6. ASSESSMENT OF POTENTIAL ENVIRONMENTAL EFFECTS

6.1 GREENHOUSE GAS MANAGEMENT

6.1.1 Rationale

A scoping process was used by KGHM Ajax Mining Inc. (KAM) to identify and select Greenhouse Gas (GHG) Management as a Valued Component (VC) for inclusion in the Environmental Assessment (EA) of the Ajax Project (the Project). The purpose of the scoping process is to allow the EA to focus on the components the Project that are valued and have the greatest potential to cause significant adverse effects (Beanlands and Duinker 1983). Valued Components are components of the natural and human environment that are considered to be of scientific, ecological, economic, social, cultural, or heritage importance (Environmental Assessment Office and Canadian Environmental Assessment Agency 2013). In addition, the Project must be likely to affect the VC for it to be included in an EA.

Greenhouse Gas Management was identified as a potential VC by government agencies, stakeholders, Aboriginal communities, and the public for inclusion in the EA during the scoping process because GHG emissions, from both natural and anthropogenic factors have been attributed to climate change (Warren and Lemmen 2014). Greenhouse Gases are gases that trap heat in the atmosphere. The primary GHGs in the earth's atmosphere are carbon dioxide (CO_2); methane (CH_4); nitrous oxide (N_2) and ozone (O_3); fluorinated gases entirely from anthropogenic sources are also found in the atmosphere (Environment Canada 2013a). Greenhouse Gas emissions from anthropogenic sources have been identified as the main cause of recent global warming and are predicted to be the primary cause of continued warming over the next 100 years (Warren and Lemmen 2014).

It is widely acknowledged that climate change is occurring in Canada, with reported changes in air temperature, precipitation snow and ice cover (Warren and Lemmen 2014). The Federal-Provincial-Territorial Committee on Climate Change and Environmental Assessment (2003) states that "climate change has been recognized internationally and by the federal, provincial and territorial governments in Canada as an important environmental issue". Incorporating climate change considerations in an assessment can help determine if a project is consistent with jurisdictional initiatives for the management GHG emissions (Federal-Provincial-Territorial Committee on Climate Change and Environmental Assessment 2003). The assessment of Project effects on GHG Management is challenging, given that the potential adverse effects of climate change as a result of GHG emissions are global in nature and the Project's individual contribution is indiscernible from all other sources of GHG emissions in the atmosphere. Therefore, the assessment of Project effects on GHG Management compare the Project's anticipated GHG emissions to provincial, national and sector norms as shown in Table 6.1-14.

Greenhouse Gas Management was selected for inclusion in the EA based on issues raised during consultation with government agencies, stakeholders, Aboriginal communities, and the public. Government agencies that expressed an interest in seeing GHG Management assessed as a VC included the Environmental Assessment Office (EAO) and Canadian Environmental Assessment Agency (CEA Agency) and members of the Technical Working Group (Environment Canada;

Ministry of Environment; BC Ministry of Energy, Mines and Natural Gas; and Interior Health). Stakeholders that provided input into the scoping process included the Kamloops Food Policy Council, Kamloops 350.org, and the Kamloops Area Preservation Association (Environmental Assessment Office and Canadian Environmental Assessment Agency, 2013).

Concerns raised during the public consultation period on Revision 1 of the Application Information Requirements (AIR)/Environmental Impact Statement Guidelines (EIS Guidelines) were summarized in a document submitted by KAM to the EAO and CEA Agency (KGHM-Ajax Mining Inc. 2013). Subsequent to the release of Revision 1 of the AIR/EIS Guidelines, KAM revised the design of the Project and submitted a revised AIR/EIS Guidelines to reflect the design changes; this document was posted on the EAO website on November 7, 2014 for public consultation. The public comment period for the revised AIR/EIS Guidelines was held between November 18, 2014, and December 18, 2014. Key issues interpreted from public comments received on the AIR/EIS Guidelines that were considered to be related to GHG Management are summarized and presented in Table 6.1-1 along with responses from KAM.

Table 6.1-1. Public Comments Related to Greenhouse Gas Management

Key Issues	Summary of KAM's Responses
Climate change/increased greenhouse gas emission	Discussion of Greenhouse Gas emissions presented in the Application will follow guidance documents recommended by regulatory bodies. Best management practices will be followed to minimize Project-related GHG emissions.

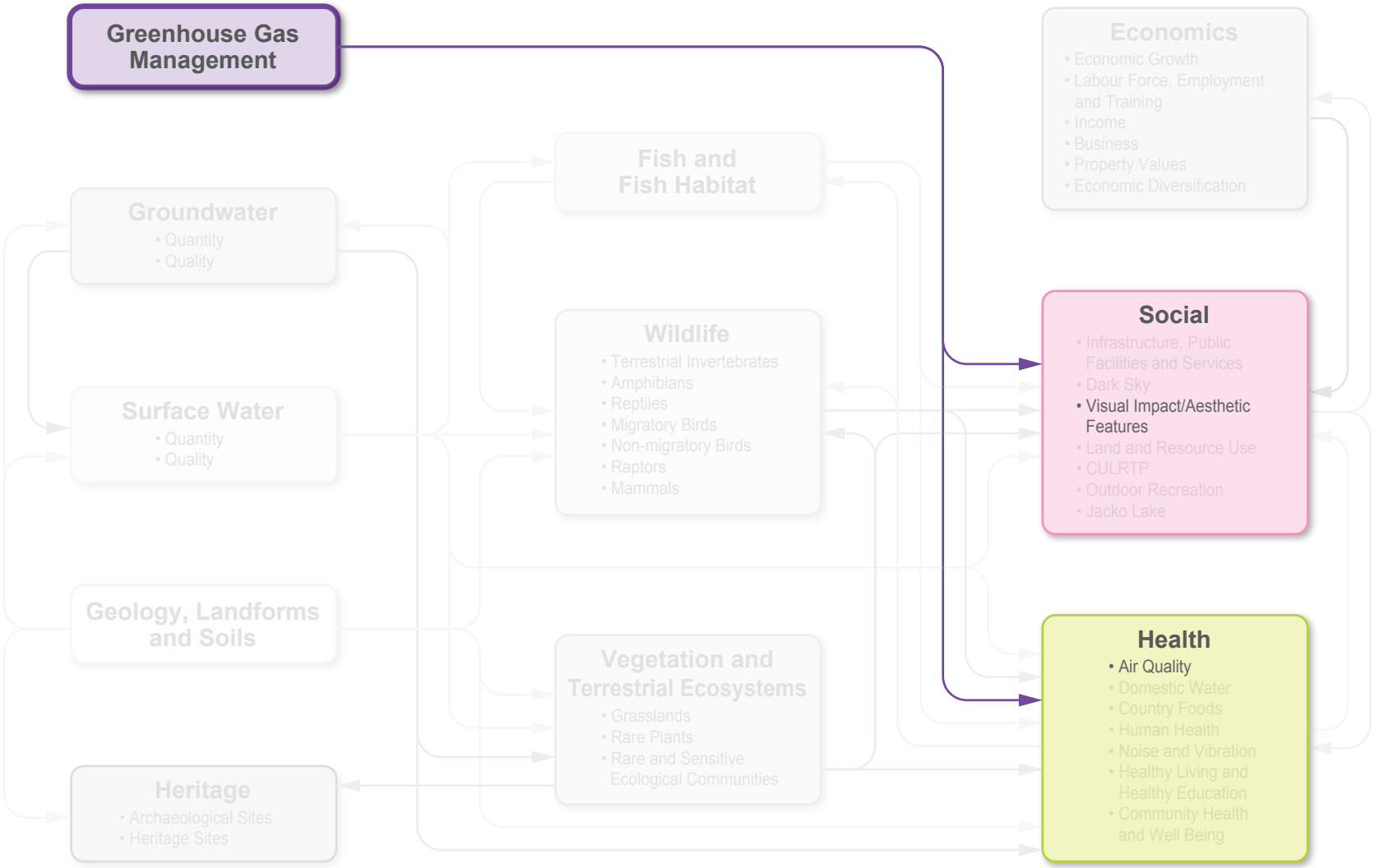
The Stk'emlupsemc te Secwépemc Nation have expressed concerns related to climate change, specifically as it may pertain to Jacko Creek, Jacko Lake, and Peterson Creek, as well as the health of the larger ecosystem within the Stk'emlups te Secwépemc territory (AMEC 2015). The Ashcroft Indian Band (AIB) shared concerns with KAM related to climate change including suggestions to use liquefied natural gas (LNG) powered trucks and purchase carbon credits (AMEC 2015).

The Ministry of Environment recommends that meteorology and climate studies be conducted to characterize the atmospheric environment in its current state and to develop an understanding of potential impacts that a project can have on climate and potential effects that weather and climate can have on a project (Ministry of Environment 2012a). This section of the Application/EIS evaluates the potential effects of the Project on GHGs, whereas Section 17.5 of the Application/EIS assesses potential effects of the environment (including weather and climate) on the Project.

GHG Management was included as a VC for the EA because Project activities will emit GHGs through the burning of fuel in mobile and stationary heavy equipment and vehicles, both on and off the Mine Site, and through blasting. The Project will also contribute indirectly to GHG production from the use of purchased electricity and through the transport of materials and supplies by contractors, and personnel on and off the Mine Site. The Project will also affect existing carbon sinks through clearing of existing groundcover for components such as the Open Pit, Mine Rock Storage Facilities (MRSF), and Tailings Storage Facility (TSF). Reclamation of disturbed areas will mitigate for the temporary loss of some existing carbon sinks.

As shown on Figure 6.1-1, the results of the GHG Management VC effects assessment will be used to inform the assessment of Visual Impact/Aesthetic Features VC (Social) and Air Quality (Health).

Figure 6.1-1
Greenhouse Gas Management



6.1.2 Background

6.1.2.1 Regional Overview

The regional climate is characteristic of the BC Interior Region, with generally low total precipitation and high evaporation that equate to dry conditions (Knight Piésold Ltd. 2014). Meteorological data (temperature, relative humidity, precipitation, and wind speed and direction) have been collected in the Project area since 2006 and continue to be collected to date. The 2014 Climatology Report (prepared by Knight Piésold Ltd.) is included as Appendix 6.1-A of the Application/EIS. The Climatology Report characterizes the climate of the region as:

- the long-term average annual temperature is 6.4°C, with average monthly temperatures ranging from 18.7°C in July to -4.9°C in December;
- the long-term mean annual precipitation is 336 mm: the mean annual snowfall (snow water equivalent) is 101 mm, while the mean annual rainfall is 235 mm;
- the 1 in 10 year maximum 24-hr precipitation is estimated as 43 mm, while the probable maximum 24-hr precipitation is estimated as 219 mm;
- relative humidity varies throughout the year, but is typically highest in mid-winter and lowest in mid-summer, with respective estimated long-term monthly average values of approximately 88.5% in January and 48.6% in July; and
- the mean annual lake evaporation is estimated to be 585 mm.

According to the Pacific Climate Impacts Consortium (PCIC), by the 2050s mean temperatures in BC are expected to increase by approximately 1.8°C; winter precipitation is predicted to increase by 8%, summer precipitation is expected to decrease by 1%; and winter snowfall is predicted to decrease by 58% compared with 1961 to 1990 baseline values (Knight Piésold Ltd. 2014). These anticipated climatic changes could affect streamflow patterns, as warmer winters would raise freezing levels and decrease the amount of precipitation stored as snow during the winter months, which would also result in lower freshet flows due to the decreased snowpack (Knight Piésold Ltd. 2014).

Total GHG emissions in BC in 2012 from all sectors, as reported in the Provincial Inventory Report (PIR), were 61.5 Mt carbon dioxide equivalent (CO_2eq) (Ministry of Environment 2014c). The energy sector accounted for the majority of GHG emissions in 2012 (at approximately 79.0%), with transportation sources (an energy sub-sector) accounting for 37.9% of the total. Within the Thompson-Nicola Regional District (TNRD), total GHG emissions from transportation, buildings, and solid waste in 2010 was approximately 949,978 t of CO_2eq (Thompson-Nicola Regional District 2014) with transportation sources accounting for the majority of emissions (or approximately 64%).

6.1.2.2 Historical Activities

The historical information presented in this section has been supplied by ERM Rescan and is based on the Domtar Inc. Kamloops Mill Annual Air Report for 2013.

The region surrounding the Project has a long history of human activity that contributes to the current 'baseline' condition, which is defined more specifically in the following section of this assessment.

The Kamloops area grew after the First World War until development slowed during the Depression and the Second World War. After this period, the City began to grow again, and much of the land that had formerly been used for farming in the valley was used for residential development. Ranching (including cattle grazing) also developed, and is currently ongoing immediately within and adjacent to the Project.

The Project is located within the Kamloops Forest District, which is part of the Kamloops Timber Supply Area (TSA). Tree-killing bark beetles (including mountain pine beetle, spruce beetle, and Douglas fir beetle) continue to pose a threat to the forests. The Project is located in the Greenstone Beetle Management Unit, where more than 30% of the area is identified as susceptible to the mountain pine beetle. In response to the pine beetle, in 2008, the Annual Allowable Cut for the TSA was determined to be 4 million cubic metres; this harvest level (and priority for beetle management) will remain in place until 2018 unless otherwise altered.

The Domtar Pulp Mill is located immediately west of Kamloops on the Thompson River. This pulp mill was originally built by Weyerhaeuser in 1972 and became part of Domtar in 2007. Numerous capital improvements have been made to the mill over the years. One of the pulp lines was closed in 2013; Domtar reports that this closure has corresponded with a significant reduction in odour complaints, and in particulate emissions (Domtar 2014).

Mining activity in the Project area can be traced back over 100 years with exploration in the Project area beginning in the 1880s and continuing intermittently to present. Copper, gold, and iron mineralization was discovered at the Iron Mask Mine near Kamloops in 1896. Nearby properties, including the Wheal Tamar, Ajax, and Monte Carlo claims were explored in the following years.

The Afton Mine went into operation in 1977. Mining operations were initiated on the Ajax East and Ajax West pits in 1989 and subsequently suspended in 1991 due to depressed metal prices. A second period of production began in 1994 and was again suspended in 1997. The raw ore from the Ajax pits was trucked approximately 10 km west to the processing plant adjacent to the Afton pit. During these periods of production, it is estimated that 17 Mt of ore was mined and 13 Mt of ore was milled. In the late 1990s, the tailings facility and project components were decommissioned and reclaimed by the Afton Mine in accordance with their closure plan. At the Ajax site, this includes reclaimed waste rock dumps adjacent to Peterson Creek in the location of the proposed Ore Stockpiles.

The New Afton Mine occupies the site of the historic Afton Mine infrastructure. New Afton began underground mining immediately beneath the historic Afton Mine open pit in June 2012. This mine is able to produce up to 11,000 tonnes per day of raw ore though the processing plant. Currently the mine is licenced to draw up to approximately 7,000 m^3 per day from Kamloops Lake for water supply to the processing plant. An application to withdraw an additional approximately 5,000 m^3 per day is currently in review.

6.1.2.3 Baseline Studies

This section presents firstly the Climate Baseline and then the GHG Emissions Baseline (of other emitting facilities, provincial and national emissions targets, national, provincial, regional, and local policies and regulations and the mining industry profile).

A Climate Baseline has been provided to satisfy the information requirements outline in the AIR/EIS Guidelines for the Project. This section of the Application/EIS presents an introduction to the baseline information collection program (sample sites, sample frequency, etc.) for meteorology as it pertains to greenhouse gas emissions in the Project area. A detailed meteorological report is provided as Appendix 6.1-A. 2014 Climatology Report. Specifically, baseline climate data has been compiled from regional and site climate stations and includes:

- mean monthly and annual temperature;
- mean monthly and annual precipitation;
- probable maximum precipitation;
- mean monthly and annual solar radiation;
- relative humidity; and
- wind speed and direction.

A GHG Emissions Baseline has been provided to satisfy the information requirements outline in the AIR/EIS Guidelines for the Project and to enable a comparison of the anticipated GHG emissions of the Project to the GHG emissions of other industrial facilities and emissions targets for BC and Canada. Specifically, baseline GHG emissions have been:

- compiled from emitting facilities and provincial reports for other comparable greenhouse gas contributing facilities in the Province; and
- discussed in the context of the community energy efficiencies inventory for the city of Kamloops.

Climate Baseline

The 2014 Climatology Report is included as Appendix 6.1-A to the Application/EIS and is a baseline climatological characterization of the Ajax Project and regional area (Knight Piésold Ltd. 2014). This report presents site and regional climate data and provides estimated long-term values for the Project area.

Data Sources

Meteorological data collection for the Project commenced in November 2006. Golder Associates installed the GOLDMET climate station at the location of the Ajax Project exploration camp at an elevation of 940 masl. Due to differing installation standards when the station was installed in 2006, data from the GOLDMET station are considered to be of lower quality and were therefore not used in climate analyses. In August 2010, Knight Piésold Ltd. installed the AJAXMET station at an elevation of 950 masl near Sugarloaf Mountain. The AJAXAQ-1 station was recently installed by KAM at an elevation of 1052 masl near the proposed location of the TSF. The names, locations and periods of record of the Project's current climate stations are summarised in Table 6.1-2 and shown on Figure 6.1-2.

Figure 6.1-2
Regional and Project Climate Stations

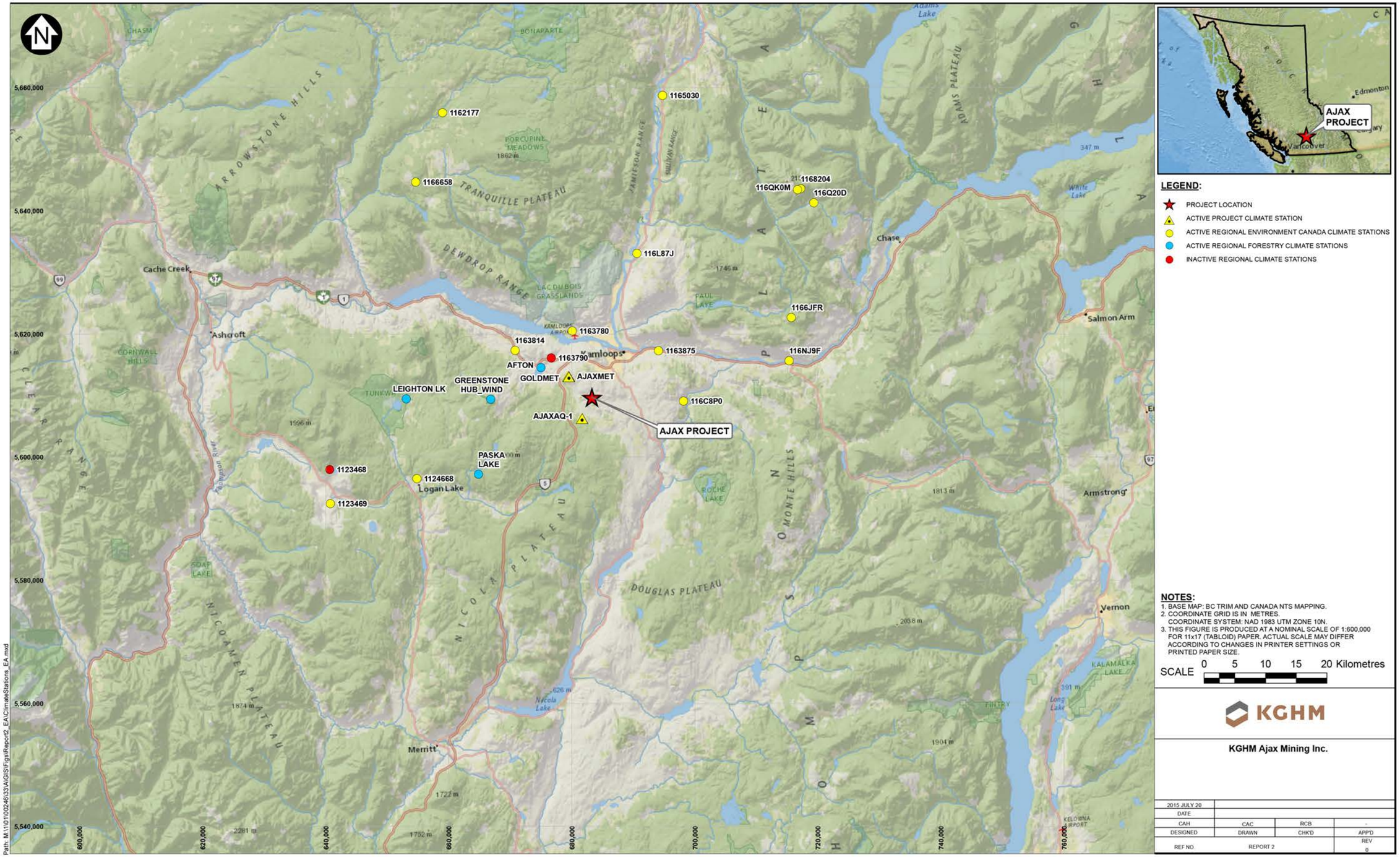


Table 6.1-2. Project Climate Stations

Station Name	Total Years of Record	Complete Years of Record	Start Year	End Year	Latitude	Longitude	Elevation (m)
AJAXAQ-1	0.5	0	2014	2014	50°34'49"N	120°26'8"W	1,051
AJAXMET	5	3	2010	2014	50°38'32"N	120°27'44"W	950

CR1000 dataloggers were installed at the AJAXMET and AJAXAQ-1 climate stations by Knight Piésold Ltd. and data were collected at hourly increments. The dataloggers for these two climate stations were set to Pacific Standard Time (PST) to avoid data gaps and overlaps and to be consistent with standard monitoring practices. The Project's climate stations monitored the following parameters:

- air Temperature (°C)
- relative humidity (%)
- atmospheric pressure (kPa)
- precipitation (mm)
- solar radiation (W/m^2),
- wind speed (m/s), and
- wind direction (degrees from true north and standard deviation).

Over five years of site specific climate data is available from the AJAXMET climate station and was used to characterize the baseline climate for the Project. Data from the AJAXAQ-1 climate station was not used because only four months of data were available and this short duration was not considered to be representative.

The baseline climate for the Project was characterized by supplementing short-term site specific data with long-term regional data collected at nearby regional climate stations operated by Environment Canada (EC) and the BC Ministry of Forests, Lands and Natural Resource Operations (BC MFLNRO). The names, locations and periods of record of regional climate stations are summarised in Table 6.1-3 and shown on Figure 6.1-2.

The majority of the regional climate stations have been deactivated by EC or BC MFLNRO and data from most of the inactive stations were not used for the analysis, with the exception of the Logan Lake and Kamloops Afton Mines climate stations. The Kamloops Afton Mines climate station is located approximately 4 km from the Mine Site at an elevation of 780 masl, but only provides reliable precipitation data during non-freeze months that have a monthly mean temperature greater than zero degrees Celsius.

Table 6.1-3. Regional Climate Stations

Station Name	Station ID	Latitude, Longitude	Active	Elevation (masl)	Distance from Site (from the TSF in km)	Start Year	End Year	Span of Record (years)	Complete Years	Mean Annual Precipitation (mm)
Afton	322	50.673, -120.482	Yes	780	4.0	1988	2014	27	6	234
Leighton Lake	307	50.615, -120.836	Yes	1,167	21.3	1982	2014	33	6	292
Monte Creek	116NJ9F	50.653, -119.954	No	351	40.9	1986	2007	22	20	360
Pinantan Lake	1166JFR	50.716, -119.945	No	960	42.1	1986	2006	21	7	479
Sun Peaks (Lower)	116Q20D	50.882, -119.882	No	1,260	52.4	1994	2008	15	0	N/A
Sun Peaks (Upper)	116QK0M	50.902, -119.918	Yes	2,040	51.3	1994	2013	20	0	N/A
Sun Peaks Mountain	1168204	50.903, -119.911	No	1,814	51.8	1980	2008	29	1	1,024
Kamloops Valleyview	1163875	50.675, -120.253	No	347	19.9	1962	2005	44	32	283
Kamloops Pratt Road	116C8P0	50.600, -120.200	Yes	640	24.2	1986	2014	29	23	374
Kamloops Rayleigh	116L87J	50.818, -120.295	No	357	25.1	1986	2002	17	7	340
McLure	1165030	51.047, -120.222	No	381	49.4	1967	2009	43	35	450
Kamloops Airport	1163780	50.708, -120.450	Yes	345	6.9	1953	2014	62	60	269
Kamloops Cherry Creek	1163814	50.683, -120.583	No	556	4.9	1970	1974	5	3	258
Highland Valley Lornex	1123469	50.467, -121.017	No	1,268	40.2	1967	2011	45	31	391
Highland Valley BCCL	1123468	50.500, -121.000	No	1,470	37.2	1966	1989	24	10	385
Logan Lake	1124668	50.500, -120.817	No	1,101	26.3	1971	2005	35	8	394
Red Lake	1166658	50.933, -120.800	Yes	1,162	41.0	1974	2013	40	23	493
Criss Creek	1162177	51.033, -120.733	Yes	1,122	45.3	1988	2013	26	23	449
Kamloops Afton Mines	1163790	51.666, -120.500	No	701	5.0	1977	1993	17	13	305

Notes:
"Complete Years" refers to total precipitation data.
British Columbia Forest, Lands and Natural Resources Operation data was derived from <http://bcwildfire.ca/weather/stations.htm>.
Environment Canada data was derived from <www.climate.weatheroffice.ec.gc.ca/climatedata/canada_e.html>.

Long term climate is predicted to change and there is some concern about whether or not historical climate records reasonably represent conditions that might be expected over the life of the Project and into Post Closure. The 2014 Climatology Report characterizes long term climate trends for the Project area (Appendix 6.1-A). Historic trends of annual temperature, precipitation, and unit runoff were examined to analyze long-term regional climate trends for the Project area. The Kamloops Airport climate station has the longest climate record available in the region with over 61 years of complete data from 1951-2011; this dataset was used to analyze long-term regional climate trends.

Methods

Site specific data from primarily the AJAXMET climate station were correlated with data from regional climate stations to generate synthetic long-term series. The methodologies for characterizing long term temperature, relative humidity, wind velocity and direction, precipitation, potential evapotranspiration and sublimation are detailed in the 2014 Climatology Report presented as Appendix 6.1-A of the Application/EIS.

Climate trends were reviewed for the Project area by assessing trends for temperature data sets for Average Annual Mean Maximum Monthly Temperature, Mean Annual Temperature and Average Annual Mean Minimum Monthly Temperature. Climate cycles were reviewed in terms of strong atmospheric and oceanic climate forcings that may be responsible for increasing temperature trends.

Baseline Results

Detailed characterization of the baseline climate for the Project area is presented in the Climatology Report (Appendix 6.1-A). The key findings of the baseline study that are generally applicable at an elevation of 950 masl are:

- The long-term average annual temperature is estimated to be 6.4 ^{o}C, with average monthly temperatures ranging from 18.7 °C in July to -4.9 °C in December.
- Relative humidity varies throughout the year, but is typically highest in mid-winter and lowest in mid-summer, with respective estimated long-term monthly average values of approximately 88.5% in January and 48.6% in July.
- The average wind speed for the period of record is 2.3 m/s at the AJAXMET station and the wind blows predominantly north-westerly in the summer and south-south-easterly in the winter.
- The long-term mean annual precipitation is estimated to be 336 mm.
- Precipitation is reasonably evenly distributed throughout the year, although June and July are typically the wettest months due to convective storm activity.
- Approximately 30% of precipitation is expected to fall as snow, corresponding to the mean annual snowfall (snow water equivalent) of 101 mm.
- Approximately 70% of precipitation is expected to fall as rain, corresponding to the mean annual rainfall of 235 mm.
- The mean annual lake evaporation is estimated to be 585 mm.

