fragmentation, edge effects, and changes to hydrology can be minimized but not avoided. Mitigation measures to avoid the potential introduction and spread of invasive plants will help reduce potential introductions but may not avoid this effect altogether.

Loss of rare plant and lichen species is expected to be a cumulative residual effect because surface clearing activities at the KSM Project are expected to result in removal of rare plants/lichens and associated critical habitat. Furthermore, the Brucejack Gold Mine Project could result in alteration of rare plant/lichens or habitat. Rare plants and lichens are habitat-specific and the unique combinations of environmental conditions that characterize their habitats are also rare and cannot be easily reproduced, if at all. Alteration of rare plant and/or lichen habitat is also considered a cumulative residual effect because indirect effects, such as deposition of fugitive dust and changes to hydrology, can be minimized but not avoided entirely.

The residual cumulative effects on the receptor valued components in question were characterized in terms of magnitude, geographic extent, duration, frequency, reversibility, and resiliency, according to the definitions in Table 34.5-12.

Table 34.5-12. Magnitude Threshold for each Terrestrial Ecology Receptor Valued Components

Definition of Magnitude for Terrestrial Ecology Sub-components	Magnitude of Effect
< 1% loss of amount of habitat available in the CEA boundary	None
1-10% loss of amount of habitat available in the CEA boundary	Low
11-25% loss of amount of habitat available in the CEA boundary	Moderate
> 25% loss of amount of habitat available in the CEA boundary	High

It is very difficult to accurately determine the magnitude of loss and alteration of terrestrial ecosystems within a cumulative context due to data limitations, disparate methodologies between projects, and an overall absence of measurable criteria and indicators. Nevertheless, there is some empirical information on amount of habitat loss (i.e., ecosystems) beyond which effects to wildlife species is predicted to be unacceptably high. Therefore, the magnitude of loss and alteration of terrestrial ecosystems was based on threshold levels for habitat loss.

The magnitude threshold takes into consideration the amounts of landscape disturbance beyond which measures of ecological degradation increase in intensity. This idea has been supported empirically, and has been useful in determining risks to wildlife species from landscape disturbance, which include not only habitat loss but also other ecological changes that negatively affect species (Scrimgeour, Hvenegaard, and Tchir 2008). Habitat thresholds also can be defined based on perceived risk. For example, habitat loss thresholds for the Great Bear Rainforest in BC were defined based on expert opinion: greater than 30% habitat loss was identified as a threshold amount representing a transition

from low risk to higher risk of uncertain magnitude (Price et al. 2009). Combining these two approaches (i.e., landscape disturbance thresholds and expert-derived risk thresholds), thresholds for habitat loss of greater than 30 to 40% can be defined as amounts of habitat loss predicted to cause unacceptable risks to species (Scrimgeour, Hvenegaard, and Tchir 2008; Price, Roburn, and MacKinnon 2009).

Applying a precautionary approach, a high-magnitude effect was designated at 25% loss of the total amount of habitat available. The magnitude of the effect on relevant terrestrial ecology receptor VCs within the CEA was calculated relative to the amount of each VC available within the CEA boundary.

The magnitude of an effect on rare plants and lichens or associated habitat was determined based on the BC Conservation Data Centre and the NatureServe Ranks (BC MOF 1992; NatureServe 2012), which provide definitions on the level of rarity of a species. This information was used to determine severity of residual effects to rare plants and lichens (Chapter 16, Table 16.7-3).

The duration, frequency, reversibility, resiliency, and context of Project-related effects were determined based on reviews of other similar projects' monitoring results, relevant scientific literature information attained through community consultation, and professional judgement.

Detailed evaluation of the cumulative residual effects and significance is presented in Section 16.10.9, and is summarized below in Table 34.5-13.

34.5.6 Wetlands

34.5.6.1 Summary of Project-specific Residual Effects on Wetlands

The potential effects of the Project on wetlands are assessed in Chapter 17, Assessment of Potential Wetlands Effects. Wetland extent and function were selected as receptor VCs for the CEA, because they play a key role in the maintenance of hydrologic cycles, wildlife habitat, nutrient cycling, water quality, biodiversity, and carbon sequestration. The functions and ecological processes that occur in wetlands are vital to ecosystems and organisms at a much greater scale than their localized boundaries and limited extent suggest.

The footprint analysis for the Project determined that 32.9 ha of wetlands will be at high risk of function alteration. The majority of the potential alteration is adjacent to the exploration access road, while effects from dustfall are expected at the Brucejack Mine Site. The alteration of wetland function was carried through as a residual effect because it is expected that mitigation efforts will not return wetland function to baseline level. However, the effects of alteration of wetland functions are generally reversible in the long-term (e.g., after Construction, Closure, and Post-closure activities are complete), except where infrastructure such as roads and transmission lines are not reclaimed as continued use may degrade adjacent ecosystems. Wetlands are sensitive to disturbance, have low resiliency compared to most upland ecosystems, and they recover more slowly in many cases. Implementing management measures to help ameliorate impacts during the life of the mine will help ensure successful restoration of wetland functions Post-closure. As a result of planned implementation of mitigation and monitoring programs, residual wetland effects associated with the Project are assessed as **not significant** (Table 34.5-14).

The following sections provide an examination of the relationship between the residual effects of the Project and those of other projects and activities. A matrix identifying the potential cumulative effect interactions of past, present and future projects and activities on wetlands is provided in Table 34.4-1.

Table 34.5-13. Significance Determination of Cumulative Residual Effects for Terrestrial Ecology

	Cumulative Residual Effects Characterization Criteria									
Cumulative Residual Effects	**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 medium-term, reversible long-term, irreversible)*	**Resiliency** *(low, neutral, high)*	**Ecological Context** *(low, neutral, high)*	**Likelihood** *(low, medium, high)*	**Significance of Adverse Cumulative Residual Effects** *(not significant, significant)*	**Confidence** *(low, medium, high)*
Loss and alteration of ecosystem function and/or extent on Alpine Ecosystems	Low	Far future	Regular	Regional	Irreversible	Low	Neutral	Medium	Not significant	Medium
Loss and alteration of ecosystem function and/or extent on Forested Ecosystems	Low	Long-term	Regular	Regional	Reversible medium-term	Neutral	Neutral	Medium	Not significant	Medium
Loss and alteration of ecosystem function and/or extent on Floodplain Ecosystems	Low	Medium-term	Regular	Regional	Reversible medium-term to long-term	Neutral	High	High	Not significant	Medium
Loss and/ or alteration of rare plant and lichen habitat	Moderate	Far future	Once	Beyond Regional	Irreversible	Low	High	High	Not determined	Medium

Table 34.5-14. Characterization of Project-specific Residual Effects, Significance, Confidence, and Likelihood on Wetlands

	Evaluation Criteria									
Cumulative Residual Effects	**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 medium-term, reversible long-term, irreversible)*	**Resiliency** *(low, neutral, high)*	**Ecological Context** *(low, neutral, high)*	**Likelihood** *(low, medium, high)*	**Significance of Adverse Residual Effects** *(not significant, significant)*	**Confidence** *(low, medium, high)*
Alteration of Wetland Function	Low	Long-term	Sporadic	Local	Reversible long-term	Low	High	High	Not significant	High

34.5.6.2 Cumulative Effects Assessment Boundaries for Wetlands

Spatial Boundaries

The CEA spatial boundary is intended to encompass an area beyond which effects of the Project would not cumulatively interact with effects of other Projects. The RSA (374,433 ha) was selected as a suitable boundary to base the CEA on because it encompasses the regional setting for the Project and implicitly considers ecological factors such as height of land in boundary delineation. Given the limited size of the Project, the RSA provides a suitable spatial scale on which to evaluate the Project and encompasses other relevant regionally important projects (Figure 34.5-5).

Temporal Boundaries

The temporal boundaries of the CEA are described in Section 34.2.2. The temporal boundaries selected for the CEA extend for 20 years into Post-closure. This time frame was selected because it is anticipated that the return of wetland function to baseline conditions will take several decades after reclamation activities are completed. Where wetlands do not return to baseline conditions within this period, it is not believed that substantial difference will remain for much longer than the 20 year period. It is anticipated that these areas will be negligible and reflective of levels of natural disturbance and change in the region.

Table 34.4-1 illustrates which past, present and future projects and activities will potentially have a temporal interaction with the wetlands subject area.

34.5.6.3 Cumulative Effects Assessment on Wetlands

Potential cumulative effects on wetland function and extent were determined through a review of relevant past, present, or reasonable foreseeable future projects in relation to the proposed Project residual effects (Table 34.4-2).

No information is available on potential wetland effects from the Silbak Premier or Goldwedge mines or Long Lake or Treaty Creek Hydroelectric projects. Although no information was available for the Sulphurets Project, this project was close to the proposed Brucejack Mine Site at high elevation, and the potential impacts on wetlands were likely similar to the impacts from the Brucejack Mine Site and considered minor. Without additional project information, potential cumulative effects cannot be predicted for these projects.

The NTL occurs along Highway 37 and runs parallel to the eastern RSA boundary. For the clearing of the right-of-way (ROW) and construction of the transmission line, 2,309 ha of wetland were surveyed. Of these, 811 ha occurred on the ROW and 55 ha of wetland were identified as having loss of extent or function (Table 17.10-3 of Rescan 2010b). Much of the affected wetlands occur outside the RSA; however, as the NTL project occurs within 1 km of the proposed Brucejack Gold Mine Project, all effects on wetlands were reviewed.

The KSM Project Application/EIS identified a residual cumulative effect on wetland extent and function, but it was not expected to be significant due to the compensation and reclamation plans. The KSM Project is expected to result in the loss of 59 ha and degradation of 52 ha of wetlands (total of 111 ha affected/lost; Table 34.5-15). However, reclamation and compensation activities will create 2.5 times as many wetlands at closure than were present at baseline (275 ha of reclamation and 48 ha of compensation; Rescan 2013a). Despite the reclamation and compensation activities, the created wetlands will probably not offer the same quality or variety of functions offered by natural wetlands.

Table 34.5-15. Potential Cumulative Effects on Wetland Function and Extent from Past, Present, and Reasonably Foreseeable Future Projects

Project	Past	Present	Future	Effect	Wetland Area Affected or Lost (ha)	Total Wetland Area (ha)	Affected Wetland
Proposed Brucejack Gold Mine Project			x	Function alteration (High)	33	518	6%
Brucejack Exploration and Bulk Sample Program		x		Wetland loss	2	518	0.4%
Sulphurets Mine	x			Unknown	Unknown	-	-
Northwest Transmission Line		x		Wetland loss	55	811	7%
KSM Project			x	Wetland loss/function alteration	111	522	21%
Silbak Premier Mine	x			Information unavailable	Information unavailable		
Goldwedge Mine	x			Information unavailable	Information unavailable		
Long Lake Hydroelectric			x	Information unavailable	Information unavailable	-	-
Treaty Creek Hydroelectric			x	Information unavailable	Information unavailable	-	-
Total					**201**	**1,851**[1]	**11%**

[1] *The 518 ha for Brucejack wetland area was only added once to the total area.*

There was 1.8 ha of wetland area lost due to construction of the exploration access road for the Brucejack Exploration Project (Table 34.5-15). Ongoing functional alteration is addressed in this assessment. Strategically locating the Brucejack Access Road minimized loss of wetland extent, as the road avoided crossing most wetlands.

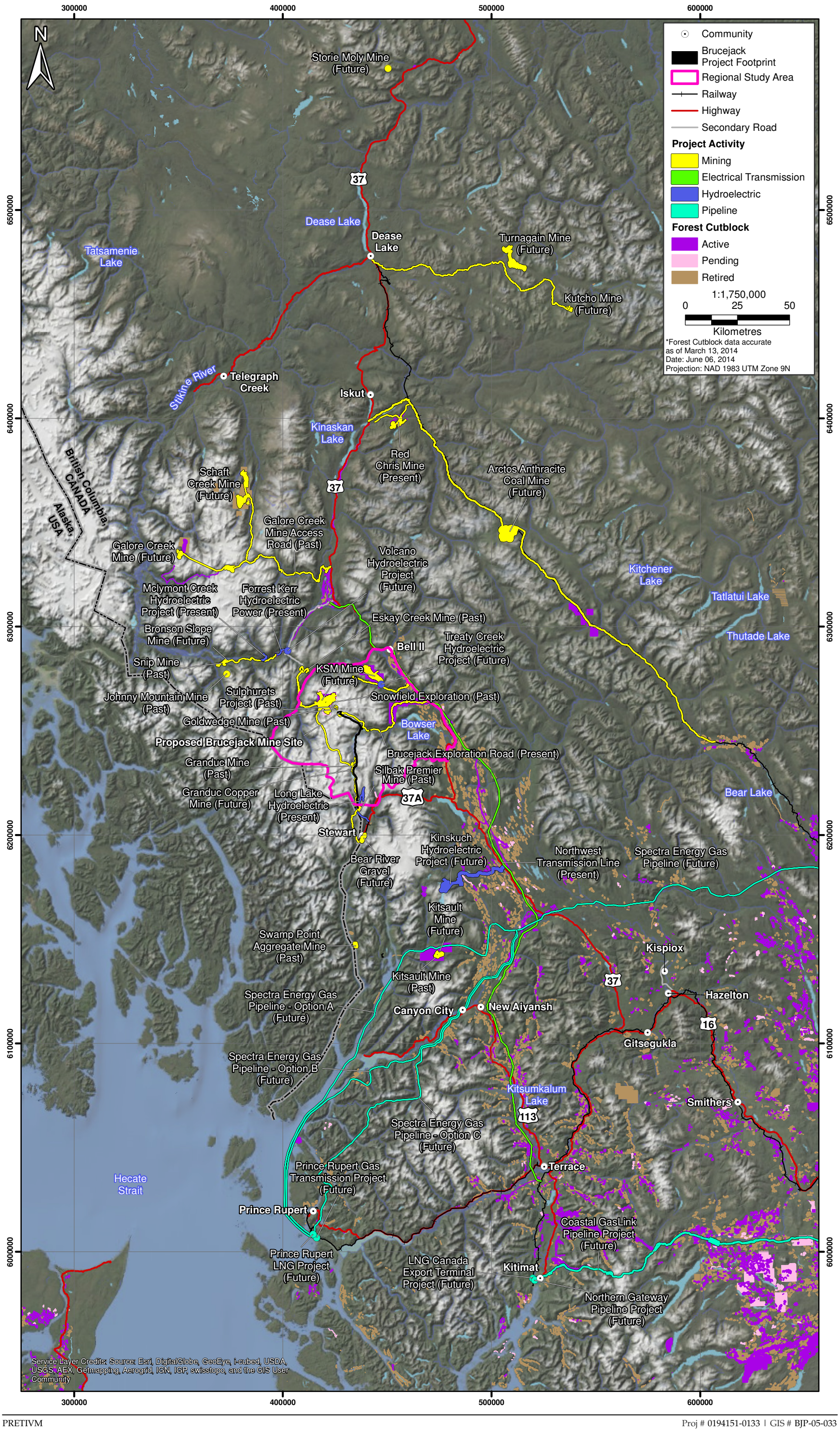
The proposed Project overlaps the Cassiar and Nass Timber Supply Areas. There has been historical forest harvesting activities in the vicinity of the proposed Project, but there has been no recent logging activity in the Bob Quinn area. Two of the three licences overlap the proposed Project infrastructure; however, use of the Brucejack Access Road by forest companies will not be permitted, so increased access and harvesting opportunities are not predicted.

No quantitate data are available for the forest industry effects on wetland extent or function. However, forest activities in relation to wetlands are guided by Land Resource Management Plans and regulated by the *Forest and Range Practices Act* (2002b). The CIS LRMP (BC ILMB 2000) provides detailed guidance on the location of roads, harvesting methods, and wetland buffer to forest licensees, which mitigate impacts on wetlands and dictates that best management practices from the Forest Practices Code *Riparian Management Area Guidebook* (BC MOE and BC MOF 1995) be employed. Based on these comprehensive measures, effects on wetlands by forestry related activities are anticipated to be negligible.

The Project will affect wetland extent and function as will other projects in the region (Table 34.4-2). The cumulative effects on wetland extent will be limited to projects near the Brucejack Gold Mine Project as effects on individual wetlands are local. Projects where an expected cumulative loss of the extent of wetlands is expected are detailed in Table 34.5-15.

Figure 34.5-5

Cumulative Effects Scoping: Projects and Activities Interacting with the Project for Wetland Ecosystems



A residual cumulative effect on the loss of wetland extent and alteration of function is expected due to additive losses in the region. However, it is not expected that this effect will be significant because of the limited loss of wetlands associated with the Brucejack Exploration Project and limited alteration of function associated with the Project. Compensation and reclamation activities planned for the KSM Project will also mitigate cumulative effects on regional wetland extent and function.

34.5.6.4 Mitigation Measures to Address Cumulative Effects on Wetlands

No additional mitigation measures are recommended to address cumulative effects on wetland extent or function due to the Project.

Compensation and reclamation for the KSM Project will, at closure, result in 2.5 times as many wetlands than were present at baseline. Compensation efforts for this project include development of wetland features into three fish habitat compensation projects. Creation of a wetland near Smithers, BC will create education, research, and recreation benefits. Although the communities will be different than those present at baseline, the reclaimed wetlands will provide habitat function for migratory birds and moose, hydrological functions such as water storage, and ecological functions such as complex ecosystems.

34.5.6.5 Summary of Residual Cumulative Effects on Wetlands

Cumulative residual effects are effects that remain after the implementation of all mitigation measures; they are summarized for wetlands in Table 34.5-16.

Table 34.5-16. Summary of Cumulative Residual Effects on Wetlands

Wetlands	Timing of Cumulative Residual Effect[1]	Description of Cause-Effect[2]	Description of Additional Mitigation (if any)	Description of Cumulative Residual Effect	Significance of Residual Effects
Wetland Extent	Construction to Post-closure	Construction footprints - Loss extent due to Construction	KSM Project reclamation and compensation plans, Brucejack exploration access road decommissioning	Loss of extent	Not significant
Wetland Function	Construction to Post-closure	Construction activities, road use, upgrades, and maintenance - sedimentation, hydrological changes, invasive species, fragmentation, edge effects, and dust	KSM Project reclamation and compensation plans, Brucejack exploration access road decommissioning	Altered function of affected wetlands for at least 20 years	Not significant

[1] Refers to the Project phase or other timeframe during which the effect will be experienced by the receptor VC.
[2] "Cause-effect" refers to the relationship between the Project component or physical activity that is causing the change or effect in the condition of the receptor VC and the actual change or effect that results.

The cumulative effects of the proposed Project and the other projects assessed as part of the wetlands CEA are not significant (Table 34.5-17). It was assumed that the effects from previous projects were all in high risk categories. The residual effects are however regional in extent and long-term, but will be within the range of natural variation at a regional scale. The effects are reversible in the long-term if mitigation measures are adhered to and reclamation and compensation plans are implemented. Once a significance determination was made, the confidence in the significance prediction was evaluated to assess scientific certainty in the result.

Table 34.5-17. Significance Determination of Cumulative Residual Effects for Wetlands

Cumulative Residual Effects	Cumulative Residual Effects Characterization Criteria									
	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 medium-term, reversible long-term, irreversible)*	**Resiliency** *(low, neutral, high)*	**Ecological Context** *(low, neutral, high)*	**Likelihood** *(low, medium, high)*	**Significance of Adverse Cumulative Residual Effects** *(not significant, significant)*	**Confidence** *(low, medium, high)*
Wetland Function	Low	Far future	Sporadic	Regional	Reversible long-term	Low	Neutral	High	Not significant	Medium

Cumulative wetlands effects for the Project and projects within or directly adjacent to the RSA were assessed. The KSM, NTL, Long Lake Hydroelectric, Treaty Creek Hydroelectric, Brucejack Exploration, and Sulphurets projects were reviewed in the wetlands CEA. Data were not available for wetland extent and effects on function for the Sulphurets, Long Lake, and Treaty Creek projects; however, the KSM, Brucejack Exploration, and NTL projects had information on wetland extent and function effects.

A residual cumulative effect on the loss of wetland extent and alteration of function is expected due to additive losses in the region. However, this effect is not expected to be significant, because of the limited loss of wetlands associated with the Brucejack Exploration Project and limited alteration of function associated with the proposed Brucejack Gold Mine Project. Compensation and reclamation activities planned for the KSM Project will also mitigate cumulative effects on regional wetland extent and function. The NTL environmental assessment identified that less than 7% of wetlands along the ROW would be affected, which is similar to the Brucejack Gold Mine Project (Table 17.11-1 of Rescan 2010b). In summary, the potential cumulative effects of the proposed Brucejack Gold Mine Project and other projects in the area on wetland extent and function are considered to be **not significant** (Table 34.5-17).

34.5.7 Wildlife

34.5.7.1 Summary of Project-specific Residual Effects on Wildlife

The potential effects of the Project on wildlife are assessed in Chapter 18, Assessment of Potential Wildlife Effects. The receptor VCs that were carried forward into this wildlife CEA are:

- moose;
- mountain goat;
- grizzly bear;
- American marten; and
- western toad.

Potential residual effects on wildlife identified and assessed include: habitat loss/alteration, disruption of movement, direct mortality and injury, indirect mortality, sensory disturbance, attractants, and chemical hazards. As a result of design changes and planned implementation of mitigation and monitoring programs, residual wildlife effects associated with the Project are assessed as **not significant** (Table 34.5-18).

Table 34.5-18. Summary of Project-specific Residual Effects, Mitigation, and Significance on Wildlife

Residual Effects	Project Phase(s)	Mitigation Measures	Significance
Moose			
Disruption of Movement	Construction and Operation	Traffic and road management, employee education, snow clearing protocol (e.g., gaps in snowbanks).	Not significant
Direct Mortality and Injury	Construction and Operation	Traffic and road management, vegetation management at identified wildlife crossings, and monitoring.	Not significant
Indirect Mortality	Construction, Operation, Closure, and Post-closure	Minimize development of new roads, control access on existing Project roads, and monitoring.	Not significant

(continued)

Table 34.5-18. Summary of Project-specific Residual Effects, Mitigation, and Significance on Wildlife (completed)

Residual Effects	Project Phase(s)	Mitigation Measures	Significance
Mountain Goat			
Sensory Disturbance	Construction and Operation	Practice the current BC guidelines for air traffic near mountain goat habitat.	Not significant
Indirect Mortality	Construction, Operation, Closure, and Post-closure	Limit road access to employees with no public access.	Not significant
Grizzly Bear			
Disruption of Movement	Construction and Operation	Traffic and road management, employee education	Not significant
Direct Mortality and Injury	Construction and Operation	Traffic and road management, vegetation management at identified wildlife crossings, and monitoring.	Not significant
Indirect Mortality	Construction, Operation, Closure, and Post-closure	Restrict road access, controlled gate at Highway 37 intersection to deter trespassers.	Not significant
Attractants	Construction and Operation	Wildlife Management and Monitoring Plan (Section 29.21), Waste management protocol, employee education, and plant less attractive roadside vegetation.	Not significant
American Marten			
Attractants	Construction and Operation	Waste management protocol and prohibit entry into infrastructure.	Not significant
Western Toad			
Direct Mortality and Injury	Construction and Operation	Pre-clearing surveys, monitoring and management plans, amphibian tunnels and culverts, and adaptive management.	Not significant

The following sections provide an examination of the relationship between the residual effects of the Project and those of other projects and activities. A matrix identifying the potential cumulative effect interactions of past, present, and future projects and activities on wildlife is provided in Table 34.4-1.

34.5.7.2 Cumulative Effects Assessment Boundaries for Wildlife

Spatial Boundaries

Spatial boundaries were chosen to evaluate the effects on individual animals and populations of animals. The effects on animals of wide-ranging species that may move outside of the RSA (e.g., moose, mountain goat, and grizzly bear) were examined by calculating two spatial boundaries: a Movement Area and a CEA Area. The Movement Area is defined as the distance away from the Project that an average animal of a particular species may travel in a year (e.g., maximum home range size or maximum linear distance travelled).

The CEA Area used provincial population boundaries, such as Wildlife Management Units (WMUs), or natural boundaries. Three main spatial scales were selected for the CEA Areas:

1. The grizzly bear population unit (GBPU) boundaries (the outer periphery of the three GBPUs that converge at the Project; used for grizzly bears).

2. The wildlife management area, used for moose and mountain goat, which consisted of three WMUs that converge at the Project (WMUs 6-21, 6-16, and 6-17).
3. The adjusted RSA based on the RSA used in the wildlife effects assessment, with species-specific adjustments to the RSA boundary based on home range size (used for American marten and western toad, which can move slightly farther than the original RSA boundary).

Further information on the rationale for the spatial boundaries and maximum range size calculations for each wildlife VC is outlined in Chapter 18, Assessment of Potential Wildlife Effects. Figures 34.5-6 to 34.5-10 display the Movement Areas and the CEA Area used for examining effects on each VC.