- The 1 in 10 year maximum 24-hr precipitation is estimated to be 43.2 mm.
- The probable maximum 24-hr precipitation is estimated to be 219.1 mm.
- Sublimation was estimated to be 28 mm for the winter season.

Long term climate trends analysis indicate an overall increase in annual mean temperature at a rate of approximately 0.3°C per decade, which is generally consistent with the PCIC prediction for the Project area. The composition of annual precipitation is predicted to change, with increased rainfall and decreased snowfall. The long term climate trends suggest that the baseline climate conditions may be different (warmer, more rain, less snow) in the future than during the period of historical record for the Project area.

The expectation is that BC is entering the next cold phase of the Pacific Decadal Oscillation (PDO) which is generally associated with colder and wetter conditions in BC (Pike et al. 2008). The annual mean temperature trends for each past phase of the PDO indicate that the PDO has very little influence and that it is reasonable to conclude that increases in temperature will persist in the foreseeable future even with the next cold phase of the PDO.

GHG Emissions Baseline of Other Emitting Facilities

The purpose of presenting a GHG Emissions Baseline of Other Emitting Facilities is to enable a comparison of the anticipated GHG emissions of the Project to the GHG emissions of other industrial facilities and emitters. By reviewing the GHG emission of other industrial facilities and emitters, one can determine if the Project is likely to generate high or medium volumes of GHG emissions. Examples of projects likely to generate high or medium GHG emissions include activities such as large scale industrial manufacturing, coal-fired generating plants, and electrical generation through the burning of fossil fuels (Federal-Provincial-Territorial Committee on Climate Change and Environmental Assessment 2003).

This section of the Application/EIS includes a summary of the existing/baseline GHG emitting facilities in BC and their reported GHG contributions to satisfy the information requirement of the AIR/EIS Guideline. The pre-Project contribution of GHGs to the atmosphere is assumed to be zero prior to the commencement of Project-related activities in the Construction phase.

Data Sources

Existing data sources utilized to develop the GHG Emissions Baseline include:

- annual BC Greenhouse Gas Inventory Report, Ministry of Environment;
- previously submitted Environmental Assessment Applications/EIS for proposed mines in BC;
- currently operating mines in BC; and
- national, provincial, regional and local policies and regulations including the community energy efficiencies inventory for the city of Kamloops.

Methods

Publicly available existing information was reviewed to generate the GHG Emissions Baseline for other emitting facilities.

The *BC Reporting Regulation* of the *Greenhouse Gas Reduction (Cap and Trade) Act* requires that industrial facilities in BC that emit 10,000 tonnes or more of CO_2eq per year report their emissions to government on an annual basis. Information related to GHGs emitted by the mining industry is documented in the BC Greenhouse Gas Inventory Report 2012 prepared by the Ministry of Environment (Ministry of Environment 2014c).

Summaries of the national, provincial, regional and local policies and regulations that may apply to the Project and a profile of the metal mining industry are also presented in this section of the Application/EIS.

Baseline Results

Other Emitting Facilities

Within the 30 km by 30 km area, there are two existing industrial facilities that emit 10,000 tonnes or more of CO_2eq per year and report their emissions to the provincial government on an annual basis. These included in 2012 the New Gold Mine (13,224 tonnes CO_2eq) and the Domtar Mill (1,772,560 tonnes CO_2eq).

A desktop scoping level review was conducted of other proposed and currently operating metal mining projects in BC and compared with the Project to determine if the potential exists to generate high or medium GHG emissions from metal mining projects. All operating facilities that have GHG emissions of 50,000 tonnes CO_2eq or more per year are required to submit a report to Environment Canada in accordance with the Greenhouse Gas Emissions Reporting Program (GHGRP) under the authority of Section 46 of the *Canadian Environmental Protection Act*, 1999 (Environment Canada 2014c). Reported Facility Greenhouse Gas Data for 2012 are available on the Environment Canada website (Environment Canada 2014b).

For comparison, proposed metal mines currently under provincial review, have recently received an Environmental Assessment Certificate (EAC), or currently operating are presented in Table 6.1-4 (Environmental Assessment Office 2014).

A total of 256,883,133 tonnes of GHG emissions were reported from 549 facilities in 2012. Eight coal mines in BC submitting data to Environment Canada's Greenhouse Gas Emissions Reporting Program had average GHG emissions of 234,419 tonnes of CO_2eq in 2012, while seven pulp and paper mills in BC reported average GHG emissions of 103,010 tonnes of CO_2eq. The Fort Nelson Gas Plant – Spectra Energy Transmission reported the largest GHG emissions in 2012, with 1,683,927 tonnes of CO_2eq.

Based on this preliminary scoping step, the Ajax Project, a metal mine with a production rate of 60,000 tonnes per day, is anticipated to generate low to medium GHG emissions within the range of other proposed, approved and operating metal mines in BC listed in Table 6.1-4.

Table 6.1-4. Proposed and Currently Operating Metal Mines in BC

Metal Mining Project	Status	Production (tonnes of ore/day)	Greenhouse Gas Emissions (CO_2eq/year)
KSM (Kerr-Sulphurets-Mitchell) Gold/ Copper/Silver/Molybdenum Project	EAC received July 2014	130,000	112,664 predicted in construction 170,285 predicted in operations (Rescan Environmental Services 2013)
Morrison Copper/Gold Project	Under Review	30,000	30,200 predicted (Rescan Environmental Services 2009)
Kitsault Molybdenum Mine Project	EAC received March 2013	40,000 to 50,000	35,845 predicted (AMEC 2011)
Prosperity Gold-Copper Project	EAC received January 2010	70,000	57,408 predicted in construction 52,636 predicted in operations (Canadian Environmental Assessment Agency 2010)
Gibraltar Copper-Molybdenum Mine	Operating	85,000	70,959 actual in 2012 (Taseko 2013)
Mount Polley Copper and Gold Mine	Operations Suspended 2014	22,191	41,826 actual in 2012 (Imperial Metals Corporation 2013)
New Afton Gold Mine	Operating	11,000	13,224 actual in 2012 (Ministry of Environment 2014b)
Teck Highland Valley Copper Mine (Copper and Molybdenum)	Operating	135,000	158,435 actual in 2012 (Teck 2013)

British Columbia Emissions

British Columbia was responsible for contributing approximately 8.9% of Canada's GHG emissions in 2008. The following information related specifically to the mining industry is presented in the BC Greenhouse Gas Inventory Report 2012 (Ministry of the Environment 2014c):

- The Energy Sector (which includes emissions from stationary and transport fuel combustion and fugitive emissions from the fossil fuel industry) accounted for 48,587 kt of BC GHG emissions in 2012 (79% of the total), an increase of 1.5% since 2009.
- Emissions from energy sub-sector 'a' (Stationary Combustion Sources) totalled 20,438 kt; emissions from energy sub-sector 'b' (Transport) were 23,334 kt.
- Stationary Combustion Sources from the mining and oil and natural gas extraction category totalled 1,759 kt CO_2eq; this represented an increase of 24.2% and 520.0% in the 3-year and 10-year trends, respectively.
- Road Transportation accounts for the majority of GHG emissions in the energy Transport sub-sector category, with 14,581 kt CO_2eq; the 3-year and 10-year trends showed a decrease of 6.1% and 0.7%, respectively.
- Off-road gasoline and diesel emissions are included as "other transportation", and totalled 3,572 kt CO_2eq in 2012. The 3-year trend showed an increase of 49.8%; the key factors influencing this trend were described as forest, mining and agriculture off-road vehicle activity.

- Afforestation, Deforestation and other land use conversions produced a total of 3,558 kt in 2012, equal to 5.8% of total BC emissions; the 3-year trend showed an increase of 7.5%.

National Policies and Regulations

Canada became a signatory to the Kyoto Protocol under the United Nations Framework Convention on Climate Change (UNFCCC) in 1998 and formally ratified participation in Kyoto in 2002. Under the Kyoto Protocol, Canada committed to reducing its GHG emissions to 6% below 1990 levels by 2012 (Environment Canada 2013b). Canada's Climate Action plan was released in 2002 and described measures that Canada would take to meet its climate change commitments to the Kyoto Protocol (Government of Canada 2002). Emission intensity reduction targets were implemented by the federal government in October 2006, designed to improve the health of the environment; short-term emission reduction targets were expected to come into force in 2010 (Government of Canada 2007). However, in 2010 the government announced that programs and policies to begin to reduce Canada's emissions had only been recently introduced and implemented, and therefore the benefits would not fully accrue during the Kyoto period; Canada formally withdrew from the Kyoto Protocol in December 2011 (Government of Canada 2010).

Canada remained a signatory to the UNFCC and a Party to the Conference of the Parties, participating in annual Conference of the Parties sessions and negotiations. The Copenhagen Accord came about as a result of the 15th Conference of the Parties in 2009, and includes emission reduction commitments from all major emitters; in 2010 Canada committed to reducing its GHG emissions to 17% below 2005 levels by 2020 (Environment Canada 2013b).

In the "Regulatory Framework for Air Emissions" the Canadian government outlined a regulatory agenda for industrial sources, transportation, and consumer and commercial products and committed to reducing total GHG emissions by 20% by 2020 and by 60% to 70% by 2050, relative to 2006 levels (Government of Canada 2007). Canada has implemented a sector-by-sector regulatory approach to reduce GHG emissions, starting with the transportation and electricity sectors (Government of Canada 2014a). However, it is estimated that Canada's GHG emissions will not be met with existing measures, and that GHG emissions will be 7.4% above 2005 levels, instead of 17% below (Office of the Auditor General of Canada 2012). The current government approach to address climate change is through regulations to reduce GHG emissions; investment in clean energy technology and climate change adaptation; scientific research to support policy development; and supporting international climate change efforts (Government of Canada 2014b).

Canada is committed to working internationally to address climate change through the United Nations, including through providing greenhouse gas emissions data and reporting on progress in reducing net greenhouse gas emissions (Government of Canada 2014b). In support of this, operating facilities that have GHG emissions of 50,000 tonnes or more per year in carbon dioxide equivalent units are required to submit a report to Environment Canada in accordance with the GHGRP; these data allow the federal government to develop a precise picture of the sources and amounts of GHGs from facilities, and evaluate climate change policies and strategies (Environment Canada 2014c).

Provincial Policies and Regulations

The Government of BC has enacted several pieces of climate-action legislation, including the *Greenhouse Gas Reduction Targets Act* (GGRTA) and *Greenhouse Gas Reduction (Renewable and Low Carbon Fuel Requirements) Act*. The GGRTA was passed in November 2007 and came into force January 2008; it sets legislated targets for reducing greenhouse gases, which include:

- reducing GHG emissions by at least 33% less than 2007 emission levels by 2020; and
- reducing GHG emissions by at least 80% less than 2007 emission levels by 2050.

The GGRTA applies to emissions from public sector organizations, including schools, colleges, universities, health authorities, and Crown corporations. The *Carbon Neutral Government Regulation* under the GGRTA was enacted in December 2008, and applies to the provincial public sector. The government achieved carbon neutrality for the years 2010, 2011, and 2012, by reducing emissions as much as possible and purchasing reductions/offsets to reach net-zero GHG emissions (Ministry of Environment 2013). The GGRTA also provided authority for the *Emission Offsets Regulation* (enacted in December 2008, and amended in December 2010). This regulation applies to the provincial government's commitment to a carbon-neutral public sector and sets out requirements for GHG reductions and removals to be recognized as emission offsets.

The *Carbon Tax Act* was enacted in 2008; the tax applies to the purchase of fuels and is collected in the same way as other motor fuel taxes. The Ministry of Finance describes the tax as one based on GHG emissions generated from burning fuels that will "elicit a powerful market response" (Ministry of Finance 2014). Businesses and individuals can reduce the amount they pay by reducing fuel consumption, increasing fuel efficiency, using cleaner fuels, or adopting new technologies (Ministry of Finance 2014).

The *Greenhouse Gas Reduction (Cap and Trade) Act*, enacted in May 2008, provides the statutory basis for a market-based cap and trade system to reduce GHG emissions from large emitters. Cap and trade regulatory systems establish an overall limit on emissions ("cap") and allow emitters to buy and sell emissions allowances or buy offset units ("trade") (Ministry of Environment 2008a). The Reporting Regulation of the Act, passed in November 2009, is the mechanism by which industrial operations that emit 10,000 tonnes or more of CO_2eq are required to submit their Facility GHG Reports to the Province; the reports are posted publicly on the Ministry of Environment website. The proposed Offsets Regulation would establish a single standard for developing compliance grade offsets, and establish criteria to track emission reductions. The proposed Emissions Trading Regulation will establish a market for trading cap-and-trade compliance units, and include rules on how allowances are created, distributed, auctioned, traded, tracked, and retired.

The *Greenhouse Gas Reduction (Emissions Standards) Statutes Amendment Act* was passed in May 2008, with the purpose of reducing GHG emissions from some industrial operations. As a result of this Act, amendments were made to the *Environmental Management Act*, the *Forest Act*, and the *Forest and Range Practices Act* (Ministry of Environment 2008b). Changes to the *Environmental Management Act* pertain primarily to waste management facilities and electricity generation facilities; changes to the *Forest Act* and *Forest and Range Practices Act* are related to the use of waste wood as a potential energy source and the use of beetle-kill wood (Ministry of Environment 2008b).

The *Greenhouse Gas Reduction (Renewable and Low Carbon Fuel Requirements) Act* was passed in April 2008; the purpose of the act is to set new requirements for transportation fuels to promote the use of renewable fuel in transportation fuel blends and decrease the amount of carbon. The BC Energy Plan committed the Province to establish a 5% average renewable fuel standard for diesel fuel and gasoline by 2010; the *Greenhouse Gas Reduction (Renewable and Low Carbon Fuel Requirements) Act* created the regulatory framework to meet this goal (Ministry of Energy, Mines and Petroleum Resources 2008).

The *Greenhouse Gas Reduction (Vehicle Emissions Standards) Act* was also passed in 2008; the standards were designed to cut GHG emissions by 30% relative to 2008 vehicle models by 2016. The Act is not currently in force.

Regional Policies and Regulations

The TNRD passed a recommendation in 2011 to adopt an Official Community Plans Amendment Bylaw requiring local governments to include GHG reduction targets, policies, and actions (Thompson-Nicola Regional District 2011). The TNRD publishes a Community Energy and Emissions Inventory (CEEI) Report every two years as part of its commitment to the Climate Action Charter (Thompson-Nicola Regional District 2014). The 2010 CEEI reported that GHG emission sources were dominated by on-road transportation (64%), followed by buildings (29%) and solid waste (7%); these values were similar to those reported for the province of BC. Light trucks, vans, and SUVs contributed 40% of the on-road transportation emissions; commercial vehicles and tractor trailer trucks were responsible for 19% and 15% of the emissions, respectively, and small and large passenger cars contributing 14% and 9%.

Local Policies and Regulations Including the Community Energy Efficiencies Inventory

The city of Kamloops signed the BC Climate Action Charter in 2007, pledging to significantly cut GHG emissions, and is working to become a carbon neutral government as part of its commitment (City of Kamloops website, August 26, 2014). Local governments that are signatories to the Charter commit to measuring and reporting on their community's GHG emissions profile; work toward carbon neutrality in corporate emissions; plan for more compact, more energy efficient communities; and report annually on their progress toward achieving these goals (Ministry of Environment website, August 26, 2014a).

The Kamloops Official Community Plan lists the following targets to reduce GHG emissions:

- reducing community-wide GHG emissions by 40% below 2007 levels by 2020;
- reducing residential-based GHG emissions to 0.9 tonnes per capita by 2020;
- reducing transportation related GHG emissions to 2.4 tonnes per capita by 2020;
- increasing use of alternative transportation to 30% of all trips; and
- reducing absolute GHG emissions from municipal corporate operations to 4,600 tonnes by 2020 (45% reduction).

The city also set a goal of achieving municipal corporate carbon neutrality by 2012 and investing 100% of carbon offsets through local initiatives in partnership with other public and private sector entities (Hardman 2014). Annual corporate emissions reported by the city of Kamloops in 2013 were

approximately 8,472 tonnes CO_2eq for emissions from services delivered directly by the local government and approximately 287 tonnes CO_2eq for emissions from contracted services (Hardman 2014). The city Corporate Energy and Emissions Plan is currently in development.

Mining Industry Profile

Articles 4 and 12 of the UNFCCC commit signatories to the Copenhagen Accord to develop and publish national inventories of anthropogenic GHG emissions by sources and removals by sinks; Canada's National Inventory Report is submitted to the UNFCCC by April 15 of each year (Environment Canada 2013b). Emissions are reported for six sectors as defined by the Intergovernmental Panel on Climate Change; these sectors are:

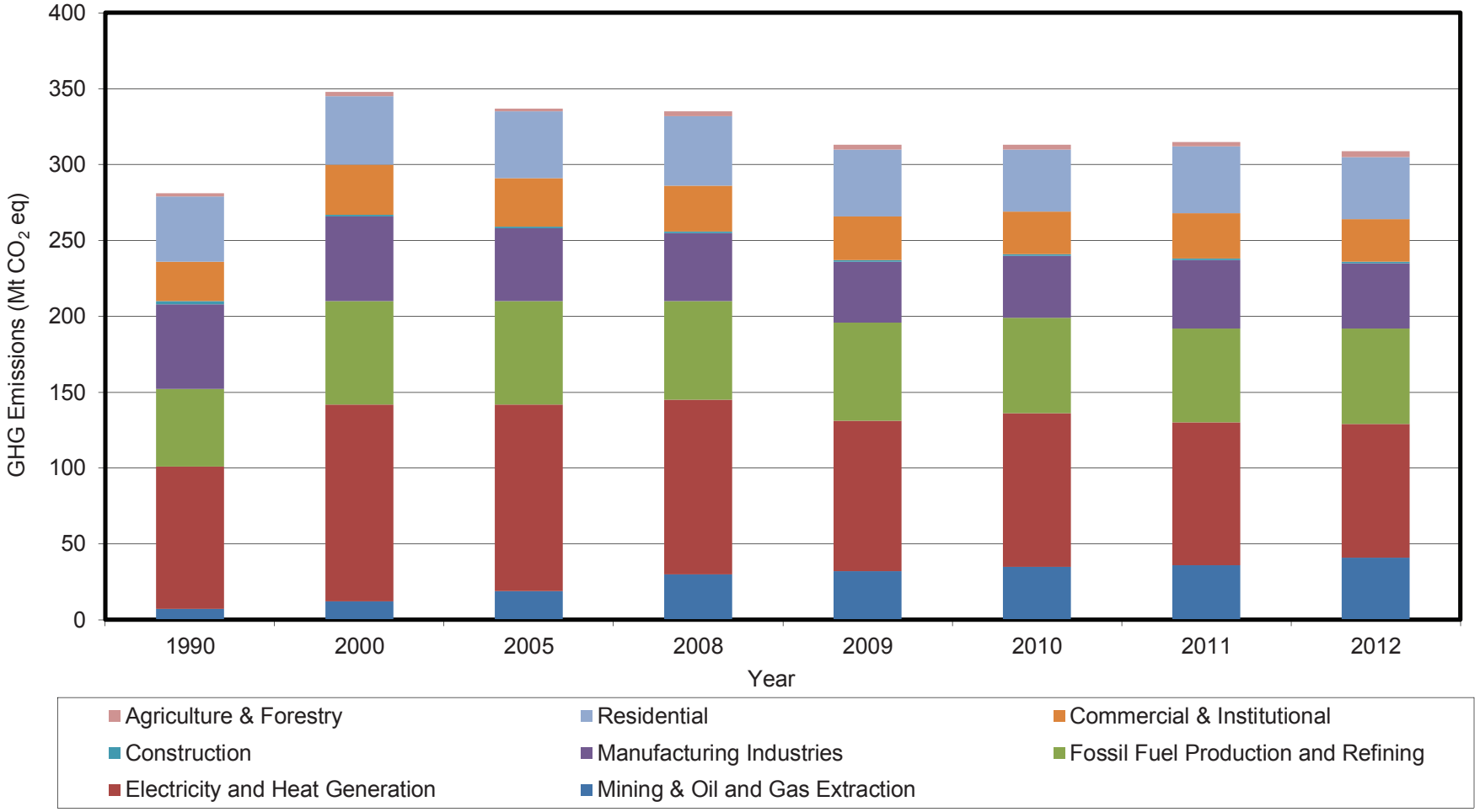
- Energy
- Industrial Processes
- Solvent and Other Product Use
- Agriculture
- Waste, and Land Use
- Land Use, Land-Use Change and Forestry (LULUCF).

In 2012, Canada's total GHG emissions were estimated to be 699 megatonnes (Mt) CO_2eq, excluding land use change estimates; the energy sector accounted for 566 Mt CO_2eq (Environment Canada 2013b). Within the energy sector, GHG emissions from stationary combustion sources used in the Mining and Oil and Gas Extraction category have increased in all reporting periods since 1990 (Figure 6.1-3); most of the growth in energy emissions is reported in the Mining and Oil and Gas Extraction and the Road Transportation categories (Environment Canada 2013b). The increase in emissions from the Mining and Oil and Gas Extraction category is primarily related to a 72% increase in the total production of crude oil and natural gas (Environment Canada 2013b). Emissions from heavy-duty diesel vehicles increased by 109% between 1990 and 2012; this was attributed to a 137% increase in tonne-kilometres shipped by for-hire trucking between 1990 and 2003 (Environment Canada 2013b).

The National Inventory Report also presents GHG emission data by economic sector; mining is included within the Emissions Intensive and Trade Exposed Industries economic sector (Environment Canada 2013b). Within the economic sector categories, increases in GHG emissions were largely the result of growth in the oil and gas and transportation areas; decreases were seen in the Electricity (6 Mt) and Emissions Intensive and Trade Exposed Industries (17 Mt) in the reporting period between 1990 and 2012 (Figure 6.1-4).

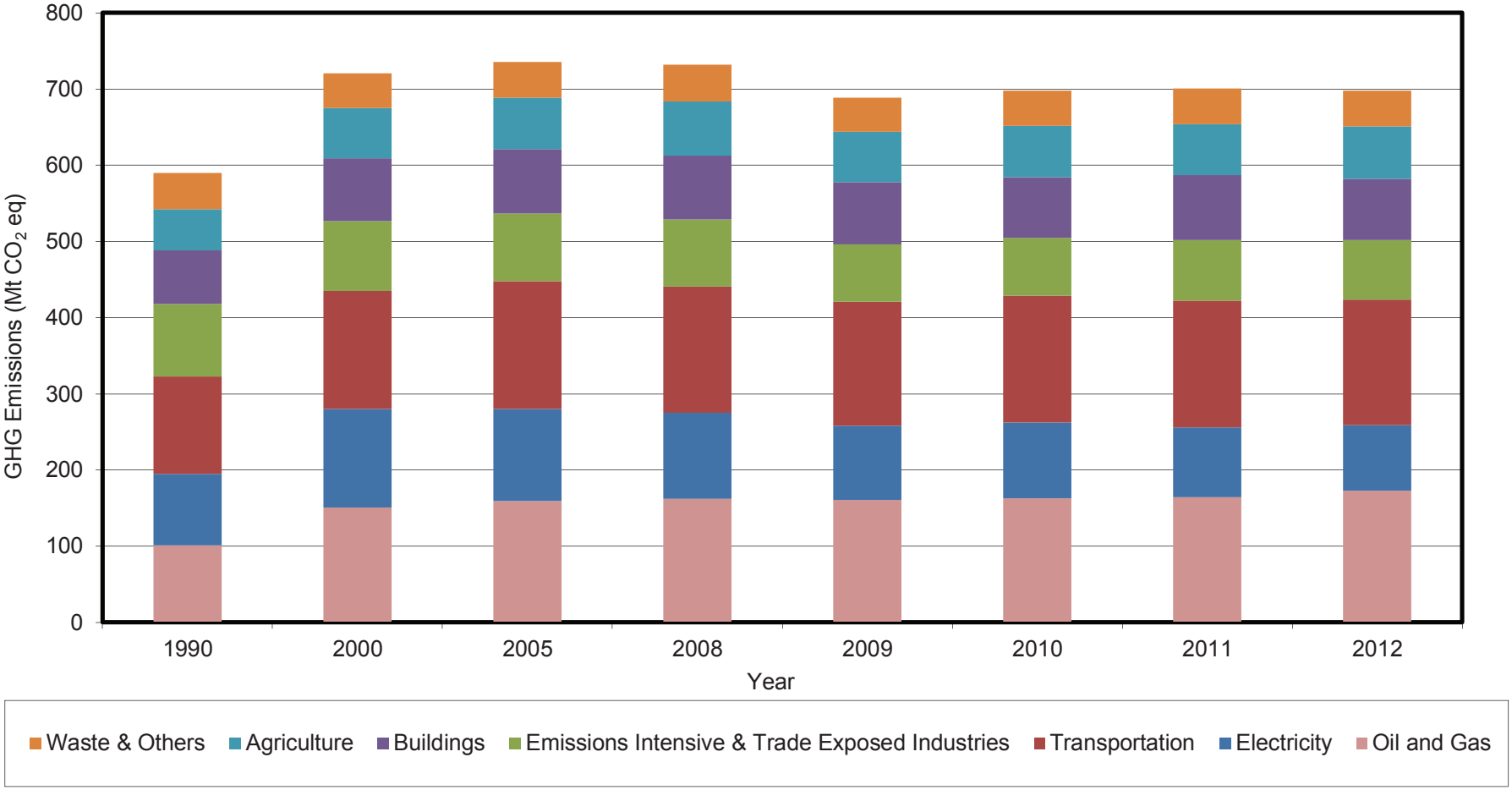
Information related to the mining industry can be found in the BC Greenhouse Gas Inventory Report 2012 and was summarized in Section 6.1.2.3 (Ministry of the Environment 2012b). A total of 719,450 tonnes CO_2eq were reported by the 12 metal mines that submitted data under the Environment Canada Greenhouse Gas Emissions Reporting Program in 2012. Highland Valley Copper, Mount Polley, and Gibraltar were the only BC mines that reported in 2012, with a total of 271,220 tonnes CO_2eq.

Figure 6.1-3
Energy GHG Emissions from Stationary Combustion Sources (1990-2012)



NOTES:
1. SOURCE: NATIONAL INVENTORY REPORT 1990-2012: GREENHOUSE GAS SOURCES AND SINKS IN CANADA - EXECUTIVE SUMMARY. ENVIRONMENT CANADA 2014.

Figure 6.1-4
GHG Emissions by Economic Sector (1990-2012)



NOTES:
1. SOURCE: NATIONAL INVENTORY REPORT 1990-2012: GREENHOUSE GAS SOURCES AND SINKS IN CANADA - EXECUTIVE SUMMARY. ENVIRONMENT CANADA 2014.
2. MINING IS INCLUDED IN THE EMISSIONS INTENSIVE AND TRADE EXPOSED INDUSTRIES. OTHER INDUSTRIES INCLUDE SMELTING AND REFINING, AND PRODUCTION/PROCESSING OF INDUSTRIAL GOODS.