After identifying the CEA and Movement Areas for wildlife VCs, these areas were used to narrow the focus of the CEA. This was conducted in two ways: first, the projects and project components that fall outside of the CEA Area for each VC were scoped out of the assessment. Second, the elevations of all projects within the CEA Area for each VC were considered against the elevation ranges of each VC; projects within the CEA Area for each VC, but outside of their capable elevation range, were also eliminated. A summary of projects included and excluded for each VC is presented in Chapter 18, Assessment of Potential Wildlife Effects (Tables 18.9-4 to 18.9-13).

Temporal Boundaries

The temporal boundaries of the CEA are described in Section 34.2.2. Table 34.4-1 illustrates which past, present, and future projects and activities will potentially have a temporal interaction with the wildlife subject area.

34.5.7.3 Cumulative Effects Assessment on Wildlife

Moose

At least one past, present, or reasonably foreseeable future project or land use activity will interact with the three residual effects on moose identified for the Project. Therefore, the CEA is conducted for the following three potential cumulative effects on moose:

- disruption to movement;
- direct mortality; and
- indirect mortality.

Potential cumulative effects primarily result from impacts of roads, transmission lines, and/or increased traffic volume. Corridors (roads and transmission lines) and increased traffic can disrupt moose movement leading to habitat fragmentation. Corridors also provide easy access to areas for hunters (indirect mortality). A larger amount of roads and traffic can also increase vehicle-moose collisions (direct mortality). Past, present, or reasonably foreseeable future projects that use or create roads and transmission lines that may interact with the moose Movement Area or CEA Area are outlined in Table 34.4-1.

Cumulative Effects of Disruption of Movement on Moose

The Application/EIS (Section 18.7.1.1) predicts a low-magnitude residual effect of disruption to movement of moose, which was not significant with mitigation because moose are anticipated to re-occupy habitat and resume movement patterns once the barriers of traffic volume, sensory disturbance, and habitat alterations have been considerably reduced or removed. This residual effect was brought forward into the CEA, which considers all sources of likely residual movement disruptors due to past, present, and foreseeable future projects and land use activities (Table 34.4-2) that could affect moose within and surrounding the Project (Figure 34.5-6).

Figure 34.5-6

Moose Cumulative Effects Assessment Area and Movement Area

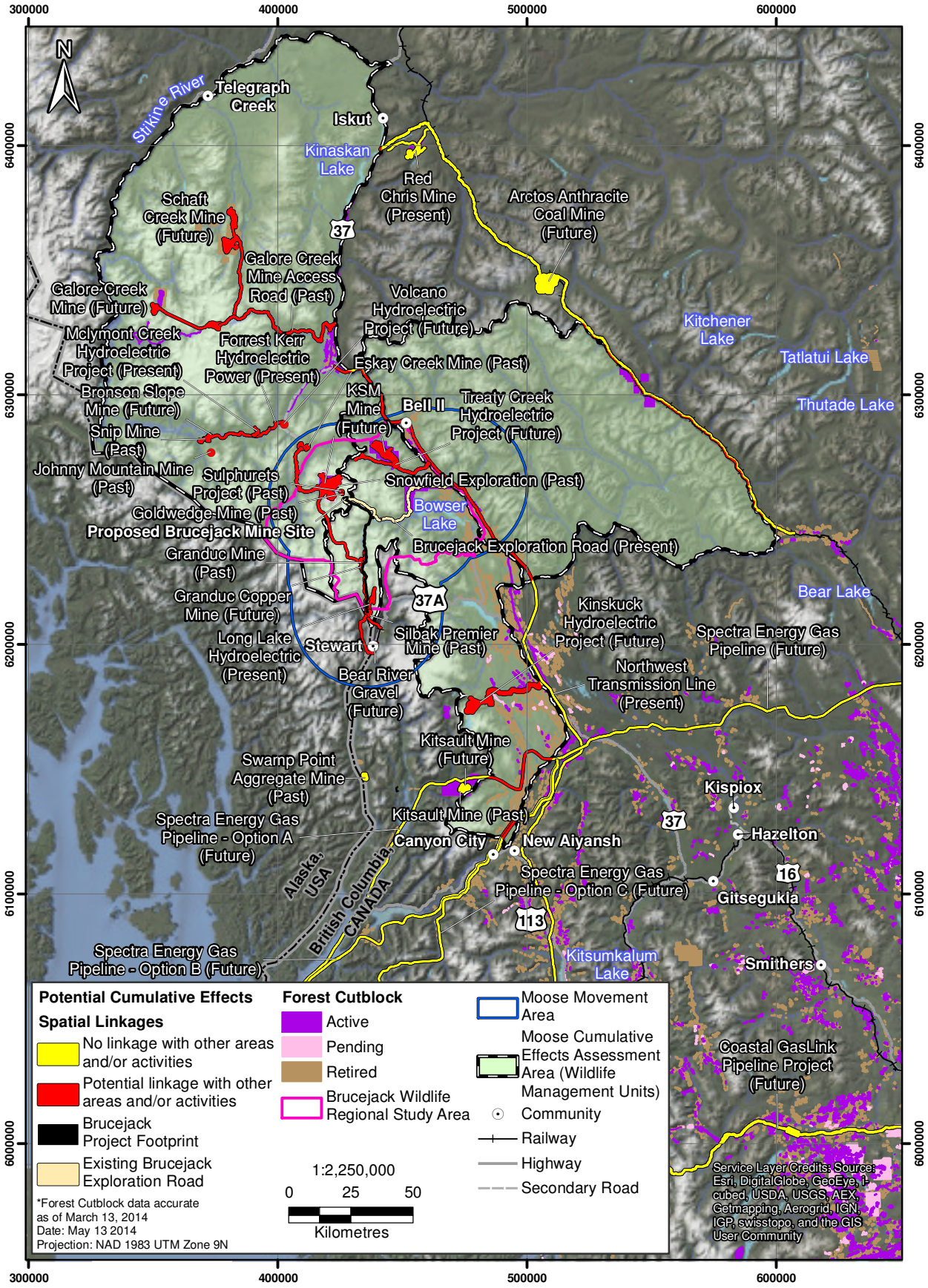


Figure 34.5-7

Mountain Goat Cumulative Effects Assessment Area and Movement Area

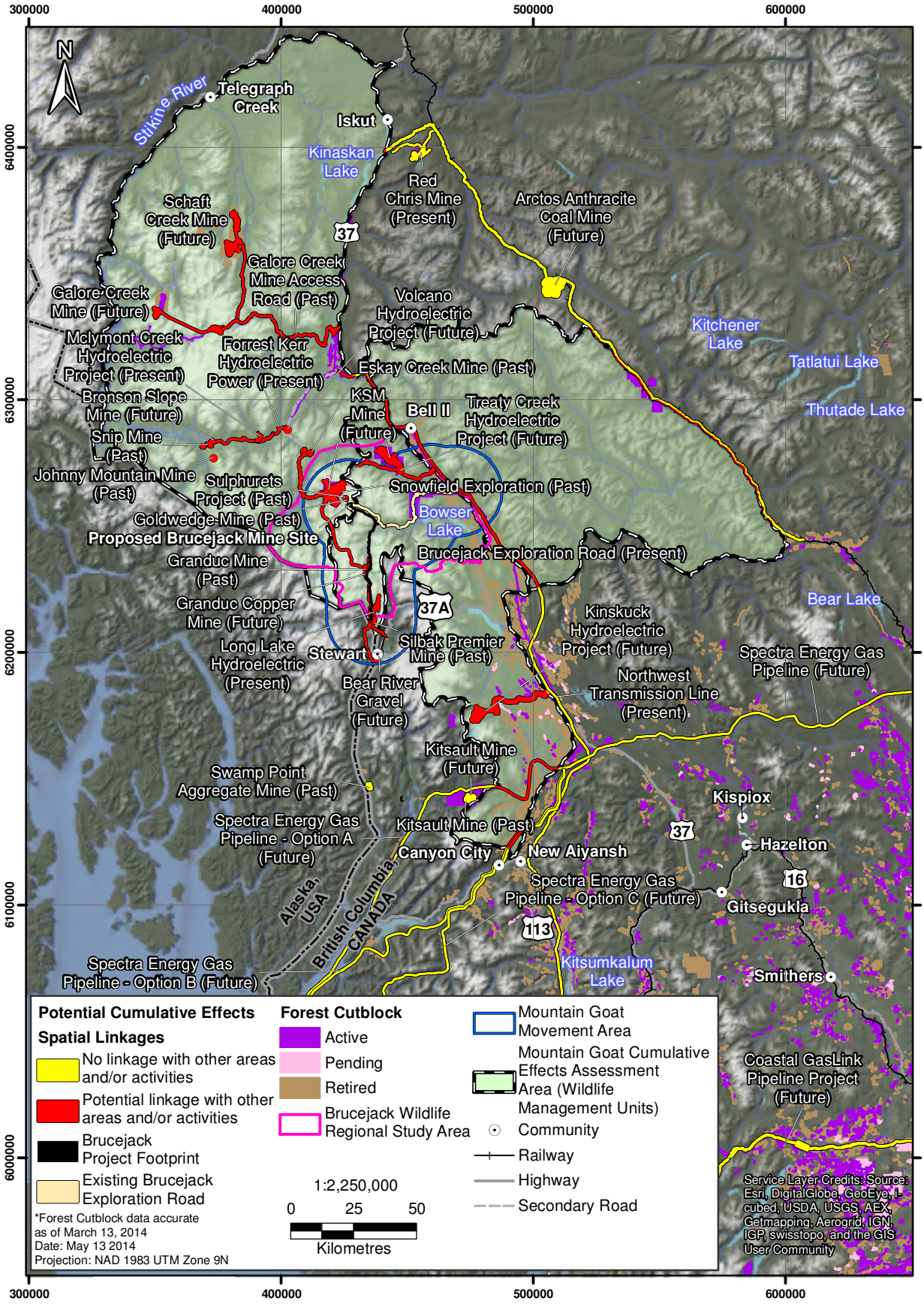


Figure 34.5-8

Grizzly Bear Cumulative Effects Assessment Area and Movement Area

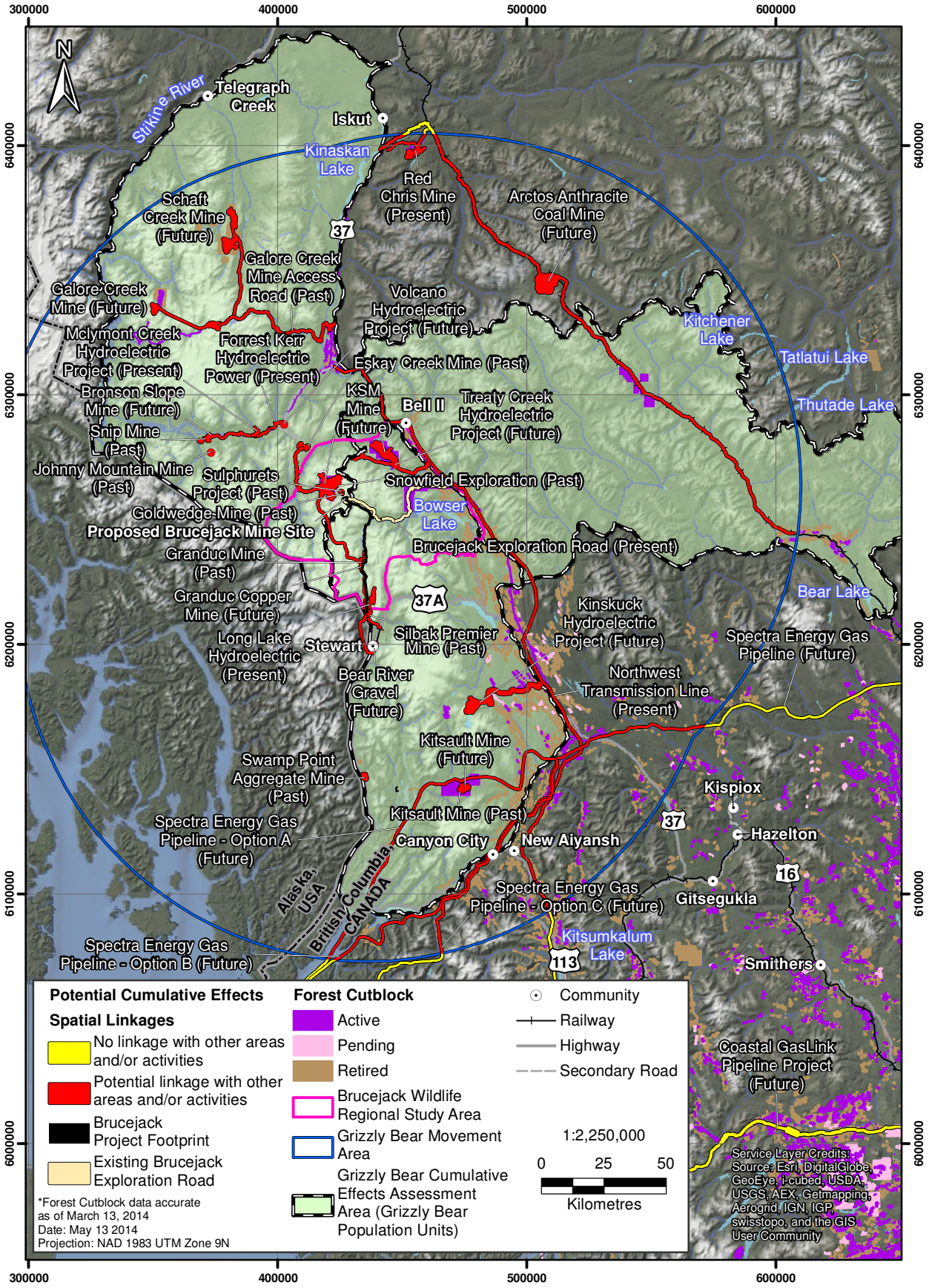


Figure 34.5-9

American Marten Cumulative Effects Assessment Area

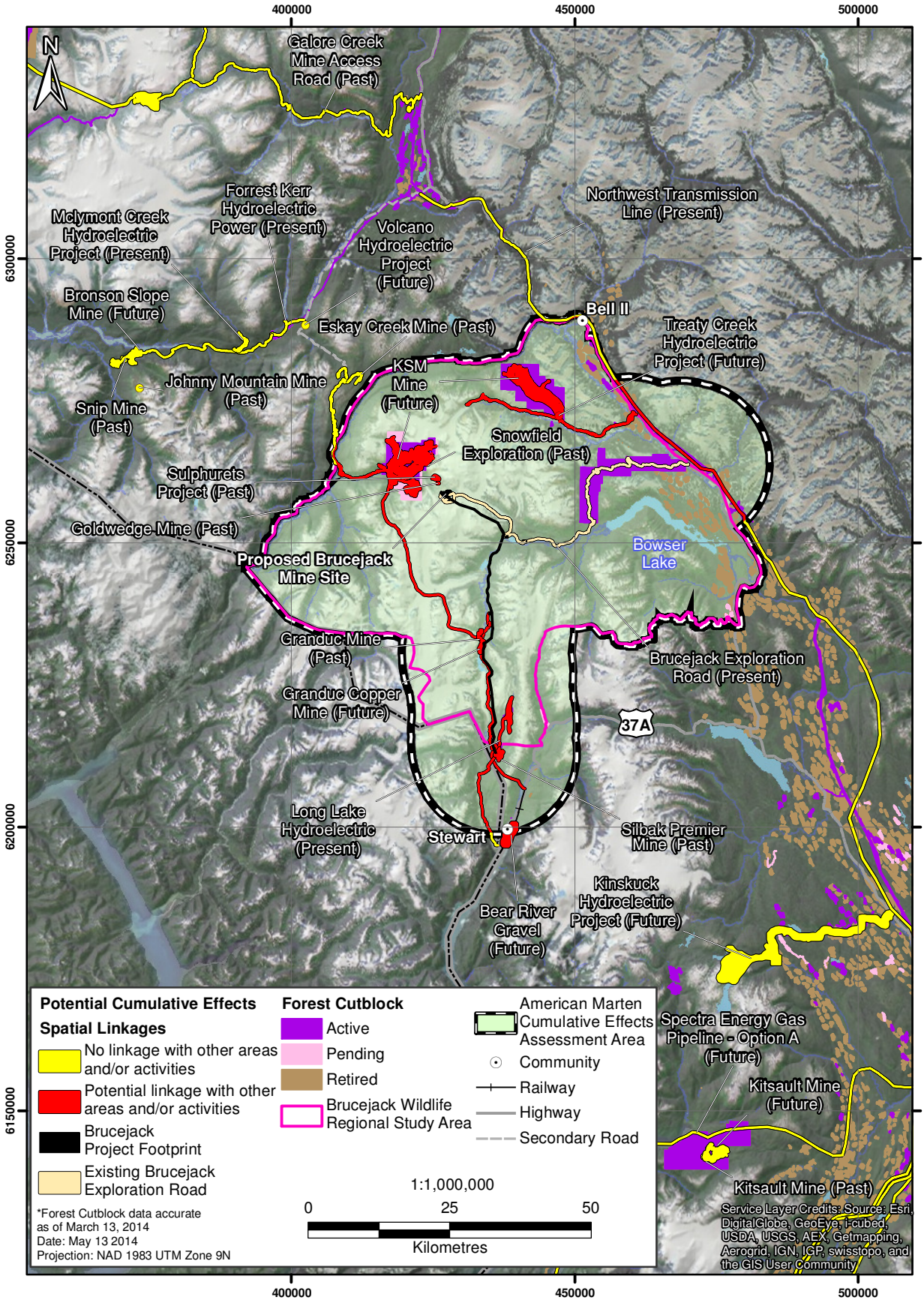
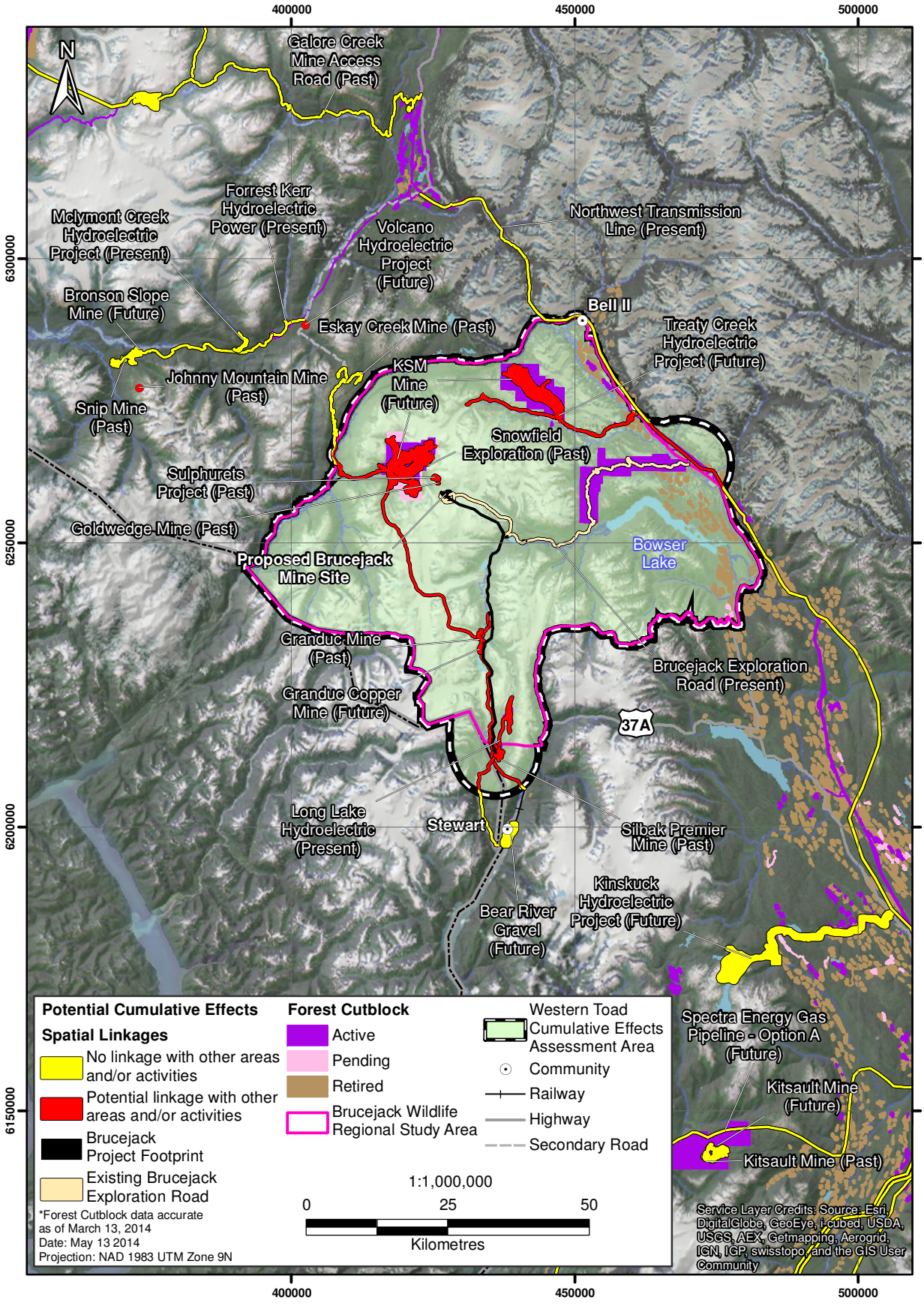


Figure 34.5-10

Western Toad Cumulative Effects Assessment Area



Roads and road traffic are the most likely aspects of industrial activity that could cumulatively disrupt movements of moose within the CEA Area. Moose may avoid crossing roads that have high traffic volumes. Thresholds (specific to moose) above which moose in BC will not cross roads are unavailable. Müller and Berthoud (1997) used data from a variety of locations to distinguish three stepped levels of barrier effects to wildlife based on road traffic: 1) roads with less than 1,000 vehicles per day (42 vehicles per hour [VPH]) are permeable to most wildlife species (see grizzly bear for exception)—many individuals successfully cross roads at these traffic rates and casualties are limited; 2) roads with traffic between 4,000 and 10,000 vehicles per day (166 to 416 VPH) impose a strong barrier to movement—noise and movements from the traffic will repel many individuals, and many that cross will get hit; and 3) highways with traffic levels above 10,000 vehicles per day (over 416 VPH) are impermeable to most species. These traffic rates were used as thresholds to evaluate impacts of cumulative vehicle traffic on moose.

Available traffic volumes from present and future projects within the Project Movement Area and CEA Area were converted to VPH traffic rates (Table 34.5-19). Traffic rates were based on an assumed 24-hour driving day on primary roads because industrial driving can occur throughout a 24-hour period. Background traffic data was estimated (based on 12-hour period) from periodic traffic counts taken in 2005 and 2008 on Highway 37, north of Meziadin Junction and in 2006 north of Dease Lake (BC MOTI 2011). The average background traffic of 224 vehicles per day was converted to an hourly rate based on an assumed 12-hour driving day, because most driving occurs between 7 a.m. and 7 p.m. Therefore, a background traffic rate of 18.7 VPH was added to all sections of Highway 37 and 37A.

Table 34.5-19. Traffic Data for Projects within the Brucejack Gold Mine Project Moose Cumulative Effects Assessment Boundaries

Project	CEA Time Period	Travel Route	Projected Traffic Rate (VPH based on a 24-hour day)	VPH Including Background Traffic (18.7 VPH)
Brucejack Gold Mine Project	Present	Highway 37 and Highway 37A	2.08	20.78
Forest Kerr Hydroelectric Project	Present	Highway 37 and Highway 37A	0.08	18.78
Long Lake Hydroelectric Project	Present	Highway 37 and Highway 37A	0.08	18.78
McLymont Hydroelectric Project	Present	Highway 37	0.08	18.78
Bronson Slope Project	Future	Highway 37 and Highway 37A	0.75	19.45
Galore Creek Project	Future	Highway 37	5.83	24.53
Schaft Creek Mine	Future	Highway 37 and Highway 37A	9.25	27.95
KSM Project	Future	Highway 37 and Highway 37A	Highway 37 = 3 Highway 37A = 4.1	Highway 37 = 21.7 Highway 37A = 22.8
All Projects	Present and Future	Highway 37 and Highway 37A	*Highway 37 = 21.2 *Highway 37A = 16.3	*Highway 37 = 39.9 *Highway 37A = 35

** Where data were available for different project phases on the same route, the maximum VPH was used.*

Traffic data were available for seven projects (excluding the Brucejack Gold Mine Project) within the moose CEA Area and Movement Area (Table 34.5-19). Traffic volume data were not available for one present project (Northwest Transmission Line) and four future projects (Granduc Copper Mine, Kinskuch Hydroelectric Project, Treaty Creek Hydro Project, and Volcano Hydroelectric Project). In addition, two projects are not using vehicles and roads as a form of transportation: Arctos Anthracite Coal Project (rail) and Bear River Gravel Project (ship freighters by water).

All of Highway 37 and 37A within the Movement Area and CEA Area were estimated to have hourly vehicular traffic rates below the traffic value of 42 VPH (Table 34.5-19), and roads are therefore expected to be permeable to moose. Traffic along Highway 37 (including existing background traffic) is close to the threshold (approximately 40 VPH). Therefore, a residual cumulative effect of disruption of movement on moose is anticipated.