The BC Reporting Regulation of the *Greenhouse Gas Reduction (Cap and Trade) Act* requires that industrial facilities in BC that emit 10,000 tonnes or more of CO2eq per year report their emissions to government on an annual basis; data are available from 2010 onwards. The Ministry of Environment has prepared a BC GHG inventory report as required under section 4(a) of GGRTA for every even year and summary tables for every odd year since 2007 (considered the base year for calculation of GHG emissions targets established under the GGRTA) (Ministry of the Environment 2012b). The provincial reports follow the National Inventory Reports in the use of sectors and sub-sectors (energy, industrial processes, etc.).

Data from the 2013 Consolidated BC Emissions Report Summaries are available on the Ministry of Environment website (Ministry of Environment 2014b); a total of 234 facilities reported emissions totalling 19.31 Mt of CO_2eq. Of the 234 facilities that submitted BC Emissions Report Summaries in 2013, 16 were operating mines that reported 2,177,990 tonnes CO_2eq from stationary combustion, industrial processes, fugitive sources, on-site transportation, and waste. Coal mines contributed the majority of this amount, as shown on Figure 6.1-5. Total emissions from metal mines were reported as 345,372 tonnes CO_2eq, with the Highland Valley Copper mine contributing the majority (146,105 tonnes CO_2eq). On-site transportation accounted for 86% of the emissions from metal mines.

6.1.3 Assessment Boundaries

Assessment boundaries define the maximum spatial and temporal limits within which the effects assessment for the GHG Management VC was conducted. They encompass the areas within and times during which the Project is expected to interact with the GHG VC, as well as the constraints that are placed on the assessment of those interactions due to political, social, and economic realities (administrative boundaries), and limitations in predicting or measuring changes (technical boundaries). The GHG Management LSA and RSA are shown on Figure 6.1-6.

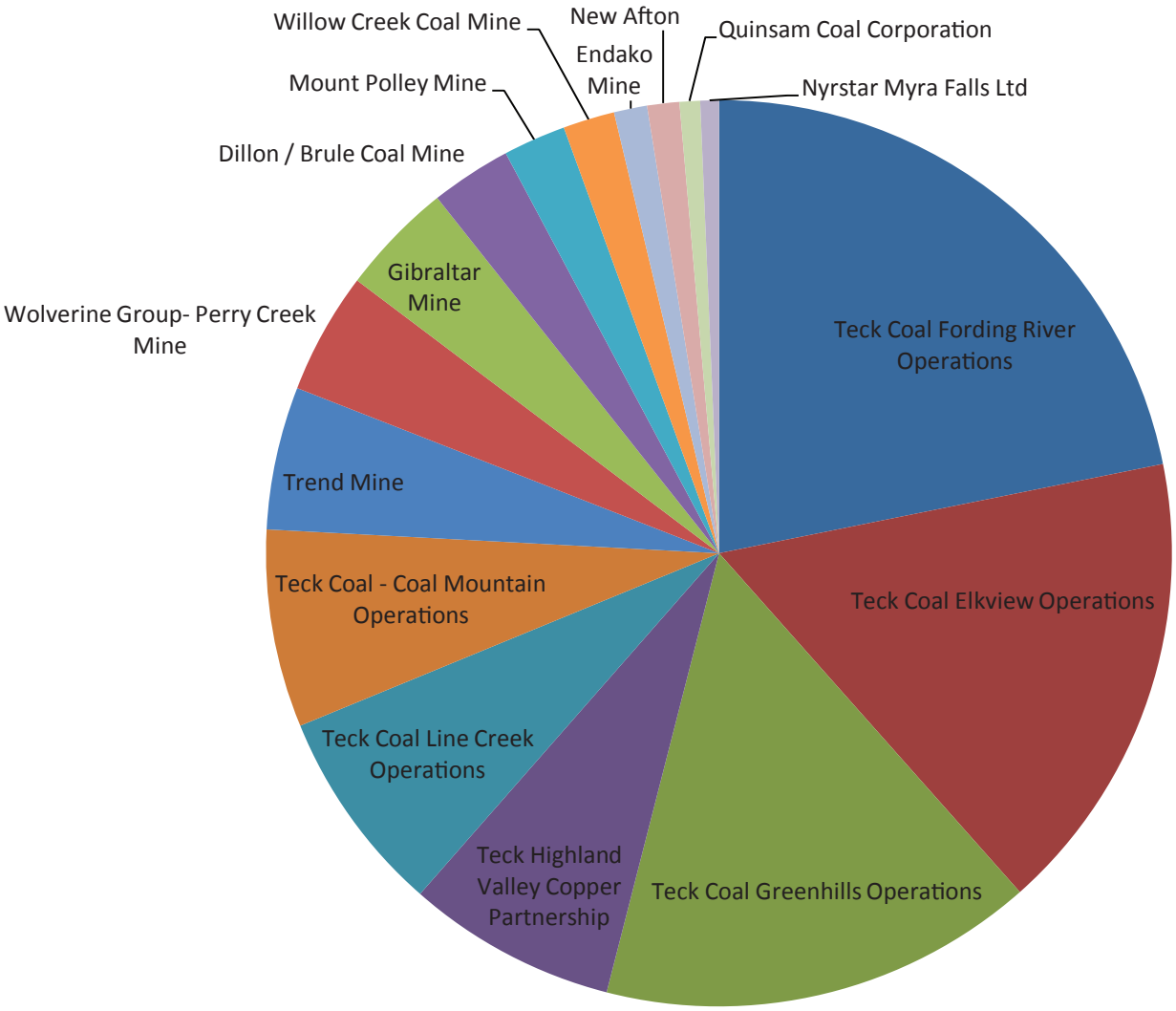
6.1.3.1 Spatial Boundaries

Local Study Area

The local study area (LSA) for the GHG Management VC is defined as the spatial area within which Project components and activities are anticipated to emit GHGs or alter the ability of the land to absorb GHGs. For the purpose of this assessment, the LSA will encompass the Mine Site, access road, transport route from the Mine Site to Port Metro Vancouver, transmission line and areas of potential land disturbance.

Regional Study Area

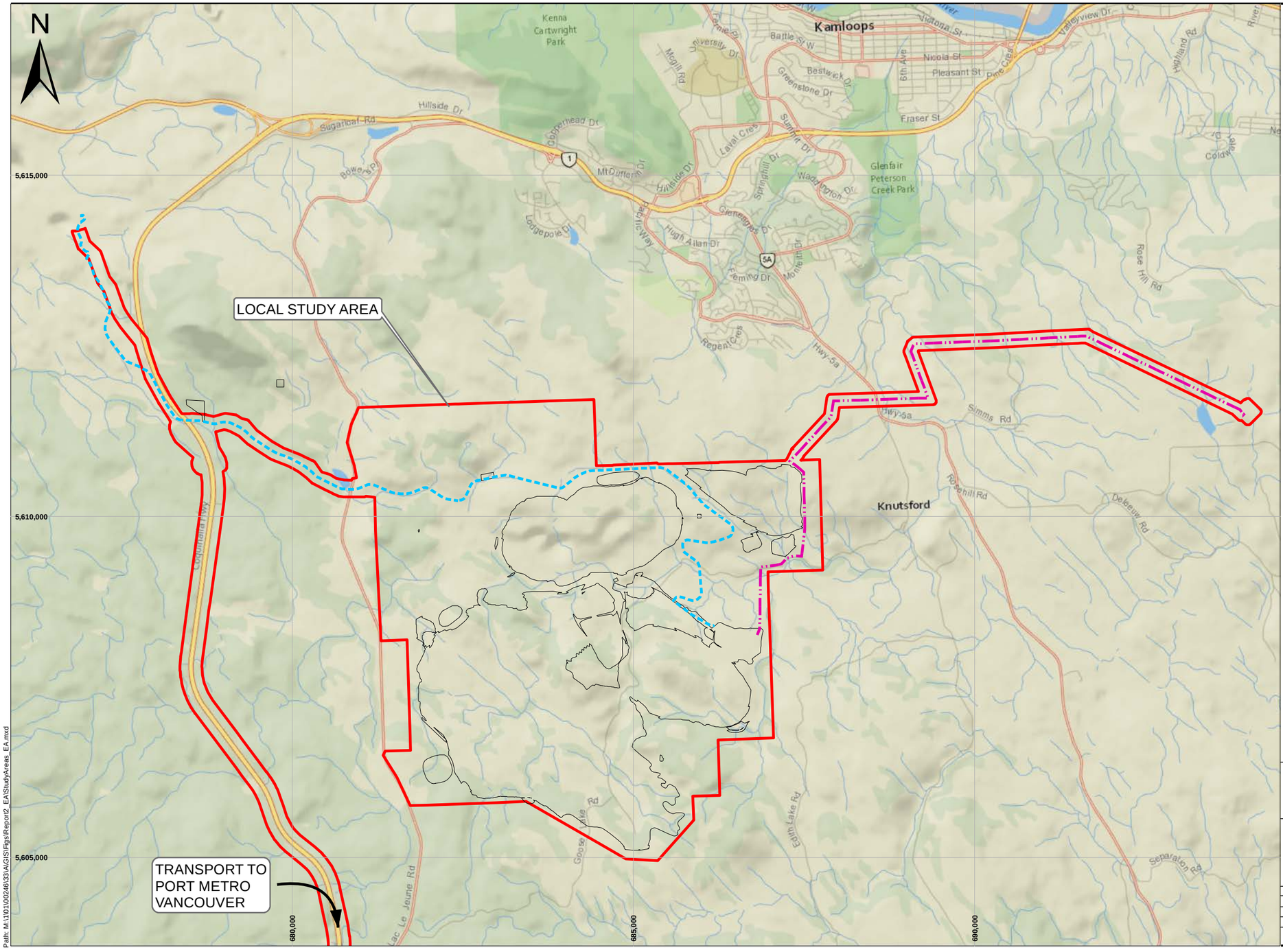
The regional study area (RSA) for the GHG Management VC is the Province of BC. Predicted Project GHGs will be compared to National and the Provincial GHG emissions.

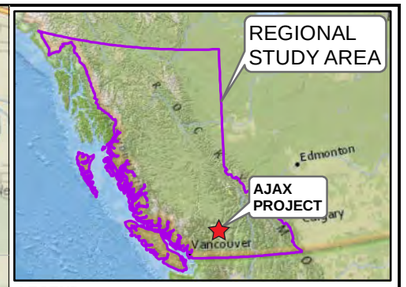


NOTES:
1. SOURCE: INDUSTRIAL FACILITY GREENHOUSE GAS EMISSION SUMMARIES 2013
http://www2.gov.bc.ca/gov/topic.page?id=14C1FA7186124D1C8CABA452C9DFCA56&title=Industrial%20Facility%20Greenhouse%20Gas%20Emissions%20

Figure 6.1-6
Greenhouse Gas Management Local and Regional Study Areas

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LEGEND:

GENERAL
- PROJECT LOCATION
- RIVER/CREEK
- LAKE
- PROVINCIAL PARK
- LOCAL STUDY AREA (LSA)
- REGIONAL STUDY AREA (RSA)

PROPOSED FACILITIES
- MINE INFRASTRUCTURE
- PROPOSED WATER SUPPLY PIPELINE
- PROPOSED TRANSMISSION LINE

NOTES:
1. BASE MAP: BC TRIM AND CANADA NTS MAPPING.
2. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD 1983 UTM ZONE 10N.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:60,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.

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6.1.3.2 Temporal Boundaries

The temporal boundaries of the assessment are the periods during which emissions will occur from Project activities and land use changes are anticipated. The temporal phases of the Project are:

- **Construction**: 2 years;
- **Operation**: 23 years;
- **Decommissioning and Closure**: 5 years (includes Project decommissioning, abandonment and reclamation activities, as well as temporary closure, and care and maintenance); and
- **Post Closure**: 5+years (includes ongoing reclamation activities and post-closure monitoring).

The focus of the GHG Management VC assessment is on the Construction and Operation phases, since the majority of Project emissions will occur during these phases. For the purpose of the assessment of the GHG Management VC, Project-related GHG emissions during decommissioning and closure and Post Closure are expected to be negligible in comparison. It is important to note that land clearing for Project infrastructure is anticipated to be on-going and progressive reclamation will be implemented, so the potential contribution of land use changes as a result of Project activities to GHG emissions will be based on the net land use alteration for the life of the Project.

6.1.3.3 Administrative Boundaries

Administrative boundaries do not influence scoping of the assessment.

6.1.3.4 Technical Boundaries

The assessment of the GHG Management VC is constrained by the fact that the contribution of an individual project to climate change cannot be measured due to the inherent global nature of the potential effects of climate change (Federal-Provincial-Territorial Committee on Climate Change and Environmental Assessment 2003). The only potential effect of the Project that is possible to consider in the assessment of the GHG Management VC is the contribution of GHG as a result of the Project based on a GHG emissions inventory. At best, the Project's predicted GHG emissions are used as a proxy for climate change and the potential adverse effects of the Project are evaluated through comparison to similar projects. Due to the technical constraints of this assessment, cumulative effects are not assessed though the Project's predicted overall GHG's emissions will be compared to the scale of provincial and federal emissions levels and targets. Also there are currently no legal requirements or benchmarks for GHG emissions within BC or Canada (Federal-Provincial-Territorial Committee on Climate Change and Environmental Assessment 2003).

6.1.4 Potential Effects of the Project and Proposed Mitigation for Greenhouse Gas Management

6.1.4.1 Identifying Potential Effects on Greenhouse Gas Management

The assessment of potential effects of the Project on GHG Management is adapted from methodology presented in "Incorporating Climate Change Considerations in Environmental Assessment: General

Guidance for Practitioners" (Federal-Provincial-Territorial Committee on Climate Change and Environmental Assessment 2003) described in detail in Section 6.1.4.

Figure 6.1-7 shows the five recommended steps of the guidance, Steps 1 to 4 are completed as part of the Environmental Assessment of the Project while Step 5 is repetitive in nature and will occur during the Construction and Operation phases of the Project.

In order to determine the magnitude of potential effects on Greenhouse Gas Management VC, an inventory of the anticipated GHG emissions of the Project is calculated and compared to the GHG emissions of other industrial facilities and emissions targets for BC and Canada.

At a preliminary level, the Project will directly generate GHG emissions through the burning of fuel in mobile and stationary heavy equipment and vehicles, both on and off site, and through blasting. The Project will also contribute indirect GHG emissions from the use of purchased electricity and through the transport of materials and supplies by contractors, and personnel on and off site. The list of components and activities associated with each phase of the Project (Construction, Operation, Decommissioning and Closure, and Post Closure) is presented in Table 6.1-5.

The Project will also affect carbon sinks through clearing of grasslands and forests for the Open Pit, MRSF, TSF and other infrastructure. Reclamation of disturbed area is anticipated to mitigate for some temporary loss of carbon sinks. The footprint area of the major facilities where land use changes are anticipated is used to calculate the potential net loss of carbon sinks as a result of the Project.

6.1.4.2 Effects on Greenhouse Gas Management

The effects of the Project on GHG Management is determined through a comprehensive inventory of GHG emission releases from the Project and GHG removals by carbon sinks for a defined area over a specified period of time (Ministry of Environment 2012b). The inventory includes emissions from both direct and indirect sources and carbon sinks, in accordance with the guidance for practitioners document (Federal-Provincial-Territorial Committee on Climate Change and Environmental Assessment document 2003).

Project-related direct and indirect emissions are separated into the following three scopes (Mining Association of Canada 2009, 2013; World Resources Institute and World Business Council for Sustainable Development 2013):

- Scope 1 Emissions: total direct emissions from sources owned or controlled by the reporting facility, including use of explosives and fossil fuel combustion by mobile and stationary equipment.
- Scope 2 Emissions: indirect GHG emissions through consumption of purchased electricity.
- Scope 3 Emissions: indirect emissions from sources owned or controlled by others that arise as a consequence of a facility activities; examples include mobile consumption in transportation services, business travel, and employee commuting.

Figure 6.1-7
GHG Management Effects Assessment Process

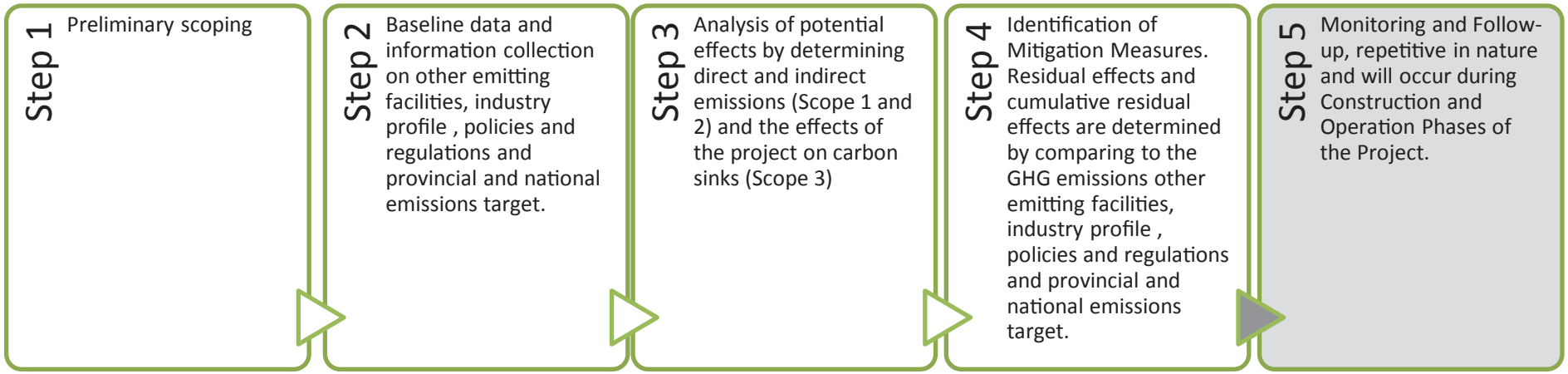


Table 6.1-5. Identifying Potential Project Interactions and Effects on Greenhouse Gas Management

	Project Component/Physical Activities	Potential Effects on Greenhouse Gas Management			
		Scope 1 Emissions	Scope 2 Emissions	Scope 3 Emissions	Land Use Change
Construction	Clearing and Grubbing	H	O	O	M
	Earthworks	O	O	O	O
	Overburden/Topsoil Stockpile	O	O	O	O
	Laydown Areas and Storage Yards	O	O	O	O
	Project Lighting	O	M	O	O
	Site Security and Fencing	O	O	O	O
	Fuel Storage and Filling Area	O	M	O	O
	Hazardous Wastes Transport, Storage, and Disposal	O	O	M	O
	Construction Wastes Transport, Storage, and Disposal	O	O	M	O
	Sewage Infrastructure and Disposal	H	M	O	O
	Public Road Realignment, Use, and Maintenance	H	O	M	O
	Site Road Construction, Use and Maintenance	H	O	O	O
	Haul Road Overpass	H	O	M	O
	Site Buildings and Process Plant	O	M	O	O
	Explosives Magazine and Storage Facilities	O	M	O	O
	Open Pit Development	H	O	O	M
	Drilling and Blasting	H	M	O	O
	Crushing Mine Rock	H	M	O	O
	Loading, Hauling, and Deposition of Mine Rock	H	O	O	O
	Temporary Ore Stockpile	O	O	O	O
	Tailing Storage Facility Development	O	O	O	O
	Power Transmission, Distribution	O	O	O	O
	Natural Gas Line	H	O	O	O
	Pipeline Utility Corridor (Potable Water, Sewage, and Site Water)	O	O	O	O
	Water Intake from Kamloops Lake	O	M	O	O
	Fire Suppression Infrastructure	O	O	O	O
	Contact Water	O	O	O	O
	Non-contact Water	O	O	O	O
	Peterson Creek Diversion	O	O	O	O
	Mine Staffing (Direct Employment)	O	O	O	O
	Contracted Employment	O	O	M	O
	Taxation	O	O	O	O

(continued)

Table 6.1-5. Identifying Potential Project Interactions and Effects on Greenhouse Gas Management (continued)

Project Component/Physical Activities		Potential Effects on Greenhouse Gas Management			
		Scope 1 Emissions	Scope 2 Emissions	Scope 3 Emissions	Land Use Change
Operation	Open Pit Development	H	O	O	M
	Drilling and Blasting	H	M	O	O
	Hauling Mine Rock and Ore from Pit	H	O	O	O
	Crushing and Conveying Ore	H	M	O	O
	Temporary Ore Stockpile	O	O	O	O
	Development of Waste Rock Management Facilities	O	O	O	O
	Stripping, Loading, Hauling, Deposition, and Contouring of Topsoil and Overburden	H	O	O	O
	Revegetation through Progressive Reclamation	O	O	O	M
	Process Plant Operation	O	M	O	O
	Deposition to Tailing Storage Facility	H	O	O	O
	Site Road Use and Maintenance (Materials, Personnel, Supplies)	H	O	O	O
	Concentrate Transport and Storage	O	O	M	O
	Explosives Magazine and Storage Facilities	O	M	O	O
	Fire Suppression Infrastructure	O	O	O	O
	Fuel Storage and Filling Area	O	M	O	O
	Hazardous Wastes Transport, Storage, and Disposal	O	O	M	O
	General Wastes Transport, Storage, and Disposal	O	O	M	O
	Sewage Infrastructure and Disposal	O	M	O	O
	Laydown Areas and Storage Yards	O	O	O	O
	Power Transmission, Distribution	O	O	O	O
	Project Lighting	O	M	O	O
	Site Access Security and Fencing	O	O	O	O
	Water Intake from Kamloops Lake	O	M	O	O
	Contact Water	O	O	O	O
	Non-contact Water	O	O	O	O
	Potable Water Treatment and Use	O	M	O	O
	Peterson Creek Diversion	O	O	O	O
	Mine Staffing (Direct Employment)	O	O	O	O
	Contracted Employment	O	O	M	O
	Taxation	O	O	O	O

(continued)

Table 6.1-5. Identifying Potential Project Interactions and Effects on Greenhouse Gas Management (completed)

Project Component/Physical Activities		Potential Effects on Greenhouse Gas Management			
		Scope 1 Emissions	Scope 2 Emissions	Scope 3 Emissions	Land Use Change
Decommissioning and Closure	Dismantling of Ancillary Buildings	L	O	O	O
	Pit Lake Planning	O	O	O	O
	Site Road/Bridge Decommissioning	L	O	O	O
	Tailing Storage Facility Decommissioning and Reclamation	L	O	L	M
	Mine Rock Management Facilities Reclamation	L	O	L	M
	Fuel Storage and Filling Area	O	O	O	O
	Hazardous Wastes Transport, Storage, and Disposal	O	O	L	O
	General Wastes Transport, Storage, and Disposal	O	O	L	O
	Sewage Infrastructure and Disposal	O	O	L	O
	Laydown Areas and Storage Yards	O	O	O	O
	Power Transmission, Distribution	O	O	O	O
	Project Lighting	O	L	O	O
	Site Access, Security and Fencing	O	O	O	O
	Contact Water	O	O	O	O
	Non-contact Water	O	O	O	O
	Potable Water Treatment and Use	O	L	O	O
	Peterson Creek Diversion	L	O	O	M
	Road use to the Project (Materials, Personnel, Supplies)	O	O	L	O
	Mine Staffing (Direct Employment)	O	O	O	O
	Contracted Employment	O	O	L	O
	Taxation	O	O	O	O
Post Closure	General Site Inspections and Maintenance	L	O	O	O
	Contact Water	O	O	O	O
	Non-contact Water	O	O	O	O
	Road use to the Project (Materials, Personnel, Supplies)	O	O	L	O
	Mine Staffing (Direct Employment)	O	O	O	O
	Contracted Employment	O	O	L	O

Notes:

O	*No interaction anticipated.*
L	*Negligible to minor interaction expected; implementation of best practices, standard mitigation and management measures; no monitoring required, no further consideration warranted.*
M	*Potential moderate interaction requiring unique active management/monitoring/mitigation; warrants further consideration.*
H	*Interaction; warrants further consideration.*

In addition to the three scopes of emissions, land use changes as a result of Project activities may affect existing carbon sinks within the Project area and over the life of the Project.

Project components, mobile and stationary equipment, and activities assessed are based on the Project Description provided in the AIR/EIS Guidelines, June 2014 Update (ERM Rescan 2014) and on design and engineering information provided by KAM (entitled EA Assessment Basis Aug18 Rev 1; June 2014 EA Mine Plan for consultants).

Project components and activities that are expected to contribute GHG emissions to the atmosphere (for Scope 1, Scope 2 and Scope 3 emissions) or result in a land use change (Land Use Change) that will affect carbon sinks are discussed in this section of the Application/EIS and summarized in the interactions matrix (Table 6.1-5).

The interactions matrix ranks Project Components and Activities by phase on a four-point scale for the potential to interact with the GHG Management VC, as follows:

- Zero (O): No interaction anticipated
- Low (L): Negligible to minor interaction expected; implementation of best practices, standard mitigation and management measures; no monitoring required, no further consideration warranted.
- Moderate (M): Potential moderate interaction requiring unique active management/ monitoring/mitigation; warrants further consideration.
- High (H): Key interaction; warrants further consideration.

Project components for which no interaction is anticipated, or for which there is a potential negligible to minor interaction are not carried forward in the assessment. Project components and activities with the potential to have a moderate or key interaction with the VC are carried forward for further analysis in the effects assessment.

For the purpose of the GHG Management VC effects assessment, Project components and activities either will contribute to Scope 1, Scope 2 or Scope 3 GHG emissions. For simplicity, Scope 1 emissions are considered to be direct emissions and are classified as High (H) interactions that warrant further consideration as a key interaction. Scope 2 and Scope 3 emissions are considered as indirect emissions and are classified as Moderate (M) interactions that may warrant further consideration. Project components and activities that will lead to land use changes that will affect existing carbon sinks are anticipated to be Moderate (M) interactions and the potential effects will be based on the net land use alteration for the life of the Project.

As mentioned above, All Project-related GHG emissions during the Decommissioning and Closure and Post Closure Phases are expected to be negligible in comparison to Project-related GHG emissions during the Construction and Operation Phases and have been determined to be Low (L) interactions that don't warrant further consideration.

The Project may contribute to GHG emission levels through two potential effects:

1. direct, indirect and other emissions (Scope 1, Scope 2 and Scope 3) will increase GHG levels in the atmosphere; and
2. land use changes, as a result of the Project, will affect carbon sinks and increase GHG levels in the atmosphere.

Effect 1: Direct and Indirect Emissions from the Project will Increase GHG Levels in the Atmosphere

The most common approach for calculating GHG emissions is to apply emissions factors, which are used to convert a unit of process activity data into an estimate of the resulting GHG emissions (Mining Association of Canada 2009). Emission releases were estimated using emission factors for fuel combustion and electricity emissions published in the 2012 provincial inventory report (Ministry of Environment 2012b). Unlike GHG inventories for operating mines, where emissions are calculated based on actual purchased quantities of fuels and metered electricity consumption, the GHG emissions for the Project is an estimate based on anticipated quantities using the best available information. The Global Warming Potential (GWP) of each GHG is used to calculate the carbon dioxide equivalence of the individual gases so that total emissions can be reported as CO_2eq. The GWPs used in the assessment were those recommended in the Technical Guidance on Reporting Greenhouse Gas Emissions (Environment Canada 2014c):

- CO_2 GWP value = 1
- CH_4 GWP value = 25
- N_2O GWP value = 29

Note that GWP values assigned by Environment Canada change over time so that total emissions calculated in one year are not necessarily comparable to total emissions reported in previous years, or total emissions reported for other projects.

Scope 1 Direct Emissions

KAM contracted Stantec Consulting Ltd. (Stantec) to quantify GHG emissions from a subset of the Project activities considered in the Application/EIS (Stantec Consulting Ltd. 2015). The GHG emissions originate from sources that are also included in the air quality emission inventory presented in Appendix E-Emissions Inventory of the Air Quality Appendix, of the Application/EIS. Stantec has prepared a memo to summarize its work to quantify Scope 1 Direct Emissions from the Project; this memo is attached as Appendix 6.1-B. The detailed assumptions and Project components included as part of the inventory of direct Project emissions are discussed in Appendix E - Emissions Inventory of the Air Quality Appendix. The information presented below for Scope 1 Direct Emissions is quoted from Appendix 6.1-B.

The Ajax Project will produce GHG emissions from the use of ammonium-nitrate fuel oil (ANFO) blasting agents and fuel burning for mobile equipment and heating.

For ANFO blasting, the following quantification methodologies were used. The Mining Association of Canada published a document entitled Energy and GHG Emissions Management Guidance (2009) which established an emission factor for carbon dioxide (CO_2) emissions originating from the use of ANFO in blasting operations. The emission factor is 0.189 kg of CO_2 per kg of ANFO used. The following formula was used to calculate the CO_2 emitted to the atmosphere as a function of ANFO usage anticipated on daily basis during the construction and operation phase of the Project.

$$CO_2\ Emissions\left(\frac{tonnes}{year}\right) = ANFO\ usage\left(\frac{tonnes}{day}\right) \times \left(\frac{365\ day}{year}\right) \times Emission\ Factor\left(\frac{0.189\ tonnes\ CO_2}{tonnes\ ANFO}\right)$$

Mobile equipment was disaggregated based on the intended Project activity with which that equipment will be involved. Similar to the air quality assessment, Tier 3 fuel consumption rates were incorporated into the emission estimation methodology, as well as the annual utilization hours. Activity data were then converted to emission assertions with the use of emission factors from the 2012 National Inventory Report (Environment Canada 2014b). The National Inventory Report provides emissions factors for light duty trucks, heavy duty vehicles and off-road vehicles fuelled by diesel. These emission factors were matched up against the fleet inventory and emissions were quantified based on the following equation.

$$Annual\ Emissions\left(\frac{tonnes}{year}\right) = Fuel\ Consumption\ Rate\left(\frac{L}{hour}\right) \times Emission\ Factor\left(\frac{g}{L}\right) \times Annual\ Utilization\left(\frac{hours}{year}\right) \times \left(\frac{tonnes}{10^6\ g}\right)$$

The total Scope 1 GHG emissions calculated from Project activities are presented below for the construction phase and the operation phase.

Construction Phase

Construction for the Project will begin with small earth works including road construction and pre-stripping. By Year -1, the Project will reach its peak pre-production activity with some pre-stripping still occurring in the pit, new haul roads will still be under development, some ditch construction will be occurring, and overburden and reclamation stockpile loading activities will continue. Year -1 is assumed to have the greatest construction activity; for this reason it is anticipated to have the greatest emissions during the Construction phase and was selected by Stantec for quantifying Construction phase GHG emissions.

In the Construction phase, Year -1, the GHG emissions calculated from ANFO blasting, mobile equipment and heating are presented in Table 6.1-6.

Table 6.1-6. Scope 1 Direct GHG Emissions during Construction (Year -1)

Activity	CO_2 (tonnes/year)	CH_4 (tonnes/year)	N_2O (tonnes/year)	CO_2eq (tonnes/year)
ANFO Blasting	910.7	n/a	n/a	910.7
Main Mining Equipment	23,143	1	0	26,024
Support Equipment	39,724	2	13	43,581

(continued)

Table 6.1-6. Scope 1 Direct GHG Emissions during Construction (Year -1) (completed)

Activity	CO_2 (tonnes/year)	CH_4 (tonnes/year)	N_2O (tonnes/year)	CO_2eq (tonnes/year)
Explosives Transport	2,096	0.12	0.06	2,116
Access Road Vehicles	2,861	0.11	0.1	2,908
Heating During Construction	2,100	0.04	0.04	2,112
Total	**70,834**	**4**	**23**	**77,652**

Note:
n/a = Not Available. The Energy and GHG Emissions Management Guidance (Mining Association of Canada 2009) does not identify an emission factor for this substance and therefore assumed to be negligible.

Operation Phase

The Operation phase was evaluated by quantifying GHG emissions for a "worst case" year where emissions are anticipated to peak. It was decided by KAM that the "worst case" year during the Operation phase would be evaluated for the GHG emission estimations. This approach would take features from different years to create an overall worst case year. The combination of features from Year 4 and Year 8 (herein known as Year 4/8) was established to be the worst case year during the Operation phase. This combination year would have the highest amount of material moved and the highest number of equipment in operations. During Year 4/8, all large mining features, including the East MRSF, are proposed to be active.

In Year 4/8 of the Operation Phase, the GHG emissions calculated from ANFO blasting, mobile equipment and heating are presented in Table 6.1-7.

Table 6.1-7. Scope 1 Direct GHG Emissions during Operation (Year 4/8)

Activity	CO_2 (tonnes/year)	CH_4 (tonnes/year)	N_2O (tonnes/year)	CO_2eq (tonnes/year)
ANFO Blasting	3,592	n/a	n/a	3,592
Main Mining Equipment	30,975	2	13	34,831
Support Equipment	51,277	3	16	56,203
Explosives Transport	2,096	0.12	0.06	2,116
Access Road Vehicles	3,581	0.15	0.17	3,636
Heating of the Mill and Truck Stop	4,200	0.08	0.07	4,224
Total	**95,721**	**5**	**29**	**104,603**

Note:
n/a = Not Available. The Energy and GHG Emissions Management Guidance (Mining Association of Canada, 2009) does not identify an emission factor for this substance and therefore assumed to be negligible.

Scope 2 Indirect Emissions

Scope 2 indirect emissions from anticipated electricity use for the Project were calculated using the anticipated total power supply requirements for the Project, as described in the Feasibility Report for the Project (Wardrop 2012) multiplied by the consumption intensity values used by the Government of British Columbia (Ministry of Environment 2012b).

Construction Phase

The Project will contribute GHG emissions from the proposed use of electrical energy imported from the BC Hydro grid through a new transmission line. Electricity will be provided from a new tap point from the existing BC Hydro 230 kV transmission line 2L265 to the east of the Project. Approximately 9 km of 230 kV pole structured overhead line will be constructed and will tie in to a new 230 kV step down substation.

The construction of the 9km of transmission line and the step down substation is anticipated to occur during the Construction phase, therefore the Project's contribution to GHG emissions from electricity use during the Construction phase will be negligible and is assumed to be zero. Similarly, it is assumed that the transmission line will be dismantled during the Decommissioning and Closure phase, so GHG emissions from electricity use after the Operation phase is assumed to be zero.

Operation Phase

During the Operation phase of the Project, the Feasibility Study estimated that the process plant would require 470,538,348 kWh annually, with an additional 1,408,109 kWh per year for general and administration use (Wardrop 2012). Anticipated electrical equipment that will be used during the Operation phase includes:

- electric shovel;
- blasthole drill;
- crusher;
- conveyors;
- screens;
- centrifuges;
- pumps;
- motors;
- agitators; and
- air compressors.

Other Project components that may use electricity during the Operation phase are identified in the Interactions Matrix in Table 6.1-5 under the Scope 2 column.

GHG emissions from anticipated electricity use during the Operation phase were calculated using the anticipated power supply requirements multiplied by the consumption intensity values used in provincial reporting (Ministry of Environment 2012b). Between 1990 and 2012 the consumption intensity values ranged from 9.1 to 37; to provide a conservative estimate of GHG emissions, the average consumption intensity value reported by the Government of British Columbia between 1990 and 2012 was used (23 g CO_2eq/kWh). Scope 2 GHG emissions for the Project were predicted to be 10,822 tonnes CO_2eq per year during the Operation phase.

Scope 3 Other Indirect Emissions

Scope 3 other indirect emissions include GHG emissions that arise from components or activities related to a project that are not owned or controlled by the company or project in question; they can occur both "upstream" and "downstream" of a project in a company's value chain (World Resources Institute and World Business Council for Sustainable Development 2013). The GHG Protocol delineates 15 categories within Scope 3; those that could potentially pertain to the Project include (World Resources Institute and World Business Council for Sustainable Development 2013):

- Extraction, production, and transportation of goods and services or capital goods purchased by the company.
- Extraction, production, and transportation of fuels and energy purchased by the company, including transmission and distribution losses associated with energy requirements.
- Disposal and treatment of waste generated in operations in facilities not owned or controlled by the company.
- Employee transportation for business-related activities.
- Transportation of employees between their homes and work sites.
- Downstream transportation and distribution of products sold by the company.
- Processing, use, and end of life treatment of sold products.

Typically, a Scope 3 inventory includes upstream and downstream activities associated with the production and transportation of the equipment, as well as for the extraction of materials used to produce the equipment. Also usually included are the extraction, production and transportation of plant reagents and consumables such as tires on the upstream side. Emissions associated with inland freight, ocean freight, and smelters and refineries could be included if the information is available. However, calculating Scope 3 emissions requires having the emission factors and detailed information about the upstream and downstream activities that are not owned or controlled by KAM or the Project.

The emission factors that are required to calculate GHG emissions for a material or product are "life cycle emission factors" (emissions that occur at every stage of a material or product's life) and "cradle to gate emission factors" (all emissions that occur in the life cycle of a material or product) (World Resources Institute and World Business Council for Sustainable Development 2013). Life cycle emission factors can also be used to calculate GHG emissions associated with extraction, production, and transportation of fuels purchased by the company; "combustion emission factors" can also be used, which include only the emissions that occur from combusting the fuel (World Resources Institute and World Business Council for Sustainable Development 2013). Activity data may be provided by suppliers (contract manufacturers, materials and parts suppliers, capital equipment suppliers, waste management companies, etc.), or from secondary data sources, including industry averaged-data (World Resources Institute and World Business Council for Sustainable Development 2013).

For the Project, available information on upstream and downstream activities, equipment suppliers and sources that would contribute to GHG emissions is limited due to the fact that these activities are not owned or controlled by KAM or the Project or the activities have not been determined. A simplified Scope 3 emission inventory was conducted for the effects assessment based on the best

available information and included fuel consumption emissions associated with employee commuting during construction and operation (Category 7 of the GHG Protocol) and transport of concentrate to the port of Vancouver (Category 9 of the GHG Protocol).

The GHG Protocol Tool for Mobile Combustion (Version 2.2) developed by the World Resources Institute (2008) was used to calculate Scope 3 emissions. The following assumptions were used in the accounting tool:

- Mine employees will use newer model (2005 to present) cars that use gasoline fuel.
- Concentrate will be shipped during the Operation phase in heavy duty articulated trucks that use diesel fuel.
- Diesel buses will be used during the Construction phase to transport employees between downtown Kamloops and the Mine Site.

Construction Phase

The Project is anticipated to employ 1,800 people during the peak of the Construction phase, a conservative estimate used for the purposes of the assessment. During the Construction phase, employees will access the site through the use of buses and personal vehicles. Total CO_2eq emissions from employee travel were calculated based on the anticipated distance travelled by potential employees (from preliminary data supplied by KAM). Total passenger cars per day are estimated to be conservatively 300 during the Construction phase. Assuming coach buses are provided to transport employees from Kamloops, and further assuming that there will be an average of 50 seats per bus, 30 buses will also be required for daily employee transport to the Mine Site during the construction phase.

During the initial Construction phase (first 6 months) the route to the Mine Site will be along Lac Le Jeune Road to the Haul Road Intersection; during Construction and Operation, the route to the Mine Site will be from the Inks Lake Interchange on the Coquihalla Highway. For the purpose of the assessment it is assumed that all Project employees will reside in Kamloops, therefore the distance travelled by each passenger vehicle will be approximately 40 km return during the Construction phase. Total passenger vehicle commuter distance was estimated as 4,380,000 km annually and total bus distance is estimated as 438,000 km annually during the Construction phase.

For the purpose of the effects assessment, concentrate trucks are not anticipated in the Construction phase.

During the Construction phase, GHG emissions from personal vehicles and buses used to transport employees to and from the Mine Site is predicted to be 1,820 tonnes CO_2eq annually.

Operation Phase

The Project is anticipated to employ 580 employees during the peak of the Operation phase, which is a conservative estimate for purposes of the assessment. During the Operation phase only personal vehicles will be used as coach buses will no longer be provided for employee transport to and from the Mine Site. Total CO_2eq emissions from employee travel were calculated based on the anticipated

distance travelled by potential employees (from preliminary data supplied by KAM). Total passenger cars per day are estimated to be conservatively 467 during the Operation phase.

During the Operation phase, the route to the Mine Site will be from the Inks Lake Interchange on the Coquihalla Highway. For the purpose of the emissions assessment it is assumed that all Project employees will reside in Kamloops, therefore the distance travelled by each passenger vehicle will be approximately 46 km return during the Operation phase. Total passenger vehicle commuter distance was estimated as 7,840,930 km annually during the Operation phase.

The number of concentrate trucks from the Mine Site to Port Metro Vancouver is anticipated to be 23 trucks per day during the 21 years of the operation phase; trucks will access Vancouver via the Inks Lake interchange and then south along the Coquihalla Highway, a one-way distance of approximately 345 km.

During the operation phase passenger vehicles are predicted to emit 1,907 tonnes CO_2eq annually and concentrate trucks are predicted to emit 3,158 tonnes CO_2eq annually.

Effect 2: Land Use Changes as a Result of the Project will Affect Carbon Sinks and Increase GHG Levels in the Atmosphere

The Project will change atmospheric GHG emission levels through land use alterations. Construction and operation of the Project will require clearing of existing grasslands, shrubs and forests and result in increased GHG emissions levels from the temporary or permanent removal of existing carbon sinks.

Processes, activities or mechanisms which remove GHG from the atmosphere are referred to as "sinks" and atmospheric CO_2 can accumulate as carbon in vegetation and soils in terrestrial ecosystems (United Nations Framework Convention on Climate Change 2015). Forests present a significant global carbon sink with an accumulated carbon stock through the growth of trees and an increase in soil carbon. It is estimated that the world's forests store more than 650 gigatonnes of carbon, the majority of it in the biomass (44%) and soil (45%), with the remainder in dead wood and litter (11%). Croplands and grasslands also act as carbon sinks, however, most of these carbon stocks are found below-ground, in the plant organic matter and soil (United Nations Framework Convention on Climate Change 2015).

Rates of emissions associated with land use change depend on land area, geographic location, growing conditions, species, density, and age (Ministry of Environment 2012b). The Intergovernmental Panel on Climate Change (IPCC) Good Practice Guidance for Land Use, Land Use Change and Forestry (Penman et al 2003) provides estimation methodologies, quality assurance and control procedures and accounting primarily for use in national GHG inventories, but it can also provide a foundation for estimating the efficiency of GHG sinks to remove GHGs on a smaller scale (Ravin and Raine 2007).

For this assessment, the removal of CO_2 by carbon sinks is assumed to be equal to the net change in the spatial area of terrestrial components that act as carbon sinks prior to the construction of the Project and following reclamation. The following Project activities are anticipated to result in land use changes that will affect terrestrial components that act as carbon sinks:

- Clearing and Grubbing;
- Open Pit Development;
- Peterson Creek Diversion;
- Re-vegetation through Progressive Reclamation;
- TSF Decommissioning and Reclamation; and
- MRSF Reclamation.

It is assumed that clearing and grubbing will be required for all Project infrastructures and will represent the maximum land area potentially disturbed by the Project. Table 6.1-8 presents the maximum surface area for each primary facility at the Mine Site.

Table 6.1-8. Facility Maximum Surface Area

Primary Mine Site Facility	Footprint Area (ha)
Open Pit	250.0
East Mine Rock Storage Facility	100.3
South Mine Rock Storage Facility	207.2
Tailings Embankment Mine Rock Storage Facility	156.3
Topsoil	21.6
Overburden	50.2
Medium Grade Stockpile	22.3
Low Grade Stockpile	33.2
Tailings Storage Facility Embankments	179.1
Total	**1,020.2**

The land use change calculations were carried out by VAST Resources and summarized by Terrestrial Ecosystem Mapping (TEM) structural stage in Table 6.1-9. The land use change calculations focused on potential changes in land uses at the Mine Site at the final end land cover/use. The assumptions applied in this exercise included:

- the transmission line corridor will be reclaimed to its pre-development TEM structural stage and the net change in land cover/use is zero;
- the access roads will be reclaimed to their pre-development TEM structural stage and the net change in land cover/use is zero;
- shrub and woody species planting will account for approximately 10% of the total reclaimed area that is planted or seeded with the primary focus on achieving slope and aspect positions;
- over several decades and depending on land management practices that are adopted in operations, there will presumably be some ingress and natural regeneration that will expand the size of the reclaimed areas; and
- some features such as the TSF and related embankments will be seeded to grass/forbs species.

Table 6.1-9. Land Use Change by TEM Structural Stage

TEM Structural Stage	Description	Baseline Land Use (ha)	Project End Land Use (ha)
Sparse/bryoid	Comprised of the existing pits, disturbances and rock outcroppings.	68.6	312.5
Herbaceous	Comprised of grasslands, forbs, riparian (aquatic) and dwarf shrubs. The majority of facilities (including the MRSF and TSF embankments) will initially be seeded to native or agronomic grass/forb mixtures in order to achieve agricultural (grazing) and wildlife objectives. Over time it is anticipated that there will be some ingrowth of shrubs and wooded species from adjacent areas and the composition will be comprised of planted and natural regeneration.	1,440.7	1,236.4
Shrub/Herb	Predominately sage, rose, willow and snowberry depending on the moisture regime. Low (<2 m height), Tall (2-10 m height). Combination of plantings and natural regeneration and ingress depending on species.	65.2	25.0
Pole/Sapling Forest	Predominately aspen copse species established in depressional areas for wildlife habitat. Consisting of trembling aspen, rose, dogwood and willow.	113.4	35.0
Young Forest	Consisting of Douglas-fir and Ponderosa pine forests and some Engelmann Spruce.	176.4	50.0
Mature Forest	Consisting of Douglas-fir and Ponderosa pine forests and some Engelmann Spruce.	37.1	10.0
Water Features	Water features including akaline lakes and seasonal watercourses.	27.5	260.0
Total		**1,928.9**	**1,928.9**

Note:
Information provided by VAST Resources

To be consistent with the United Nations Framework Convention on Climate Change LULUCF reporting, the TEM structural stages can be combined into top-level land categories for GHG inventory reporting (Milne and Jallow 2003). These top-level land categories and definitions are:

- Forest land: all land (managed and unmanaged) with woody vegetation consistent with thresholds used to define forest land in the national GHG inventory;
- Cropland: arable and tillage land, and agro-forestry systems;
- Grassland: rangelands and pasture land that are not considered as cropland, including all managed and unmanaged grassland, from wild lands to recreational areas;
- Wetlands: land that is covered or saturated by water for all or part of the year, including reservoirs, natural rivers and lakes;
- Settlement: all developed land, including transportation infrastructure and human settlements; and
- Other Land: bare soil, rock, ice, and all unmanaged land areas that do not fall into any of the other five categories.

The LULUCF inventory tabulation of top-level land categories based on the structural stages is shown in Table 6.1-10.

Table 6.1-10. Top Level Land Use Category Areas

Top Level Land Use Category	TEM Structural Stage	Baseline Land Use (ha)	End Land Use (ha)
Forest Land	Pole-sapling forests Young forests Mature forests	326.9	95.0
Grasslands	Herbaceous Shrub/Herb	1,505.9	1,261.4
Wetlands[1]	Water Features	27.5	260
Other Land	Sparse/byroid	68.6	312.5
Total Land Use		**1,928.9**	**1,928.9**

Note:
[1] Wetlands are not included in the GHG assessment for the Project because some wetlands act as carbon sources while others act as carbon sinks.

The BC PIR (Ministry of Environment 2012b) notes that emission estimates for the LULUCF sector have a high degree of uncertainty compared to other sectors due in part to the difficulty in accounting for complex ecological processes. Afforestation, deforestation, grassland to cropland conversion, and conversion to wetlands are the only LULUCF categories counted in the BC 2012 PIR (Ministry of Environment 2012b). For the purpose of this assessment, GHG emissions are calculated based on the net difference between land area cleared and land area reclaimed and re-vegetated at the end of mine life by top level land use category.

To calculate GHG emissions associated with land use change for forests, BC PIR emission factor was used (Ministry of Environment 2012b). Settlement-related emission factors are described in the BC PIR as those typically occurring in the Pacific Maritime terrestrial ecozone, in which the standing tree volume per hectare is higher than in the Boreal Plains ecozone, where there is relatively more agriculture-related deforestation (Ministry of Environment 2012b). The Pacific Maritime terrestrial ecozone, located along the BC coast, has precipitation exceeding 4,000 mm a year in some areas, while the Boreal Plains ecozone in BC is in the northeast section of the province, with annual precipitation of approximately 300 mm. The Ajax Project is in the Montane Cordillera ecozone; southeast of the Coast Mountains within this ecozone annual precipitation is approximately 300 mm.

Tree size, age, and species affect the amount of carbon that trees can absorb, with large trees at maturity storing approximately 1,000 times more carbon dioxide than saplings (Ravin and Raine 2007). Based on the ecozone, and the fact that most of the forested land in the Project area is shrubby forest or immature forest, with only approximately 11% mature or old growth forest, the emission factor of 255 tonnes of GHGs per hectare was used for forest land.

Calculation of changes in carbon stocks in grasslands follows the IPCC methodology and takes into account carbon stocks in living biomass as well as in soil, for a specific climate, soil, and management combination. The method used for estimating carbon change in grasslands takes into

account both aboveground biomass and soils. Grasslands generally have vegetation dominated by perennials and annual production of biomass can be large; however, because of rapid turnover and removal through grazing and wildfire, the standing stock of aboveground biomass rarely exceeds a few tonnes per hectare (Penman et al. 2003). In addition, carbon stocks in the aboveground herbaceous components are usually small, therefore aboveground grass biomass is only considered for estimating non-CO_2 emissions from burning (Penman et al. 2003). For the purpose of this assessment it is assumed that grasslands will not be burned for development of the Ajax Project, therefore emission factors for soils will only be used in the calculation of GHG emissions from grassland land use change. The default reference carbon stock for grasslands is the warm, temperate dry areas (19 tonnes C/ha). The stock change factor for land use change, management regime, and factor for input of organic matter are all assigned a default base factor of 1, therefore the soil carbon stock is 19 tonnes C/ha. The emission factor for grassland soils is 69.6 tonnes CO_2eq/ha and was calculated based on the tonnes of carbon multiplied by 3.67 (Penman et al. 2003).

Land use change to wetlands are reported in Table 6.1-10 though are not included in the GHG assessment for the Project because some wetlands act as carbon sources while others act as carbon sinks; additional data and complex wetland carbon budgets would be required. The Project is anticipated to result in a net increase in wetland features as result of the creation of Pit Lake.

In the IPCC Good Practice Guidance the Other Land category includes bare soil, rock, and ice, as well as other areas that do not fall into any of the other land use categories. In accordance with the IPCC guidelines, changes in carbon stocks and removals in Other Land areas do not need to be assessed (Penman et al. 2003).

The net change in land use, based on areas lost and reclaimed, is shown in Table 6.1-11. Although there will be some progressive reclamation during Operation, the majority of reclamation will occur during the Closure and Decommissioning phase. To remain comparable with other GHG accounting estimates for recent EAs, average annual GHG emissions are calculated based on GHG emissions per land use category averaged over the life of the Project (30 years in total: 2 years of Construction, 23 years of Operation, and 5 years of Decommissioning and Closure).

Table 6.1-11. Land Use Change Emissions

Land Use Category	Baseline (ha)	End Land Use (ha)	Net Change (±) (ha)	Emissions Factor (tonnes CO_2eq/ha)	Total GHG Emissions (tonnes CO_2eq)	Average Annual GHG Emissions (tonnes CO_2eq/year)
Forest Land	327	95	232	255	59,134	1,971
Grassland	1,505	1,261	244	69	17,017	567
Total	**1,832**	**1,356**	**476**	**324**	**76,151**	**2,538**

Note:
Average annual GHG emissions are calculated over the life of the Project (30 years in total: 2 years of Construction, 23 years of Operation, and 5 years of Decommissioning and Closure).

As seen in Table 6.1-11, total annual average change in GHG levels in the atmosphere as a result of land use changes from the Project is anticipated to be 2,538 CO_2eq/year.

Emissions Summary

Annual anticipated greenhouse gas emissions associated with Project activities during Construction and Operation and net land use change are summarized in Table 6.1-12.

Table 6.1-12. Annual GHG Emissions Summary

Category	Project Phase	
	Construction CO_2eq (tonnes/year)	Operation CO_2eq (tonnes/year)
Scope 1	77,652	104,603
Scope 2	0	10,822
Scope 3	1,820	5,065
Land Use Change	2,538	2,538
Total	**82,010**	**123,028**

Notes:
Scope 1 is based on Year -1 of Construction.
Scope 2 is based on Year 4/5 of Operation.

As seen in Table 6.1-12, GHG emissions will be almost 1.5 times higher during the Operation phase compared to the Construction phase; during both phases the combustion of fossil fuels in mobile and stationary equipment and machinery accounts for the majority of emissions. Scope 1 activities contribute the highest emissions during both the Construction and Operation phases. Land use changes represent a relatively small portion of the total GHG emissions of the Project.

6.1.4.3 Mitigation Measures for Greenhouse Gas Management

Mitigation measures for potential effects of the Project on the GHG Management VC are proposed to reduce GHG emissions from Scope 1, 2 and 3 emission sources and minimize land use changes. Mitigation measures that were incorporated into the Project at the design phase have already been considered in the effects assessment for the GHG Management VC; the mitigation measures proposed below by KAM will further reduce the Project's potential adverse effects.

The development of mitigations measures to reduce potential effects of the Project on the GHG Management VC has taken into consideration the methodology presented in "Incorporating Climate Change Considerations in Environmental Assessment: General Guidance for Practitioners" (Federal-Provincial-Territorial Committee on Climate Change and Environmental Assessment 2003).

This section discusses the mitigation measures proposed by KAM to avoid, minimize and compensate adverse effects to the Greenhouse Gas VC resulting from the Project and its activities.

Avoidance Mitigation Measures

During the design phase of the Project, assessments were undertaken by KAM to evaluate different options for carrying out the Project. Various design options were selected that avoid or prevent GHG emissions from the Project. For example, access and haul roads were designed to minimize

distances and larger trucks for ore and waste transport were selected to minimize the number of trips required between the source and destination.

During equipment procurement and selection, KAM will take into consideration energy conservation measures such as the selection of the mill to reduce the overall energy requirements of the Project during operations. KAM will also consider the use of alternate fuels such as biodiesel or natural gas if feasible and select the best achievable technology (technology that can achieve the best emissions standards and that has been shown to be economically feasible through commercial application) for mine fleet equipment. The selected buildings on the Mine Site will be well-insulated and high-performance with properly sized heating equipment for energy efficiency and heat conservation.