Moose may also avoid moving through habitat abutting project footprints due to noise or other disturbances (Johnson et al. 2005; Laurian et al. 2008; Stankowich 2008). Movement of moose may also be reduced or impeded where snowbanks and/or earthberms have been created along road edges or within clearings that minimize crossing potential. Earth berms and snowbank heights of 60 to 90 cm along road verges may inhibit road crossing, or the ability of moose to clear the road to get out of the way of oncoming traffic (Peek et al. 1982).

Cumulative Effect of Direct Mortality on Moose

The Application/EIS (Section 18.7.1.2), predicts a low-magnitude effect of direct mortality on moose, which was predicted to be not significant with mitigation. Direct mortality was still considered a potential residual effect to be carried forward into the CEA due to the social, cultural, and economic importance of moose in the region and their sensitivity to moose-vehicle collisions. The potential cumulative effect of increased traffic along Highway 37 within the CEA Area for moose was examined quantitatively, where possible, using available traffic data from the various projects.

In most areas of North America, the largest source of direct mortality of moose is moose-vehicle collision. Increased traffic in the moose CEA Area was evaluated for the potential to increase moose-vehicle collisions and thereby direct moose mortality. Moose-vehicle collisions in northern BC are more frequent in winter (December and January), coinciding with times of highest snowfall when moose select roads as travel corridors, as they provide ease of movement (Sielecki 2004, 2010).

There are five Landmark Kilometre Inventory (LKI) segments along Highway 37 that overlap with the CEA Area from Gitwangak (Kitwanga) north to Dease Lake (LKI segments 3710, 3720, 3730, 3740, and 3750). Between 1993 and 2013, there were 305 reported vehicle accidents with moose in the five LKI segments along Highway 37. The majority (60%), of moose collisions occurred in the winter: January (N = 78), February (N = 59), and December (N = 47).

It is estimated that the wildlife collision numbers recorded by the Wildlife Accident Reporting System (WARS) may only represent 25 to 35% of the actual number of animals killed on roads (Sielecki 2010); therefore, the number of vehicle collisions could be approximately three times greater than reported by the WARS data. The average number of vehicle-moose collisions per year along Highway 37 within the five LKI segments is 5.3. Based on the estimate that the data are under-reported by approximately 70%, the current average number of vehicle-moose collisions along Highway 37 within the CEA Area could in fact be up to 17.7 per year.

The number of moose mortalities due to vehicle strikes may increase with traffic levels or may remain constant. Background traffic rates along Highway 37 were estimated as 18.7 VPH using traffic data (based on a 12-hour period) from periodic traffic counts taken in 2005 and 2008 on Highway 37, north of Meziadin Junction, and in 2006 north of Dease Lake (BC MOTI 2011). Using the available data from other projects (Table 34.5-19), traffic may double, increasing by approximately 21 VPH along Highway 37, for a total of approximately 40 VPH including existing traffic (the Project accounts for approximately 2 VPH). Therefore, if traffic is doubled and a linear relationship is assumed between vehicles per hour and vehicle collisions, then the number of vehicle-moose collisions may double within the CEA Area; therefore, a residual cumulative effect is anticipated.

Cumulative Effect of Indirect Mortality on Moose

The Application/EIS (Section 18.7.1.3) predicts a low-magnitude residual effect of indirect mortality of moose, which was not significant with mitigation. The potential residual effect for indirect mortality is expected to result from increased access and human use of the area. Any new roads built for the Project will be gated and controlled for the life of the Project; at closure, non-essential roads will be deactivated. Increased access may not be completely avoided or mitigated and is a potential adverse residual effect. This section assesses the overall effect of indirect mortality on moose within the CEA Area and Movement Area for moose (Figure 34.5-6).

Increased mortality rates often occur as an unintended consequence of increased access routes into an area. This well-documented phenomenon is due to mortality as a result of increased access to hunters and increased vulnerability of moose due to reduced cover (Timmerman and Gollat 1982; Girard and Joyal 1984; Eason 1989). Road creation in high-quality moose habitat, particularly when roads are cleared in the winter, could also increase predator access into areas occupied by moose. This could, in turn, increase predator-induced mortality of moose.

Currently, the road density within the moose CEA Area is 0.073 km/km^2 and within the moose Movement Area is 0.08 km/km^2. The inclusion of roads created by future projects increases this value by 12% for the CEA Area (0.082 km/km^2), and by 34% for the Movement Area (0.094 km/km^2). The access road developed in part with the Brucejack Exploration and Bulk Sample project, which will be utilized by the Project, has recently created 72.6 km of new road. This access road represents 23% of the proposed new roads in the moose CEA Area and 38% of the proposed new roads in the moose Movement Area. Where these roads are used for mining, they will be access controlled, which will reduce the effect of increased hunting to low levels. Where new roads are not access controlled—such as forestry roads—this effect may increase. Overall, a residual cumulative effect of indirect mortality due to increased hunting access and predator-induced mortality is anticipated.

Mountain Goats

Two residual effects on mountain goats identified for the Project will interact with at least one project or activity. The CEA is conducted for the following potential cumulative effects on mountain goats:

- sensory disturbance; and
- indirect mortality.

Cumulative Effects of Sensory Disturbance on Mountain Goats

The Application/EIS (Section 18.7.2.1) predicts a low magnitude residual effect of sensory disturbance for mountain goats that was not significant with mitigation. The effect of sensory disturbance is primarily due to aircraft and helicopter noise within high-quality mountain goat winter and summer habitat. This residual effect was brought forward into the CEA, which considers all sources of likely residual sensory disturbance that could affect mountain goat populations within the mountain goat CEA Area (Figure 34.5-7).

Mountain goats are considered to be more susceptible to disturbances from noise, helicopters, vehicles, and other industrial activity than other ungulate species (Côté 1996; Goldstein et al. 2005; Festa-Bianchet and Côté 2007). As a consequence, helicopters in BC are required to remain greater than 2,000 m from habitats containing goats (Management Plan for the Mountain Goat in British Columbia; BC MOE 2010).

Mining, hydroelectric, and exploration projects that may disturb goats through helicopter activities were assessed in the CEA Area and Movement Area for mountain goats (Figure 34.5-7). The area of disturbance from applicable projects was calculated using a 2-km buffer. These calculations represent a worst case scenario where all projects go forward and are operating or being constructed simultaneously.

Within mountain goat habitat (i.e., Boreal Altai Fescue Alpine [BAFA] BEC zones) in the CEA Area, a total of 20,621 ha (3% of the available BAFA in the CEA Area) is within the 2 km buffer, and is therefore estimated to be disturbed for mountain goats by industrial helicopter activities. However, this includes the area already considered lost or altered (138 ha) in Section 18.6.2.2 (Habitat Loss and Alteration) and disturbed (8,715 ha) in Section 18.6.2.3 (Sensory Disturbance). Within the Movement Area, 1,970.2 ha (4.6% of the available BAFA in the Movement Area) is within the 2-km buffer, and is therefore estimated to be disturbed for mountain goats. This includes the area already considered lost or altered (138 ha) in Section 18.6.2.2 (Habitat Loss and Alteration) and disturbed (8,715 ha) in Section 18.6.2.3 (Sensory Disturbance).

Cumulative Effect of Indirect Mortality on Mountain Goats

The Application/EIS (Section 18.7.2.2) predicts a residual effect of indirect mortality on mountain goats. This effect was of low magnitude and not significant (minor) with mitigation. To determine the potential cumulative effects of indirect mortality on mountain goats, relevant projects potentially contributing to increased access to the area were considered within the CEA Area and Movement Area (Figure 34.5-7).

Increased access into previously inaccessible mountain goat habitat can increase indirect mortality of mountain goats due to increased hunting. Mountain goat populations are sensitive to adult female mortality because of comparatively late age at first reproduction (four to five years old). In addition, mountain goats have low production and low survival of kids (Hamel et al. 2006; Festa-Bianchet and Côté 2007), as a large proportion of mountain goats die within their first or second year of life (Smith 1986). Road creation in high elevation areas, particularly when roads are cleared in the winter, could also increase predator access into areas occupied by goats. This could, in turn, increase predator-induced mortality of young goats.

In order to determine the level of access for hunting via access roads, an assessment of alpine roads was undertaken. Using the biogeoclimatic zones of BC, BAFA was identified as suitable mountain goat habitat. Access to BAFA habitat within the mountain goat CEA boundary could facilitate hunting, thus increasing indirect mortality. There are currently 7.2 km of gravel roads and 1.9 km of forestry roads (total of 9.1 km) accessing BAFA mountain goat habitat within the CEA Area. Two foreseeable future projects, the Brucejack Gold Mine Project and Galore Creek Mine, will add another 2.01 and 1.1 km of roads within the BAFA zone, respectively. Overall, the Brucejack Gold Mine Project will increase the amount of roads accessing mountain goat habitat by 22%. The majority of this access is located at the mine site area, which can be controlled as long as the mine is operational. Within the mountain goat Movement Area, the only future project with new roads accessing the BAFA zone is the Brucejack Gold Mine Project, with 2 km of mining access roads along with the 1.9 km of forestry roads that already exist.

Very few public or forestry access roads are built into high-elevation mountain goat habitat. If roads are constructed within goat habitat, they will likely be industrial roads, and therefore access would likely be controlled, preventing increased hunting. Despite mitigation, it is anticipated that the potential cumulative effect of indirect mortality may result in a cumulative residual effect to mountain goats.

Grizzly Bears

All four residual effects on grizzly bears identified for the Project will interact with at least one project or activity. The CEA is conducted for the following potential cumulative effects on grizzly bears:

- disruption to movement;
- direct mortality;
- indirect mortality; and
- attractants.

Cumulative Effect of Disruption of Movement on Grizzly Bears

The Application/EIS (Section 18.7.3.1) predicts a low-magnitude residual effect of disruption to movement of grizzly bears, which was not significant. With mitigation, grizzly bears are anticipated to re-occupy habitat and resume movement patterns once the barriers of traffic volume, sensory disturbance, and habitat alterations have been considerably reduced or removed. This residual effect was brought forward into the CEA, which considers all sources of likely residual movement disruptors due to relevant projects and human land use activities (Table 34.4-2) that could affect grizzly bears within and surrounding the Project (Figure 34.5-8).

Roads and road traffic are the most likely industrial features that could disrupt movements of grizzly bears. Waller and Servheen (2005) reported that bears will cross roads when traffic volumes are less than 10 VPH, but natural crossing rates can be disrupted when traffic rates exceed this value. Available traffic volumes along Highway 37 from present and future projects within the Movement Area and CEA Area were converted to VPH (Table 34.5-20). Traffic rates were based on an assumed 24-hour driving day on primary roads because industrial driving can occur throughout a 24-hour period. Background traffic data were estimated (based on 12-hour period) from periodic traffic counts taken in 2005 and 2008 on Highway 37, north of Meziadin Junction and in 2006 north of Dease Lake (BC MOTI 2011).

Table 34.5-20. Traffic Data for Projects within the Brucejack Gold Mine Project Grizzly Bear Cumulative Effects Assessment Boundaries

Project	CEA Time Period	Travel Route	Projected Traffic Rate (VPH based on a 24-hour day)	VPH Including Background Traffic (18.7 VPH)
Brucejack Gold Mine Project	Present	Highway 37 and Highway 37A	2.08	20.78
Forest Kerr Hydroelectric Project	Present	Highway 37 and Highway 37A	0.08	18.78
Long Lake Hydroelectric Project	Present	Highway 37 and Highway 37A	0.08	18.78
McLymont Hydroelectric Project	Present	Highway 37	0.08	18.78
Bronson Slope Project	Future	Highway 37 and Highway 37A	0.75	19.45
Galore Creek Mine	Future	Highway 37	5.83	24.53
Kitsault Mine (Future)	Future	Highway 37 and Highway 37A	4.5	23.2
Schaft Creek Mine	Future	Highway 37 and Highway 37A	9.25	27.95
KSM Project	Future	Highway 37	3	21.7
		Highway 37A	4.1	22.8
All Projects	Present and Future	*Highway 37	25.7	44.4
		*Highway 37A	20.8	39.5

** Where data were available for different time periods on the same route the maximum VPH was used.*

Traffic volume data were also not available for the following projects: NTL (present), Treaty Creek Hydro Project (future), Volcano Hydroelectric Project (future), Granduc Copper Mine (future), and Kinskuch Hydroelectric Project (future). In addition, two projects are not using vehicles and roads as a form of transportation: Arctos Anthracite Coal Project (rail) and Bear River Gravel Project (ship freighters by water).

The average background traffic of 224 vehicles per day was converted to an hourly rate based on an assumed 12-hour driving day, because most driving occurs between 7 a.m. and 7 p.m. Therefore, a background traffic rate of 18.7 VPH was added to all sections of Highway 37 and 37A. The background traffic levels on Highway 37 and 37A are almost twice the 10 VPH threshold, potentially already causing a detectable barrier to grizzly bear movement across the highway (Waller and Servheen 2005).

Traffic data were available for eight projects (excluding the Brucejack Gold Mine Project; Table 34.5-20). The addition of traffic from all nine projects along Highway 37 would result in 25.7 VPH, and 20.8 VPH along Highway 37A. The addition of all projects to the baseline brings the total traffic to approximately 44.4 VPH along Highway 37 and 40 VPH along Highway 37A. Traffic on the Brucejack Access Road (3.6 VPH) and KSM Project access roads (maximum of 3.4 VPH) is expected to remain below the threshold of 10 VPH and is therefore not expected to cause a barrier to grizzly bear movement. Traffic due to the Project alone is not enough to cause a disruption of movement for grizzly bears (maximum addition of 3.6 VPH).

The prediction that Highway 37 and 37A are currently acting as a barrier to grizzly bear movement may fragment the population, which increases the chance of local population fluctuations (Lande 1988; Woodroffe and Ginsberg 1998) and reduce gene flow across the barrier (Frankham, Ballou, and Briscoe 2002). The highways may also cause changes to energy budgets of bears that have to travel farther to reach seasonal habitats or that may be excluded from good quality habitat. Although these effects have been identified as already occurring at baseline conditions prior to the addition of predicted traffic from the Project, all nine projects combined will increase the VPH along Highway 37 and Highway 37A; therefore, a cumulative residual effect of disruption to movement on grizzly bears is predicted.

Cumulative Effect of Direct Mortality on Grizzly Bears

The Application/EIS (Section 18.7.3.2) predicts that the residual effect of direct mortality of grizzly bears will be of low magnitude and reversible in the long term, which was determined to be not significant with mitigation. The potential residual effect for direct mortality of grizzly bears predicted for the Project was due to vehicle collisions. This residual effect was brought forward into the CEA, which considers all residual sources of direct mortality due to all relevant projects and human uses of the area that could impact the grizzly bear populations within and surrounding the Project.

Government records (Compulsory Inspection Database) over the past three decades in BC show that, on average, 339 of a total estimated population of 15,900 grizzly bears in BC are killed each year by humans (Rockwell 2012). The vast majority of human-induced mortalities are due to legal harvest (87%). Other causes, in order of decreasing importance, include the destruction of problem bears (7%), illegal kills (3%), vehicular collisions (1.6%), and rail kills (1%). Sources of direct mortality that could be affected by increased human development in the CEA Area and Movement Area include motor vehicle and rail collisions and avalanche control. Hunting (documented and undocumented) is considered in the Indirect Mortality section and destruction of problem bears is considered in the Attractants section below.

Vehicle strikes could increase in some parts of the CEA Area and Movement Area due to increased road densities and traffic from multiple projects. There are five LKI segments along Highway 37 that overlap with the CEA Area from Gitwangak north to Dease Lake (LKI segments 3710, 3720, 3730, 3740, and 3750).

Between 1993 and 2013, there were 126 reported vehicle accidents with bears in the five LKI segments along Highway 37, which are likely an overestimate of grizzly bear collisions as they include reports of black bears (Sielecki 2013). The majority (62%), of bear collisions occurred in September (N = 28), August (N = 25), and July (N = 25).

It is estimated that the wildlife collision numbers recorded by the WARS system may only represent 25 to 35% of the actual number of animals killed on roads (Sielecki 2010); therefore, the number of vehicle collisions could be 65 to 75% higher than reported by the WARS data. The average number of vehicle-bear collisions per year along Highway 37 within the LKI segments is 6.3. Based on the estimate that the data are under-reported by approximately 70%, the number of vehicle-bear collisions along Highway 37 within the CEA Area could in fact be 21 per year.

The number of mortalities due to vehicle strikes may increase with traffic levels (as was predicted for moose) or may remain constant. Grizzly bears are known to avoid highways at even low traffic levels (see previous section, Cumulative Effects of Disruption of Movement on Grizzly Bears), which may act to curb any increases in traffic mortality. For instance, vehicle strikes in areas with higher traffic rates than those expected on Highway 37 account for a relatively small percentage (less than 3%) of human-induced bear mortalities (Rockwell 2012). Rail strikes (due to the coal transport rail line) may also increase with increased use of rail transport in the CEA Area; however, rail strikes also account for a very small percentage of recorded mortalities in the provincial records since bears are hibernating during winter when rail-wildlife issues are common.

Increased avalanche control in the bear CEA Area may also increase grizzly bear mortality if an avalanche covers their den. Bears may also emerge from hibernation if blasting is sufficiently close. The risk of this occurring is also considered low due to relatively few projects occurring within habitat selected by grizzly bears for denning (e.g., MHmm2).

The predicted project-related increases in traffic along regional highways are predicted to result in a cumulative residual effect of direct mortality from vehicle collisions for grizzly bears. Some grizzly bears will avoid highways at even low traffic levels (Section 18.6.3.5); however, it is anticipated that grizzly bear mortality will occur as a result of cumulative increases in traffic across the landscape along project access roads and Highways 37 and 37A.

Cumulative Effect of Indirect Mortality on Grizzly Bears

The Application/EIS (Section 18.7.3.4) predicts that there will be a low magnitude residual effect of indirect mortality to grizzly bears due to increased hunting pressure resulting from increased access. Indirect mortality was determined to be not significant because with mitigation it was anticipated that the residual effect will not impair the local or regional populations. This residual effect was brought forward into the CEA, which considers all residual sources of indirect mortality due to relevant projects and human use of the area (Table 34.4-2), which could affect the grizzly bear populations in the grizzly bear CEA Area (Figure 34.5-8).

Grizzly bears experience increases in legal and illegal/unreported harvest as a consequence of increased road access by hunters (Schallenberger 1980; Zager 1980; McLellan and Mace 1985; Aune and Kasworm 1989). A disproportionate number of human-caused grizzly bear mortalities are known to occur near roads (McLellan and Mace 1985). For example, 63% of bear mortalities occurred within 1 km of a road in the Rocky Mountains (Aune and Kasworm 1989). This well-documented phenomenon is due to increased access to hunters and increased “defence of life” property kills, and illegal kills (Titus and Beier 1991; Schoen et al. 1994).

Road density (km/km^2) acts as a proxy for predicting indirect mortality of grizzly bears. All past, existing, and foreseeable projects within the grizzly bear CEA Area and Movement Area were considered potential sources of indirect mortality as a result of road development. Proposed access road development information was not available for the Treaty Creek Hydroelectric Project and Schaft Creek Mine projects. No new access roads are proposed for the following foreseeable future projects: Goldwedge Mine, Volcano Hydroelectric Project, Bear River Gravel, Kinskuch Hydroelectric Project, Kitsault Mine, and the Granduc Copper Mine.

Road density is conservatively predicted to increase by 4.9% in the grizzly bear Movement Area (from 0.14 km/km^2 to 0.15 km/km^2), and 9.3% in the grizzly bear CEA Area (0.07 km/km^2 to 0.08 km/km^2). Increases in indirect mortality rates are expected to mirror those increases. The access road developed for the Brucejack Exploration project, which will be used by the Project, has recently created 35 km of new road and rehabilitated 37.6 km of a prior exploration access road. This access road represents 23% of the proposed new roads in both the CEA Area and Movement Area for grizzly bears. Mining access roads will be controlled, which will reduce the effect of increased hunting to low levels. Where new roads are not access controlled—such as forestry roads—this effect may increase. Overall a residual cumulative effect of indirect mortality due to increased hunting access is anticipated.

Cumulative Effect of Attractants on Grizzly Bears

The Application/EIS predicts a low-magnitude residual effect of attractants for grizzly bears that was determined to be not significant with the implementation of mitigation (Section 18.7.3.5; Section 29.21, Wildlife Management and Monitoring Plan). Grizzly bears are attracted to the odours from human activity such as camps, waste, or carrion along roads. This residual effect is brought forward into the CEA, which considers all residual effects of attractants due to all relevant projects and human use of the area, which could impact the grizzly bear populations within and surrounding the Project (Figure 34.5-8).

The majority of problem bears that are destroyed in North America are bears that were attracted to food such as compost, garbage, roadside mortality, or roadside litter. Food-acclimated bears lose their fear of humans, become a danger, and are often destroyed. From 1989 to 1993, an average of 20 grizzly bears were destroyed per year in BC because of conflict with humans (Rockwell 2012).

It is anticipated that there will be a cumulative residual effect of attractants to grizzly bears due to the recognized risk of camp infrastructure developing problem bears. Developments in the region are remote and overlap grizzly bear habitat so an inevitable encounter with bears often occur. More projects and land-use activities across the landscape result in an increased attractant exposure for grizzly bear individuals and populations. An analysis of the Compulsory Inspection Database over the past three decades in BC shows that, on average, 7% of human-induced mortalities were due to the destruction of problem bears; this accounts for approximately 24 of 339 grizzly bear deaths per year (Rockwell 2012). As projects are added to the CEA Area, the amount of attractants and chances of creating problem bears also increases.

A total of 24 different projects and land-use activities were identified as having the potential to contribute attractants to grizzly bears within the Project grizzly bear CEA Area and Movement Area. The assessment did not include past hydroelectric projects and past land-use activities because they will not contribute to attractant concerns for grizzly bears. All of the existing hydroelectric projects were included—except for Long Lake—because these projects are still undergoing construction so will have associated personnel and waste management concerns. All past mines and existing and foreseeable future projects and land-use activities were considered as having the potential to attract grizzly bears to sites. The cumulative effect of attractants on grizzly bears within the CEA Area and Movement Area are anticipated to result in a cumulative residual effect.

American Marten

One residual effect on American marten identified for the Project will interact with at least one project or activity. The CEA is conducted for effect of attractants on American marten.

Cumulative Effect of Attractants on American Marten

The Application/EIS predicts a low-magnitude residual effect of attractants for American marten that was determined to be not significant with the implementation of mitigation (Section 18.7.4.1). American marten are attracted to industrial projects by odours, shelter, food, and prey (Ruggiero et al. 1994). This residual effect is brought forward into the CEA, which considers all residual effects of attractants due to all relevant projects and human use of the area (Table 34.4-2), which could impact American marten within and surrounding the Project (Figure 34.5-9).

Typically when a marten has been exposed to food waste or human shelter it is quite challenging to dissuade them from similar types of attractants. The majority of problem marten are destroyed because of this high level of site fidelity to sources of attractants. The most effective means of mitigating marten attractants is by prevention with a thorough examination of project sites to identify potential sources of attractants such as food wastes and rodent populations, and by blocking entry into infrastructure. The presence of marten attractants within the CEA increases with the number of projects, which will correlate with marten control mortality events.

All past mines, existing mines and land-use activities, and future projects and land-use activities were considered as having potential attractant interactions with marten. Along with the Brucejack Gold Mine Project, the eight projects identified within the CEA and with relevance to marten attractants were: Brucejack Exploration and Bulk Sample, Goldwedge Mine, Snowfields Exploration, Northwest Transmission Line, Bear River Gravel, Treaty Creek Hydroelectric, KSM Project, and the proposed Granduc Copper Mine. The two land-use activities were resident and Aboriginal harvest, and mineral and energy resource exploration.

The assessment did not include past land-use activities because they will not contribute residual attractant concerns for marten at this time. The Long Lake hydroelectric project was also not included because construction is complete so it is not anticipated to contribute measurable attractants for marten at this time. The Northwest Transmission line, on the other hand, was included because although it is a project that will likely contribute very little attractant potential to marten when it is operational, it is still within the construction phase of development. It was included within this assessment to account for potential attractants associated with the numerous personnel and camps that are required to build the transmission line.

Due to the presence of multiple projects and land-use activities with the potential to be sources of marten attractants within the CEA Area, a cumulative residual effect was determined for American marten populations. Mitigation measures and awareness of problem marten are anticipated to be consistent for the one existing and four foreseeable future projects within the CEA Area, thereby limiting this effect considerably. Attractants at the historical projects within the CEA Area are anticipated to be very limited.

Western Toads

The cumulative effects on western toad were assessed within the CEA Area identified for western toads (Figure 34.5-9). Two potential cumulative effects are predicted to have residual effects on western toads after mitigation:

- direct mortality; and
- indirect mortality.

Potential cumulative effects primarily result from impacts of access roads due to vehicle-collisions (direct mortality) and wetland degradation (indirect mortality) due to sedimentation of wetlands adjacent to roads. Past, present, or reasonably foreseeable future projects or activities that have or are developing new access roads that may interact with the western toad CEA Area are outlined in Table 34.4-2. Projects excluded from the CEA are outlined in Chapter 18 (Table 18.9-13).