These avoidance measures will assist KAM to prevent GHG emissions from the Project.

Minimization Mitigation Measures

Throughout all phases of the Project, GHG emissions will be minimized by reducing energy and fuel consumption and choosing lower GHG emission models for equipment, vehicles, and technology. The Project proposes to utilize buses/multi-passenger vehicles to transport crews to and from job sites during the Construction phase to reduce personal vehicle trips. As well, the Project will maintain vehicles in good operating condition to meet emission standards (especially catalytic converters and particulate filters for diesel engines).

Equipment and vehicle operators will receive training related to control of air emissions and mitigation measures. Vehicle operators will be required to operate vehicles within the posted maximum speed limits and to reduce idling to minimize emissions. Other aspects of staff training could include mitigation measures to improve fuel efficiency of equipment used to reduce GHGs emissions.

Land clearing will be minimized and the Project will progressively vegetate disturbed areas including temporary soil and overburden stockpiles and road cuts to reduce the loss of carbon sinks as a result of land use changes. As part of the Closure and Reclamation Plan (see section 3.18 of the Application/EIS), previous disturbed areas will be re-vegetated prior to Post Closure to Closure objectives.

Environmental Management Plans

KAM will verify the GHG forecasts during Construction and Operation as part of the Project's monitoring and management plan for GHG emissions which require annual reporting to Environment Canada and/or the Ministry of Environment. The effectiveness of the mitigation measures implemented for the Project will be assessed by KAM and the GHG emissions data will be reviewed annually to determine if any trends are evident and if remedial actions are necessary. Remedial actions or additional mitigation measures will be considered if:

- GHG emissions with an upward trend; and/or
- issues or concerns raised by regulators reviewing the annual reports

Where necessary, remedial measures will be implemented by KAM for the Project. Potential changes, including technological advances and/or regulatory changes, will be responded to by KAM and the Air Quality Management Plan will be revised accordingly.

Towards Sustainable Mining Energy Use and Greenhouse Gas Emissions Management Protocol

KAM is a member of the Mining Association of Canada and subscribes to the guiding principles of the Towards Sustainable Mining (TSM) initiative. The guiding principles are a set of commitments backed by specific performance indicators, which member companies report their performance against. Energy use and greenhouse gas emissions management is one area for which performance indicators have been developed.

According to the guiding principles, the Energy Use and GHG Emissions Management protocol consists of three performance indicators that seek to confirm whether a facility has established a comprehensive system for energy use and GHG emissions. The three performance indicators include:

1. Energy use and greenhouse gas emissions management systems;
2. Energy use and greenhouse gas emissions reporting systems; and
3. Energy and greenhouse gas emissions performance targets.

As a subscriber to the TSM guiding principles, the environmental management system will assign accountability from senior management, as well as demonstrate that the Project includes a process for the regular review of energy data and results are integrated with operator actions as required.

KAM will also provide energy awareness training and have systems in place to track and report energy use and GHG emissions data for both internal and external reporting.

Summary

Residual effects of the Project on the GHG Management VC are anticipated to remain after the implementation of mitigation measures, though the potential exists for GHG emissions to be further mitigated through technological advances in fuel and energy efficiency. As well, carbon offsetting programs may become available to the Project under a regulated regime and could be considered by KAM. The residual effects of the Project on the GHG Management VC is predicted to be the emission of approximately 82 kt CO_2eq/yr during Construction phase and 123 kt CO_2eq/yr during Operation phase.

6.1.5 Residual Project Effects and Their Significance

6.1.5.1 Summary of Residual Effects

The residual effects of the Project on the GHG Management VC that are anticipated to remain after the implementation of mitigation measures are summarized in Table 6.1-13. As described in greater detail in Section 6.1.4.2, the maximum increase in GHG emissions from the Project is predicted to be up to 123 kt CO_2eq/yr during Operation but is lower during the Construction phase at 82 kt CO_2eq/yr.

Compared to 2012 emissions documented in the National Inventory Report, estimated average GHG emissions for the Operation phase (123 kt CO_2eq/yr) of the Ajax Project represent less than 0.017%

of the national total of 699 Mt CO_2eq. According to Environment Canada (2013a), total national GHG emissions in 2020 are expected to be 734 Mt; estimated emissions from the Ajax Project represent approximately 0.016% of this total. At the provincial level, the estimated GHG emissions during Operation represent 0.048% of the total emissions reported for all reporting facilities in 2013.

Note that the percentages calculated for the Ajax Project are conservative overestimates of total federal reported values because facilities reporting to Environment Canada under the GHGRP are only required to calculate direct (Scope 1) emissions, not indirect emissions incurred as a result of upstream and downstream activities or electricity purchases, or land use changes that have been included in the Ajax Project calculations (Environment Canada 2014c). Project-related effects on provincial and federal GHG emissions can therefore be considered negligible.

Project Comparison with Mining Industry Profile and Other Emitting Facilities

The Ajax Project emission intensity was calculated for comparison with values reported in the KSM Environmental Effects Assessment (Rescan 2009). Emission intensity is calculated based on annual tonnes of CO_2eq per kilotonne of milled ore. Based on a mill throughput of 70,000 tonnes of ore per day for the Ajax Project, the emission intensity factor during the Operation phase will be 4.8 tonnes of CO_2eq per kilotonne of milled ore. The emission intensity is similar to that estimated for the KSM Project (3.5 tonnes of CO_2eq per kilotonne of milled ore) as well as reported for the operating Teck Highland Valley Copper Partnership (3.8 tonnes of CO_2eq per kilotonne of milled ore). Note that the emission intensity factor for the Ajax Project was calculated solely on the worst case Operation phase, whereas for the KSM Project, the emission intensity factory is based on the average of the Construction and Operation phases.

Project Compliance with Regulations and Policies

Based on the GHG inventory, KAM will be required to submit a report to Environment Canada in accordance with the Greenhouse Gas Emissions Reporting Program under the authority of Section 46 of the *Canadian Environmental Protection Act*, 1999, since annual GHG emissions during the majority of operational years will exceed 50,000 tonnes CO_2eq. Emissions are anticipated to decline below reporting requirements in the Decommissioning and Closure phase. KAM will also be required to submit annual Facility GHG Reports to the provincial Ministry of Environment during years when emissions exceed 10,000 tonnes or more of CO_2eq, in accordance with the Reporting Regulation of the *Greenhouse Gas Reduction (Cap and Trade) Act*; emissions are anticipated to exceed this value starting in the Construction phase.

No specific legislation currently targets the mining industry. The Project will be secondarily affected by regulations under the *Canadian Environmental Protection Act*, 1999; the Heavy-duty Vehicle and Engine Greenhouse Gas Emission Regulations establish emission standards and test procedures in order to reduce greenhouse gas emissions from heavy-duty vehicles and engines. This regulation applies to vehicles manufactured in Canada or imported into Canada. With these regulations in place, GHG emissions from the 2018 model-year heavy-duty vehicles will be reduced by up to 23%; the new regulation is estimated to result in a cumulative reduction of 19.1 megatonnes in GHG emissions over the lifetime of vehicles produced between 2014 and 2018 (Environment Canada 2013c). Environment Canada (2013a) also notes that although absolute emissions in the freight subsector are expected to increase, the average fuel efficiency of trucks will improve by 2020 as a result of the new heavy duty vehicle regulations.

Table 6.1-13. Summary of Residual Effects on Greenhouse Gas Management

Valued Component	Project Phase (timing of effect)	Project Component/Physical Activity	Description of Cause-Effect	Description of Mitigation Measure(s)	Description of Residual Effect
Greenhouse Gas Management	C, O	• Fuel Storage and Filling Area • Hazardous Wastes Transport, Storage, and Disposal • Construction Wastes Transport, Storage, and Disposal • Sewage Infrastructure and Disposal • Public Road Realignment, Use, and Maintenance • Site Road Construction, Use and Maintenance • Peterson Creek Bridge Construction, Use, and Maintenance • Site Buildings and Process Plant • Explosives Magazine and Storage Facilities • Open Pit Development • Drilling and Blasting • Crushing Waste Rock • Loading, Hauling, and Deposition of Waste Rock • Natural Gas Line • Stripping, Loading, Hauling, Deposition, and Contouring of Topsoil and Overburden • Process Plant Operation • Deposition to Tailing Storage Facility • Site Road Use and Maintenance (Materials, Personnel, Supplies) • Concentrate Transport and Storage • Fuel Storage and Filling Area • General Wastes Transport, Storage, and Disposal • Project Lighting • Water Intake from Kamloops Lake • Potable Water Treatment and Use • Contracted Employment	GHG emissions from each component or activity incrementally increases atmospheric GHG levels	• access and haul roads designed to minimize distances • larger trucks for ore and waste transport to minimize number of trips • consider energy conservation in equipment procurement and selection • consider the use of alternate fuels • select the best achievable technology • maintain vehicles in good operating condition • utilize buses/multi-passenger vehicles to transport crews • train equipment and vehicle operators to reduce GHG emissions • operate vehicles within the posted maximum speed limits and reduce idling	Increase in atmospheric GHG
Greenhouse Gas Management	Net Change	• Clearing and Grubbing • Open Pit Development • Re-vegetation through Progressive Reclamation • Tailing Storage Facility Decommissioning and Reclamation • Mine Rock Management Facilities Reclamation • Peterson Creek Diversion	Land changes will decrease carbon sinks and increase atmospheric GHG levels.	• Land clearing will be minimized for the Project where practical and economically achievable • progressively re-vegetate or re-vegetate disturbed areas prior to Closure	Increase in atmospheric GHG

Notes:
"Cause-effect" refers to the relationship between the Project component/physical activity that is causing the change or effect in the condition of the VC.
Project Phase: (C) Construction, (O) Operation

Similarly, it is expected that other federal and provincial legislation such as the Passenger Automobile and Light Truck Greenhouse Gas Emission Regulations will result in reduced GHG emissions from Scope 3 sources such as employee commuting and transport of materials and supplies to site, and product from site to Port Metro Vancouver.

6.1.5.2 Criteria for Characterization of Residual Effects

Assigning criteria to characterize the residual effects of the Project on GHG Management is challenging, given that the potential adverse effects of climate change are global in nature and the Project's individual contribution is indiscernible from all other sources of GHG emissions in the atmosphere. Therefore, the proxies that have been assigned to characterize the residual effects of the Project on GHG Management compare the Project's anticipated GHG emissions to provincial, national and sector norms as shown in Table 6.1-14.

6.1.5.3 Characterization of Residual Effects

The residual effects of GHG emissions from the Project are shown in Table 6.1-15 with the definitions from Table 6.1-14 to determine the significance residual effects.

The magnitude of the residual effect is Negligible because the predicted increase in atmospheric GHG levels as a result of Project activities is less than 0.048% compared to provincial totals in 2013 and less than 0.016% of national predicted GHG emissions in 2020. As well, the magnitude of the residual GHG emissions from the Ajax Project is similar to other comparable mining projects in BC. The duration of the residual effect was selected as Far Future because of the long life of GHGs in the atmosphere and the geographic extent of the GHGs emissions was rated as Beyond Regional given the global nature of the atmosphere. Greenhouse Gas emissions are anticipated to be both Regular and Sporadic during the Construction and Operation phases from Project activities. The frequency of the residual effect was rated as Regular overall for both phases of the Project. Given that carbon sinks have the ability to remove GHGs from the atmosphere, the reversibility of the residual effect was rated as **Reversible Long-term** rather than Irreversible. The atmosphere is considered to be **Neutral** in terms of resiliency because it has the ability to accommodate the anticipated GHG emissions from the Project.

6.1.5.4 Significance of Residual Effects

The determination of significance for the residual effect of the increase in atmospheric GHG levels of up to 123 kt CO_2eq/yr due to Scope 1, 2 and 3 Emissions and Land Use Changes from the Ajax Project is assessed to be **Not Significant (Minor)**. The primary reason for this assessment is the negligible magnitude of the anticipated Project-related GHG emissions compared to provincial and national emissions and other comparable mining projects.

As described above, total national GHG emissions in 2020 are expected to be 734 Mt; estimated emissions from the Ajax Project represent approximately 0.016% of this total. At the provincial level, the estimated GHG emissions during Operation represent 0.048% of the total emissions reported for all reporting facilities in 2013.

The Project and KAM will be subject to provincial and federal requirements for reporting. GHG management will be developed for the Project prior to Construction which will outline GHG emissions monitoring and reporting activities and Project mitigation measures.

6.1.5.5 Characterization of Likelihood and Confidence

The likelihood and confidence level ratings for the residual effect of the Project are considered **High** because GHGs will be emitted by the Project through Scope 1, Scope 2 and Scope 3 activities and land use changes, and the GHGs emitted will contribute to atmospheric GHG levels.

6.1.5.6 Summary of Residual Effects Assessment and Significance

As summarized in Table 6.1-16, the Project's anticipated GHG emissions are considered **Not Significant (Minor)** because of the negligible magnitude of the anticipated Project-related GHG emissions compared to provincial and national emissions and other comparable mining projects.

The assessment of the GHG Management VC was constrained by the fact that the contribution of an individual project to climate change cannot be measured. Due to this constraint, rather than assessing cumulative effects, the Project's predicted overall GHG's emissions was compared to the scale of provincial emissions levels and targets.

6.1.6 Cumulative Effects

Cumulative effects are the result of a project-related effect interacting with the effects of other human actions (i.e., anthropogenic developments, projects, or activities) to produce a combined effect. However, current guidance states that the "EA process cannot consider the bulk of GHG emitted from already existing development… unlike most project-related environmental effects, the contribution of an individual project to climate change cannot be measured" (Federal-Provincial-Territorial Committee on Climate Change and Environmental Assessment 2003). Due to this technical constraint, rather than assessing cumulative effects, the Project's predicted overall GHG's emissions were compared to the scale of provincial and federal emissions levels and targets (please refer to Section 6.1.5.1). By making the Project comparisons to provincial emissions levels and targets, the environmental importance of the Ajax Project's anticipated GHG contribution can be assessed by placing it in the context of the policy objectives or regulations of the relevant jurisdictions.

The magnitude of the predicted increase in atmospheric GHG levels as a result of Project activities is anticipated to be the emission of up to 123 kt CO_2eq/yr during the Operation phase and up to 82 kt CO_2eq/yr during the Construction phase. This predicted effect is comparable to other operating and proposed mining projects in BC. At the provincial level, the estimated GHG emissions during Operation represent 0.048% of the total emissions reported for all reporting facilities in 2013.At the National level the most current projections for 2020 are 734 Mt CO_2eq; estimated emissions from the Ajax Project will represent approximately 0.016% of this total.

As described in Section 6.1.4.3, KAM is committed to a number of avenues of mitigation to minimize GHG emissions from the Project. In this context, the Project's contribution to residual cumulative effects are considered to be negligible and determined to be not significant (minor) because the contribution of GHGs by the project are less than 0.048% of the provincial GHG contributions and less than 0.016% of the National GHG contributions (Table 6.1-17).

Table 6.1-14. Definitions of Characterization Criteria for Residual Effects on Greenhouse Gas Management

Magnitude	Duration	Frequency	Geographic Extent (Physical/Biophysical)	Reversibility	Resiliency	Likelihood of Effects	
						Probability	Confidence Level
How severe will the effect be?	*How long will the effect last?*	*How often will the effect occur?*	*How far will the effect reach?*	*To what degree is the effect reversible?*	*How resilient is the receiving environment or population?*	*How likely is the effect to occur?*	*How certain is this analysis?*
Negligible: No or very little detectable change from baseline conditions: GHG emissions increase by < 0.01% compared to national totals, and/or < 0.1% compared to provincial totals, and are less than the industry profile.	**Short-term:** Effect lasts 1 year	**Once:** Effect is confined to one discrete period in time during the life of the Project (less than 1% of the time during the Project phase)	**Local:** Effect extends only to immediate air column above the Project footprint.	**Reversible Short-term:** Effect can be reversed relatively quickly.	**Low:** The atmosphere has a low resilience to imposed stresses, and will not easily adapt to the effect.	**High:** It is highly likely that this effect will occur.	**High:** < 80% confidence. There is a good understanding of the cause-effect relationship and all necessary data are available for the Project area. There is a low degree of uncertainty and variation from the predicted effect is expected to be low.
Minor: Differs from the average value for baseline conditions to a small degree: GHG emissions increase by > 0.01% but < 0.1% compared to national totals, and/or > 0.1% but < 1% compared to provincial totals, and are within the range of the industry profile.	**Medium-term:** Effect lasts 1 to 10 years.	**Sporadic:** Effect an effect that occurs at sporadic or intermittent intervals during any phase of the Project (between 2% and 10% of the time during the Project phase)	**Landscape:** Effect extends beyond the Project footprint by 5 to 50 km.	**Reversible Long-term:** Effect can be reversed many years after activity ceases.	**Neutral:** The atmosphere has a neutral resilience to imposed stresses and may be able to respond and adapt to the effect.	**Medium:** This effect is likely, but may not occur.	**Medium:** 50 to 80% confidence. The cause-effect relationships are not fully understood, there are a number of unknown external variables, or data for the Project area are incomplete. There is a moderate degree of uncertainty; while results may vary, predictions are relatively confident.
Medium: Differs substantially from the average value for baseline conditions and approaches the limits of natural variation: GHG emissions increase by > 0.1% compared to national totals, and/or by > 1% compared to provincial totals, and is within the range of the industry profile.	**Long-term:** Effect lasts between 11 and 100 years.	**Regular:** Effect occurs on a regular basis during the life span of the Project (or between 11% and 80% of the time during the Project phase)	**Regional:** Effect extends across the broader region beyond the Project footprint by 51 to 100 km.	**Irreversible:** Effect cannot be reversed (i.e., is permanent).	**High:** The atmosphere has a high natural resilience to imposed stresses, and can respond and adapt to the effect.	**Low:** This effect is unlikely but could occur.	**Low:** < 50% confidence. The cause-effect relationships are poorly understood, there are a number of unknown external variables, and data for the Project area are incomplete. High degree of uncertainty and final results may vary considerably.
Major: Differs substantially from baseline conditions, resulting in a detectable change beyond the range of natural variation: GHG emissions increase by > 0.1% compared to national totals, and/or by > 1% compared to provincial totals, and is greater than the range of the industry profile.	**Far Future:** Effect lasts more than 100 years.	**Continuous:** Effect occurs constantly during the life of the Project (or more than 81% of the time during the Project phase)	**Beyond Regional:** Effect extends beyond the regional scale, and may extend across or beyond the province.				

Table 6.1-15. Characterization of Residual Effects, Significance, Likelihood and Confidence on Greenhouse Gas Management

Residual Effect	Residual Effects Characterization Criteria						Significance of Adverse Residual Effects	Likelihood and Confidence	
	Magnitude	Duration	Frequency	Geographic Extent	Reversibility	Resiliency		Probability	Confidence
Increase in atmospheric GHG of up to 123 kt CO_2eq/yr during Construction and Operation due to Scope 1, 2 and 3 Emissions and Land Use Changes	Negligible	Far Future	Regular	Beyond Regional	Reversible Long-term	Neutral	Not Significant (minor)	High	High

Table 6.1-16. Summary of Residual Effects, Mitigation, and Significance on Greenhouse Gas Management

Residual Effects	Project Phase	Mitigation Measures	Significance
Increase in atmospheric GHG of up to 123 kt CO_2eq/yr during Construction and Operation due to Scope 1, 2 and 3 Emissions and Land Use Changes	C, O	• Greenhouse Gas Reporting • Access and haul roads designed to minimize distances • Larger trucks for ore and waste transport to minimize number of trips • Consider energy conservation in equipment procurement and selection • Consider the use of alternate fuels • Select the best achievable technology • Maintain vehicles in good operating condition • Utilize buses/multi-passenger vehicles to transport crews • Train equipment and vehicle operators to reduce GHG emissions • Operate vehicles within the posted maximum speed limits and reduce idling • Land clearing will be minimized for the Project where practical and economically achievable • Progressively re-vegetate or re-vegetate disturbed areas prior to Closure	Not Significant (Minor)

Note:
Project Phase: (C) Construction, (O) Operation

6.1.7 Conclusion

The Ajax Project is anticipated to emit up to 123 kt CO_2eq/yr during the Operation phase and up to 82 kt CO_2eq/yr during the Construction phase. The effects assessment compared the Project-related GHG emissions to provincial reported emissions and with comparable proposed and operating mining projects in BC to determine the significance of the residual effect and significance of the residual cumulative effect. The Project will increase atmospheric GHG emission even after the application of mitigation measures, though the predicted residual GHG emissions are considered to be negligible and assessed as not significant (minor). In the context of provincial emissions levels and targets, the Project's contribution to residual cumulative effects are considered to be negligible and determined to be not significant (minor).

The Project will be required to comply with legislated provincial and national reporting and mitigation requirements. The Project will be required to assess and report on GHG emissions on an annual basis provincially under the BC Reporting Regulation and federally under the *Canadian Environmental Protection Act*.

Table 6.1-17. Summary of Residual Effects, Mitigation, and Significance for Greenhouse Gas Management

Residual Effects	Project Phase	Mitigation Measures	Residual Effect Significance	Residual Cumulative Effect Significance
Increase in atmospheric GHG of up to 123 kt CO_2eq/yr during Construction and Operation due to Scope 1, 2 and 3 Emissions and Land Use Changes	C, O	• Greenhouse Gas Reporting • Access and haul roads designed to minimize distances • Larger trucks for ore and waste transport to minimize number of trips • Consider energy conservation in equipment procurement and selection • Consider the use of alternate fuels • Select the best achievable technology • Maintain vehicles in good operating condition • Utilize buses/multi-passenger vehicles to transport crews • Train equipment and vehicle operators to reduce GHG emissions • Operate vehicles within the posted maximum speed limits and reduce idling • Land clearing will be minimized for the Project where practical and economically achievable • Progressively re-vegetate or re-vegetate disturbed areas prior to Closure	Not Significant (Minor)	Not Significant (Minor)

Notes:
Residual cumulative effect significance was interpreted in the context of provincial and federal emissions levels and targets.
Project Phase: (C) Construction, (O) Operation

6.2 GEOLOGY, LANDFORMS, AND SOILS

6.2.1 Rationale

This section addresses environmental effects expected to result from Project-related disturbance to Valued Components (VCs) associated with the Geology, Landforms and Soils component for the Ajax Project. The VC and issues identification scoping process recognised a number of key issues and potential indicators related to the Geology, Landforms and Soils disciplines. The relevance of the VC was validated through consideration of Aboriginal interest, public or other stakeholder input, and scientific/professional knowledge rationales are presented in Table 6.2-1. The primary reason for selecting Geology, Landforms and Soils as a VC is to meet provincial and federal information requirements for mine development. For the purpose of this assessment, the Geology, Landforms and Soils VC is defined as landforms (topography and physiography), bedrock and surficial geology, and topsoil. Terrain stability and geohazards are also related to these landforms and also discussed.

Table 6.2-1. Geology, Landforms and Soils Indicators Included in the Application/EIS

Indicators	Identified by*				Rationale for Inclusion
	AG	G	P/S	SK	
Physiography and Topography			Y		Alteration of baseline landscape
Surficial Geology			Y		Re-distribution of baseline surficial geology
Soil Disturbance	Y	Y	Y	Y	Soil types and erosion (vulnerability) Removal of soil during the Construction phase that is salvaged and stockpiled Concern with changes to soil stability
Terrain Stability and Accelerated Erosion			Y		Terrain stability and accelerated erosion Pit wall slope stability
Terrain Stability Aberdeen Hills			Y		Effect of pit blasting on re-activating historic landslides in Aberdeen Hills
Geohazards			Y	Y	Seismic criteria for pit walls, MRSFs and TSF

**AG – Aboriginal Group; G – Guideline requirement; P/S = Public/Stakeholder; SK = Scientific/Professional knowledge*

Descriptions of indicators selected for the Geology, Landforms and Soils VC that are summarised in Table 6.2.1 are defined as follows:

Physiography and Topography – Physiography and topography refers to the development of a landscape through processes of deposition and erosion and is defined by the surface expression, relief or shape of the landscape. The development of the Project would directly alter the existing baseline landscape.

Surficial Geology – Surficial geology refers to the overburden soils which constitute the landscape largely derived from glacial processes. Different depositional and erosional environments produce distinct parent materials, which can directly influence both landform expression (topography and physiography) and soil formation. The Project would remove existing parent material as a result of Construction and Operations activities.

Soil Disturbance – Topsoil varies across the landscape, influenced by a variety of factors, including surficial geology, drainage, and topography. Soil disturbance is the physical removal of soil during the Construction, Operation, and Decommissioning and Closure phases. This action is most commonly associated with the salvage and stockpiling of baseline soils.

Terrain Stability and Accelerated Erosion – Terrain Stability refers to the alteration of baseline slope gradients and surface characteristics that may result in terrain which is susceptible to increased instability. Soils susceptible to accelerated erosion will be identified. For this assessment, pit wall slope stability of Pit Lake in the Post Closure phase is discussed.

Terrain Stability Aberdeen Hills – Terrain Stability Aberdeen Hills refers to potential effects of Open Pit blasting vibrations re-activating historic landslides in Aberdeen Hills, a residential subdivision of Kamloops located 2.9 km from the Project.

Geohazards – Terrain hazards refers to the potential of natural hazards to affect the Project including risk of a seismic event, snow avalanche and hazards associated with karst occurrences.

The assessment of effects to Geology, Landforms and Soils is largely related to direct ground disturbance from Project activities (as described further in Section 6.2.4). The information developed to support the analysis of this VC also contributes to other analyses for other VCs, as summarised in Figure 6.2-1. For example, terrain stability mapping is linked with terrestrial ecosystem mapping, which supports habitat modelling for wildlife VCs; and landform identification helps to support evaluation of archaeological potential. Terrain stability is also evaluated further under Section 17.5, Effects of the Environment on the Project and Section 17.6, Accidents and Malfunctions. The assessment does not specifically include a description of geotechnical investigations completed to support the design of Project facilities. A number of geotechnical studies have been undertaken in support of Project design and are described in the Project Description (Section 3.3).

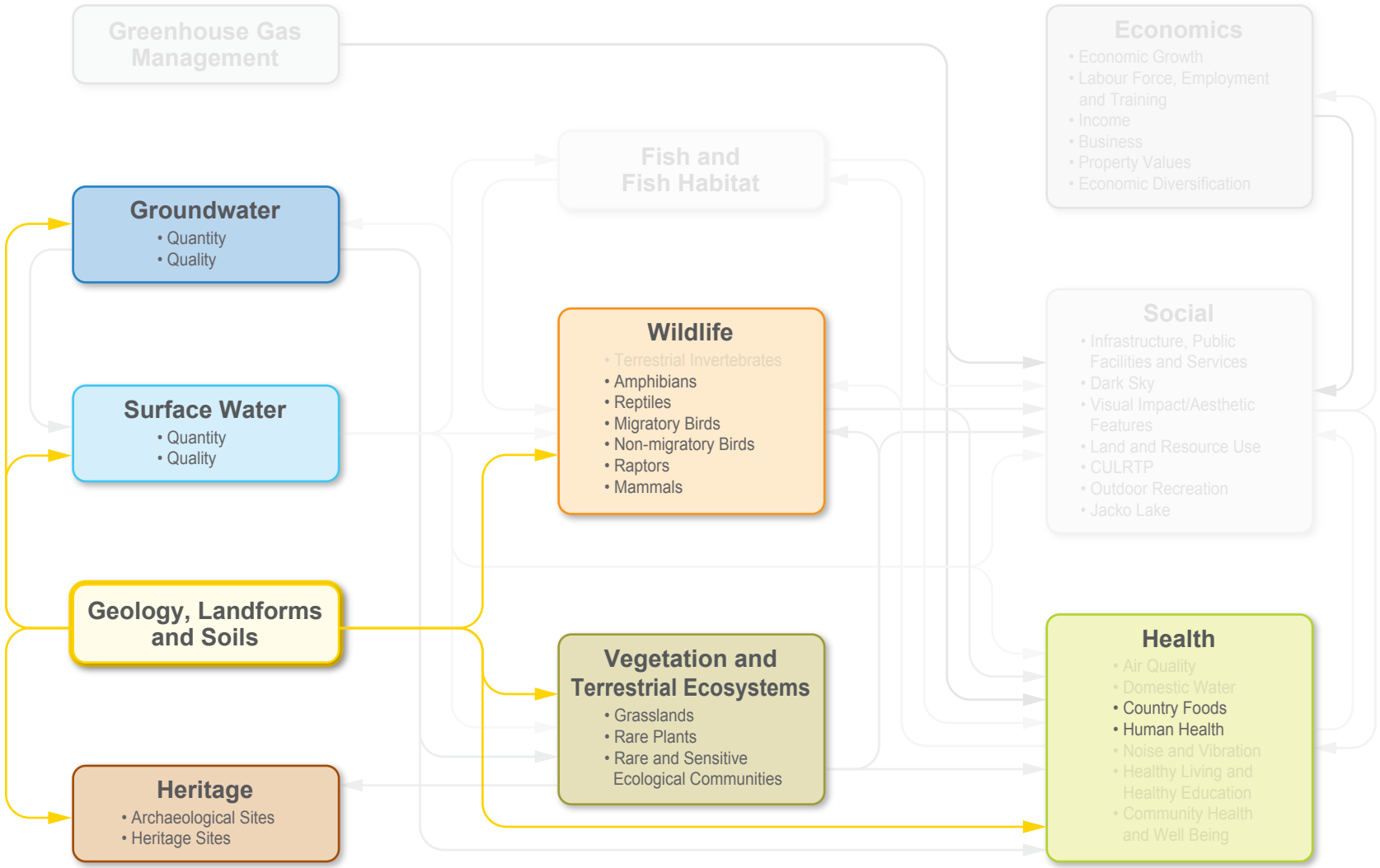
6.2.2 Background

6.2.2.1 Regional Overview

The Project lies within the Thompson Plateau characterized by gentle undulating uplands with rounded hill tops, separated by large valleys. The surficial geology near the Project is characterized by landforms and surficial geology that reflect a history of glaciation. The Project is underlain by the Lower Paleozoic to Early Jurassic arc-volcanic, plutonic and sedimentary rocks of the Nicola Group, which is overlain by the Eocene Kamloops Group. The Nicola Group rocks have been intruded by Late Triassic to Early Jurassic Iron Mask Batholith.

Figure 6.2-1

Valued Component Interaction for Geology, Landforms and Soils



6.2.2.2 Historical Activities

The Project history is discussed in Project Background, Section 2.2.3. The region surrounding the Project has a long history of human activity that contributes to the current 'baseline' condition, which is defined more specifically in the following section of this assessment. Kamloops derives its name from the Secwepemc word "Tk'emlúps", which refers to the meeting of the North and South Thompson rivers. The area was first inhabited by approximately 3,000 members of the Shuswap tribe, part of the Interior Salish Nation. Fur trading began in the area in the early 1800s. The fur trading posts were located in various locations in what is now Kamloops.

British Columbia officially became part of Canada in 1871, and construction of the transcontinental railroad was completed in 1885, encouraging the growth of a small village on the shore of the Thompson River. The village grew rapidly and by 1893 the population had risen to approximately 500 and became incorporated as a city with public works. In the following years, there were a number of infrastructural developments, including bridges that connected villages on either side of the rivers. During this time, the timber industry was growing, and the vegetable and orchard farming industry grew, with most of the land used for this purpose located in the valley. The Kamloops area grew after the First World War until development slowed during the Depression and the Second World War. After this period, the City began to grow again, and much of the land that had formerly been used for farming in the valley was used for residential development. Ranching (including cattle grazing) also developed, and is currently ongoing immediately within and adjacent to the Project.

Mining activity in the Project area can be traced back over 100 years with exploration in the Project area beginning in the 1880s and continuing intermittently to present. Copper, gold, and iron mineralization was discovered at the Iron Mask Mine near Kamloops in 1896. Nearby properties (including the Wheal Tamar, Ajax, and Monte Carlo claims) were explored in the following years.

The Afton Mine went into operation in 1977. Mining operations were initiated on the Ajax East and Ajax West pits in 1989 and subsequently suspended in 1991 due to depressed metal prices. A second period of production began in 1994 and was again suspended in 1997. The raw ore from the Ajax pits was trucked approximately 10 km west to the processing plant adjacent to the Afton pit. During these periods of production, it is estimated that 17 Mt of ore was mined and 13 Mt of ore was milled. In the late 1990s, the tailings facility and project components were decommissioned and reclaimed by the Afton Mine in accordance with their closure plan. At the Ajax site, this includes reclaimed Mine Rock Storage Facilities (MRSFs) adjacent to Peterson Creek in the location of the proposed Ore Stockpiles. The New Afton Mine occupies the site of the historic Afton Mine infrastructure. New Afton began underground mining immediately beneath the historic Afton Mine open pit in June 2012.

6.2.2.3 Baseline Studies

The objective of the baseline study was to better understand existing conditions for Geology, Landforms and Soils in the Local Study Area (LSA) and the Regional Study Area (RSA) of the Project (see Section 6.2.3.1 for further description of study areas). The AIR/EIS Guidelines (BC EAO 2015) specify that background descriptions of the regional environment for Geology, Landforms and Soils VC should include:

- topography and physiography;
- bedrock geology (stratigraphy, rock properties, mineral deposits, faults and fractures);
- surficial geology;
- terrain stability;
- soil types;
- erosion (vulnerability); and
- geohazards (seismic activity, karst, etc.).

This section provides a benchmark for evaluating the potential effects of the Project by characterizing the pre-disturbance conditions for the Landforms, Geology and Soils VC.

Data Sources

Regional and historical data sources supported the baseline studies including published geological literature and baseline maps by the Geological Survey of Canada. A Reconnaissance Terrain and Terrain Stability Mapping (RTSM) study for the Project was conducted by Knight Pièsold Ltd. (KP) and is included as Appendix 6.2-A of the Application/EIS. A baseline soil characterization study was conducted by VAST Resource Solutions (VAST) and is included as Appendix 3-E. A study of the LSA faults was conducted by Dr. K. V. Campbell and is included in Appendix 6.2-C (BGC 2015). Open Pit geotechnical slope design was conducted by SRK Consulting (Australasia) Pty Ltd. (SRK) and is included in Appendices 6.2-C and 6.2-E. A study of the Open Pit blast vibrations effects on Aberdeen Hills area was conducted by KP and is included in Appendix 6.2-D. Seismic Hazard and Seismic Stability analysis was conducted for Afton Mine by Klohn Crippen Berger and included in Appendix 6.2-E.

Methods

Different methods of investigations were undertaken by qualified professionals to characterize the baseline Landform, Geology and Soils VC. An overview of the primary methods of data collection is described below for ease of review, though the reviewer should refer to the baseline reports for additional detail.

Topography and Physiography – Light Detection and Ranging (LiDAR) derived topographic contours facilitated determination of accurate slope angles, which were used in Terrain and Terrain Stability Mapping. Slope Angle Maps of the LSA were prepared using the *ArcView* GIS software with the '*3d-Analyst*' extension. The Slope Angle Maps were generated from the 5 m LiDAR Survey contours. The slope angle classes used correspond with those in the Terrain Classification System for British Columbia (Howes and Kenk 1997). A geomorphic interpretation of the Bare Earth Digital Elevation Model (DEM) examined in 3D using the *Global Mapper* software package after applying the '*slope shader*' function. The vertical scale was exaggerated to accentuate the landforms. The baseline report is provided in Appendix 6.2-A.

Bedrock Geology – Bedrock geology for the RSA is detailed from published geological literature from Kwong (1987) and Logan and Mihalynuk (2005) that was summarised by Wardrop (2009 and 2011) in Sections 3.1.1 and 3.1.2, Project Description. A study of the major faults of the LSA was conducted by Dr. K. V. Campbell (2011) and is provided in Appendix 6.2-C.

Surficial Geology – Terrain mapping was undertaken by KP (as defined by Howes and Kenk 1997) to categorize, describe and delineate characteristics and attributes of surficial materials, landforms and geological processes within the natural landscape. KP undertook Air Photo Interpretation (API) of digital stereo pairs using aerial photographs taken in 2000 (yr.) at a nominal scale of 1:17,000. Field-truthing was undertaken by KP including examination and description of natural soil and bedrock exposures as well as exposures in cut slopes. Hand-excavated test pits were dug in areas where there were no surface exposures. The terrain mapping was undertaken to Terrain Survey Intensity Level 'C'; approximately 24% of the polygons were field-checked. Supplementary data was obtained by reviewing the findings of 385 test pits undertaken in the LSA as part of a geotechnical site investigation program to support Project design. The baseline report is provided in Appendix 6.2-A.

Topsoil – The baseline soil assessment by Polar Geoscience Ltd. developed a detailed bio-terrain map, and included a detailed field assessment of soils, surficial materials, vegetation and other landscape features within the LSA. Bio-terrain mapping was completed on stereoscopic colour API at a scale of approximately 1:17,000 by following the standard British Columbia procedures for terrain classification (Howes and Kenk 1997), mapping methods (Resources Inventory Committee 1996), and bioterrain mapping methodology (Resources Inventory Committee 1998a). Soil inspections were conducted at 526 sites over approximately 1,705 ha. The bio-terrain mapping was undertaken to an Intensity Level of SIL 1, with an average of one inspection per 4.4 ha, sufficient for baseline soil mapping at the anticipated 1:5,000 production scale. Chemical and physical analyses were completed on selected samples to provide information on soil nutrient regime, metals concentrations, and physical characteristics relevant to water and nutrient holding capacity, erosivity and suitability as plant growth media. The baseline report is provided in Appendix 3-E.

Terrain Stability Mapping – Terrain Stability Mapping was undertaken by KP to define the existing terrain stability conditions (as defined by Howes and Kenk 1997), to identify the potential for alteration of terrain stability related to Construction activities. Information on the terrain maps, provides information on the pre-mining 'land capability' and is used in reclamation studies to mitigate risks posed by natural hazards identified in the Project. Terrain Stability Mapping describes the predicted response of the terrain to timber harvesting/vegetation stripping at proposed sites for infrastructure development. Terrain Stability Mapping is the earliest, hazard-avoidance phase of the terrain hazards assessment process in order to mitigate the landslide risk. The baseline report is provided in Appendix 6.2-A. Open Pit Slope Stability analysis of the Ajax Open Pit was conducted by SRK and is provided in Appendices 6.2-D and 6.2-E.

Aberdeen Hills Slope Stability - Bedrock and surficial geology for the Aberdeen Area was summarised by Geotex Consultants Limited (1996). Slope stability work on landslides was conducted by Golder Associates (2006 to 2011). An assessment of possible effects of Open Pit blasting on terrain stability in the Aberdeen Hills area was conducted by KP and provided in Appendix 6.2-D.

Seismicity - A seismicity assessment was completed for the RSA by Klohn Crippen Berger (2011); this included a review of the regional seismicity and a probabilistic seismic hazard analysis. This report is provided in Appendix 6.2-E. A seismic hazard calculation for the site was obtained from Natural Resources Canada (NRCan); the values are in accordance with the 2010 National Building Code.

Characterization of Geology, Landforms and Soils Baseline Condition

Physiography and Topography

The Project lies within the Thompson Plateau, a subdivision of the Interior Plateau Physiographic Region. The Thompson Plateau is characterized by gentle undulating uplands with rounded hill tops, separated by large valleys. The Thompson Plateau is a late Tertiary erosional surface that has been dissected by the Thompson River and its tributaries, and by the Similkameen and Okanagan Rivers (Holland 1976). Most of the LSA consists of elongated, northwest-southeast trending, rolling grasslands with forested areas at higher slope elevations. Extensive Pleistocene glaciation has produced the topography of low rolling hills with deep accumulations of glacial till and numerous glacial landforms such as drumlins, kames and eskers.

The elevation of the LSA varies between approximately 850 and 1,100 metres above sea level (masl) in which the most prominent landform is the Sugarloaf Hill which has an elevation of 1,130 masl. Eighty-five percent of the LSA contains gentle (6 to 26%) to plain (0 to 5%) slope angles. A band of moderate sloped (27 to 49%) terrain extends in a northwest direction across the LSA, crossing south of Jacko Lake. This area comprises a series of rounded hills that are typically steeper on the northwest side of the hills; creating a 'crag and tail' type drumlinized terrain that indicates the direction of ice advance was to the southeast. Less than one percent of the LSA contains steep slope angles (>70%). The terrain along the water supply pipeline corridor is predominantly gently inclined slope angles. The transmission line corridor is predominantly gently inclined slope angles then crosses moderately steep slopes adjacent to Peterson Creek. Slope angles for the LSA are summarised in Table 6.2-2.

Table 6.2-2. Summary of Slope Angles within the Local Study Area

Slope Class	Slope Angles	Area (ha)	% Project Footprint
Plain	0 to 5%	1,659	23%
Gentle	6 to 26%	4,454	62%
Moderate	27 to 49%	839	12%
Moderately Steep	50 to 70%	148	2%
Steep	>70%	35	<1%
Total		**7,135**	**100%**

[1] Slope angle classes following Howes and Kenk (1999).
[2] Slope angles for LSA assessed using slope angle maps generated from 5 m LiDAR survey contours.

Bedrock Geology, Faults and Rock Properties

The Project is underlain by the Upper Triassic Nicola Group volcanics and sedimentary units, interlayered tuffs, breccias, flows and flow breccias that are typically well indurated and weakly metamorphosed (greenschist facies). These have been intruded by the northwest trending, Late

Triassic to Early Jurassic Iron Mask Batholith, with dimensions up to 34 km long and up to 5 km wide. Several mineral deposits and showings are associated with the Iron Mask Batholith, including Afton, Ajax East, Ajax West, Crescent, and Pothook. Multiple intrusive phases of the Iron Mask Batholith have been identified in the area, including Pothook, Iron Mask Hybrid, Cherry Creek and Sugarloaf phases. The middle Eocene sedimentary rocks of the Kamloops Group unconformably overlie the rocks of the Nicola Group and Iron Mask Batholith within the region. Landslides related to the rocks of the Kamloops Group have been previously noted in the region (Geotex Consultants Ltd. 1996, Golder Associates 2011), particularly in the Aberdeen Hills subdivision to the northeast of the Project. The tuffaceous sandstones, siltstones and shales of the Kamloops Group have not been identified within the LSA; these rocks are found in the Aberdeen Hills area within the RSA.

The key stratigraphic sequence of geological events presented in order of oldest to youngest is summarised as follows:

- Nicola Group Volcanics (Triassic age) emplaced;
- Iron Mask Batholith intruded into Nicola Group rocks (Late Triassic to Early Jurassic);
- sustained period of erosion and weathering and tectonic activity leading to faulting;
- Kamloops Group (middle Eocene) emplaced;
- Pleistocene ice sheet deeply gouged and sculpted the bedrock; the rounded ridge tops suggest the entire area was completely overridden by ice. Ice flowed generally from the northwest to the southeast across the LSA. Glacial sediments were deposited at the base of the ice sheet discussed in the surficial geology section below.

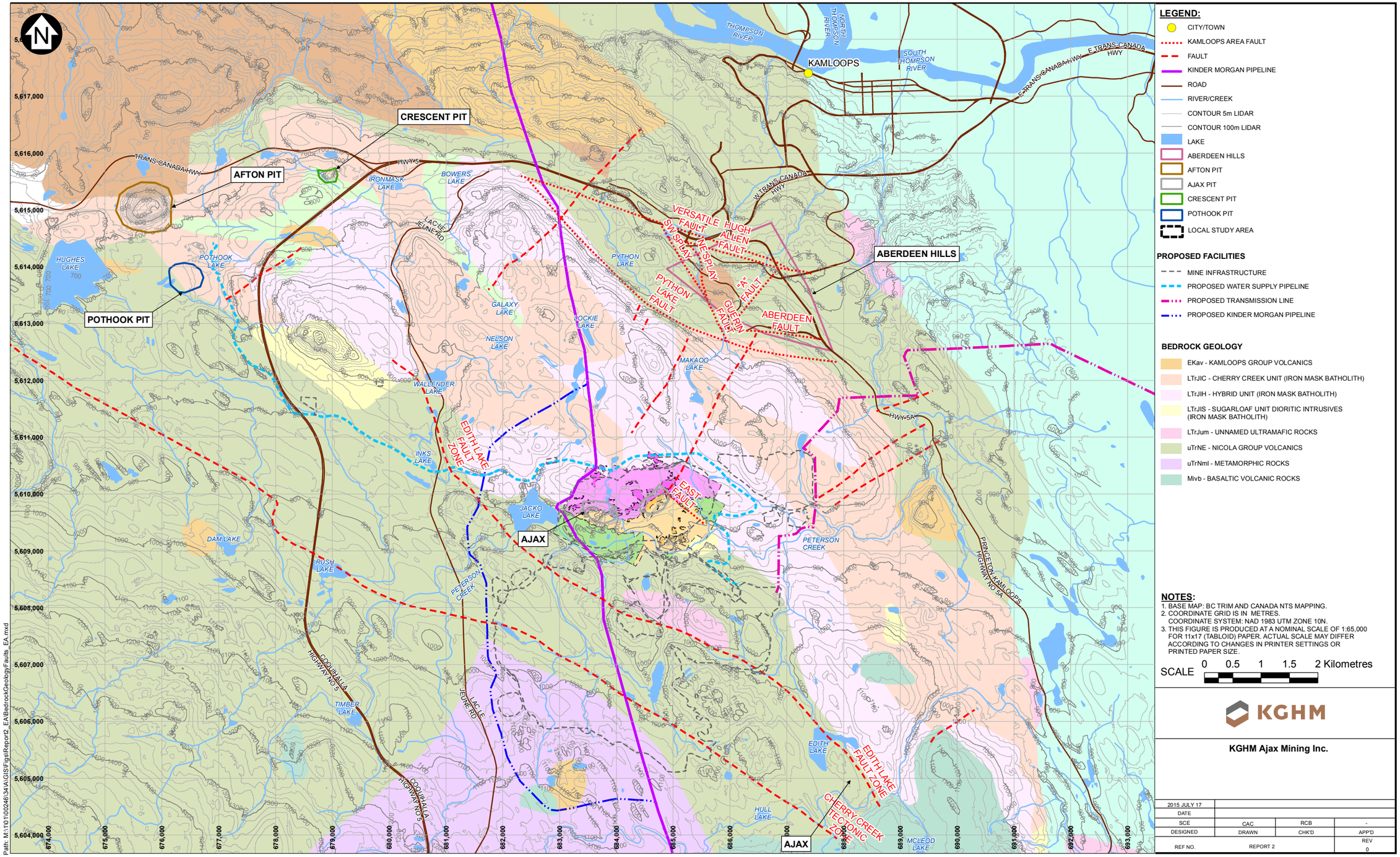
Bedrock geology and faults for the Project are presented on Figure 6.2-2.

Uranium within the Ajax pit was identified by the BC Environmental Assessment Office (BC EAO) and KGHM Ajax Mining Ltd. (KAM) Community Advisory Group as a potential area of concern during the scoping and issues identification phase. Over 33,523 samples were analyzed by KAM with a lower detection limit of 0.1 ppm; the average uranium content was 0.78 ppm. Only 2.8% of the samples analyzed at the low detection limit were above 1.8 ppm (and the average crustal abundance of uranium is around 1.8 ppm). Baseline uranium concentrations for the Project can be characterized as below normal crustal abundance and are not a potential issue of concern, and therefore not carried forward into the assessment for the Geology, Landforms and Soils VC. For additional information see Section 3.3 Project Description – Mineralization.

The regional structural geology setting of the Nicola Group Volcanics and the Iron Mask Batholith follow regional northwest - southeast trends. The Cherry Creek Tectonic Zone (CCTZ), approximately 2 km southwest of the Open Pit, is representative of this trend. The Edith Lake Fault Zone (ELFZ), located approximately 1 km southwest of the proposed Open Pit, is possibly associated with this trend. The East Pit Fault mapped within the proposed Open Pit area follows a similar trend to this regional fault set, and appears to be the dominant fabric through the LSA.

Figure 6.2-2
Bedrock Geology and Faults

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LEGEND:

- CITY/TOWN
- KAMLOOPS AREA FAULT
- FAULT
- KINDER MORGAN PIPELINE
- ROAD
- RIVER/CREEK
- CONTOUR 5m LIDAR
- CONTOUR 100m LIDAR
- LAKE
- ABERDEEN HILLS
- AFTON PIT
- AJAX PIT
- CRESCENT PIT
- POTHOOK PIT
- LOCAL STUDY AREA

PROPOSED FACILITIES

- MINE INFRASTRUCTURE
- PROPOSED WATER SUPPLY PIPELINE
- PROPOSED TRANSMISSION LINE
- PROPOSED KINDER MORGAN PIPELINE

BEDROCK GEOLOGY

- EKav - KAMLOOPS GROUP VOLCANICS
- LTrJIC - CHERRY CREEK UNIT (IRON MASK BATHOLITH)
- LTrJIH - HYBRID UNIT (IRON MASK BATHOLITH)
- LTrJIS - SUGARLOAF UNIT DIORITIC INTRUSIVES (IRON MASK BATHOLITH)
- LTrJum - UNNAMED ULTRAMAFIC ROCKS
- uTrNE - NICOLA GROUP VOLCANICS
- uTrNml - METAMORPHIC ROCKS
- Mivb - BASALTIC VOLCANIC ROCKS

NOTES:

1. BASE MAP: BC TRIM AND CANADA NTS MAPPING.
2. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD 1983 UTM ZONE 10N.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:65,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.

SCALE 0 0.5 1 1.5 2 Kilometres

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Other fault sets include inferred normal faults striking approximately north-south that are observed to truncate faults of the northwest-trending set. Northeast striking faults are interpreted to be post-intrusion of the Iron Mask Batholith while east-west striking faults are from faulted contacts between the geology units. Other faults observed are related to the contacts between individual geological units, such as the contacts between the Iron Mask Batholith, the Nicola Volcanic Group and the Kamloops Group. Identified faults are presented on Figure 6.2-2.

Surficial Geology

The Project is characterized by landforms that reflect the area's history of glaciation. Deglaciation occurred between about 14,000 and 11,000 years ago. Deglaciation took place by downwashing so that the uplands emerged from beneath the ice while tongues of ice remained in the valley bottoms. Stagnant ice in the valley bottoms impounded a large but temporary glacial lake along the Thompson, South Thompson and North Thompson River Valleys called 'Glacial Lake Thompson'. Downwashing ice often forms characteristic subglacial and ice-marginal landforms on gentle surfaces, such as, eskers, kames, and meltwater channels. Temporary glacial lakes formed in depressions in front of the ice margin. Kettle terrace deposits are mapped along several of the tributary drainage lines to Peterson Creek. Glacial lake deposits, which had been exposed following the breaching of the ice dam in the South Thompson River valley, were mobilized by wind and deposited in upslope areas as eolian sediments in the para-glacial period. Glacial sediments and weathered bedrock have been re-worked on steeper slopes to form colluvium. The glacial sands and gravels were locally incised by stream flow along Peterson Creek creating terraces. Fluvial sediments continue to be deposited along the active water courses during post-glacial times. Descriptions of the surficial geology types identified in the terrain mapping exercise for the LSA are summarised below. Terrain mapping of the LSA is presented on Figure 6.2-3. Surficial geology types are summarised by area and percent of LSA in Table 6.2-3.

Table 6.2-3. Summary of Surficial Geology Distribution within the LSA

Surficial Geology Unit Name	Surficial Material Unit Code	Baseline Extent	
		ha	% of LSA
Anthropogenic Material	A	296	4%
Fluvial Active	Ff, Fp	147	2%
Organic Accumulations	O	83	1%
Eolian Sediments	E	303	4%
Colluvium Deposits	C	275	4%
Lake / Glacial Lake Deposits	LG, L	169	2%
Glaciofluvial Deposits	FG	305	4%
Glacial Till (Moraine)	M	5,188	73%
Bedrock	D/R	368	5%
LSA Total Area		**7,135**	**100%**

[1] *Baseline Terrain Mapping for LSA following Howes and Kenk (1999).*
[2] *Baseline extent based on Terrain Mapping of LSA.*

Anthropogenic Areas (A) – Anthropogenic areas comprising Open Pit and mine rock storage facilities from historic mining occupy approximately 296 ha or 4% of the LSA. The historic Ajax Open Pit and mine rock storage facilities are located in the north part of the Mine Site footprint. The historic Afton mine rock storage facilities and Open Pit and current New Afton Mine Site infrastructure to support current underground mining are located at the northwest end of the water supply pipeline corridor.

Fluvial Deposits (Ff, Fp) – The active fluvial channel of Peterson Creek is up to about 5 m-wide in the Mine Site footprint. The flood plain adjacent to Peterson Creek is up to approximately 50 m-wide. Fluvial deposits were mapped in small areas of the East Mine Rock Storage Facility (EMRSF), West Mine Rock Storage Facility (WMRSF), Tailings Storage Facility (TSF) and Open Pit. Fluvial deposits occupy approximately 147 ha or 2% of the LSA.

Organic Accumulations (O) – Organic swamps were mapped in small areas of the TSF, EMRSF, WMRSF and South Mine Rock Storage Facility (SMRSF). The organic swamps are very poorly-drained with standing water being present for some of the year. Organic accumulations occupy approximately 83 ha or 1% of the LSA.

Eolian Sediments (E) – Eolian sediments (loess) are wind-blown fine grained soils re-worked by flash floods. Eolian sediments were identified on broad northwest-southeast oriented terrain in the west part of the TSF basin, the northeast part of the Mine Site footprint and south of Inks Lake. Eolian sediments occupy approximately 303 ha or 4% of the LSA.

Colluvium Deposits (C) – Colluvium deposits are found in a broad area composed of bedrock outcrops in hill top settings surrounded by moderately steep colluvial slopes. This area extends in a northwest direction across the Mine Site footprint and includes the northeast parts of the WMRSF and TSF footprints generally following the ELFZ. Colluvium deposits occupy approximately 275 ha or 4% of the LSA.