The type of cumulative effect from the remaining projects is the result of a nibbling loss—the gradual disturbance and loss of habitat. Road density, vehicle traffic, and wetland sedimentation can all have cumulative effects on the western toad within the CEA Area boundary.

Cumulative Effect of Direct Mortality on Western Toads

The Application/EIS (Section 18.6.10.5) predicts a low-magnitude residual effect of direct mortality for western toad that was not significant with mitigation. This residual effect was due to predicted risks associated with vehicle collisions during movements or migrations or due to vegetation clearing, which could lead to direct mortality due to crushing by heavy machinery or felled trees. This residual effect is brought forward into the CEA, which considers all sources of direct mortality due to relevant projects that could affect western toad populations within and surrounding the Project (Figure 34.5-10).

Migrations of western toads typically occur within a few days, and a large proportion of the local population can cross roads near breeding sites within hours. Therefore, the risk of direct mortality of this species will increase as more roads and cumulative traffic is added to the area. Increases in traffic rates and the creation of new roads due to additional projects within the CEA Area could increase the risk of vehicle collisions for western toads. Road density is expected to increase by 28% in the western toad CEA Area, from a present density of 0.1 km/km^2 to a future density of 0.13 km/km^2. This value excludes the Alaskan portion of the CEA boundary representing only 2% of the total area. Currently, there is 382.8 km of roads within the CEA boundary and another 107.7 km planned. The majority of this new road construction (68 km) is due to the future KSM Project.

The probability of western toads experiencing mortality by vehicles may increase proportional to the scale of road and traffic increases. It is predicted that the potential cumulative effect of direct mortality may result in a cumulative residual effect to western toads.

Cumulative Effect of Indirect Mortality on Western Toads

The Application/EIS (Section 18.6.10.6) predicts a low magnitude residual effect of indirect mortality for western toad, primarily due to sedimentation and degradation of wetland function, which was not significant with mitigation. Degradation of wetland function may contribute to indirect mortality in the western toad CEA Area. This residual effect is brought forward into the CEA, which considers all sources of indirect mortality due to relevant projects that could affect western toad populations within and surrounding the Project (Figure 34.5-10).

All roads were assessed for past, present, and foreseeable future projects to determine the amount of potential wetland habitat that may become degraded. All wetlands within 100 m of existing and future roads were assumed to potentially become degraded; however, because this analysis does not identify breeding ponds specifically, the overall wetland habitat impacted will be an overestimate. Currently, there are an estimated 99.8 ha of wetlands (marsh and swamp) within 100 m of existing roads (including highways 37 and 37A) and within the western toad CEA Area. Future projects may result in an additional 19.4 ha of wetlands that could become degraded (19% of the available wetlands). Therefore, because approximately 19% of the available wetlands near roads may become degraded within the CEA Area due to sedimentation of roads, a cumulative residual effect of indirect mortality to western toads is thus anticipated.

34.5.7.4 Mitigation Measures to Address Cumulative Effects on Wildlife

Pretivm will consider participating in regional monitoring programs that address sensory disturbance, disruption of movement, and direct and indirect mortality, by contributing to regionally-based monitoring initiatives where those monitoring initiatives replace proposed Project-specific monitoring, and these monitoring activities are approved by relevant provincial authorities and stakeholders.

Mitigation Measures to Address Cumulative Effects of Sensory Disturbance

Sensory disturbance was identified as a potential cumulative effect on mountain goats. The Project, as well as other projects, contributing to sensory disturbance for mountain goats are expected to follow relevant best management practices and legislative requirements, and to avoid high-quality habitat, UWR, and mineral licks. Projects operating within 500 m of a UWR or occupied goat range are expected to mitigate their development activities seasonally, following the General Wildlife Management Measures under the *Forest and Range Practices Act* (2002b). Helicopters flying over UWR or occupied mountain goat habitat are expected to adhere to setbacks of 2,000 m horizontal distance and 400 m vertical distance, as set out in the Management Plan for Mountain Goats in BC (BC MOE 2010).

Mitigation Measures to Address Cumulative Effects of Disruption of Movement

Disruption of movement was identified as a potential cumulative effect on moose and grizzly bears. Pretivm, as well as other proponents, will try to minimize their traffic volumes and will follow all relevant acts, regulations, and best management practices for the activities that they carry out. It is also expected that proponents will avoid placing infrastructure across or within moose and grizzly bear travel networks where this can be avoided. Where winter use of roads is required and snow clearing activity will occur, it is assumed that gaps in snowbanks will be created at frequent intervals and along corners to allow moose to cross and clear roads. Other proponents are also expected to attempt to design projects such that they meet the objectives of the CIS LRMP and the Nass South SRMP.

Mitigation Measures to Address Cumulative Effects of Direct Mortality

Direct mortality was identified as a potential cumulative effect on moose, grizzly bears, and western toads. It is expected that all other projects will include similar mitigation measures as adopted by the Project, primarily setting speed limits and installing toad tunnels where appropriate along project access roads, and will follow all relevant legislation, regulations, and best management practices for the activities that they carry out.

Mitigation Measures to Address Cumulative Effects of Indirect Mortality

Indirect mortality was identified as a potential cumulative effect on moose, mountain goats, grizzly bears, and western toads. It is expected that all other industrial projects will include similar mitigation measures as adopted by the Project to minimize the impacts of new road creation on indirect mortality rates for moose, mountain goats, grizzly bears, and western toads, and that each project will follow relevant acts, regulations, and best management practices for the activities that they carry out. It is expected that all industry roads would have controlled access, and that only forestry roads would potentially result in increased access.

Mitigation Measures to Address Cumulative Effects of Attractants

Attractants were identified as a potential cumulative effect on grizzly bears and American marten. It is expected that all other industrial projects within the CEA Area assessed in this report will include similar mitigation measures as adopted by the Project for attractant management to minimize the impacts of increased attraction of grizzly bears and American marten to human-use sites, and will follow all relevant acts, regulations, and best management practices for the activities that they carry out. Reporting of any failures in project attractant management programs, including those of the Project, will be important.

34.5.7.5 Summary of Residual Cumulative Effects on Wildlife

The assessment of cumulative effects evaluated the effects of the Brucejack Gold Mine Project in addition to other mining project, hydroelectric projects, forestry and other land use activities in the CEA Area. A scoping process identified which wildlife VCs, additional projects, and potential effects were to be evaluated (Section 18.9, Cumulative Effects Assessment for Wildlife). The five wildlife VCs with residual effects were evaluated (moose, mountain goat, grizzly bear, American marten, and western toad).

Tables 34.5-21 through 34.5-26 characterize the cumulative residual effects, likelihood, determination of significance, and level of confidence in the assessment of significance for moose, mountain goats, grizzly bears, American marten, and western toads, respectively. All cumulative effects on wildlife VCs are assessed as **not significant**.

34.5.8 Economics

34.5.8.1 Summary of Project-specific Residual Effects on Economics

The potential effects of the Project on the economic environment are assessed in Chapter 19, Assessment of Potential Economic Effects. The receptor VC included in this Economic CEA is:

- labour market.

The economic effects assessment determined the Project is expected to result in two residual effects on the labour market, including: 1) increased competition for labour and wage inflation; and 2) decrease in employment at Closure (Table 34.5-27). The former refers to employment competition between businesses and industry and the Project, and includes the potential for this to result in wage inflation. The latter refers to the loss of employment that will occur following the completion of the Construction and Operation phases of the Project. The Closure phase of the Brucejack Gold Mine Project might coincide with the closure of other projects and, therefore, it would be expected to cumulatively contribute to the level of unemployment in the LSA communities.

Each of these residual effects has the potential to act cumulatively with the effects of other projects and activities within the RSA. However, it is important to note that the design and implementation of future projects and activities may change due to their conceptual nature, thus leading to some uncertainty in predicting the potential for cumulative effects.

The following sections provide an examination of the relationship between the residual effects of the Project and those of other projects and activities. A matrix identifying the potential cumulative effect interactions of past, present and future projects and activities on the economic environment is provided in Table 34.4-1.

34.5.8.2 Cumulative Effects Assessment Boundaries for Economics

Spatial Boundaries

The spatial boundaries for the economics CEA are based on the RSA used for the economic effects assessment (Figure 34.5-11). There are a relatively large number of past and present and reasonably foreseeable projects (mainly mines) in northwestern BC that have affected or could potentially affect the labour market and economic development in the region. These projects and activities may interact spatially with the Project effects on the economies of LSA communities and the region. Projects and activities considered to have a spatial linkage with the Project are shown in Figure 34.5-11.

Table 34.5-21. Summary of Cumulative Residual Effects on Wildlife

Wildlife VCs	Cumulative Effect	Timing of Cumulative Residual Effect[1]	Description of Cause-Effect[2]	Description of Additional Mitigation (if any)	Description of Cumulative Residual Effect	Significance of Cumulative Residual Effect
Moose, grizzly bear	Disruption of movement	Construction and Operation	Increase in barriers (roads, increased traffic volumes)	Participate in regional monitoring programs if applicable.	Spatial crowding of projects results in an additive effect of increased traffic volume, which causes barriers within moose and grizzly bear movement routes. The additive effect of the nibbling loss of habitat also reduces connectivity along the landscape.	Not significant
Mountain goat	Sensory disturbance	Construction and Operation	Aircraft and helicopter noise	Follow current BC Guidelines for air traffic near mountain goat habitat	Nibbling loss due to gradual disturbance to habitat.	Not significant
Moose, grizzly bear, western toad	Direct mortality	Construction and Operation	Increased traffic results in increased potential for vehicular collisions with wildlife, causing mortality	Other proponents are expected to follow all relevant acts, regulations, and best management practices for the activities that they carry out, and to mitigate and monitor direct mortality, similar to the Project.	The additive effect of spatial crowding of access roads results in greater exposure to traffic mortality. Increased traffic volumes along the highways increase the risk of vehicle collisions.	
Moose, mountain goat, grizzly bear, western toad	Indirect mortality	Construction and Operation	Increased access for hunting (roads, transmission lines); sedimentation from roads adjacent to wetlands degrading toad breeding habitat	It is expected that all industry roads would have controlled access, and that only forestry roads would potentially result in increased access. It is expected that all new roads will following guidelines regarding sedimentation and erosion control.	Spatial crowding and growth-inducing potential of access roads results in increased hunting opportunities and potential cumulative mortality from harvest, and potential increase in the possibility of sedimentation and loss of wetland function.	Not significant
Grizzly bear, American marten	Attractants	Construction and Operation	Industrial projects all have an inherent risk for producing attractants - more projects results in increased exposure to attractants for grizzly bear and American marten	Other proponents are expected to include similar mitigation measures as adopted by the Project for attractant management to minimize the impacts of increased attraction of grizzly bears and marten to human-use sites, and will follow all relevant acts, regulations, and best management practices for the activities that they carry out. Tracking of any failures in project attractant management programs, including those of the Project, will be important.	The spatial crowding of projects causes recurring exposure to attractants, which results in an additive effect for habituation with potential subsequent mortality.	

[1] *Refers to the Project phase or other timeframe during which the effect will be experienced by the intermediate receptor or VC.*
[2] *"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.*

Table 34.5-22. Significance Determination of Cumulative Residual Effects for Moose

Cumulative Residual Effects	Cumulative Residual Effects Characterization Criteria							Likelihood *(low, medium, high)*	Significance of Adverse Cumulative 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 medium-term, reversible long-term, irreversible)*	**Resiliency** *(low, neutral, high)*	**Ecological Context** *(low, neutral, high)*			
Disruption of movement	Low	Far future	Sporadic	Regional	Reversible long-term	Low	High	Medium	Not significant	Low
Direct mortality	Moderate	Long-term	Sporadic	Regional	Reversible long-term	Low	High	Medium	Not significant	Medium
Indirect mortality	Low	Far future	Sporadic	Regional	Reversible long-term	Low	High	Low	Not significant	Medium

Table 34.5-23. Significance Determination of Cumulative Residual Effects for Mountain Goats

Cumulative Residual Effects	Cumulative Residual Effects Characterization Criteria							Likelihood *(low, medium, high)*	Significance of Adverse Cumulative 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 medium-term, reversible long-term, irreversible)*	**Resiliency** *(low, neutral, high)*	**Ecological Context** *(low, neutral, high)*			
Sensory disturbance	Low	Medium-term	Sporadic	Regional	Reversible short-term	Low	Neutral	Medium	Not significant	Medium
Indirect mortality	Low	Medium-term	Sporadic	Regional	Reversible long-term	Low	Neutral	Low	Not significant	Medium

Table 34.5-24. Significance Determination of Cumulative Residual Effects for Grizzly Bears

Cumulative Residual Effects	Cumulative Residual Effects Characterization Criteria									
	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 medium-term, reversible long-term, irreversible)*	**Resiliency** *(low, neutral, high)*	**Ecological Context** *(low, neutral, high)*	**Likelihood** *(low, medium, high)*	**Significance of Adverse Cumulative Residual Effects** *(not significant, significant)*	**Confidence** *(low, medium, high)*
Disruption of movement	Moderate	Long-term	Sporadic	Regional	Reversible long-term	Neutral	Neutral	High	Not significant	Medium
Direct mortality	Low	Long-term	Sporadic	Regional	Reversible long-term	Neutral	Neutral	Medium	Not significant	Medium
Indirect mortality	Low	Far future	Sporadic	Regional	Reversible long-term	Neutral	Neutral	Medium	Not significant	Medium
Attractants	Low	Long-term	Sporadic	Local	Reversible long-term	Neutral	Neutral	High	Not significant	Medium

Table 34.5-25. Significance Determination of Cumulative Residual Effects for American Marten

Cumulative Residual Effects	Cumulative Residual Effects Characterization Criteria									
	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 medium-term, reversible long-term, irreversible)*	**Resiliency** *(low, neutral, high)*	**Ecological Context** *(low, neutral, high)*	**Likelihood** *(low, medium, high)*	**Significance of Adverse Cumulative Residual Effects** *(not significant, significant)*	**Confidence** *(low, medium, high)*
Attractants	Low	Long-term	Sporadic	Regional	Reversible long-term	Neutral	Neutral	Medium	Not significant	Medium

Table 34.5-26. Significance Determination of Cumulative Residual Effects for Western Toads

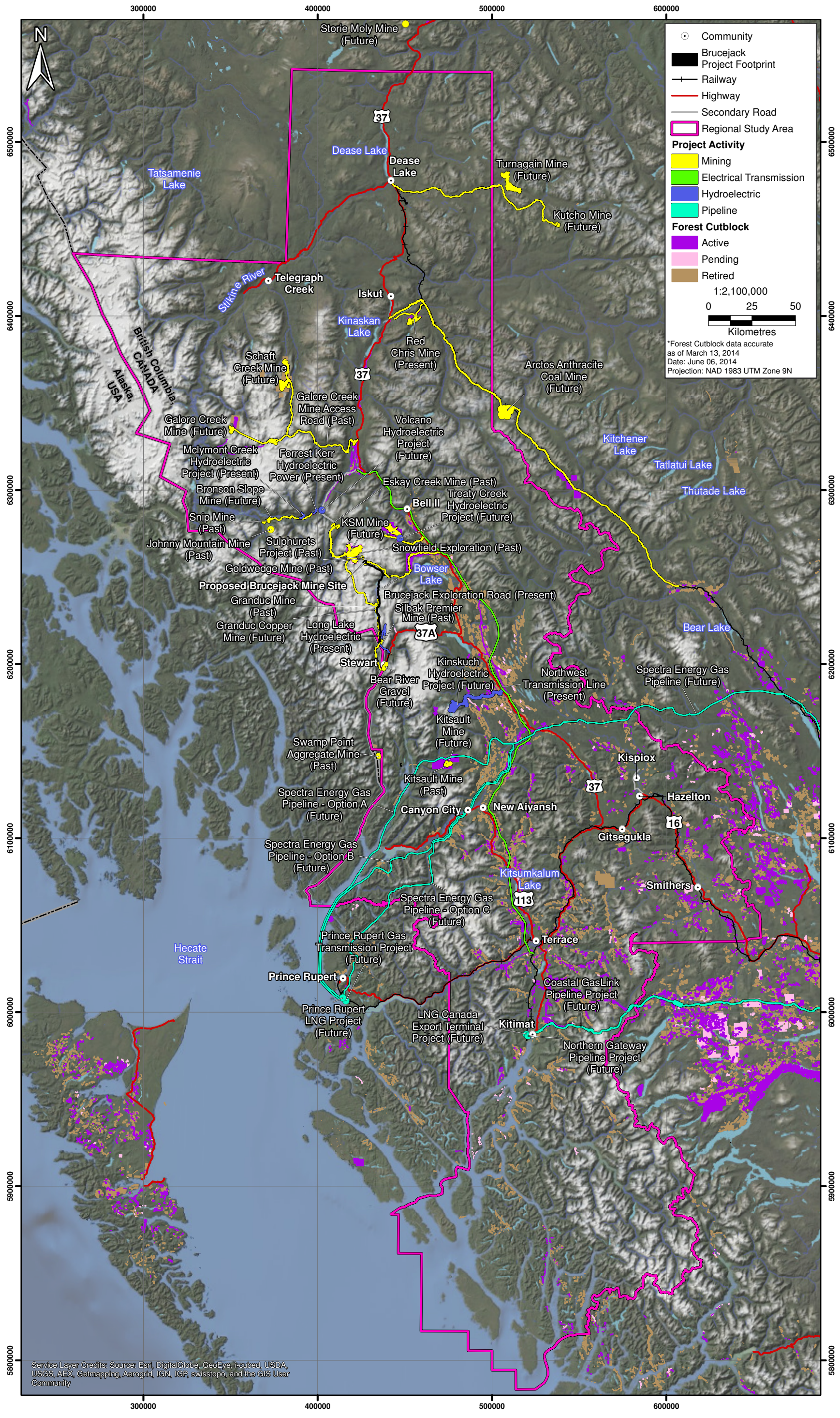
Cumulative Residual Effects	Cumulative Residual Effects Characterization Criteria									
	Magnitude *(low, moderate, high)*	**Duration** *(short-term, medium-term, long-term, far future)*	**Frequency** *(once, sporadic, regular, continuous)*	**Geographic Extent** *(local, landscape, regional, beyond regional)*	**Reversibility** *(reversible short-term, reversible medium-term, reversible long-term, irreversible)*	**Resiliency** *(low, neutral, high)*	**Ecological Context** *(low, neutral, high)*	**Likelihood** *(low, medium, high)*	**Significance of Adverse Cumulative Residual Effects** *(not significant, significant)*	**Confidence** *(low, medium, high)*
Direct mortality and injury	Low	Long-term	Sporadic	Regional	Reversible long-term	Low	High	Medium	Not significant	Medium

Table 34.5-27. Summary of Project-specific Residual Effects, Mitigation, and Significance on the Economy

Residual Effects	Project Phase(s)	Mitigation Measures	Significance
Labour Market			
Increased competition for labour and wage Inflation	Construction, Operation	Communications with Aboriginal and non-Aboriginal communities; communications with educational institutions, human resources policies and programs.	Not significant
Decrease in employment at Closure	Closure	Communications with Aboriginal and non-Aboriginal communities; workforce transition programs.	Not significant

Figure 34.5-11

Economic Cumulative Effects Assessment Boundary Showing All Other Projects and Activities Relevant to Economic Conditions in the Vicinity of the Brucejack Gold Mine Project



Temporal Boundaries

The temporal boundaries of the CEA are described in Section 34.2.2. Present projects (i.e., Red Chris Mine), and future mine, hydroelectric, LNG and pipeline projects have a temporal linkage for economics, such that these current and future projects and activities may cause similar economic changes to the Project at a similar time. All past projects and activities are assessed as not having a temporal linkage with economics because there are no longer any substantial employment and expenditures associated with these past projects and activities. Furthermore, any residual adverse effects of past projects would be captured as a contribution to baseline conditions.

Table 34.4-1 illustrates which present and future projects and activities will potentially have a temporal interaction with the economics subject area.

34.5.8.3 Cumulative Effects Assessment on Economics

The predicted residual effects of the Project on the labour market include: 1) increased competition for skilled-labour and wage inflation; and 2) decreased employment at Closure. Potential cumulative effects on economics were determined through a review of relevant past, present, or reasonable foreseeable future projects in relation to the proposed Project residual effects (Table 34.4-2).

Increased Competition for Labour and Wage Inflation

The operation of the Project will require skilled labour that will be hired from the economic RSA, from within the province and beyond. In Section 19.5.1.1, Project employment requirements indicate that the Project, over the 22-year life, will create an estimated 12,353 person-years of employment with as many as 619 full-time jobs. However, other present and future projects in the region, especially mining projects that require a large labour base, will contribute to this demand. For example, Red Chris Mine is expected to begin commissioning in June 2014 with an estimated 28 years of production and approximately 315 on-site jobs (Gillstrom, Anand, and and S. Robertson 2012). The KSM Project is expected to be in operations for 52 years, creating up to 930 permanent jobs during mine operation (Seabridge Gold 2012).

There is a limited number of skilled workers in the region, so labour requirements for present and future mine projects may temporally overlap with the Brucejack Gold Mine Project, cumulatively contributing to the demand for skilled labour. This cumulative effect may also induce wage inflation pressures on local employers as employment at the mines will offer a higher pay compared to locally available employment.

BC's mining sector is currently experiencing a labour shortage. This shortage is due to a number of factors, including recent economic growth and changes in population demographics. With high commodity prices, substantial expenditures on exploration, and the development of energy infrastructure in remote locations, the BC mining sector is poised for further growth in the longer term. In an already shrinking labour force, mining sector-related skills are becoming increasingly scarce as the experienced labour force retires, adding additional human resource challenges (MIHR 2008, 2011; Pollen 2011). However, the recently established BC Centre of Training Excellence in Mining (CTEM) is set to support the province's mine training providers in meeting industry needs and to ensure students have access to targeted training that will provide them with strong, marketable skill for the mineral industry (NWCC 2013).

Currently, around 15% of BC mining workers are 55 years of age and over, with around 28% aged 45 to 54, and around 25% aged 35 to 44. Retirements are predicted to rise over the next 10 years, the number of school graduates is expected to decline slightly, and fewer younger people are anticipated to choose the mining industry, further depleting the available number of mining workers. The number of mining workers in the mid-career range (33 to 44 years old) is currently relatively low, leaving fewer experienced mining workers to mentor those entering the industry (MIHR 2012).

The currently available number of mining workers[1] in BC is lower than that needed to fill all positions in the BC mining sector. Projections are that approximately 16,770 mining workers will be needed over the next 10 years in BC. Mining sector occupations that are predicted to be the hardest to fill include heavy equipment operators, heavy duty mechanics, construction millwrights, industrial mechanics, and industrial electricians (MIHR 2012).

It is likely that the Brucejack Gold Mine Project will face a highly competitive labour market. In addition to competition with other mining developments in BC, the Project will have to compete with large-scale developments in other provinces, such as the oil sands in Alberta or the potash and oil and gas industries in Saskatchewan (MIHR 2008, 2011). There will also be competition with labour requirements for the LNG projects in Kitimat and Prince Rupert and related pipeline projects (in particular the construction workforce). Although competition will be high, there are opportunities to increase attraction and retention of traditionally underrepresented groups, such as Aboriginal peoples. Potential labour shortages and impacts to other sectors can be mitigated with investment in training programs, and engagement of Aboriginal peoples and women (MIHR 2012).

Decrease in Employment at Project Closure

Northwest BC tends to have an unemployment rate above the provincial and national average. Based on 2011 NHS data, the unemployment rate in the Regional District of Kitimat Stikine was approximately 12.9% (Statistics Canada 2013), above the provincial unemployment rate of 7.8%; the unemployment rate was 14.1% in 2006, at that time the provincial unemployment rate was at 6.0% and the national unemployment rate at 6.6% (Statistics Canada 2007). In 2012, the unemployment rate in the North Coast, including Nechako, was at 10.7%; this was the highest regional unemployment rate recorded in the province of BC (BC Stats 2013). The Brucejack Gold Mine Project, as well as other present and future projects will contribute to the employment in the region, hiring skilled workers and general labour and, therefore, decreasing the regional unemployment rate. However, following the Post-closure phase all Project-related employment will cease. With coinciding closure of future projects and resulting termination of employment, the potential for the unemployment rate to deviate from baseline conditions is substantial.

There will be approximately 431 to 619 full-time jobs lost when the Project ceases operations. This is anticipated to occur around year 2038. However, at the same time the Closure of other present and future projects, such as the Red Chris Mine, might cumulatively contribute to this effect. Potential interactions from other projects are also possible. Therefore, it is expected that projects such as the Red Chris Mine or the Galore Creek Project and other projects will interact spatially with the Brucejack Gold Mine Project as the closure of one or more of the projects will result in an overlapping decrease in employment in the economic RSA.

34.5.8.4 Mitigation Measures to Address Cumulative Effects on Economics

Mitigation Measures for the Increased Competition for Labour and Wage Inflation

As described in Chapter 19, Assessment of Potential Economic Effects, the Project will implement adaptive management to mitigate the competitive pressures for skilled labour and wage inflation pressures. However, the development of the Brucejack Gold Mine Project, and its cumulative interaction with other present or future projects, may result in the competition for labour and wages despite the implemented mitigation measures.