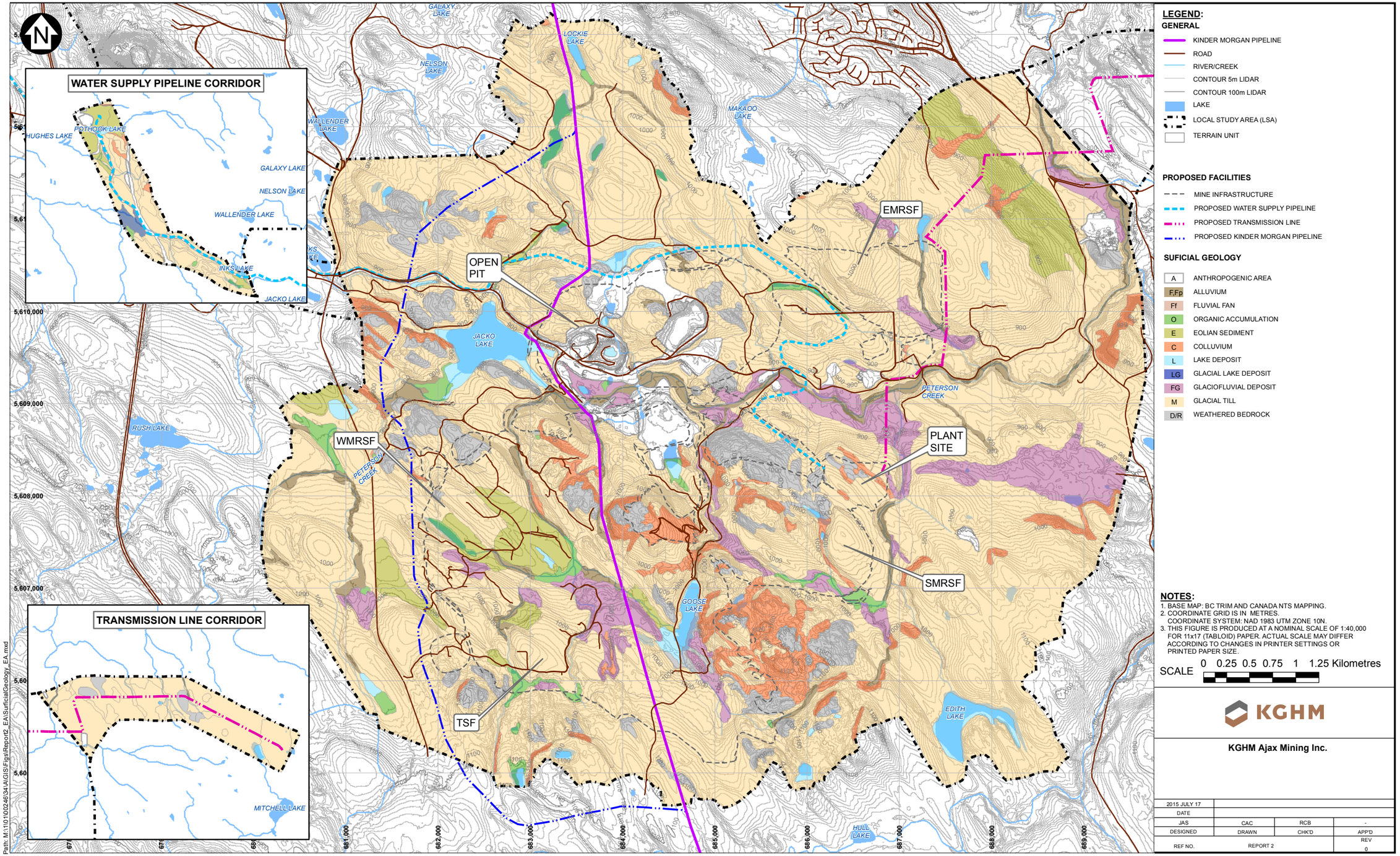
Glacial Lake Deposits (LG, L) – Lake (active) deposits and glacial lake deposits occupy approximately 169 ha or 2% of the LSA (active and glacial were combined because of their small distribution and similar grain size deposition method). Fine grained laminated glacial lake deposits were mapped in the vicinity of Peterson Creek. Minor lake deposits were mapped at the EMRSF, and in lowlands surrounding Jacko, Edith and Goose lakes.

Glaciofluvial Deposits (FG) – Poorly sorted gravel and sand, which are characterized by irregular hummocks and kettles, including kame complexes, kame terraces and terraced kame delta deposits were identified adjacent to Peterson Creek and in areas to the south and west of Goose Lake. Glaciofluvial deposits occupy approximately 305 ha or 4% of the LSA.

Glacial Till Deposits (M) - The most dominant surficial material found within the Project are glacial till deposits that occupy approximately 5,188 ha or 73% of the LSA. These glacial till deposits consist of minor sand, gravel, and silt, and can have variability in thickness, ranging from few to several meters thick. Glacial till can be further subdivided into loose to compact ablation till and compact to very dense lodgement till. The widespread distribution of drumlins (characterized by streamlined forms in the predominant direction of ice advance) suggests that lodgement till is more common within the LSA than ablation till.

Figure 6.2-3
Terrain Map of Surficial Geology

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LEGEND:

GENERAL
- KINDER MORGAN PIPELINE
- ROAD
- RIVER/CREEK
- CONTOUR 5m LIDAR
- CONTOUR 100m LIDAR
- LAKE
- LOCAL STUDY AREA (LSA)
- TERRAIN UNIT

PROPOSED FACILITIES
- MINE INFRASTRUCTURE
- PROPOSED WATER SUPPLY PIPELINE
- PROPOSED TRANSMISSION LINE
- PROPOSED KINDER MORGAN PIPELINE

SUFICIAL GEOLOGY
- A — ANTHROPOGENIC AREA
- F,Fp — ALLUVIUM
- Ff — FLUVIAL FAN
- O — ORGANIC ACCUMULATION
- E — EOLIAN SEDIMENT
- C — COLLUVIUM
- L — LAKE DEPOSIT
- LG — GLACIAL LAKE DEPOSIT
- FG — GLACIOFLUVIAL DEPOSIT
- M — GLACIAL TILL
- D/R — WEATHERED BEDROCK

NOTES:
1. BASE MAP: BC TRIM AND CANADA NTS MAPPING.
2. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD 1983 UTM ZONE 10N.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:40,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.

SCALE 0 0.25 0.5 0.75 1 1.25 Kilometres

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Outcropping Bedrock (D/R) – Bedrock outcrops occupy approximately 368 ha or 5% of the LSA. Areas of rock outcrop and near-surface rocks typically occur as pods in the LSA, generally following the ELFZ. Small areas of bedrock exposure were mapped at the sites of the TSF, SMRSF, WMRSF and Open Pit.

Terrain Stability

Terrain stability refers to the likelihood of a landslide initiating in a terrain polygon following timber harvesting and road construction for mine development. Terrain stability class criteria were used to develop Terrain Stability Maps following Howe and Kenk (1999) class definitions. Three terrain stability classes were used:

- **Stable (S) –** Identified as terrain with a 'negligible' to 'low' likelihood of landslide initiation following timber harvesting and road construction for mine development.
- **Potentially unstable (P) –** Expected to contain areas with a 'moderate' likelihood of landslide initiation following timber harvesting and road construction for mine development.
- **Unstable (U) –** Expected to contain areas where there is a 'high' likelihood of landslide initiation following timber harvesting and road construction for mine development.

Relatively few historical landslides were identified within the Project LSA. The Terrain Stability Mapping indicated that 98% of the LSA is 'stable', having a 'negligible' to 'low' likelihood of landslides in relation to mine construction disturbance. A further 2% of the LSA is considered 'potentially unstable' and less than 1 ha identified as 'unstable'. Terrain Mapping of LSA is presented on Figure 6.2-4. Terrain stability mapping areas are summarised by area and percent of LSA in Table 6.2-4.

Table 6.2-4. Summary of Slope Stability Potential within the LSA

Terrain Stability Class	Likelihood of Landslide Initiation	Area (ha)	% Project LSA
Stable	Negligible	7,010	98%
Potentially Unstable	Moderate	123	2%
Unstable	High	1	<1%
LSA Total Area		**7,135**	**100%**

[1] *Baseline Terrain Stability Mapping for LSA following Howe and Kenk (1999).*
[2] *Baseline extent based on Terrain Mapping of LSA.*

Terrain Stability – Open Pit

Slope stability analyses were developed for the proposed Ajax Open Pit by SRK and are provided in Appendices 6.2-D and 6.2-E. Detailed kinematic slope stability analyses were performed using various data sources including oriented drill core and televiewer surveys. Flatter inter-ramp slope angles were selected for the areas where adverse structural features and weaker lithologies are expected to be encountered (i.e., Ajax Pit Sector 6). Further rock mass sensitivity analyses were

conducted for the inter-ramp scale slopes to demonstrate the slope stability under various uncertainties, including soil/rock mass strength parameters, and pore water pressure conditions. The recommended slope configurations represented engineering best practice based on available geotechnical information along with some reasonable but slightly conservative assumptions, corresponding slope stability analysis results, and experience in the Project region. The proposed pit slope angles of 44 to 50 degree inter-ramp angles, and 45 to 53 degree overall slope angles are reasonable to mitigate the risk of pit wall failure provided that controlled blasting, effective slope depressurization, and careful slope monitoring are implemented throughout the pit operations.

Terrain Stability – Aberdeen Hills Area

The closest community to the LSA is the Aberdeen Hills area, a subdivision of the City of Kamloops (CoK), located approximately 2.9 km north-northeast from the site of the proposed Ajax Pit. The Aberdeen Hills area is located outside the LSA, but is included within the RSA boundary for the Geology, Landforms and Soils VC. This is based on feedback received on the VC selection process during the pre-Application phase where concerns were noted with how blasting vibrations from the Project Open Pit development may affect the stability of the known historic landslides.

The Aberdeen Hills area was identified as having a history of terrain instability that pre-dates subdivision development. There is potential for large-scale landslides in the Aberdeen Hills area that are associated with the combination of presence of Kamloops Group bedrock, gentle slope angles, and high groundwater pressure. The Aberdeen Hills area topography slopes towards the north-northeast at an overall slope angle of approximately 14 to 16%. Past failures have occurred on sliding surfaces at or near the interface between the surficial soils (commonly glacial till) and underlying Kamloops Group bedrock. The instability of the Kamloops Group bedrock is largely attributed to layers of volcanic ash (tuff) which alter to highly plastic swelling clays sensitive to groundwater.

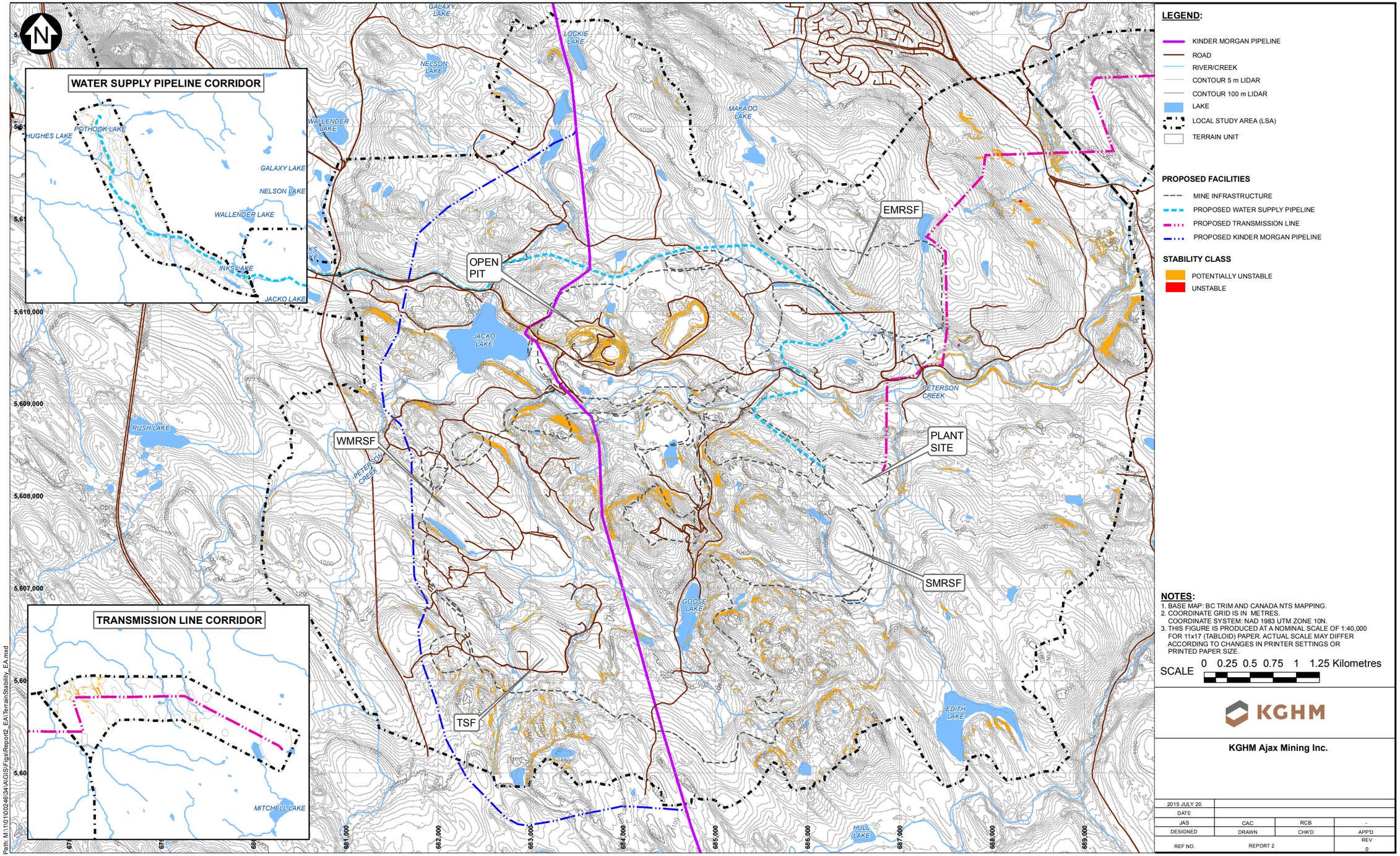
Six landslides have been identified by Golder Associates (2011) within the Aberdeen Hills area. Five of the identified Aberdeen Hill subdivision landslides were interpreted to have occurred in the last 30 years; the sixth landslide 'Slide A' is an ancient slide that is not known to have moved during that time period. Aberdeen Hills is managed today by a sophisticated network of pumping wells supervised by the CoK and Golder Associates. Slope stability assessments are routinely undertaken for the Aberdeen Hills area by consultants on behalf of the CoK.

Erosion Potential

Terrain mapping did not identify any existing widespread areas of sheet erosion within the LSA. Negligible amounts of gully erosion were observed in cut slopes in moderately steep slope angles of glacial till, particularly in the west part of the Mine Site. Gully erosion was also identified on moderately inclined natural slopes in areas of drumlinized terrain. Silt-rich eolian sediments, glacial lake deposits and organic soils are expected to be particularly prone to erosion during the Construction phase, once the vegetation has been stripped. These silt-rich soils (eolian sediments, glacial lake deposits and organic soils) account for 558 ha or less than 8% of the LSA.

Figure 6.2-4
Terrain Stability Map

Knight Piésold CONSULTING



LEGEND:

- KINDER MORGAN PIPELINE
- ROAD
- RIVER/CREEK
- CONTOUR 5 m LIDAR
- CONTOUR 100 m LIDAR
- LAKE
- LOCAL STUDY AREA (LSA)
- TERRAIN UNIT

PROPOSED FACILITIES

- MINE INFRASTRUCTURE
- PROPOSED WATER SUPPLY PIPELINE
- PROPOSED TRANSMISSION LINE
- PROPOSED KINDER MORGAN PIPELINE

STABILITY CLASS

- POTENTIALLY UNSTABLE
- UNSTABLE

NOTES:

1. BASE MAP: BC TRIM AND CANADA NTS MAPPING.
2. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD 1983 UTM ZONE 10N.
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Topsoil

The following soil types were identified in the bio-terrain mapping for the LSA, described in accordance with the Canadian System of Soil Classification:

- Orthic Dark Brown Chernozems;
- Eutric Brunisols (Degraded, Lithic);
- Carbonated Black and/or Orthic Humic Regosols; and
- Calcareous Anthropogenic materials associated with the former Afton mine operations.

Of these soil types, Dark Brown Chernozems and Brunisols developed on calcareous morainal materials are the most prevalent within the LSA. Chernozem soils have developed where grasses are the dominant vegetation. Surficial textures are typically silt loam; coarse fragment content is variable and average pH of the A horizon is 7.2. Black Chernozems are found in some toe slope areas and imperfect drainage corridors associated with slope wash. In some instances there are accumulations of 1.5 m of silt textured soil material with little or no coarse fragments. Brunisols are found in areas dominated by conifers. They typically have a fragile, dusty, thin A soil horizon overlying a thicker, compact B soil horizon with loam to silt loam textures and an average pH of 7.2. The A and B soil horizons overlie a calcareous C soil horizon.

Soil depth and quality are extremely variable across the LSA, with low gradient, moisture enriched sites producing significantly larger quantities of good quality soil with low coarse fragment content and favourable structure and textures. In contrast, steeper drier sites often produce thin, fragile soils with many coarse fragments. Across the LSA the average depth of the A soil horizon is 19 cm and ranges from 13 to 26 cm, while the average depth of the B soil horizon is 22 cm with a range from 17 to 30 cm. The B soil horizon generally has more coarse fragments than the A horizon. In edaphically wetter areas soil profiles are much deeper, with topsoil horizons occasionally exceeding 1.5 metres in depth. These areas can yield large amounts of high quality growing medium.

Based on the terrain and surficial geology information collected, baseline topsoil for the Project has been categorized into Soil Map Units (SMU) according to their physical and spatial characteristics. Descriptions of the SMU types identified in the bioterrain mapping exercise for the LSA is summarised below and displayed on Figure 6.2-5.

SMU 1 – Dark Brown and Black Chernozem soils formed in edaphically wetter locations, often at toe slopes and imperfectly drained linear depressions where soil accumulation has resulted from slope wash. The typical texture is silt to silt loam with generally less than 5% coarse fragments. Average depth of the A soil horizon is 18 cm although local accumulations can be up to 1.5 m and the B soil horizon depth averages 20 cm. SMU 1 covers approximately 131 ha or 2% of the LSA.

SMU 2 – Dark Brown Chernozems belonging to the Glimpse soil association developed in sandy or loamy fluvioglacial deposits. The A soil horizon has an average depth of 15 cm and favourable B soil horizon an average depth of 21 cm. These soils developed on sandy or loamy glaciofluvial deposits in very gently sloping to gently rolling (<10% slopes) terrain with vegetation dominated by grasses and shrubs. SMU 2 covers approximately 516 ha or 9% of the LSA.

SMU 3 – Thin Dark Brown Chernozems (Alymer, Trapp Lake and Tullee soil associations) developed on weakly to moderately calcareous glacial till parent materials. Surface textures range from sandy loam to silty clay loam, with moderate to high coarse fragments in the B soil horizon. Average A and B soil horizon depths are 18 and 22 cm, respectively. SMU 3 soils are the predominant topsoil and occupy approximately 3,457 ha or 63% of the LSA.

SMU 3K – Thin Dark Brown Chernozems (Alymer, Trapp Lake and Tullee soil associations) with calcareous A soil horizon developed on moderately to strongly calcareous glacial till parent materials. Surface textures range from sandy loam to silty clay loam, with moderate to high coarse fragments in the B soil horizon. Average A and B soil horizon depths are 20 and 17 cm, respectively. SMU 3K covers approximately 111 ha or 2% of the LSA.

SMU 4 – Fragile Eutric Brunisols (Andrew, Timber, Tullee soil association components) developed on weakly to moderately calcareous glacial till parent materials under forest vegetation. Surface textures range from sandy loam to silty loam, with moderate to high coarse fragments in the B soil horizon. Average A and B soil horizon depths are 14 and 29 cm, respectively. SMU 4 covers approximately 721 ha or 13% of the LSA.

SMU 5 – Fragile Eutric/Lithic Brunisols (Andrew, Timber, Trapp Lake soil association components) developed on shallow glacial till parent materials overlying colluvium and/or weathered bedrock deposits. Surface textures range from sandy loam to silty loam, with moderate to high coarse fragment content in both the A and B soil horizons. Average A and B soil horizon depths are 20 and 16 cm, respectively. SMU 5 covers approximately 197 ha or 4% of the LSA.

SMU 6 – Anthropogenic disturbances associated with the mine rock storage facilities of the historic mine operations generally comprised of admixed A, B and C soil horizons and as a result are moderately to strongly calcareous to the surface. These soils are unsuitable for reclamation purposes. SMU 6 covers approximately 276 ha or 5% of the LSA.

SMU 99 – Saline/brackish soils are found in wetlands and depressed areas, and cover approximately 103 ha or 2% of the LSA. These soils are unsuitable for reclamation purposes.

Soil Map Units are summarised by area and percent of LSA in Table 6.2-5 including the relationship between mapped SMUs for the Ajax Project and previously completed soil survey mapping unit codes as described in Soils of the Ashcroft Map Area (Young et al. 1992).

Seismicity

The Project is situated within central British Columbia (BC), where the level of recorded historical seismic activity is considered to be low level (Klohn Crippen Berger 2011). The seismic hazards at the LSA are dominated by shallow crustal earthquakes. The seismic activity north of the Project is low in an area confined by the Queen Charlotte Fault to the west and the North Rocky Mountain Trench to the east. The seismic activity generally decreases in an easterly direction towards the Project from the active Subduction Zone. Relatively more historical earthquakes have occurred in the Southern Rocky Mountain area located east of the Project.

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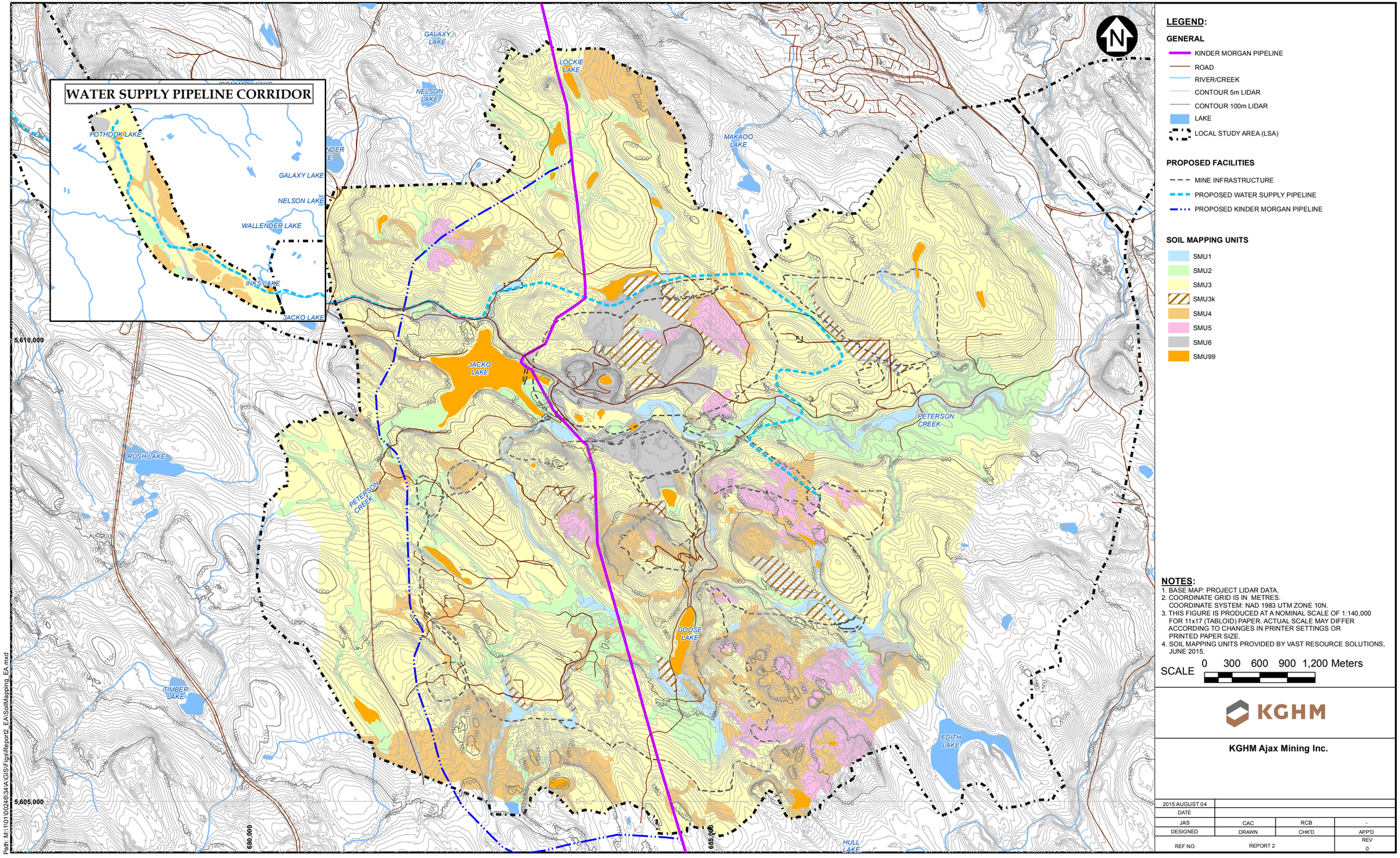


Table 6.2-5. Summary of Topsoil Distribution within the LSA

Soil Map Units	Soil Survey Mapping Unit Code 1	Average A Horizon Depth (cm)	Average B Horizon Depth (cm)	Baseline Extent	
				Area (ha)	% of LSA
SMU 1	FS11, GS1	18	20	113	2%
SMU 2	GS1, GS3	15	21	516	9%
SMU 3	AY1, TP1, TE1, TE2	18	22	3,457	63%
SMU 3K	AY1, TP1, TE1, TE2	20	17	111	2%
SMU 4	AD2, TM5, TE4	14	23	721	13%
SMU 5	AD2, TM5, TP5	20	16	197	4%
SMU 6	n/a	n/a	n/a	276	5%
SMU 99	n/a	n/a	n/a	103	2%
LSA Total Area				**5,513**	**100%**

[1] *Soil associations described in Soils of the Ashcroft Map Area (Young et al. 1992)*

Major faults onshore within BC generally trend in a north-westerly direction consistent with the overall regional tectonic pattern, but many faults also strike across this trend. Most reports describe the major fault movements in BC as having occurred several tens of millions years ago, and there has not been a published case of Quaternary fault surface rupture associated with an earthquake. None of the major regional and local faults are considered active except for the Hell Creek Fault which is located 125 km from the Project (Klohn Crippen Berger 2011).

The Kamloops region is characterized by a low level of historical seismicity. A seismic hazard calculation for the site was obtained from Natural Resources Canada (NRCan); the values are in accordance with the 2010 National Building Code. The peak horizontal ground accelerations for firm ground and different return periods are summarized in Table 6.2-6.

Table 6.2-6. Seismic Hazard Values

Return Period (Years)	100	475	1,000	2,475	10,000
Probability of Exceedance per Annum	1%	0.21%	0.1%	0.0404%	0.01%
Probability of Exceedance in 50 years	40%	10%	5%	2%	0.5%
Peak Ground Acceleration (g)	0.034	0.072	0.097	0.138	0.34

[1] *Seismic Hazard Values obtained from Natural Resources Canada (NRCan) and are in accordance with the 2010 National Building Code.*

Snow Avalanches

Geohazard assessments undertaken for the Project indicate that the site has a relatively low hazard with respect to avalanches. Avalanche risk areas are typically recognized by the following conditions:

- steeper slopes, ranging between 28 and 55 degrees;
- upstream slope changes greater than 10 degrees, which promote breaking of the continuity of the snow blanket; and

- existing vegetation cover (e.g., dense tree coverage prevents the creation of a compact and homogeneous snow layer).