[1] Here mining workers are those with education and skills training relevant to the mining sector whom have worked in the mining sector for at least one year, also termed “mining talent” by the Mining Industry Human Resources Council (MIHR 2012).

There are no specific mitigation or management measures expected from other projects or activities to address effect on availability of skilled labour and wage inflation; however, it is expected that other large resource development projects, to meet the labour and skill requirements for existing and future projects, would adopt mitigation and management measures similar to those of the Brucejack Gold Mine Project.

Mitigation Measures for the Decrease in Employment at Closure

As described in Chapter 19, Assessment of Potential Economic Effects, management practices and adaptive management will be implemented to mitigate the potential Project effect on the decrease in employment at Closure. This includes facilitation of the transition of the workforce to other employment through activities such as assistance with the identification of and preparation for appropriate job opportunities. Further, training activities will be facilitated to maximize work experience, education and skill development.

There are no specific mitigation or management measures expected from other projects; however, it is expected that other large resource development projects would adopt mitigation and management measures similar to those of the Brucejack Gold Mine Project.

34.5.8.5 Summary of Residual Cumulative Effects on Economics

Cumulative residual effects are those effects remaining after the implementation of all mitigation measures and are summarized in Table 34.5-28. The cumulative residual effects of the Project and other projects on "increased competition for labour and wage inflation" and "decreased employment at Closure" are predicted to be **significant** (Table 34.5-29). For the purposes of the CEA, it is assumed that the other identified current and future projects implement mitigation to appropriately address those project effects. However, with respect to the identified adverse economic effects, it is recognized that unilateral mitigation by each proponent may not effectively address the cumulative effects because of the additive and synergistic nature and scale of the effects.

Table 34.5-29 characterizes the cumulative residual effects, likelihood, determination of significance, and level of confidence in the assessment of significance for labour market and economic development, respectively.

34.5.9 Social

34.5.9.1 Summary of Project-specific Residual Effects on Social Valued Components

The potential effects of the Project on the social environment are assessed in Chapter 20, Assessment of Potential Social Effects. The receptor VCs included in the Social Environment CEA are:

- education, skills, and training;
- community infrastructure, services, and housing; and
- worker and family well-being.

The residual effect for education, skills, and training is the increased demand for educational services and programs within the LSA during the early period of the Operation phase (Table 34.5-30). The reason for the residual effect post-application of mitigation is that even with mitigation it will take time for education institutions within the RSA and LSA to increase their capacity to meet demands.

The two residual effects for community infrastructure, services, and housing are: increased demand for infrastructure and housing as a result of population in-migration, and increased demand for health and social services (Table 34.5-30). One of the residual effects (i.e., increased demand on housing and infrastructure) in Aboriginal communities is expected to be present during both the Construction and Operation phases of the Project, even with the application of mitigation. This is because it will take time to address the housing and infrastructure issues faced by First Nations and Nisga'a Nation communities.

Table 34.5-28. Summary of Cumulative Residual Effects on the Economy

	Timing of Cumulative Residual Effect[1]	Description of Cause-Effect[2]	Description of Additional Mitigation (if any)	Description of Cumulative Residual Effect	Significance of Residual Effects
Labour Market					
Increased competition for labour and wage inflation	Construction, Operation	A number of future projects will require a substantial workforce base during Construction and Operation, mostly skilled trades and professionals that will be hired from the economic RSA and beyond. Due to the composition of the current labour force, projects will compete for skilled labour with other projects and local businesses. Further, this will likely affect the level of wage in the economic RSA as mine projects offer a substantially higher pay.	No additional mitigation measures other than those implement by the Project and mitigation measures potentially implemented by other proposed projects.	Short term there will be an adjustment period, but in the long term no cumulative residual effect is anticipated.	Significant
Decrease in employment at Closure	Closure	During Closure, employment will be reduced. This will cumulatively contribute to the unemployment level in the economic RSA in the case where more than one project ceases operation at a similar time.	No additional mitigation measures other than those implement by the Project and mitigation measures potentially implemented by other proposed projects.	Short term there will be an adjustment period, but in the long term no cumulative residual effect is anticipated.	Significant

[1] *Refers to the Project phase or other timeframe during which the effect will be experienced by the intermediate receptor or VC.*
[2] *"Cause-effect" refers to the relationship between the Project component/physical activity that is causing the change or effect in the condition of the receptor VC.*

Table 34.5-29. Significance Determination of Cumulative Residual Effects on Labour Market

	Cumulative Residual Effects Characterization Criteria									
Cumulative Residual Effects	**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 medium-term, reversible long-term, irreversible)*	**Resiliency** *(low, neutral, high)*	**Ecological Context** *(low, neutral, high)*	**Likelihood** *(low, medium, high)*	**Significance of Adverse Cumulative Residual Effects** *(not significant, significant)*	**Confidence** *(low, medium, high)*
Increased competition for labour and wage inflation	High	Long-term	Continuous	Regional	Reversible long-term	Moderate	Neutral	Medium	Significant	Medium
Decrease in employment at Closure	High	Short-term	Sporadic	Regional	Reversible short-term	Moderate	Neutral	Medium	Significant	Medium

Table 34.5-30. Summary of Project-specific Residual Effects, Mitigation, and Significance on Social Environment

Residual Effects	Project Phase(s)	Mitigation Measures	Significance
Education, Skills, and Training			
Increased demand for educational services and programs in the LSA	Operation	Communicate Project development and workforce schedule with communities and educational institutions	Not significant
Community Infrastructure, Services and Housing			
Increased demand for infrastructure and housing	Construction and Operation	Communicate Project development and workforce schedule with communities	Not significant
Increase demand on health and social services	Construction and Operation	Communicate Project development and workforce schedule with communities	Not significant
Family and Worker Well-being			
Increase in transient workers coming into LSA communities	Construction and Operation	Communicate Project development and workforce schedule with communities where workers are picked up/dropped off	Not significant
Increased levels of stress and anxiety on families due to rotational work	Construction and Operation	Employee assistance program	Not significant
Increase in poor lifestyle choices	Construction and Operation	Human resource policies and employee assistance program	Not significant

There are three residual effects for worker and family well-being (Table 34.5-30). They are: increase in transient workers coming into LSA communities, increase in levels of stress and anxiety on workers and families due to rotational work, and increase in poor lifestyle choices. It is expected that the increase in transient workers coming into the RSA and LSA will occur during both the Construction and Operation phases of the Project, even with the application of mitigation. These residual effects are related to the fact that with mitigation the effects will decrease; however, the effect will still exist as there is no guarantee that workers or their families will access the services and supports available to them. In addition, certain individuals are expected to be more susceptible or vulnerable to the changes.

The following sections provide an examination of the relationship between the residual effects of the Project and those of other projects and activities. A matrix identifying the potential cumulative effect interactions of past, present, and future projects and activities on the social environment is provided in Table 34.4-1.

34.5.9.2 Cumulative Effects Assessment Boundaries for Social Valued Components

Spatial Boundaries

The spatial boundaries for the social CEA are based on the RSA used for the social effects assessment (Figure 34.5-12). The RSA contains a number of past, present, and reasonable foreseeable projects (mainly mines) that have created, do create, or will create changes in employment, income, population, infrastructure, services, health and education (see Figure 34.5-12). These projects and activities may interact spatially with the Projects' effects on the social conditions of the LSA communities and the region.

Temporal Boundaries

The temporal boundaries of the CEA are described in Section 34.2.2. Present mine and electrical transmission projects (i.e., NTL and Red Chris Mine), and future mine and hydroelectric projects may cause social changes that are similar to the Project and that occur at a similar time. Past projects and activities are not considered to be temporally linked to the Project, as they no longer produce any notable residual social effects.

Table 34.4-1 illustrates which present and future projects and activities will potentially have a temporal interaction with the social subject area.

Administrative Boundaries

The same boundaries apply for the CEA as for the social effects assessment (Section 20.4.2.3). It should be noted that regional subdivisions of the province, for example, include areas defined by regional districts, municipal areas, Local Health Areas (LHAs), college regions, and economic development zones. The borders of these regions and categories do not necessarily coincide with one another and often change over time; in addition they do not necessarily coincide with RSA and LSA boundaries. Furthermore, the traditional territories of relevant First Nations transcend many of these contemporary boundaries, and cultural linkages may extend across different administrative jurisdictions.

The administrative boundaries that are most relevant to the social effects assessment as they both influenced the information available and reflect the management of key socio-economic issues by governments include:

- municipalities and regional districts; the RSA includes two regional districts:
  - Regional District of Kitimat-Stikine — provides local government services to rural and unincorporated settlements within an 100,000 km^2 area of northwest BC, including the municipalities of Kitimat, Terrace, Stewart, Hazelton, and New Hazelton (RDKS 2012);
  - Electoral Area "A" of the Regional District of Bulkley-Nechako — covers approximately 3,688 km^2 and includes Smithers, several unincorporated settlements, and surrounding rural areas.
- LHAs in the RSA:
  - Snow County LHA (Stewart);
  - Nisga'a LHA;
  - Upper Skeena LHA;
  - Smithers LHA; and
  - Terrace LHA.
- First Nations reserves and Nisga'a Nation land.

Aboriginal governance takes several forms in BC, most of which are represented in the RSA (see Section 20.3.3) and range from hereditary systems to those outlined in the *Indian Act* (1985b). Table 34.5-31 lists the Aboriginal communities within the RSA and the type of governance system which they have. The exception is Nisga'a Nation, which is governed by Nisga'a Lisims Government (NLG) established under the *Nisga'a Final Agreement* between Nisga'a Nation and the governments of Canada and British Columbia (NLG, Province of BC, and Government of Canada 1998). The overarching framework of Nisga'a governance is derived from the traditional laws and practices of Nisga'a people (see Appendix 19-A, Brucejack Gold Mine Project: Socio-economic Baseline Report) with guidance and interpretation provided by the Council of Elders (NLG 2002). NLG governance is also guided by, and operates within, the *Constitution Act* (1982) and the *Canadian Charter of Rights and Freedoms*.

Figure 34.5-12

Cumulative Effects Scoping: Projects and Activities Interacting with the Brucejack Project for Socio-economics

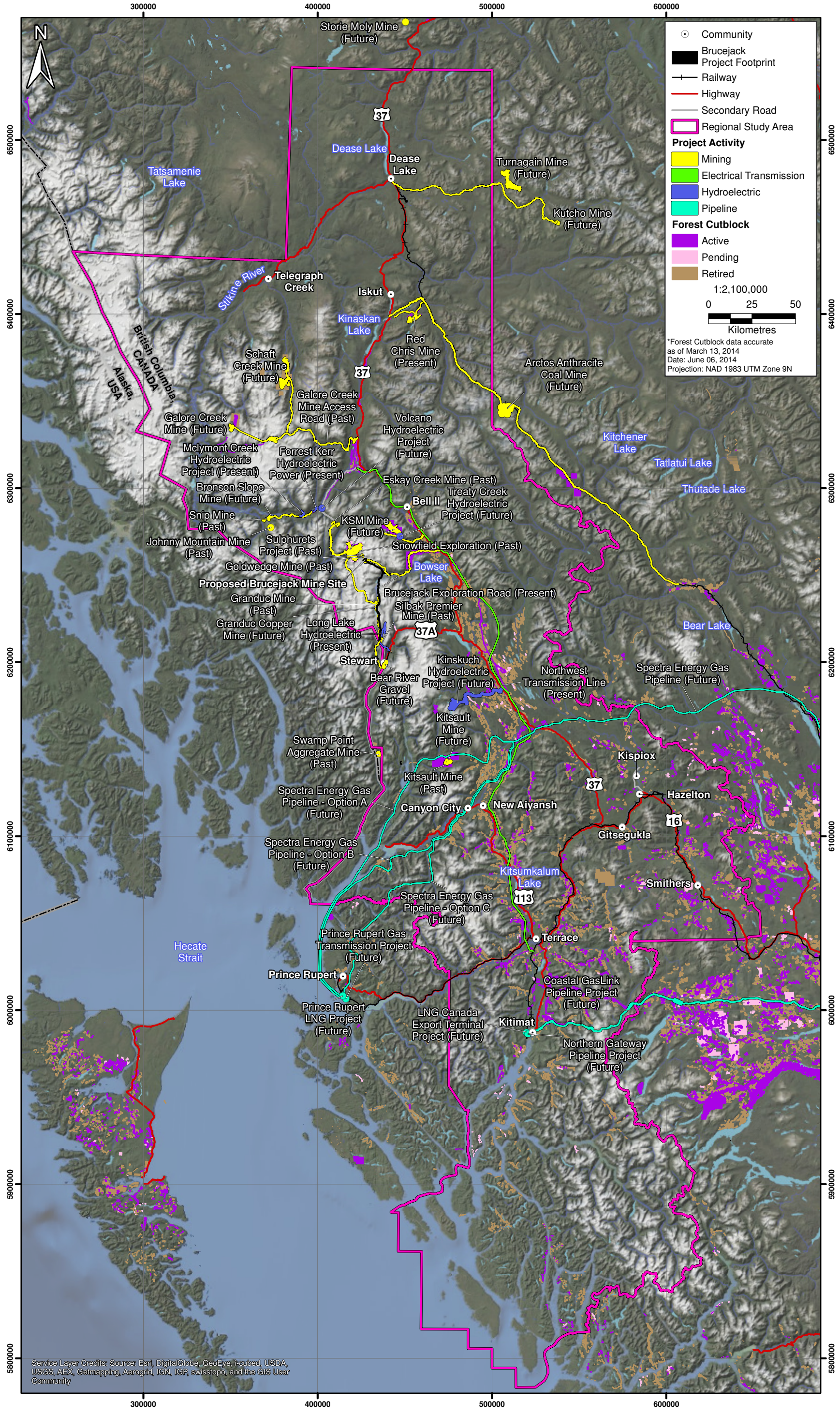


Table 34.5-31. Aboriginal Governance in the Regional Study Area

Type of Organization	Organization	Functions
Treaty Nation	Nisga'a Lisims Government	Administration of government operations Regulatory jurisdiction and administration of government programs and services; financial, land and resource, and fisheries management
	Gitlaxt'aamiks Village Government	Local governance, programs and services
	Gitwinksihlkw Village Government	Local governance, programs and services
	Laxgaltsap Village Government	Local governance, programs and services
	Gingolx Village Government	Local governance, programs and services
First Nations	Skii km Lax Ha	Aboriginal rights and title, land use planning
	Iskut First Nation	Local governance (Iskut) Tribal/Band governance and services Health
	Tahltan Central Council	Represents the Tahltan Indian Band and Iskut First Nation on issues of joint concern (e.g., Aboriginal rights and title, land use planning)
	Tahltan Band	Local governance (Telegraph Creek, Dease Lake 9) Tribal/Band governance and services
	Gitxsan Chiefs' Office	Tribal/Band governance and services
	Gitxsan Treaty Office	Aboriginal rights and title, land use planning
	Gitxsan Communities (Gitwangak, Gitaanmax, Gitsegukla, Kispiox, Glen Vowel)	Band governance and services
	Gitanyow Hereditary Chiefs Office	Aboriginal rights and title, land use planning
	Gitanyow Band Council	Tribal/Band governance and services Health

34.5.9.3 Cumulative Effects Assessment on Social Valued Components

Cumulative Effects on Education, Skills and Training

The cumulative effect related to increased demand for educational services and programs in the RSA and LSA is characterized as both spatial and temporal crowding, additive and synergistic. There are 12 current and reasonably-foreseeable future projects within the RSA that are mining projects. The one current project is the Red Chris mine. Of these 12 projects, seven are slated to have construction begin at the same time as the Project. These seven projects are estimated to generate over 2,000 jobs during their construction phases and employment figures just below that for operation phases (Chapter 6, Assessment Methodology, Sections 6.9.2.1, 6.9.2.2 and 6.9.2.3). The high number of jobs available combined with all the projects occurring within a similar timeframe suggests that educational institutions within the RSA would struggle to meet this sharp increase in demand for mining-related programs. Essentially demand would outpace capacity, thereby limiting access. Spatial crowding is applicable as all of these projects are occurring within the RSA and temporal crowding applies as seven of the 12 projects are due to begin their construction phases around the same time. In short, educational institutions within the RSA are predicted to struggle in the short-term.

The 11 reasonably-foreseeable future projects will work in a linear way, as all the projects will work to increase demand for mining-related programs within the RSA far beyond what current capacity is able to handle. There is a potential that there will also be a synergistic effect as the result of the lack of capacity

could mean that people living within the RSA are less employable as they do not have the required skills and training to access the employment opportunities; therefore, they would lose out on the economic benefits of the projects being present in the RSA. The cumulative effects associated with increase in demand for educational services and programs will primarily be felt by educational institutions in Terrace and Smithers, which act as hubs for educational programs and services within the RSA.

Cumulative Effects on Community Infrastructure, Services and Housing

As indicated in Table 34.5-30, there are two adverse residual effects for community infrastructure, services, and housing related to the Project's social effects assessment:

- increased demand for infrastructure and housing as a result of population in-migration; and
- increased demand on health and social services.

The cumulative effects related to these residual effects are expected to be spatial and temporal crowding, additive and synergistic.

Increased Demand for Infrastructure and Housing as a Result of Population In-migration

After reviewing all of the projects considered in this CEA, 16 projects are considered to have the potential to affect housing and infrastructure within the RSA in First Nation and Nisga'a Nation communities (see Table 34.4-2). Due to the current state of housing and infrastructure in these communities (waitlists for housing, overcrowding and lack of adequate housing infrastructure), any in-migration of population is expected to have an adverse residual effect without changes to current procedures to provide housing.

Of the 16 projects (mining, pipeline, and hydroelectric) that could potentially interact with housing and infrastructure, 11 are predicted to have construction periods that begin around the same time as the Project's, which means that there will be substantial regional employment opportunities during both construction (peak employment period will be construction for all projects) and operation. These opportunities will draw Aboriginal peoples back to their home communities as opportunities for economic advancement through employment with associated projects will be readily available.

The cumulative effect is characterized as both spatial and temporal crowding as all of these projects are occurring within the RSA and some within 50 km of the Project. In addition, the receptor will have difficulty recovering due to the timing of the 11 projects which are predicted to kick-off around the same time (the year 2015). These projects will combine in a linear fashion, meaning the cumulative effect is additive in nature, as all the projects work to increase demand for housing and infrastructure in these communities in a short period of time. There is also the potential for a synergistic effect, as people moving back to their home communities may decide to look in other communities for housing if there is none available in their own communities, potentially contributing to a housing issue in key hubs, including Terrace, Smithers, and Stewart.

Increased Demand on Health and Social Services

After reviewing all of the projects considered in this CEA, 16 are considered to either likely to (six) or will possibly (10) interface with health and social services within the RSA (see Table 34.4-1).

Of the 16 projects that could potentially affect health and social services within the RSA, 11 are predicted to have construction periods that begin around the same time as the Project's. Terrace acts as a health service centre within the RSA, providing services to many residents. There are also current issues with capacity (e.g., emergency services in Stewart) within the RSA. The sheer number of

projects and, in particular, those that have construction phases that are planned to begin at the same time as the Brucejack Gold Mine Project indicates that there is an increased potential for demand to outstrip capacity and, therefore, affect access and quality of services within the RSA.

The cumulative effect is characterized as both spatial and temporal crowding. Essentially, a large number of projects may be occurring in a brief period of time. The cumulative effect will be spatial as there will be a sharp increase in demand for health and social services within the RSA from the projects themselves, as well as from the predicted increase in population associated with the increase in the number of employment opportunities. The cumulative effect will also be temporal; with so many projects predicted to occur in the same timeframe, it will leave very little time for health and social services to recover and meet the increase in demand, at least in the short-term. The cumulative effect will also be additive in nature, as the effect will increase in a linear way with each project contributing to the overall effect to health and social services in the RSA. It is possible that there will also be a synergistic effect in the short-term—if people are unable to access services due to a lack of capacity there could be a decrease in overall health conditions within the RSA as people are not able to get the treatment they need. It is predicted that this cumulative effect will primarily occur in the key hubs within the RSA—Terrace, Smithers and Stewart—and it is expected that this effect will take place primarily during the Construction phase of the Project. As time passes, health and social services are predicted to recover with proper mitigation.

34.5.9.4 Cumulative Effects on Worker and Family Well-being

As indicated in Table 34.5-31, there are three adverse residual effects for community infrastructure, services, and housing related to the Project's social effects assessment. The cumulative effects related to these residual effects are expected to be spatial and temporal crowding, additive and, in some cases, synergistic effects.

Increase in Transient Workers Coming into Local Study Area Communities

Of the 26 projects that have been included for consideration in the CEA (see Table 34.4-1) there are 10 that are thought to have likely interactions with this social residual effect and 10 that are predicted to have possible interactions with this residual effect. These projects have been considered to have interactions due to their start dates for construction or their proximity to the Project.

These 20 projects are estimated to generate over 3,000 jobs during their construction phases and employment figures just below that for operation phases (Chapter 6, Assessment Methodology, Sections 6.9.2.1, 6.9.2.2, and 6.9.2.3). The high number of jobs available combined with all the projects occurring within a similar timeframe suggests that there could be high levels of in-migration to the RSA and LSA. Migrant/transient workers tend not to contribute to communities and can often have adverse effects to overall community well-being. This in-migration of transient workers is expected to occur both during construction and operation phases, as people will be drawn to the employment opportunities that will be available during each phase. It is predicted that this in-migration will be focused on the hub communities of Terrace, Smithers, and Stewart.

This cumulative effect is characterized as being spatial and temporal in nature, due to the restricted area where the effect is predicted to occur and the number of projects that will stimulate the cumulative effect, as well as the short timeframe within which it will occur. These hub communities will struggle to recover in the short-term and potentially in the long-term as well. The cumulative effect is also characterized as additive, as it is predicted that each project will add in a linear fashion to the residual social effect of increase number of transient workers coming into the RSA and LSA.

Increased Levels of Stress and Anxiety on Workers and Families due to Rotational Work

Of the 26 projects that have been included for consideration in the CEA (see Table 34.4-1), 10 are predicted to have a "likely" interaction with this social residual effect and 10 are predicted to have a "possible" interaction. Eighty percent of the reasonably-foreseeable future projects are considered to be operating on either a fly-in/fly-out (FIFO) work rotation or another type of rotational schedule.

As discussed in Section 20.5.3, Key Effects on Family and Worker Well-being), increased levels of stress and anxiety are associated with the prevalence of FIFO work. It is reasonable to assume that with the number of projects operating in the RSA with FIFO schedules that there will be cumulative effects related to an increase in stress and anxiety for workers and their families. It is also reasonable to predict that as the majority of the in-migration of population will occur in the hubs of the RSA (Terrace, Smithers, and Stewart) that these are the areas where these cumulative effects will be most evident. This cumulative effect will occur during both the Construction and Operation phases.

This cumulative effect is characterized as being spatial and temporal crowding in nature. It is spatial as it is predicted that there will be overlapping effects of the FIFO work rotation within the RSA, due to the number of jobs that will be based on this rotation. It is temporal as the effects from the FIFO work rotation on worker and family stress and anxiety levels will likely occur in a very short period of time and it is likely that some workers and families will have challenges in effectively managing this effect in the short-term. The cumulative effect is also additive in nature as the projects combine in a linear fashion to increase the effect. The cumulative effect could also be considered to be synergistic, because if there are increases in levels of stress and anxiety for workers and their families this will in turn increase demand for health and social services in the RSA. As mentioned above, health and social services are predicted to also be experiencing an adverse cumulative effect related to a lack of capacity and it may mean that they will have additional difficulties in being able to respond to the needs of workers and families in the RSA.

Aboriginal communities are seen as being particularly sensitive and already suffer from high rates of illness and social issues (Appendix 19-A, Socio-Economic Baseline Report; Chapter 20, Assessment of Potential Social Effects, Sections 20.3 and 20.5.3).

Increase in Poor Lifestyle Choices

Of the 26 projects that have been included for consideration in the CEA (see Table 34.4-1) there are 10 that are predicted to have a "likely" interaction with this social residual effect and 10 that are predicted to have a "possible" interaction with this residual social effect. The vast majority of the reasonably-foreseeable future projects are considered to be operating on either a FIFO work rotation or another type of rotational schedule. As discussed in Section 20.5.3, FIFO schedules associated with the mining industry can lead to increased levels of stress and anxiety for workers and their families. In addition, increase in income and a lack of money management skills and knowledge lead to poor choices on how money is spent.

As discussed in Section 20.5.3, poor lifestyle choices are associated with the prevalence of FIFO rotation work. It is reasonable to assume that with the number of projects operating in the RSA with FIFO schedules that there will be cumulative effects related to an increase in poor lifestyle choices. It is reasonable also to assume that as the majority of the in-migration of population will occur in the hubs of the RSA (Terrace, Smithers, and Stewart) that these are the areas where these cumulative effects will be most evident. This cumulative effect will occur during both the Construction and Operation phases.

This cumulative effect is characterized as being spatial and temporal crowding, for the same reasons as for the other cumulative effects for the social environment. There are a large number of projects happening in a very short period of time and all within the social impact RSA. This will lead to cumulative effects as there are overlapping effects related to the number of jobs and the short time period that these changes are expected to take place. The cumulative effect is also additive, as the cumulative effects are expect to combine in a linear way. There is also the potential for synergistic cumulative effects, as with the increase in stress and anxiety for workers and their families associated with poor lifestyle choices. The increase in poor lifestyle choices on such a large scale within the RSA may further adversely affect health and social services in the RSA with more people suffering from alcohol and drug misuse-related illness and issues. Aboriginal communities are seen as being particularly sensitive and already suffer from higher rates of alcohol and drug misuse (Appendix 19-A, Socio-Economic Baseline Report; Chapter 20, Assessment of Potential Social Effects, Sections 20.3 and 20.5.3).

34.5.9.5 Mitigation Measures to Address Cumulative Effects on Social Valued Components

The Proponent cannot be held solely responsible for mitigation related to the above discussed cumulative effects for each of the VCs. The sheer number of projects and proponents involved in contributing to the cumulative effects within the RSA makes singular action by the Proponent an ineffective mitigation measure to address the cumulative social effects. In addition, many of the identified social effects are in areas that are the lead responsibility of governments—such as the community infrastructure, health care, and social services. The scale of the cumulative social effects has the potential to alter the social environment within the RSA.

The Proponent is not responsible for this shift in the social environment. Rather, it is the responsibility of all proponents with projects within the RSA to work together in a collaborative fashion in order to mitigate the cumulative effects, working in concert with governments. In particular, ongoing engagement of the municipalities of Terrace, Smithers, and Stewart will be important in order to ensure that the effects are mitigated in the most effective manner and that mitigation occurs at the earliest stage possible, prior to the commencement of Construction, in order to build capacity and awareness at an early stage.

In addition to the mitigation previously identified for Project effects, the Proponent is committed to engaging key stakeholders to participate in the development of other mitigation as required in order to maximize Project benefits and minimize adverse effects, including cumulative effects. This may include, for example, participating in and facilitating the development of action plans as led by governments, as well as ongoing adaptive management of cumulative effects within the RSA. As determined by governments, planning may include specific points related to:

- the capacity of educational institutions within the RSA to respond to the predicted increase in demand for mining-related programs, in particular in the short term;
- the current housing and infrastructure situation in First Nation and Nisga'a Nation communities in the RSA;
- health and services efforts within the RSA focusing on building capacity in the long term and avoiding cumulative effects as much as possible in the short term;
- specific measures that look at ways to build capacity around some of the risks associated with the FIFO rotational work and increases in household incomes—specifically, increased levels of stress and anxiety and poor lifestyle choices—as well as looking to address the potential for transient workers coming into the hub communities of Terrace, Smithers, and Stewart.

34.5.9.6 Summary of Residual Cumulative Effects on Social Valued Components

For the purposes of this assessment, it is assumed that the other identified current and future projects implement mitigation to appropriately address those project effects. However, with respect to the identified adverse social effects, it is recognized that unilateral mitigation by each proponent may not effectively address the cumulative effects because of the additive and synergistic nature and scale of the effects. Planning and response by governments, with the participation of proponents as corporate citizens, will be important. Planning and program response should be developed with all relevant proponents, Aboriginal communities, municipalities, and other government agencies together to effectively target some of the key cumulative effects for the social environment for:

- education, skills development, and training;
- community infrastructure, services, and housing; and
- worker and family well-being.

For the purposes of this assessment it is assumed that this type of response will occur, to the extent necessary and appropriate to further contribute to the mitigation of cumulative effects within the social impact RSA. This will be driven by the recognition of the scale of infrastructure and resource development in the area. If this regional level planning is adopted it can be said that there will be an adjustment period in the short term, with the potential for residual cumulative effects; however, in the long term it is expected that the mitigations measures put in place will address the cumulative effects and there will be no residual cumulative effects.

Cumulative residual effects are those effects remaining after the implementation of all mitigation measures and are summarized in Table 34.5-32. The details of the significance ratings for the cumulative effects on worker and family well-being are provided in the table below (Table 34.5-33). The characterization of residual effects on all VCs is summarized in Chapter 20, Assessment of Potential Social Effects.

Table 34.5-32. Summary of Cumulative Residual Effects on Social Environment

Social Environment	Timing of Cumulative Residual Effect[1]	Description of Cause-Effect	Description of Additional Mitigation (if any)	Description of Cumulative Residual Effect	Significance of Residual Effects
Education, Skills Development and Training					
Increase demand for educational services and programs in the LSA	Construction and Operation	Employment and labour opportunities associated with all of the projects in the RSA leading to a sharp increase in demand for education.	Project-specific mitigation, and regional collaboration and planning	Short term there will be an adjustment period, but in the long term no cumulative residual effect is anticipated.	Not significant
Community Infrastructure, Services, and Housing					
Increased demand for infrastructure and housing as a result of population in-migration	Construction and Operation	Employment and labour opportunities associated with all the projects will lead to in-migration of Aboriginal peoples back to their home communities.	Project-specific mitigation, and regional collaboration and planning	Short term there will be an adjustment period, but in the long term no cumulative residual effect is anticipated.	Not significant

(continued)

Table 34.5-32. Summary of Cumulative Residual Effects on Social Environment (completed)

Social Environment	Timing of Cumulative Residual Effect[1]	Description of Cause-Effect	Description of Additional Mitigation (if any)	Description of Cumulative Residual Effect	Significance of Residual Effects
Community Infrastructure, Services, and Housing (cont'd)					
Increase demand on health and social services	Construction and Operation	Employment and labour opportunities, procurement of goods and services, and the presence of the projects will lead to an increase demand for health and social services.	Project-specific mitigation, and regional collaboration and planning	Short term there will be an adjustment period, but in the long term no cumulative residual effect is anticipated.	Not significant
Worker and Family Well-being					
Increased transient workers coming into LSA communities	Construction and Operation	With the convergence of many construction and operation phases for a number of projects it is anticipated that there will be an in-migration of workers into the RSA	Project-specific mitigation, and regional collaboration and planning	Short term there will be an adjustment period, but in the long term no cumulative residual effect is anticipated.	Not significant
Increased levels of stress and anxiety on workers and families due to rotational work	Construction and Operation	Due to the prevalence of the FIFO and other forms of work rotation associated with the projects, an increase in the levels of stress and anxiety in the RSA is predicted	Project-specific mitigation, and regional collaboration and planning	Short term there will be an adjustment period, but in the long term no cumulative residual effect is anticipated.	Not significant
Increase in poor lifestyle choices	Construction and Operation	Due to the prevalence of the FIFO and other forms of work rotation associated with the projects, an increase in poor lifestyle choices is predicted	Project-specific mitigation, and regional collaboration and planning	Short term there will be an adjustment period, but in the long term no cumulative residual effect is anticipated.	Not significant

[1] *Refers to the Project phase or other timeframe during which the effect will be experienced by the intermediate receptor or VC.*

34.5.10 Health

34.5.10.1 Summary of Project-specific Residual Effects on Health

The potential effects of the Project on health are assessed in Chapter 21, Assessment of Potential Health Effects. Project-specific residual effects to human health were identified due to changes in noise levels (Section 21.6.1), air quality (Section 21.6.2), or water quality (Section 21.6.3) and are summarized in Table 34.5-34.

Table 34.5-33. Significance Determination of Cumulative Residual Effects for Social Environment

Cumulative Residual Effects	Cumulative Residual Effects Characterization Criteria								
	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 medium-term, reversible long-term, irreversible)*	**Resiliency** *(low, neutral, high)*	**Likelihood** *(low, medium, high)*	**Significance of Adverse Cumulative Residual Effects** *(not significant, significant)*	**Confidence** *(low, medium, high)*
Education, Skills Development, and Training									
Increased demand for educational programs in the LSA	Low	Short-term	Sporadic	Regional	Reversible short-term	High	Medium	Not significant	Medium
Community Infrastructure, Services, and Housing									
Increased demand for infrastructure and housing as a result of population in-migration	Moderate	Medium-term	Regular	Regional/ Aboriginal Peoples	Reversible long-term	High/ Low	High	Not significant	Medium
Increased demand on health and social services	Moderate	Medium-term	Sporadic	Regional	Reversible short-term	High	High	Not significant	Medium
Worker and Family Well-being									
Increase in transient workers coming into LSA communities	Moderate	Short-term	Sporadic	Regional	Reversible short-term	Neutral	Medium	Not significant	Medium
Increased levels of stress and anxiety on workers and families due to rotational work	High	Medium-term	Regular	Regional/ Aboriginal Peoples	Reversible long-term	Neutral/ Low	Medium	Not significant	Medium
Increase in poor lifestyle choices	High	Short-term	Regular	Regional/ Aboriginal Peoples	Reversible long-term	Neutral/ Low	Medium	Not significant	Medium

Table 34.5-34. Summary of Project-specific Residual Effects, Mitigation, and Significance on Human Health due to Noise, Air Quality, and Drinking Water

Residual Effects	Project Phase(s)	Mitigation Measures	Significance
Health Effects due to Noise			
Sleep disturbance (workers at camps)	Construction and Operation	• Noise Management Plan (Section 29.11). • Following all relevant regulatory requirements. • Manage and minimize the effect of noise from operations on receptors. • Maintain an effective response mechanism to deal with issues and complaints. • Monitoring will be conducted as per regulations and to address complaints should they occur (Section 8.7, Mitigation Measures for Noise). • Building the camps from material known to prevent/reduce noise penetration.	Not significant
Speech interference, sleep disturbance, and percent highly annoyed (non-workers)	Construction and Operation	• Noise Management Plan (Section 29.11). • Following all relevant regulatory requirements. • Manage and minimize the effect of noise from operations on receptors. • Maintain an effective response mechanism to deal with issues and complaints. • Monitoring will be conducted as per regulations and to address complaints should they occur (Section 8.7, Mitigation Measures for Noise).	Not significant
Health Effects due to Air Quality			
Health effects due to SO_2, NO_2, TSP, PM_{10}, and $PM_{2.5}$ emissions (workers at camps and non-workers)	Construction and Operation	• Air quality will be monitored and mitigation strategies will be adjusted accordingly to meet BC MOE Air Quality Standards and the Air Quality Management Plan (Section 29.2). • Emission control systems (e.g., scrubbers, baghouses, and filters) will be used on stack and relevant ventilation systems to reduce emissions. • Vehicles will be maintained regularly, switching to alternative fuel such as biodiesel or natural gas, using diesel with lower sulphur content, using add-ons such as cabin heaters to reduce idling, optimizing driving speed to reduce fuel usage and fugitive road dust, use larger haul trucks to minimize the number of trips required, minimize drop distance of material into surge bin, stockpiles or between conveyor belts. Mitigation Measures included in the project design, such as underground mining process. • Air Quality Management Plan (Section 29.2). • Maintenance of equipment and vehicles on a regular basis. • Watering unpaved access road to maintain a minimum of a 2% moisture ratio and achieving at least 75% of dust control efficiency.	Not significant

(continued)

Table 34.5-34. Summary of Residual Effects, Mitigation, and Significance on Human Health due to Noise, Air Quality, and Drinking Water (completed)

Residual Effects	Project Phase(s)	Mitigation Measures	Significance
Health Effects due to Quality of Drinking Water			
Health effects due to drinking water (non-workers)	Construction and Operation	• There will be no an authorized access within the Project vicinity. • Safe transportation and storage of process chemicals, fuels, and oils as described in Chapter 5, Project Description. • Effective management of spills and emergencies according to the Spill Prevention and Response Plan (Section 29.14). • Effects of metals on water quality will be mitigated through Project design. • Dust deposition on surface water will be minimized according to the Air Quality Management Plan (Section 29.2).	Not significant

The indicators of Project residual effects from noise on human health that are included in this CEA are:

- sleep disturbance at the worker camps during the Construction and Operation phases;
- sleep disturbance of non-workers at the Skii km Lax Ha Lodge during the Construction and Operation phases; and
- speech interference and percent highly annoyed (%HA) metric for non-workers at the Skii km Lax Ha Lodge.

The parameters or indicators for air quality effects on human health that are included in this CEA are:

- nitrogen dioxide (NO_2);
- sulphur dioxide (SO_2);
- carbon monoxide (CO);
- total suspended particulates (TSP); and
- suspended particulates with diameter less than 10 and 2.5 micrometres (µm; PM_{10}, $PM_{2.5}$).

The parameters or indicators for drinking water quality effects on human health that are included in this CEA are:

- concentrations of total and dissolved metals, nutrients, turbidity, and total suspended solids (TSS).

No Project residual effects to human health were identified due to consumption of country foods (Section 21.6.4). Therefore, human health effects due to consumption of country foods are not included in this CEA.

The following sections provide an examination of the relationship between the residual effects of the Project and those of other projects and activities. A matrix identifying the potential cumulative effect interactions of past, present, and future projects and activities on health is provided in Table 34.4-1.

34.5.10.2 Cumulative Effects Assessment Boundaries for Health

Spatial and Temporal Boundaries for Noise

Noise effects are typically restricted to within 10 km of the noise source. For noise, there are no current projects or activities within 10 km of the Project and therefore there are no potential spatial interactions between the Project and current projects or activities (Figure 34.5-13).

Noise levels will immediately return to baseline levels after a project's noise sources are removed; therefore, past projects or activities were not included in the CEA for noise since they would not be expected to interact with a future project (i.e., development of the Project).

Noise generation is typically associated with the construction or operation phases of a project. Table 34.4-1 illustrates which present and future projects and activities will potentially have a temporal interaction with the noise subject area.

Spatial and Temporal Boundaries for Air Quality

The spatial linkages between the Project and the other projects are shown in Figure 34.5-14. For air quality, spatial linkage is defined as any project that has sources that may cause changes in air quality inside the Project's air quality RSA.

The temporal boundaries of the CEA are described in Section 34.2.2. The CACs used as indicators of air quality will return to baseline levels within a short period of time after a project's air emission sources are removed; therefore, past projects or activities were not included in the CEA for air quality since they would not be expected to interact with a future project (i.e., development of the Project).

Spatial and Temporal Boundaries for Drinking Water Quality

The potential for spatial linkages between the Project and the other projects are shown in Figure 34.5-15. A spatial overlap of human health residual effects due to changes in drinking water from the Brucejack Gold Mine Project with potential effects to water quality from other projects is geographically restricted to watershed boundaries that are shared between the projects. It is further restricted by the watersheds in which Project residual effects may occur (i.e., Knipple Lake, Bowser River, and Wildfire, Scott Creek and Todedada Creek watersheds). Therefore, watersheds such as Sulphurets Creek and the Unuk River were excluded from consideration for cumulative effects, since Project residual effects to drinking water quality were not identified in these areas.

The temporal boundaries of the CEA are described in Section 34.2.2. Since it is possible for effects to surface water quality to persist after a project or activity ceases, the temporal boundaries used in the CEA were the same as those used in the assessment of Project residual effects. These are described in Chapter 21, Assessment of Potential Health Effects (Section 21.4.2.2), and in Chapter 13, Assessment of Potential Surface Water Quality Effects (Section 13.4.2.2), and include the full duration of each of the four phases of the Project. All of the projects listed under spatial interaction for drinking water have the potential to have temporal interaction as well. Table 34.4-1 illustrates which present and future projects and activities will potentially have a temporal interaction with the drinking water quality subject area.

34.5.10.3 Cumulative Effects Assessment on Health

Noise

Project residual effects to human health due to noise were identified and characterized in Chapter 21, Assessment of Potential Health Effects (Section 21.7.1). Although the proposed KSM Project is within 10 km of the Project, no measurable cumulative effects on human health due to noise are expected.

Air Quality

Screening of Contaminants of Potential Concern in Air

The change in air quality predicted for the proposed KSM Project needs to be considered in the CEA since there is spatial and temporal overlap with the Project. The residual effect on air quality due to the proposed KSM Project was assessed in the KSM Project Application/EIS (Rescan 2013). The increase in pollutant concentrations or dust deposition levels predicted in the KSM Project effects assessment, plus the background levels, were used to predict future concentrations of CACs in the Brucejack Gold Mine Project air quality RSA if only the KSM Project was in operation. The calculation is shown as follows:

$$\begin{aligned} &Future\ case\ concentration\ of\ CACs\ without\ the\ Project \\ &\quad = Background + Incremental\ increase\ from\ KSM\ Project \end{aligned}$$

Figure 34.5-13

Noise CEA Boundary Showing All Other Projects and Activities Relevant to Noise in the Vicinity of the Brucejack Gold Mine Project

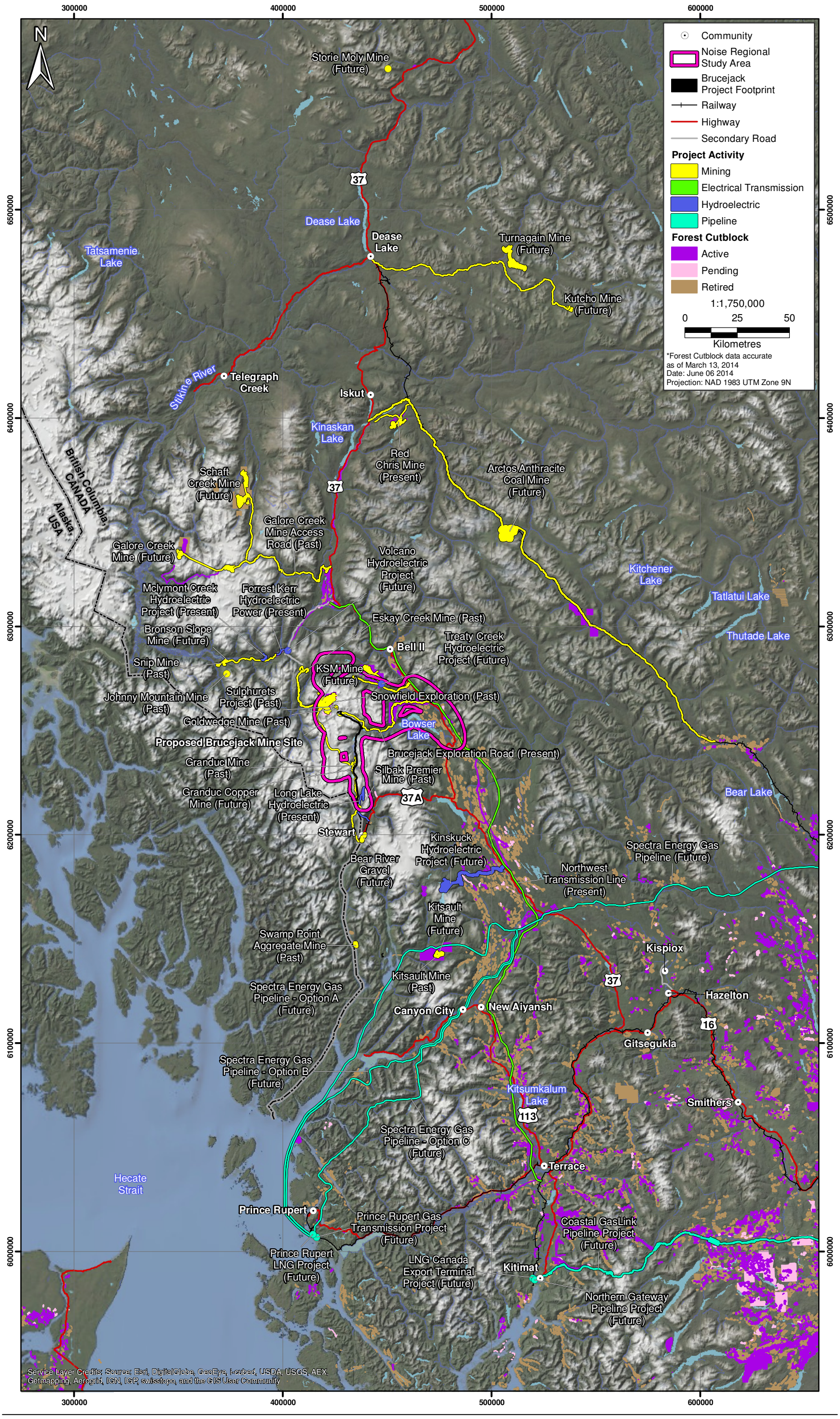


Figure 34.5-14

Air Quality CEA Boundary Showing All Other Projects and Activities Relevant to Air Quality in the Vicinity of the Brucejack Gold Mine Project

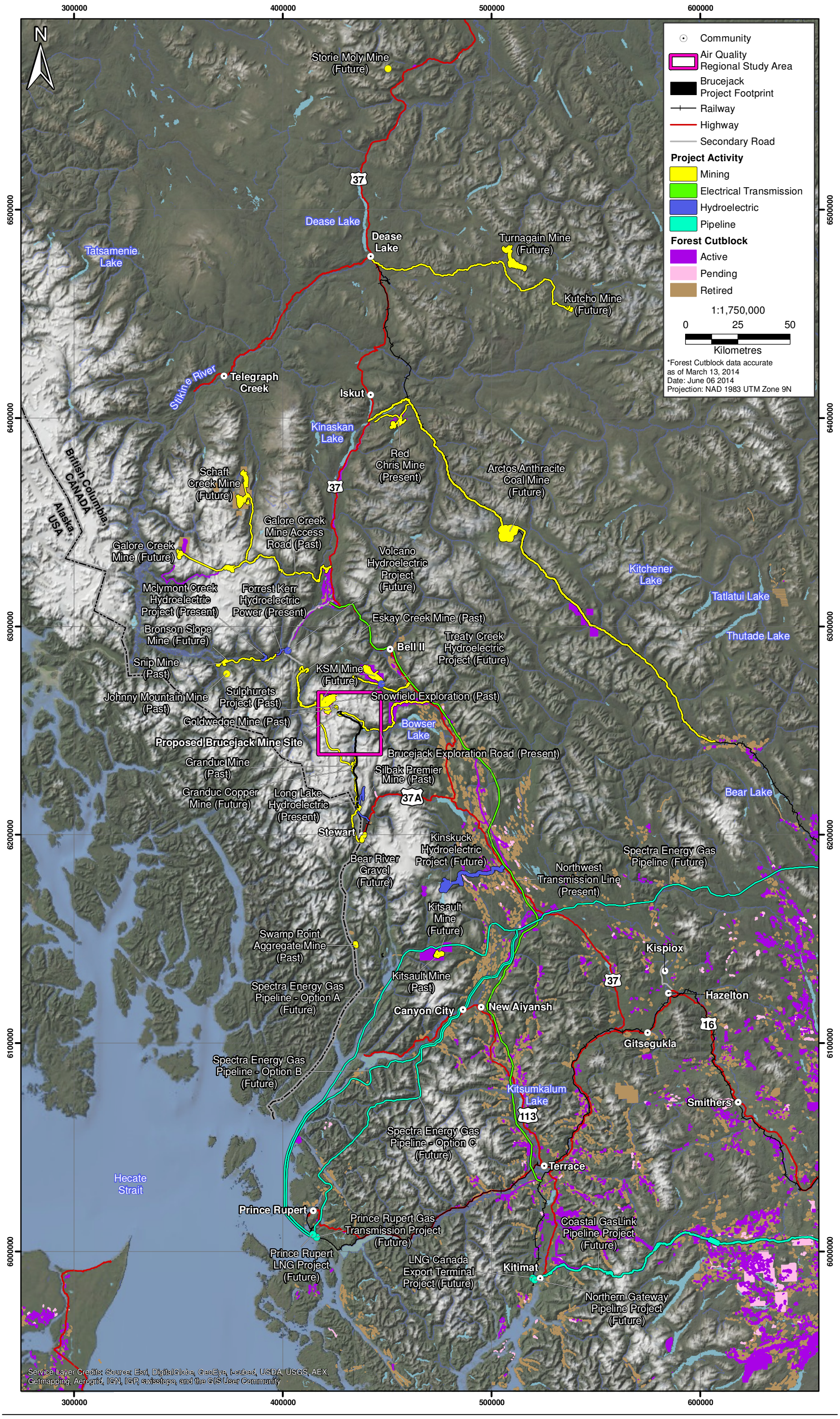
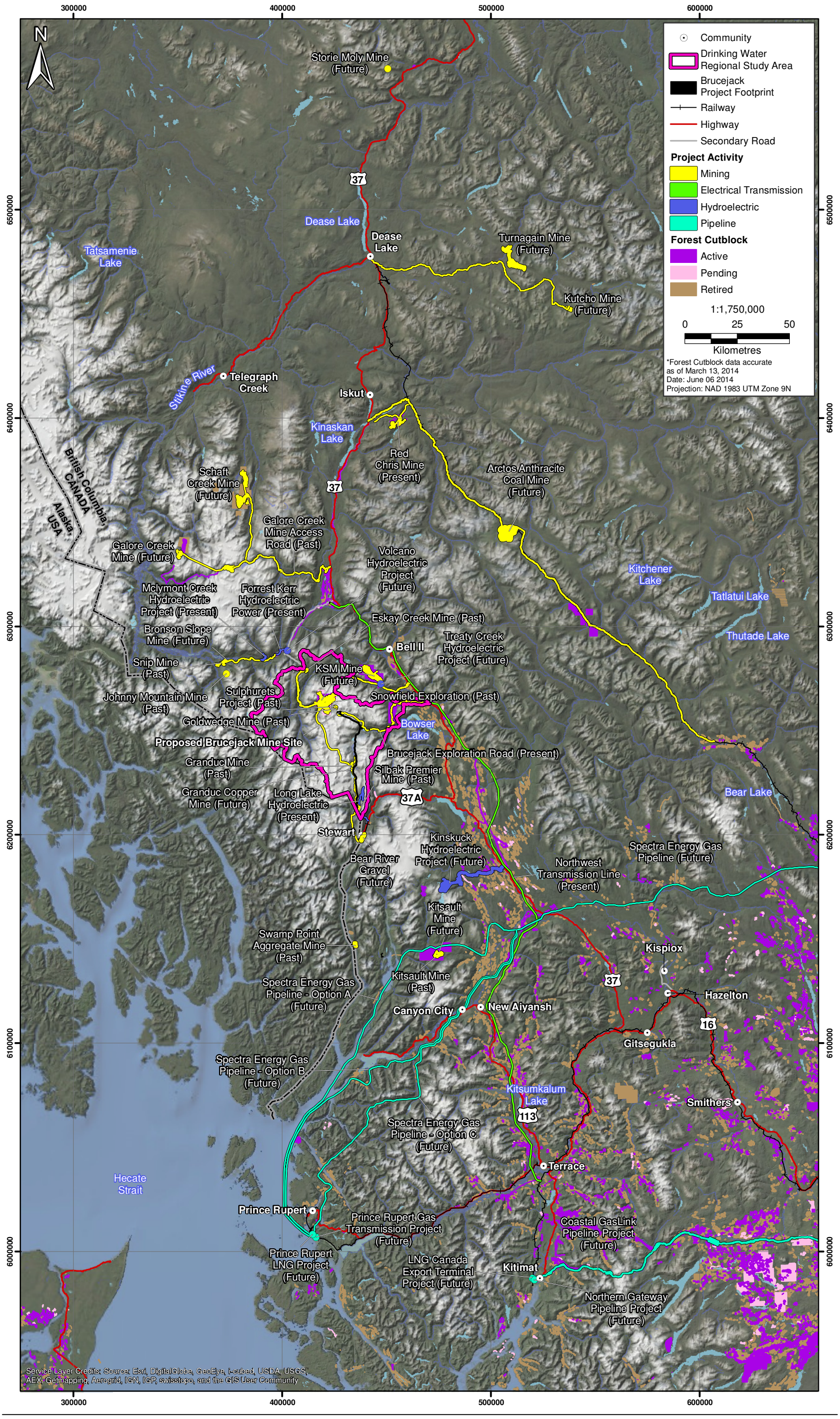


Figure 34.5-15

Drinking Water CEA Boundary Showing All Other Projects and Activities Relevant to Drinking Water in the Vicinity of the Brucejack Gold Mine Project



To determine the future predicted concentrations when both the Brucejack Gold Mine Project and KSM Project are in operation, the incremental increases to the maximum predicted CAC concentrations or dust deposition for both projects were added to the background levels. The calculation is shown as follows:

$$\begin{aligned} &Future\ case\ concentration\ of\ CACs\ with\ the\ Project \\ &\quad = Background + Incremental\ increase\ from\ Brucejack\ Gold\ Mine\ Project \\ &\quad + Incremental\ increase\ from\ KSM\ Project \end{aligned}$$

The screening process for selection of CACs is described in Chapter 21, Assessment of Potential Health Effects (Section 21.6.2.1). Concentrations of criteria air contaminants (TSP, PM_{10}, $PM_{2.5}$, NO_2, SO_2, and CO) for the cumulative assessment were modelled for human receptor locations where Project residual effects were identified, which are the Worker Mine Site Operation Camp, the Worker Transfer Station Camp, and the Skii km Lax Ha Lodge. Within the Project air quality RSA, the contribution of air emissions from the proposed KSM Project to air quality would be much smaller than the contribution of Project-related sources, since the potential for effects on air quality diminishes with distance from the source of emissions.

The predicted future case concentrations at the three human receptor locations without the Project (i.e., just the contribution of air emissions from the proposed KSM Project, plus background levels) were screened against British Columbia Ambient Air Quality Objectives (BC AAQO). The predicted CACs for the future case without the Project were below AAQO and all the hazard quotients (HQs) were less than 1.0 during the Operation phase (Table 34.5-35), indicating that the risk to human health due to the proposed KSM Project alone is below acceptable levels.

The predicted cumulative concentrations of CACs (i.e., the Project plus the proposed KSM Project, plus background) during the Operation phase in the future case with the Project were below the BC AAQOs for SO_2, NO_2, and CO concentrations at all human receptor locations that were included and therefore do not pose a risk to human health (Table 34.5-36).

The cumulative predicted 24-hour averaged TSP concentration at the Worker Mine Site Operation Camp exceeded the 24-hour averaged TSP BC AAQO concentration of 120 $\mu g/m^3$ (Table 34.5-36). Cumulative predicted 24-hour PM_{10} concentrations at the Worker Mine Site Operation Camp and the Skii km Lax Ha Lodge also exceeded the BC AAQO concentration of 50 $\mu g/m^3$. Therefore, the potential cumulative residual effects of TSP and PM_{10} on human health requires additional assessment to determine the magnitude of the risk.

Cumulative Risk Assessment for Human Health due to Air Quality

Methodology for the risk assessment of cumulative air quality effects from the KSM Project and the Brucejack Gold Mine projects followed the methodology described in Chapter 21, Assessment of Potential Health Effects (Section 21.6.2.1).

Problem Formulation

The CACs that were screened into the cumulative air quality assessment for human health included TSP at the Worker Mine Site Operation Camp, and PM_{10} at the Worker Mine Site Operation Camp and the Skii km Lax Ha Lodge. TSP and PM_{10} are considered to be threshold contaminants (i.e., COPCs that begin to have health effects above a certain threshold but are not carcinogenic), as described in Chapter 21, Assessment of Potential Health Effects (Section 21.6.2.2).

Exposure Assessment

To estimate the fraction of time exposed, it was assumed that off-duty workers occupy the Project camp areas for 12 hours a day, with worker shifts lasting 12 hours a day. The off-duty workers were

assumed to be exposed to the emissions for six months per year (182 days) due to shift rotations of two weeks on and two weeks off. This exposure duration is considered a conservative estimate since actual exposure times may be lower due to vacation or other leave from work. It was assumed that people will be exposed to Project related emissions for 22 years for Operation phase.

For the Skii km Lax Ha Lodge, it was assumed, based on information provided by Ski km La Ha (George Simpson, pers. comm., 2014), that the residents of the lodge spend 24-hours a day there through the year (365 days a year) during the entire Operation phase of the Project. This is a conservative assumption because it is unlikely that an individual spends all of their time at the Lodge throughout the entire Operation phase of the Project.

Formulas and calculations used follow the same methodology described in the Exposure Assessment section of Section 21.6.2.2. Table 34.5-37 shows the cumulative exposure dose of air contaminants (EDEI) for off-duty workers and residents at the Skii km Lax Ha Lodge during the Operation phase of the Project.

Toxicity Assessment

Toxicity assessment of the selected CACs for the cumulative assessment follows the same methodology and rationale provided in the Toxicity Assessment section of Section 21.6.2.2. Table 34.5-37 shows the standard or TRV selected for use as a toxicity threshold for human health effects due to air quality.

Risk Characterization

Risk characterization of the potential for health effects due to CAC exposure follows the methodology described in the Risk Characterization section of Section 21.6.2.2 of this assessment. Table 34.5-37 provides the results of the risk characterization.

At the Brucejack Worker Mine Site Operation Camp, all HQs calculated using the predicted cumulative concentrations of TSP and PM_{10} during the Operation phase were below 1.0, indicating that the potential for health risk to adults from inhalation of these pollutants is low.

At the Skii km Lax Ha Lodge, the HQ for cumulative PM_{10} exposure during the Operation phase was calculated to be 1.26, which is slightly greater than the HQ associated with the Project residual effect (HQ of 1.24, Section 21.6.2.2). The difference between the HQs for the Project residual effect on air quality due to PM_{10} concentrations and the cumulative residual effect due to PM_{10} concentrations is less than 2%. This suggests that, although the HQ is slightly greater than 1.0 in the future case cumulative scenario with the Project, this is primarily due to the Project residual effect (i.e., proximity to Project-related sources of air emissions) and the contribution of air emissions from other projects on air quality at receptor locations in the Project air quality RSA is negligible.

Drinking Water Quality

Although there may be overall spatial and temporal linkages between the Project and the proposed KSM Project, water quality predictions for the proposed KSM Project show that residual effects to water quality in the Bell-Irving River would not be expected (Rescan 2013), and any potential residual effects to surface water quality from the KSM Project in the Processing and Tailing Management Area is limited to localized areas close to the tailing management facility. Similarly, for the Brucejack Gold Mine Project, residual effects to drinking water quality are limited to the localized area adjacent to the Brucejack Access Road (associated with the upgrading, use, and maintenance of the road) and the magnitude was assessed to be negligible since any change in water quality is unlikely to be different than baseline conditions. Therefore, the potential for cumulative residual effects is low because the potential for residual effects for the Project and the proposed KSM Project are localized to different areas.

Table 34.5-35. Screening of Criteria Air Contaminants during the Operation Phase for Future Case without the Project at Human Receptor Locations at the Brucejack Gold Mine Project

Criteria Air Contaminants		Averaging Period	British Columbia Ambient Air Quality Objectives[1] ($\mu g/m^3$)	National Ambient Air Quality Objectives - Maximum Desirable[2] ($\mu g/m^3$)	Worker Mine Site Operation Camp							Worker Transfer Station Camp						
					Baseline Concentration ($\mu g/m^3$)	KSM Incremental Increase ($\mu g/m^3$)	Future Case Concentration without the Project ($\mu g/m^3$)	Percent Increase due to KSM (%)	Predicted Concentration > Guideline?	Hazard Quotient relative to Guideline	Selected as a COPC?	Baseline Concentration ($\mu g/m^3$)	KSM Incremental Increase ($\mu g/m^3$)	Future Case Concentration without the Project ($\mu g/m^3$)	Percent Increase due to KSM (%)	Predicted Concentration > Guideline?	Hazard Quotient relative to Guideline	Selected as a COPC?
SO_2		1-hour	450	-	4.0[4]	3.11	7.11	43.7	No	0.0158	No	4.0[4]	0.464	4.46	10.4	No	0.00992	No
		24-hour	160	-	4.0[4]	1.26	5.26	23.9	No	0.0117	No	4.0[4]	0.0543	4.05	1.34	No	0.00901	No
		Annual	25	-	2.0[4]	0.04	2.04	1.79	No	0.00453	No	2.0[4]	0.00402	2.00	0.200	No	0.00445	No
NO_2		1-hour	400	-	21[4]	40.1	61.1	65.6	No	0.136	No	21[4]	7.18	28.2	25.5	No	0.0626	No
		24-hour	200	-	21[4]	13.9	34.9	39.8	No	0.0775	No	21[4]	1.33	22.3	5.95	No	0.0496	No
		Annual	60	-	5.0[4]	0.411	5.41	7.6	No	0.0120	No	5.0[4]	0.0685	5.07	1.35	No	0.0113	No
CO		1-hour	14,300	15,000	100[4]	150	249.5	59.9	No	0.555	No	100[4]	25	125.1	20.1	No	0.278	No
		8-hour	5,500	6,000	100[4]	69	169.3	40.9	No	0.376	No	100[4]	8.17	108.2	7.55	No	0.240	No
Non-fugitive	TSP	24-hour	120	-	10[4]	42.2	52.2	80.8	No	0.116	No	10[4]	2.25	12.2	18.3	No	0.0272	No
		Annual	60	-	10[4]	1.11	11.1	10.0	No	0.0247	No	10[4]	0.156	10.2	1.54	No	0.0226	No
	PM_{10}	24-hour	50	-	3.4[5]	17.2	20.6	83.5	No	0.0457	No	3.4[5]	0.968	4.37	22.2	No	0.00971	No
	$PM_{2.5}$	24-hour	25	27[3]	1.3[5]	0.691	1.99	34.7	No	0.00442	No	1.3[5]	0.108	1.41	7.67	No	0.00313	No
		Annual	8	8.8[3]	1.3[5]	0.07	1.37	5.07	No	0.00304	No	1.3[5]	0.0137	1.31	1.04	No	0.00292	No

Criteria Air Contaminants		Averaging Period	British Columbia Ambient Air Quality Objectives[1] ($\mu g/m^3$)	National Ambient Air Quality Objectives - Maximum Desirable[2] ($\mu g/m^3$)	Skii km Lax Ha Lodge						
					Baseline Concentration ($\mu g/m^3$)	KSM Incremental Increase ($\mu g/m^3$)	Future Case Concentration without the Project ($\mu g/m^3$)	Percent Increase due to KSM (%)	Predicted Concentration > Guideline?	Hazard Quotient relative to Guideline	Selected as a COPC?
SO_2		1-hour	450	-	4.0[4]	0.700	4.70	14.9	No	0.0104	No
		24-hour	160	-	4.0[4]	0.0871	4.09	2.13	No	0.00908	No
		Annual	25	-	2.0[4]	0.00411	2.00	0.205	No	0.00445	No
NO_2		1-hour	400	-	21[4]	10.1	31.1	32.4	No	0.0690	No
		24-hour	200	-	21[4]	1.38	22.4	6.17	No	0.0497	No
		Annual	60	-	5.0[4]	0.08	5.08	1.50	No	0.0113	No
CO		1-hour	14,300	15,000	100[4]	30	129.8	23.0	No	0.288	No
		8-hour	5,500	6,000	100[4]	10	109.8	8.91	No	0.244	No
Non-fugitive	TSP	24-hour	120	-	10[4]	2.62	12.6	20.7	No	0.0280	No
		Annual	60	-	10[4]	0.157	10.2	1.55	No	0.0226	No
	PM_{10}	24-hour	50	-	3.4[5]	1.13	4.53	24.9	No	0.0101	No
	$PM_{2.5}$	24-hour	25	27[3]	1.3[5]	0.111	1.41	7.85	No	0.00313	No
		Annual	8	8.8[3]	1.3[5]	0.0139	1.31	1.06	No	0.00292	No

Notes:

[1] Government of British Columbia (2013).

[2] Environment Canada (1999).

[3] CCME (2012).

[4] Baseline concentrations of SO_2, NO_2, CO, and TSP are the maximum 30-day averaging concentrations measured by passive air sampling stations in 2012, which are compared most appropriately to annual guidelines. US EPA conversion factors were used to convert the 30-day average into 1-hour and annual averaging periods.

[5] CO and TSP baseline concentrations are the annual averages used for the Bathurst Inlet and Road Project (BIPR; located northwest of the study area), which is representative of background levels typical in Nunavut. US EPA conversion factors were used to convert into 1-hour, 8-hour, and 24-hour averaging periods.

COPC = contaminant of potential concern.

CO = carbon monoxide.

NO_2 = nitrogen dioxide.

SO_2 = sulphur dioxide.

TSP = total suspended particles.

$PM_{2.5}$ = particulate matter up to 2.5 µm in size.

PM_{10} = particulate matter up to 10 µm in size.

Concentration used for calculating chronic exposure dose is the predicted maximum concentration for 24-hour averaging.

Grey shading indicates concentrations above baseline concentration.

Bold and box indicates concentrations above guidelines.

Table 34.5-36. Screening of Criteria Air Contaminants during the Operation Phase for Future Case with the Project at Human Receptor Locations at the Brucejack Gold Mine Project

Criteria Air Contaminants	Averaging Period	British Columbia Ambient Air Quality Objectives[1] ($\mu g/m^3$)	National Ambient Air Quality Objectives - Maximum Desirable[2] ($\mu g/m^3$)	Worker Mine Site Operation Camp									
				Baseline Concentration ($\mu g/m^3$)	Predicted Air Concentration ($\mu g/m^3$)	KSM Incremental Increase ($\mu g/m^3$)	Future Cumulative Concentration	Percent Increase due to KSM (%)	Predicted Concentration > Guideline?	Hazard Quotient relative to Guideline	Predicted Concentration > Baseline?	Hazard Quotient in relation to Baseline	Selected as a COPC?
SO_2	1-hour	450	-	4.0[4]	16.8	3.11	19.9	15.7	No	0.0441	n/a	n/a	No
	24-hour	160	-	4.0[4]	7.46	1.26	8.72	14.4	No	0.0194	n/a	n/a	No
	Annual	25	-	2.0[4]	2.98	0.04	3.02	1.2	No	0.00670	n/a	n/a	No
NO_2	1-hour	400	-	21[4]	104	40.1	144	27.8	No	0.321	n/a	n/a	No
	24-hour	200	-	21[4]	84.5	13.9	98.4	14.1	No	0.219	n/a	n/a	No
	Annual	60	-	5.0[4]	28.2	0.411	28.6	1.4	No	0.0635	n/a	n/a	No
CO	1-hour	14,300	15,000	100[4]	373	150	523	28.6	No	1.1621	n/a	n/a	No
	8-hour	5,500	6,000	100[4]	191	69.3	260	26.6	No	0.579	n/a	n/a	No
TSP	24-hour	120	-	10[4]	194	42.2	236	17.9	Yes	0.525	Yes	59.0	**Yes**
	Annual	60	-	10[4]	43.7	1.11	44.8	2.5	No	0.0995	n/a	n/a	No
PM_{10}	24-hour	50	-	3.4[5]	94.6	17.2	112	15.4	Yes	0.248	Yes	28.0	**Yes**
$PM_{2.5}$	24-hour	25	27[3]	1.3[5]	17.6	0.691	18.3	3.8	No	0.0407	n/a	n/a	No
	Annual	8	8.8[3]	1.3[5]	5.92	0.0694	5.99	1.2	No	0.0133	n/a	n/a	No

Criteria Air Contaminants	Averaging Period	British Columbia Ambient Air Quality Objectives[1] ($\mu g/m^3$)	National Ambient Air Quality Objectives - Maximum Desirable[2] ($\mu g/m^3$)	Worker Transfer Station Camp									
				Baseline Concentration ($\mu g/m^3$)	Predicted Air Concentration ($\mu g/m^3$)	KSM Incremental Increase ($\mu g/m^3$)	Future Cumulative Concentration	Percent Increase due to KSM (%)	Predicted Concentration > Guideline?	Hazard Quotient relative to Guideline	Predicted Concentration > Baseline?	Hazard Quotient in relation to Baseline	Selected as a COPC?
SO_2	1-hour	450	-	4.0[4]	4.65	0.464	5.11	9.08	No	0.0114	n/a	n/a	No
	24-hour	160	-	4.0[4]	4.22	0.0543	4.28	1.27	No	0.0095	n/a	n/a	No
	Annual	25	-	2.0[4]	2.04	0.00402	2.04	0.197	No	0.0045	n/a	n/a	No
NO_2	1-hour	400	-	21[4]	94.8	7.18	102	7.04	No	0.227	n/a	n/a	No
	24-hour	200	-	21[4]	70.8	1.33	72.2	1.84	No	0.160	n/a	n/a	No
	Annual	60	-	5.0[4]	15.2	0.0685	15.2	0.450	No	0.034	n/a	n/a	No
CO	1-hour	14,300	15,000	100[4]	159	25.1	184	13.6	No	0.4093	n/a	n/a	No
	8-hour	5,500	6,000	100[4]	143	8.17	151	5.41	No	0.3353	n/a	n/a	No
TSP	24-hour	120	-	10[4]	81.8	2.25	84.0	2.67	No	0.187	n/a	n/a	No
	Annual	60	-	10[4]	22.0	0.156	22.1	0.707	No	0.049	n/a	n/a	No
PM_{10}	24-hour	50	-	3.4[5]	47.4	0.968	48.3	2.00	No	0.107	n/a	n/a	No
$PM_{2.5}$	24-hour	25	27[3]	1.3[5]	5.85	0.108	5.96	1.81	No	0.013	n/a	n/a	No
	Annual	8	8.8[3]	1.3[5]	2.61	0.0137	2.63	0.520	No	0.006	n/a	n/a	No

(continued)

Table 34.5-37. Risk Characterization for Future Case with the Project for Criteria Air Contaminants at Human Receptor Locations during the Operation Phase

		Worker Mine Site Operation Camp		Skii km Lax Ha Lodge
Parameter	**Units**	**Cumulative Total TSP, 24-hour Predicted**	**Total PM_{10}, 24-hour Predicted**	**Total PM_{10}, 24-hour Predicted**
C_{air}	mg/m^3	0.236	0.112	0.0631
RAF_{inh}	unitless	1	1	1
IR	m^3/day	16.6	16.6	16.6
D1	unitless	0.5	0.5	1
D2	unitless	1	1	1
D3	unitless	0.5	0.5	1
BW	kg	70	70	70
ED	yr	n/a	n/a	n/a
AT	yr	n/a	n/a	n/a
EDEI	**mg/kg BW/day**	**0.0140**	**0.00665**	**0.0150**
Standard/TRV[1]	mg/m^3	0.12	0.05	0.05
TDI Inhalation[2]	mg/kg BW/day	0.0285	0.0119	0.0119
Risk Characterization	**HQ**	**0.493**	**0.561**	**1.26**

Notes:
C_{air} = maximum air concentration of COPC at receptor including background (mg/m^3).
RAF_{inh} = inhalation relative absorption factor (unitless, assumed to be 1).
IR = receptor inhalation rate (assumed to be 16.6 m^3/day for adults (Health Canada 2009)).
D1 = fraction of hours per day spent at site (exposure time; unitless; assumed to be 12 hours over 24 hours).
D2 = fraction of days per week spent at site (exposure frequency; unitless; assumed to be 7 days per week).
D3 = fraction of weeks per year spent at site (exposure frequency; unitless; assumed to be 183 days per year based on two week on/two week off rotation).
BW = body weight (70 kg).
*EDEI = estimated daily exposure from inhalation of (non-carcinogenic) COPC in air (mg/kg BW/day), calculated as EDEI=(Cair*RAF*IR*D1*D2*D3)/BW.*
[1] TRV = Toxicity reference value; the National Ambient Air Quality Objectives - Maximum Desirable2 ($\mu g/m^3$).
*[2] TDI Inhalation = tolerable daily intake (mg/kg BW/day); calculated as TDI = Standard*IR*RAF_{inh}/BW.*
HQ = Hazard quotient, calculated as HQ = EDEI/TDI.
(n/a) = not applicable.
Grey shading indicates HQs greater than one and/or ILCRs greater than 1 $x10^{-5}$ (1-in-100,000).

34.5.10.4 Mitigation Measures to Address Cumulative Effects on Health

Mitigation measures for air quality have been integrated into the design of the Project, such as dust control through the use of baghouses and the wetting of the access roads, and certain mitigation measures have been proposed by both the KSM Project and Brucejack Gold Mine Projects.

Mitigation measures provided in Chapter 21, Assessment of Potential Health Effects (Section 21.5.2.2), and the associated management plans (Chapter 29) are applicable to the potential cumulative changes. Air quality will be monitored at worker camps and the non-worker human receptor location (i.e., Skii km Lax Ha Lodge) during the life of the project. If CAC levels are found to have become elevated, installation of HEPA filters will reduce CAC levels to background levels.

Project mitigation measures to protect surface water quality, which will also serve to protect drinking water quality, were outlined in Chapter 21, Assessment of Potential Health Effects (Section 21.5.3.2). Mitigation measures for the protection of water quality were also described in the KSM Project Application/EIS (Rescan 2013) for that project.

34.5.10.5 Summary of Residual Cumulative Effects on Health

Cumulative residual effects on health are those effects remaining after the implementation of all mitigation measures and are summarized in Table 34.5-38. The significance determination of cumulative residual effects for commercial land use is outlined in Table 34.5-39.

Table 34.5-38. Summary of Cumulative Residual Effects on Human Health

Human Health and its Sub-components	Timing of Cumulative Residual Effect[1]	Description of Cause-Effect[2]	Description of Additional Mitigation (if any)	Description of Cumulative Residual Effect
Health effects due to noise	Operation	Speech interference, sleep disturbance, and change in percent highly annoyed due to increased noise levels	None	Same as Project residual effect
Health effects due to air quality	Operation	Increase in NO_2, SO_2, CO, TSP, PM_{10}, and $PM_{2.5}$ levels which could affect human health due to inhalation of CACs	None	Slight increase (2%) in HQs due to PM_{10} at the Skii km Lax Ha Lodge
Health effects due to water quality	Operation	Increase in concentrations of total and dissolved metals, nutrients, turbidity, and TSS which could affect human health due to consumption of drinking water	None	Same as Project residual effect

[1] *Refers to the Project phase or other timeframe during which the effect to human health due to cumulative residual effects may occur.*
[2] *"Cause-effect" refers to the relationship between the Project component/physical activities that is causing the change or effect in the condition of the receptor VC, and the actual change or effect that results.*

34.5.11 Heritage

The potential for residual effects on heritage resources has been determined to be **negligible** and **not significant** as mitigation and management measures, including site avoidance, Project personnel education, and implementation of the Heritage Management Plan and Chance Find Procedure will be conducted/established prior to anticipated Project impacts. Therefore, the potential for cumulative effects on heritage resources is not anticipated and as a result will be reduced to **negligible** and **not significant**.

34.5.12 Navigation

As outlined in Chapter 23, Assessment of Potential Navigation Effects, a total of 49 transmission line crossings, seven road crossings, and subaqueous tailings and waste rock disposal were assessed to determine if they would have an effect on the ability to safely navigate or access navigable waters within the Project region. It was determined that there may be some localized effects of very short duration during construction and decommissioning of the various Project works, but with proper mitigation and management the overall effects will be **negligible to minor**. In addition, navigation by water is uncommon within the Project region as was determined during a desk-based study, which included a review of historical documents and consultations with various stakeholder groups, including recreational business owners and Aboriginal groups. Pretivm determined (Section 23.3.5) that, based on criteria established through case law precedent, the only navigable waterway potentially affected by Project activities is Bowser River and none of the other waterways are navigable for the purposes of the *Navigation Protection Act* (1985c).

Table 34.5-39. Significance Determination of Cumulative Residual Effects for Human Health

Cumulative Residual Effects	Cumulative Residual Effects Characterization Criteria									
	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 medium-term, reversible long-term, irreversible)*	**Resiliency** *(low, neutral, high)*	**Social Context** *(low, neutral, high)*	**Likelihood** *(low, medium, high)*	**Significance of Adverse Cumulative Residual Effects** *(not significant, significant)*	**Confidence** *(low, medium, high)*
Air quality (potential effects on off-duty workers)	Moderate	Far future	Regular	Landscape	Irreversible	Low	High	Low	Not significant	High
Air quality (potential effects on non-workers)	Moderate	Far future	Regular	Landscape	Irreversible	Low	High	Low	Not significant	High
Water quality (potential effects on non-workers)	High	Short-term	Sporadic	Local	Reversible short-term	Neutral	High	Low	Not significant	High

In conclusion, waterways potentially affected by Project works are not expected to be publicly utilized during the duration of the Project. Nevertheless, if waterways are used for public navigation, effects on navigation are expected to be negligible to minor, localized, and temporary in duration. Because the effects on the ability to safely navigate as well as the effects on navigational access were both determined to be **negligible to minor**, temporary, and local, they are not discussed further in this assessment.

No residual effects on navigation were identified, and no potential cumulative effects to stream flows or water quantity were predicted in any navigable waters (Chapter 10, Surface Water Hydrology). Therefore, a cumulative effects assessment was not undertaken for effects on navigation.

34.5.13 Land Use

34.5.13.1 Summary of Project-specific Residual Effects on Land Use

The potential effects of the Project on land use are assessed in Chapter 24, Assessment of Potential Commercial and Non-commercial Land Use Effects. The receptor VC included in this Land Use CEA is commercial land use, which includes the following sub-components: guide outfitting and commercial recreation.

Project-specific residual effects for commercial land use are: 1) changes to the experience of the natural environment and 2) changes to the distribution of wildlife resources (Table 34.5-40). As a result of planned implementation of mitigation and monitoring programs, residual land use effects associated with the Project are assessed as **not significant** (Table 34.5-40).

Table 34.5-40. Summary of Project-specific Residual Effects, Mitigation, and Significance on Commercial Land Use

Residual Effects	Project Phase(s)	Mitigation Measures	Significance
Commercial Land Use			
Changes to the experience of the natural environment	Construction and Operation	Project agrees to communicate helicopter schedules with Last Frontier Heliskiing to minimize noise and visual quality effects on heli-ski clients	Not significant
	Closure and Post-closure	None specific to land use	
Changes to the distribution of wildlife resources	Construction and Operation	Wildlife Management and Monitoring Plan (Section 29.21)	Not significant
	Closure and Post-closure	None specific to land use	

The following sections provide an examination of the relationship between the residual effects of the Project and those of other projects and activities. A matrix identifying the potential cumulative effect interactions of past, present and future projects and activities on commercial land use is provided in Table 34.4-1.

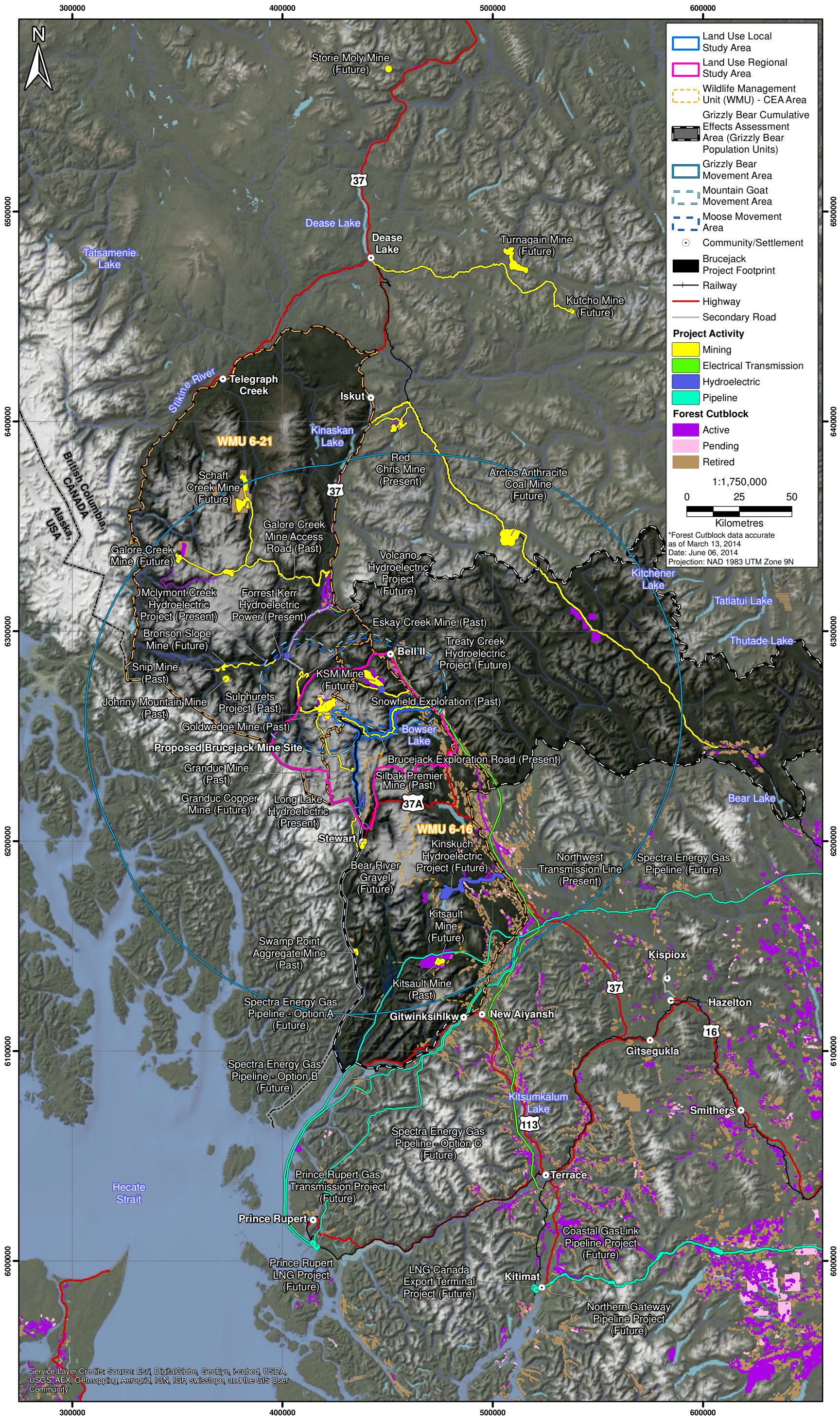
34.5.13.2 Cumulative Effects Assessment Boundaries for Commercial Land Use

Spatial Boundaries

The VCs assessed in Chapter 24, Assessment of Potential Commercial and Non-commercial Land Use Effects, are ultimately human VCs; humans define the boundaries within which they act. The projects mapped on Figure 34.5-16 are thought to have a potential cumulative interaction with the Brucejack Gold Mine Project. For the CEA spatial boundary, a mapping exercise was undertaken by overlapping the land use RSA and LSA on the map extent covered by Figure 6.7-2. Effects on wildlife resources were also taken into account in developing the map. The resulting CEA spatial boundary is shown in Figure 34.5-16.

Figure 34.5-16

Cumulative Effects Scoping: Projects and Activities Interacting with the Land Use in the Vicinity of the Brucejack Gold Mine Project



Temporal Boundaries

The temporal boundaries of the CEA are described in Section 34.2.2. Table 34.4-1 illustrates which past, present, and future projects and activities will potentially have a temporal interaction with land use.

34.5.13.3 Cumulative Effects Assessment on Commercial Land Use

Commercial land users rely on resources provided by the wilderness environment in order to carry out their activities. This effect has the potential to reduce hunting opportunities for guide outfitters within the land use RSA. Other present and foreseeable future mining, hydroelectric, and other commercial activities, such as mineral exploration, have the potential to act cumulatively contributing to a nibbling loss and additive effect in the RSA potentially resulting in further effects to mountain goat and grizzly bear.

34.5.13.4 Cumulative Effects on Guide Outfitter Licence 601036

One potential residual effect is predicted to have cumulative effects on guide outfitter licence 60136. The holder of this licence may be affected by further changes to wildlife within the RSA, or by changes to grizzly bear and mountain goat in areas outside of the land use RSA (as a result of other projects and development). This residual effect relates to a change in the abundance and distribution of mountain goat and grizzly bear.

34.5.13.5 Cumulative Effects on Commercial Recreation Licence 6406985

One potential residual effect is predicted to have cumulative effects on commercial recreation licence 6406985. The holder of this licence has been affected by past projects may be affected by sensory disturbances from other projects.

34.5.13.6 Mitigation Measures to Address Cumulative Effects on Land Use

Management plans, monitoring, and adaptive management will be implemented to mitigate changes to the abundance and disturbance to wildlife caused by the Project as outlined in Section 24.5.4. Key management plans include the following:

- Noise Management Plan (Section 29.11);
- Transportation and Access Management Plan (Section 29.16); and
- Wildlife Management and Monitoring Plan (Section 29.21).

Each of the mitigation measures and plans to address cumulative effects are outlined in the sections below. No additional Project mitigation is anticipated as a result of cumulative effects. Other large resource development projects are expected to adopt mitigation and management measures similar to those of the Brucejack Gold Mine Project. Other projects are also expected to comply with relevant government legislation with respect to noise and wildlife, among others. Summary of Residual Cumulative Effects on Land Use

Cumulative residual effects are those effects remaining after the implementation of all mitigation measures and are summarized in Table 34.5-41. The significance determination of cumulative residual effects for commercial land use is outlined in Table 34.5-42.

Table 34.5-41. Summary of Cumulative Residual Effects on Commercial Land Use

Receptor Valued Component	Timing of Cumulative Residual Effect[1]	Description of Cause-Effect[2]	Description of Additional Mitigation (if any)	Description of Cumulative Residual Effect	Significance of Residual Effects
Commercial land use	Construction, Operation	Cumulative wildlife habitat loss and fragmentation, and wildlife-vehicle interactions in the CEA spatial boundary (nibbling loss, additive)	Wildlife Management and Monitoring Plan (Section 29.21)	Potential for a reduction in hunting opportunities for commercial land users	Not significant

[1] Refers to the Project phase or other timeframe during which the effect will be experienced by the intermediate receptor or VC.
[2] "Cause-effect" refers to the relationship between the Project component/physical activity that is causing the change or effect in the condition of the receptor VC.

34.5.13.7 Guide Outfitter Licence 601036

The effects assessment determined the Brucejack Project would result in a residual effect in terms of changes to the abundance and distribution of mountain goat and grizzly bear. The residual effect was determined to be not significant. Section 18.7.2 (Chapter 18, Wildlife) concludes there will be cumulative effects to mountain goat and grizzly bear due to other development in the area. Chapter 18 concludes there will be two cumulative residual effects on mountain goat: sensory disturbance and indirect mortality and four cumulative residual effects on grizzly bears: disruption of movement, direct mortality, indirect mortality, and attractants.

34.5.13.8 Commercial Recreation Licence 6406985

The use of this licence is focused on the area south of Bowser Lake, and on the other side of Anderson Mountain, within the land use RSA. The effects assessment concluded this licence holder may be affected by changes to the experience of the natural environment as a result of Project relate noise and changes to visual aesthetics. It is unlikely that other projects would be visible or audible from the travel route associated with this licence due to their distance from the areas used under this licence.

34.5.14 Current Aboriginal Land and Resource Use

34.5.14.1 Summary of Project-specific Residual Effects on Current Aboriginal Land and Resource Use

The potential effects of the Project on Aboriginal land and resource use are assessed in Chapter 25, Assessment of Potential Effects to Current Use of Lands and Resources for Traditional Purposes. The majority of the potential effects associated with the Project and its interactions with the VCs are expected to be mitigated. The receptor VCs included in this CEA are:

- hunting/trapping opportunities and practices — one residual effect related to hunting/trapping opportunities and practices was identified:
  - change to the abundance and distribution of resources — causing a change in the location, timing, and quantity of wildlife resources harvested by the Skii km Lax Ha and Nisga'a in the LSA and RSA. This residual effect had a not significant rating, with a high likelihood and a high confidence in the rating.

Table 34.5-42. Significance Determination of Cumulative Residual Effects for Commercial Land Use Future Case with the Project

Cumulative Residual Effects	Cumulative Residual Effects Characterization Criteria								
	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 medium-term, reversible long-term, irreversible)*	**Resiliency** *(low, neutral, high)*	**Likelihood** *(low, medium, high)*	**Significance of Adverse Cumulative Residual Effects** *(not significant, significant)*	**Confidence** *(low, medium, high)*
Commercial Land Use									
Changes to the abundance and distribution of wildlife	Moderate	Long -term	Sporadic	Regional	Reversible long-term	High	Medium	Not significant	Medium

Table 34.5-43 is a summary of the anticipated residual effect of the Project on current Aboriginal land and resource use. This residual effect has been carried forward into the CEA.

Table 34.5-43. Summary of Residual Effects, Mitigation, and Significance on Current Aboriginal Land and Resource Use

Residual Effects	Project Phase(s)	Mitigation Measures	Significance
Hunting/Trapping Opportunities and Practices			
Decrease in the quantity and/or location of harvestable wildlife resources available to the Skii km Lax Ha and Nisga'a, and displacement of hunting and trapping activities in the LSA and RSA, due to change in the abundance and distribution of resources	Construction and Operation	Access restrictions, no hunting policy for employees, Wildlife Management and Monitoring Plan, helicopter flight paths, speed limits	**Not significant**

The following sections provide an examination of the relationship between the residual effects of the Project and those of other projects and activities. A matrix identifying the potential cumulative effect interactions of past, present, and future projects and activities on current Aboriginal land and resource use is provided in Table 34.4-1.

34.5.14.2 Cumulative Effects Assessment Boundaries for Current Aboriginal Land and Resource Use

Spatial Boundaries

Since Current Aboriginal Use is a human practice or activity, humans define the boundaries within which they undertake an activity. A traditional territory is usually defined as the maximum extent of an area used by an Aboriginal group for subsistence and other needs, and is at the heart of their collective identity (BC Treaty Commission 2009).

Since the residual effect of the Brucejack Gold Mine Project is only expected to affect the Skii km Lax Ha and the Nisga'a, it was determined that the CEA spatial boundary would be the outer extent of Skii km Lax Ha traditional territory and the Nass Area (Figure 34.5-17).The total area of the CEA spatial boundary is 3.07 million ha.

Temporal Boundaries

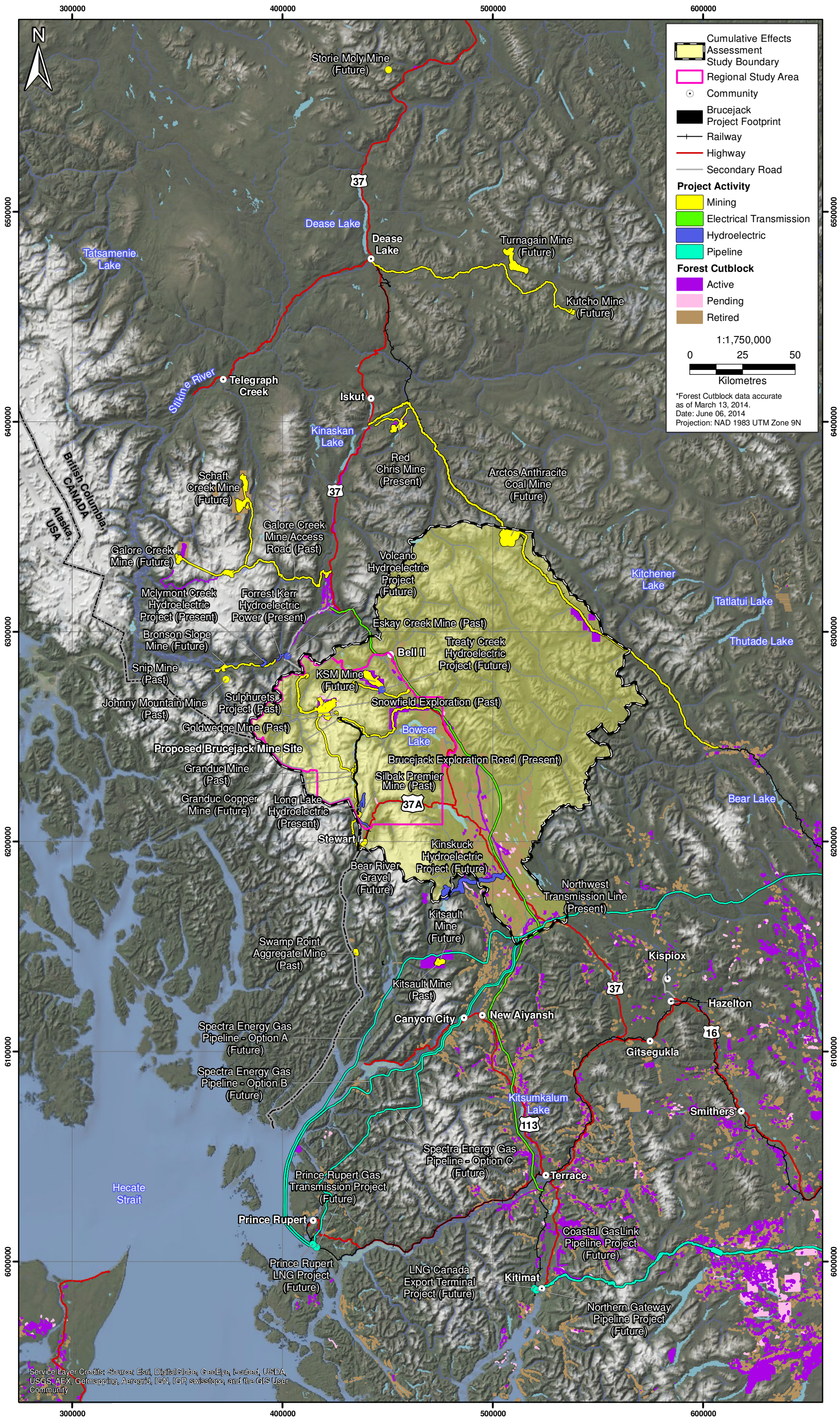
The temporal boundaries of the CEA are described in Section 34.2.2. Table 34.4-1 illustrates which past, present, and future projects and activities will potentially have a temporal interaction with the current Aboriginal use study area.

34.5.14.3 Cumulative Effects Assessment on Current Aboriginal Land and Resource Use

The CEA will discuss the cumulative effect of all of the projects present in the CEA spatial boundary and how the projects, as a whole, will interact with the residual effects to hunting/trapping opportunities and practices. This approach is being taken as details around the reasonably foreseeable future projects are not known. As the supporting evidence is not available, a detailed discussion will not be possible. In other words, the analysis will be a qualitative discussion based on a conservative approach. As stated in Chapter 25, Assessment of Potential Effects to Current Use of Lands and Resources for Traditional Purposes (Section 25.9.1.3), this CEA can only assess the cumulative effects of the projects that may interact with the Project. Also, it should be noted that effects of the Project on current Aboriginal use have been limited to the Skii km Lax Ha and the Nisga'a.

Figure 34.5-17

Current Use of Lands and Resources for Traditional Purposes:
Cumulative Effects Assessment Spatial Boundary for Environmental Effects



The effects of the Project that have the potential to act cumulatively with other projects and activities on current Aboriginal land and resource use are identified in Table 34.4-2.

Change in the Abundance and Distribution of Resources

Skii km Lax Ha and Nisga'a hunters and trappers rely on wildlife resources to carry out their activities. Development of the Brucejack Gold Mine Project is expected to have a residual effect on the abundance and distribution of these harvest resources due to sensory disturbances, disruption of wildlife movement from Project infrastructure and traffic, increased hunting pressure, and vehicle-wildlife collisions, and direct and indirect mortality.

Other present and reasonably foreseeable future mining and other commercial activities, such as mineral exploration and forestry (Table 34.5-44), as well as guide outfitting, resident hunting, and trapping have the potential to act cumulatively in the CEA spatial boundary by contributing to further changes in the abundance and distribution of resources used by the Skii km Lax Ha and Nisga'a. This is a nibbling loss effect, reducing by increments the amount of wildlife resources available for harvest. The presence of additional work camps in the CEA spatial boundary could increase the potential for odours and food waste to attract wildlife away from their home ranges. It is also an additive effect in that the projects together contribute to increasing dislocation of wildlife from their usual ranges. Wildlife will have fewer places to take refuge from noise and visual disturbances within their home ranges and increase their dislocation. The use of roads for transport of goods and personnel by these projects will result in higher numbers of wildlife-vehicle interactions and disruption of movement. Habitat lost or altered through the construction of these projects will reduce habitat available for wildlife and cause them to move into other areas. Finally, it is a growth-inducing effect by further increasing the amount of wilderness being opened up in Skii km Lax Ha traditional territory and the Nass Area to other hunters or trappers.

Table 34.5-44. Summary of Cumulative Residual Effects on Current Aboriginal Land and Resource Use

Sub-component	Timing of Cumulative Residual Effect[1]	Description of Cause-Effect[2]	Description of Additional Mitigation (if any)	Description of Cumulative Residual Effect	Significance of Residual Effects
Hunting/Trapping Opportunities and Practices	All Project phases	Cumulative sensory disturbances to wildlife, unauthorized or illegal harvesting, disruption of movement, and wildlife-vehicle interactions in the CEA spatial boundary	N/A	Changes to the location, timing and abundance of harvests by the Skii km Lax Ha and Nisga'a across the CEA spatial boundary	**Significant**

[1] Refers to the Project phase or other timeframe during which the effect will be experienced by the intermediate receptor or VC.
[2] "Cause-effect" refers to the relationship between the Project component/physical activity that is causing the change or effect in the condition of the receptor VC, and the actual change or effect that results.

34.5.14.4 Mitigation Measures to Address Cumulative Current Aboriginal Land and Resource Use

Management plans, monitoring, and adaptive management will be implemented to mitigate disturbances and changes caused by the Project on hunting/trapping opportunities and practices as outlined in Chapter 25, Assessment of Potential Effects to Current Use of Lands and Resources for

Traditional Purposes (Section 25.5.2.6). These primarily draw on mitigation measures maintained in a variety of management plans, including but not limited to the following:

- Ecosystem Management Plan (Section 29.5);
- Noise Management Plan (Section 29.11);
- Spill Prevention and Response Plan (Section 29.14);
- Transportation and Access Management Plan (Section 29.16); and
- Wildlife Management and Monitoring Plan (Section 29.21).

No additional Project mitigation is anticipated other than that discussed in Section 25.5.2.6. It is expected that other large resource development projects would adopt mitigation and management measures similar to those of the Project. It is also expected that all other projects will comply with relevant government legislation with respect to air and water quality, noise and wildlife, among others.

34.5.14.5 Summary of Residual Cumulative Effects on Current Aboriginal Land and Resource Use

Cumulative residual effects are those effects remaining after the implementation of all mitigation measures and are summarized in Table 34.5-44. The significance determination of cumulative residual effects for commercial land use is outlined in Table 34.5-45.

Table 34.5-45. Significance Determination of Cumulative Residual Effects for Hunting/Trapping Opportunities and Practices

	Cumulative Residual Effects Characterization Criteria								
Cumulative Residual Effects	**Magnitude** *(low, moderate, high)*	**Duration** *(short-term, medium-term, long-term, far future)*	**Frequency** *(once, sporadic, regular, continuous)*	**Geographic Extent** *(individual/ households, community, regional, beyond regional)*	**Reversibility** *(reversible short-term, reversible medium-term, reversible long-term, irreversible)*	**Resiliency** *(low, neutral, high)*	**Likelihood** *(low, medium, high)*	**Significance of Adverse Cumulative Residual Effects** *(not significant, significant)*	**Confidence** *(low, medium, high)*
Changes to the location, timing and abundance of harvests by the Skii km Lax Ha and Nisga'a across the CEA spatial boundary due to change in the abundance and distribution of resources	Moderate	Far future	Continuous	Aboriginal peoples	Reversible long-term	High	High	Significant	Medium

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