These conditions are rare in the LSA with moderately steep and steep slope angles accounting for only 14% of the LSA. The risk of snow avalanches within the LSA is anticipated to be negligible.

Karst

Karst geologic hazards are a naturally occurring geologic condition which are associated with rock types that have the potential to cause sinkholes that may result in property damage or is a threat to the safety of people and karst aquifers that make the groundwater vulnerable to pollution. The Project is situated in an area of no known mapped limestone lithologies and there is no record of karst terrain in the BC Geological Survey Branch (BCGS) database for the LSA (BC Ministry of Energy and Mines 2007). The risk of karst terrain presence within the LSA is anticipated to be negligible.

6.2.3 Assessment Boundaries

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

6.2.3.1 Spatial Boundaries

Local Study Area

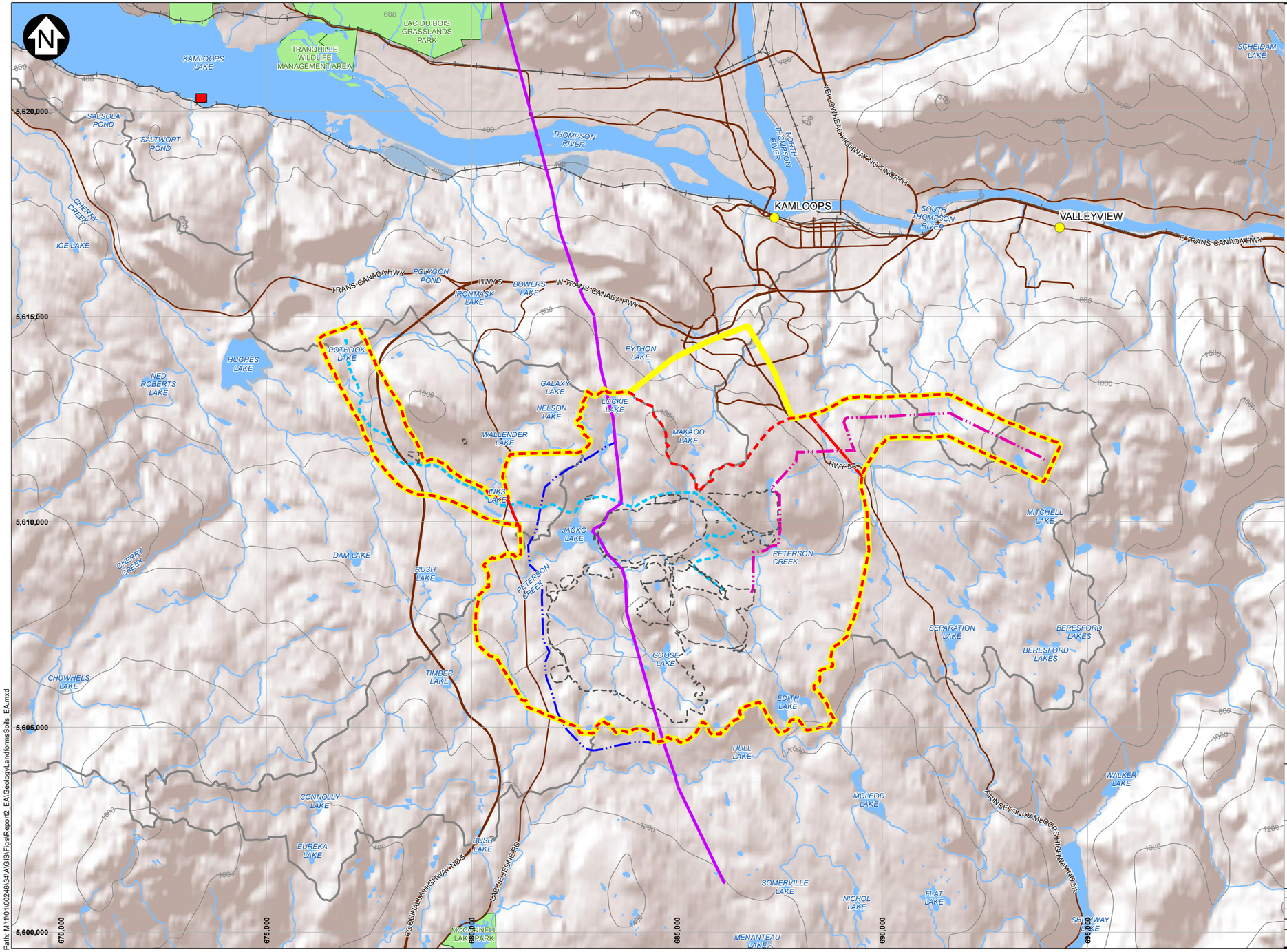
The Local Study Area (LSA) for the Geology, Landforms and Soils VC includes the Project footprint plus a 500 m buffer from Project features or up to the watershed boundary, if required. This area is anticipated to encompass the zone of direct effects. The LSA for the Geology, Landforms and Soils VC is shown on Figure 6.2-6.

Regional Study Area

The Regional Study Area (RSA) encompasses the LSA for the Geology, Landforms and Soils VC and includes the Aberdeen Hills area. The Aberdeen Hills area is a subdivision located 2.9 km from the Open Pit. The Aberdeen Hills area was identified during feedback received on the VC selection process due to expressed concerns of blast vibration from pit development potentially re-activating historic landslides within the subdivision. The RSA for the Geology, Landforms and Soils VC is shown on Figure 6.2-6.

Figure 6.2-6
Local Study Area and Regional Study Area for Geology, Landforms, and Soils

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LEGEND:

GENERAL
- CITY/TOWN
- KINDER MORGAN PIPELINE
- ROAD
- RIVER/CREEK
- RAILWAY
- CONTOUR (200 m)
- LAKE
- PROVINCIAL PARK
- WATERSHED BOUNDARY
- LOCAL STUDY AREA (LSA)
- REGIONAL STUDY AREA (RSA)

PROPOSED FACILITIES
- INTAKE
- MINE INFRASTRUCTURE
- PROPOSED WATER SUPPLY PIPELINE
- PROPOSED TRANSMISSION LINE
- PROPOSED KINDER MORGAN PIPELINE

NOTES:
1. BASE MAP: BC TRIM AND CANADA NTS MAPPING.
2. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD 1983 UTM ZONE 10N.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:100,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.

SCALE 0 1 2 3 Kilometres

KGHM

KGHM Ajax Mining Inc.

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6.2.3.2 Temporal Boundaries

Temporal boundary selection was based on a reasonable expectation of the time over which the Project would have effects on biophysical and human environmental receptors. Mine Operation is projected to be 23 years following Construction; Decommissioning and Closure and Post Closure phases would follow. Temporal boundaries of the Project, which are contingent on permitting, include four primary phases:

- **Construction**: 2 years;
- **Operation**: 23 years;
- **Decommissioning and Closure**: 5 years (includes Project Decommissioning, closure and reclamation activities, as well as temporary Closure, and care and maintenance); and
- **Post Closure**: 5+ years (includes ongoing reclamation activities and Post Closure monitoring).

The temporal boundary for the Geology, Landforms and Soils VC includes the Construction, Operation, Decommissioning and Closure and Post Closure phases of the Project.

6.2.3.3 Technical Boundaries

The technical boundary includes Aberdeen Hill Area subdivision of the CoK. This area was included based on feedback received on the VC selection process during the pre-Application phase. It should be noted that the subdivision is outside of the Ajax Project property and outside of the control of KAM, but was included based on feedback received during the VC selection process.

6.2.4 Potential Effects of the Project and Proposed Mitigation for Geology, Landforms and Soils

6.2.4.1 Identifying Potential Effects on Geology, Landforms and Soils

Potential effects of the Project on the Geology, Landforms and Soils VC that were identified from potential interactions were carried forward into the assessment includes the following indicators:

- **Alteration of baseline landforms –** The development of the Project will require the re-contouring and grading of the existing baseline physiography. This alteration is expected to continue throughout and beyond the Project Closure.
- **Re-distribution of Surficial Geology –** Development of the Open Pit, tailings management facility and borrow source areas will remove and re-distribute surficial deposits throughout all phases of the Project.
- **Soil Disturbance –** Topsoil disturbances will result from the physical removal of soil during the Construction phase and will be associated with the salvage and stockpiling of baseline soils for reclamation purposes.
- **Terrain Stability and Accelerated Erosion (Mine Site footprint) –** The potential exists for slope instability or accelerated erosion to occur as a result of a variety of Project activities throughout the life of the Project. Terrain instability and accelerated erosion can result from overburden slope failure or accelerated erosion in constructed features, such as soil

stockpiles, berms, and embankments, borrow areas; instability of reclaimed terrain, and instability of Open Pit slopes.

- **Terrain Stability; Landslide Reactivation in Aberdeen Hills** –Blasting vibrations from Pit operations has the potential to effect landslide re-activation in Aberdeen Hills area.

The indicators for the Geology, Landforms and Soils VC do not necessarily exist as independent units within the environment. Physiography and topography are directly related to the underlying surficial geology. Surficial geology is directly related to the physiography and topography as a result of sedimentation and erosion processes. Further, this interconnectivity extends beyond the Geology, Landforms and Soils discipline. For example, existing variations in topography and physiography facilitate the formation of micro-habitats and ecological niches, for floral and faunal dependents. Numerous indicators that were identified during scoping and consultation exercises are components of the environment which cannot exist in isolation of one or more of the others.

A potential effect related to geohazards is for facility/structure damage caused by seismicity and avalanches. A probabilistic seismic hazard calculation carried out by Klohn Crippen Berger (2011) indicated that the Project is situated in a region where seismic activity level is historically low. Engineering design best practises using predicted peak ground acceleration (g) for different return periods obtained from the Natural Resources Canada are incorporated into the design of all structures in accordance with the 2010 National Building Code. Seismic hazard is considered an unlikely effect for this location in Canada; therefore, it is not assessed further. Snow avalanche hazard assessments undertaken for the Project indicate that the site has a relatively low risk. Therefore, the potential for avalanches to cause facility damage is considered an unlikely effect, and this interaction is not assessed further.

An interaction matrix of potential interactions between the Geology, Landforms and Soils VC (or more specifically the indicators) and Project components and activities for each phase of the Project is provided in Table 6.2-7. The interactions matrix ranks Project Components and Activities by phase on a four-point scale for the potential to interact with the Geology, Landforms and Soils VC, as follows:

- zero (O): No interaction anticipated, no further consideration warranted.
- low (L): Negligible to minor interaction expected; implementation of best practices, standard mitigation and management measures; no monitoring required, no further consideration warranted.
- moderate (M): Potential moderate interaction requiring unique active management/ monitoring/mitigation; warrants further consideration.
- high (H): Key interaction; warrants further consideration.

Project components for which no interaction is anticipated, or for which there is a potential negligible to minor interaction are not carried forward in the assessment. Project components and activities with the potential to have a moderate or key interaction with the VC are carried forward for further analysis in the effects assessment.

Note that for the purposes of this assessment, it is assumed that Project components/activities function as designed/planned. Potential for effects of the environment on the Project, and for accidents/malfunctions (unplanned events) are evaluated in Sections 17.5 and 17.6.

Table 6.2-7. Identifying Potential Project Interactions and Effects on Geology, Landforms and Soils

Project Component/Physical Activities		Potential Effects on Geology, Landforms and Soils				
		Landforms	Surficial Geology	Soil Disturbance	Terrain Stability	Aberdeen Hills
Construction	Clearing and Grubbing	M	M	M	M	O
	Earthworks	M	M	M	M	O
	Overburden/Topsoil Stockpile	M	M	M	M	O
	Laydown Areas and Storage Yards	L	L	M	L	O
	Project Lighting	O	O	O	O	O
	Site Security and Fencing	O	O	O	O	O
	Fuel Storage and Filling Area	O	O	M	O	O
	Hazardous Wastes Transport, Storage, and Disposal	O	O	M	O	O
	Construction Wastes Transport, Storage, and Disposal	O	O	M	O	O
	Sewage Infrastructure and Disposal	L	L	L	L	O
	Public Road Realignment, Use, and Maintenance	L	L	L	L	O
	Site Road Construction, Use and Maintenance	L	L	L	L	O
	Peterson Creek Overpass Construction, Use, and Maintenance	O	O	O	O	O
	Site Buildings and Process Plant	L	L	L	L	O
	Explosives Magazine and Storage Facilities	L	L	L	L	O
	Open Pit Development	L	L	L	M	L
	Drilling and Blasting	L	L	L	M	L
	Crushing Mine Rock	L	L	O	O	O
	Loading, Hauling, and Deposition of Mine Rock	L	L	L	L	O
	Temporary Ore Stockpile	L	L	L	L	O
	Tailing Storage Facility Development	M	M	M	M	O
	Power Transmission, Distribution	L	L	L	L	O
	Natural Gas Line	L	L	L	L	O
	Pipeline Utility Corridor (Potable Water, Sewage, and Site Water)	L	L	L	L	O
	Water Intake from Kamloops Lake	O	O	O	O	O
	Fire Suppression Infrastructure	L	L	L	O	O
	Contact Water	O	O	O	O	O
	Non-contact Water	O	O	O	O	O
	Peterson Creek Diversion	L	L	L	L	O
	Mine Staffing (Direct Employment)	O	O	O	O	O
	Contracted Employment	O	O	O	O	O
	Taxation	O	O	O	O	O

(continued)

Table 6.2-7. Identifying Potential Project Interactions and Effects on Geology, Landforms and Soils (continued)

Project Component/Physical Activities		Potential Effects on Geology, Landforms and Soils				
		Landforms	Surficial Geology	Soil Disturbance	Terrain Stability	Aberdeen Hills
Operation	Open Pit Development	L	L	O	M	L
	Drilling and Blasting	L	L	O	H	L
	Hauling Mine Rock and Ore from Pit	O	O	O	L	O
	Crushing and Conveying Ore	O	O	O	O	O
	Temporary Ore Stockpile	L	L	L	L	O
	Development of Mine Rock Management Facilities	M	M	M	M	O
	Stripping, Loading, Hauling, Deposition, and Contouring of Topsoil and Overburden	M	M	H	H	O
	Revegetation through Progressive Reclamation	L	L	L	M	O
	Process Plant Operation	O	O	O	O	O
	Deposition to Tailing Storage Facility	O	O	O	O	O
	Site Road Use and Maintenance (Materials, Personnel, Supplies)	O	O	O	O	O
	Concentrate Transport and Storage	L	L	L	L	O
	Explosives Magazine and Storage Facilities	O	O	O	O	O
	Fire Suppression Infrastructure	O	O	O	O	O
	Fuel Storage and Filling Area	O	L	L	L	O
	Hazardous Wastes Transport, Storage, and Disposal	O	L	M	L	O
	General Wastes Transport, Storage, and Disposal	O	L	M	L	O
	Sewage Infrastructure and Disposal	O	L	M	L	O
	Laydown Areas and Storage Yards	O	O	O	O	O
	Power Transmission, Distribution	O	O	O	O	O
	Project Lighting	O	O	O	O	O
	Site Access Security and Fencing	O	O	O	O	O
	Water Intake from Kamloops Lake	O	O	O	O	O
	Contact Water	O	O	O	O	O
	Non-contact Water	O	O	O	O	O
	Potable Water Treatment and Use	O	O	O	O	O
	Peterson Creek Diversion	L	L	L	L	O
	Mine Staffing (Direct Employment)	O	O	O	O	O
	Contracted Employment	O	O	O	O	O
	Taxation	O	O	O	O	O

(continued)

Table 6.2-7. Identifying Potential Project Interactions and Effects on Geology, Landforms and Soils (completed)

Project Component/Physical Activities		Potential Effects on Geology, Landforms and Soils				
		Landforms	Surficial Geology	Soil Disturbance	Terrain Stability	Aberdeen Hills
Decommissioning and Closure	Dismantling of Ancillary Buildings	O	O	O	O	O
	Pit Lake Planning	O	O	O	O	O
	Site Road/Bridge Decommissioning	O	L	L	O	O
	Tailing Storage Facility Decommissioning and Reclamation	L	L	M	M	O
	Waste Rock Management Facilities Reclamation	L	L	M	M	O
	Fuel Storage and Filling Area	L	L	L	L	O
	Hazardous Wastes Transport, Storage, and Disposal	L	L	L	L	O
	General Wastes Transport, Storage, and Disposal	L	L	L	L	O
	Sewage Infrastructure and Disposal	L	L	L	L	O
	Laydown Areas and Storage Yards	L	L	L	L	O
	Power Transmission, Distribution	O	O	O	O	O
	Project Lighting	O	O	O	O	O
	Site Access, Security and Fencing	O	O	O	O	O
	Contact Water	O	O	O	O	O
	Non-contact Water	O	O	O	O	O
	Potable Water Treatment and Use	O	O	O	O	O
	Peterson Creek Diversion	L	L	M	M	O
	Road use to the Project (Materials, Personnel, Supplies)	O	O	O	O	O
	Mine Staffing (Direct Employment)	O	O	O	O	O
	Contracted Employment	O	O	O	O	O
	Taxation	O	O	O	O	O
Post Closure	General Site Inspections and Maintenance	O	O	O	O	O
	Contact Water	O	O	O	O	O
	Non-contact Water	O	O	O	O	O
	Road use to the Project (Materials, Personnel, Supplies)	O	O	O	O	O
	Mine Staffing (Direct Employment)	O	O	O	O	O
	Contracted Employment	O	O	O	O	O

O – No interaction anticipated, no further consideration is warranted
L – Negligible to minor interaction expected; implementation of best practices, standard mitigation and management measures; no monitoring required, no further consideration warranted.
M – Potential moderate interaction requiring unique active management/monitoring/mitigation; warrants further consideration.
H – Key interaction; warrants further consideration.

6.2.4.2 Effects on Geology, Landforms and Soils

Alteration of Baseline Landforms

The alteration of baseline landforms was identified as a key environmental effect for the physiography and topography indicator. Alteration of the baseline landforms will occur throughout the mine footprint as a direct consequence of surface disturbance, although the degree of alteration will vary between Project components. This interaction is expected to extend over the life of the Project, but the majority of the alterations will occur during Construction phase. The Operation phase will be characterized by limited on-going disturbance or the stabilizing of altered conditions, followed by re-contouring to develop final landforms during Closure and Decommissioning.

Baseline landforms within the LSA are gently sloping to undulating; 86% of the LSA has plain to gentle slope angles. Localised moderate slopes angles are identified along the ELFZ and Peterson Creek channel sidewalls that together cover approximately 12% of the LSA. Moderately steep to steep slope angles make up less than 2% of the LSA. The greatest degree of alteration will occur through development of the Open Pit, MRSFs and TSF where baseline landforms will not be re-established during mine Closure and Decommissioning. The Open Pit area, approximately 239 ha in extent (14% of the Mine Site disturbance area) designed to a maximum depth of 545 m will be transformed from the baseline condition into a pit lake with steep slopes angles. Development of the TSF, approximately 544 ha in extent (will make up 32% of the Mine Site disturbance area) will transform Keynes Valley into tailings beach with plain slope angles once the tailings fill the basin. TSF embankments and MRSF's development, approximately 654 ha in combined extent (39% of Mine Site disturbance area), will be transformed from the baseline condition into moderate slope angles.

Closure landform diversity is expected to be an increase in steep slopes (Open Pit development), plain slopes (tailings beach development) and moderate slopes (tailings embankment and MRSFs Construction). The majority of the topography loss in gentle slope angles, 839 ha of disturbance area, will be transformed to either steep slopes or gentle slopes. Within the Mine Site footprint, areas that will undergo relatively limited alterations of landform diversity include the plant site, infrastructure, site access and haul roads, and topsoil stockpile footprints. Alteration of the baseline landforms during development of the water supply pipeline corridor will be minimal, as this Project activity is comprised mainly of upgrading the existing areas and the water pipeline will be buried and topography returned to original conditions. Disturbances to baseline landforms will be limited primarily to the existing, previously disturbed, right-of-way during the Construction phase of the Project. Within the transmission line corridor, the spatial extent of the actual footprint associated with individual H-frame wooden poles is relatively localised. Some additional disturbance is associated with the Construction of the road access 'spurs'; however, these developments will be limited in extent and largely associated with existing disturbance features (such as additional existing transmission rights-of-ways and farm roads). The overall alteration of baseline landforms associated with the Transmission Line and water supply pipeline corridor will be limited, occurring primarily during the Construction phase.

The extent of disturbances to topography and physiography was approximated by calculating the area of disturbance to individual mapped slope angle units within the LSA. Anticipated slope angle changes within the potential disturbance area are summarised in Table 6.2-8.

Table 6.2-8. Summary of Slope Angles Change within the Potential Disturbance Area

		Baseline Extent		Project Disturbance Area		Mine Site Construction	Change in Slope Angles	
Slope Class	Slope Angles	Area (ha)	% of LSA	Area (ha)	% of disturbance area	Area (ha)	Area Change (ha)	% of Change
Plain	0 to 5%	1,659	23%	392	23%	544	152	13%
Gentle	6 to 26%	4,454	62%	1,048	62%	125	-840	-6%
Moderate	27 to 49%	839	12%	199	12%	654	455	89%
Moderately Steep	50 to 70%	148	2%	36	2%	120	0	0%
Steep	>70%	35	<1%	8	<1%	239	231	39%
Total		**7,135**	**100%**	**1,682**	**24%**	**1,682**		

Re-distribution of Surficial Geology

The removal and re-distribution of surficial material (overburden) was identified as a key potential effect of the Project. The interactions of the Project with surficial geology and the topography and physiography are closely linked. The Project components which will undergo the highest degree of alteration in landscape development of the Open Pit, TSF and Mine Rock Storage Facilities (MRSFs) will also require the highest degree of re-distribution of surficial materials.

The proposed Construction and Operation plans for the mine related components of the Project involve the removal of surficial material, quarrying of aggregate, and the re-contouring of the landscape. These activities will result in both temporary and permanent changes in the distribution of surficial material from the pre-disturbed baseline conditions. A permanent increase of coarse-textured anthropogenic materials will be associated with the development of the TSF and MRSFs corresponding to an alteration in the distribution of pre-existing baseline material.

Project interactions with surficial geology are expected to extend over the life of the Project, but most of this interaction will occur during the Construction phase. This will be followed by continued, limited on-going disturbances or the stabilizing of altered conditions in localised areas. During the Operations phase, the Open Pit, MRSFs and TSF will continue to develop in size until specifications are met.

Development of other Mine Site facilities (including the plant site; infrastructure; site access and haul roads; topsoil stockpile footprints; and seepage collection ponds), and transmission line corridor will also affect the distribution of this parent material but this will be to a lesser degree than the Project components noted above. Site preparation activities may involve some re-distribution of surficial material, but this will be limited to relatively minor disturbances during Construction and Closure activities. For the water supply pipeline corridor, re-distribution of surficial materials is expected to be limited to the Construction phase.

Similar to the analysis conducted for topography and physiography, the extent of disturbances to surficial materials was approximated by calculating the potential area of disturbance to individual mapped terrain units within the LSA. Anticipated surficial geology change within the potential disturbance area is summarised in Table 6.2-9.

Table 6.2-9. Summary of Disturbances to Surficial Geology within the Potential Disturbance Area

Surficial Material Unit Name	Surficial Material Unit Code	Baseline Extent		Project Disturbance Area	
		Area (ha)	% of LSA	Area (ha)	% of Disturbance Area
Anthropogenic Material	A	296	4%	154	9%
Fluvial Active	Ff, Fp	147	2%	51	3%
Organic Accumulations	O	83	1%	24	1%
Eolian Sediments	E	303	4%	78	5%
Colluvium Deposits	C	275	4%	101	6%
Glacial Lake Deposits	LG, L	169	2%	24	1%
Glaciofluvial Deposits	FG	305	4%	120	7%
Glacial Till (Moraine)	M	5,188	73%	1,005	60%
Bedrock	D/R	368	5%	125	7%
Total		**7,135**	**100%**	**1,682**	**100%**

[1] *"Percent affected was calculated for the Mine Site facilities only, transmission line and water supply pipeline corridors were not included as the effects will be only temporary.*

The Open Pit, MRSFs and the TSF, accounting for 1,682 ha (24% of the LSA), will undergo the greatest degree of alteration of surficial materials. The rest of the Project footprint (including the remaining areas within the Mine Site, the transmission line corridor, and the water supply pipeline corridor) are anticipated to undergo limited alterations.

Almost all of the surficial material units identified within the potential disturbance area are expected to undergo some degree of disturbance as a result of Mine Site development. Anthropogenic material is expected to undergo the greatest potential change. An estimated 154 ha or 9% of the Mine Site will be disturbed, however these deposits are man-made from the historic mining activities and are not considered an adverse potential effect. Glaciofluvial, fluvial, colluvium, glacial lake and bedrock are expected to undergo a minimal change of between 3 to 7%. This loss of area is considered to be an adverse potential effect. Although organic accumulations have a limited area in the LSA, occupying 24 ha or less than 1% of the potential disturbance area, organic parent materials will be removed and stockpiled for reclamation. Glacial till is the most dominant surficial material onsite and will have the greatest change from the Project development, a net change in extent of 60%.

Approximately 6 Mm^3 of overburden will be excavated during the pit development. Some overburden will be excavated during TSF development. As described previously, the surficial material along with Mine Rock will be used in construction of TSF embankments, MRSFs and other mine site infrastructure. This surficial material will be comprised primarily of anthropogenic material from historic mining activities.

The Project footprint will undergo reclamation during the Decommissioning and Closure phase of the Project. Detailed discussion of the proposed Decommissioning and Closure activities for the Project, including the Mine Site, transmission line corridor, and water supply pipeline Corridor, is

presented in Section 3.17, Reclamation and Closure Plan. Industry standards exist for mining Decommissioning and Closure activities and the Project has incorporated these practices into its overall design. Re-distribution of surficial materials will be limited during Decommissioning and Closure. In the case of the Project, the removed materials will not be returned to their baseline distribution. Reclamation and Closure planning has, instead, focused on measures to incorporate the re-distributed surficial materials into the Closure landscape features.

Soil Disturbance

Three potential effects associated with soil disturbance are loss of topsoil, salvage of baseline soils during construction and re-distribution of salvaged soils during soil reclamation. Soil disturbance during the Construction phase will involve the removal of surface soil for salvage, site grading, and stockpiling of salvaged materials within the Project footprint. During Operation, soil disturbance is expected to be limited and intermittent. Average salvageable topsoil thickness is approximately 0.35 m. Salvaged material will be stockpiled in strategic locations to minimize Operational disturbances to these stockpiles. Topsoil materials will be salvaged from all areas before facility Construction and development. The salvaged material will include all organic material and the upper soils horizons (A and B horizons) and potentially the C-horizon unless deemed not suitable for salvage.

For the water supply pipeline and transmission line corridor, soil disturbance will occur during initial site preparation of the Construction activities. This soil disturbance will occur primarily within the existing previously disturbed corridor of the old haul road. Some new disturbance outside of the corridor is anticipated, but the area of new disturbance will be limited in nature. Transmission line corridor development involves a limited footprint associated with the installation of the H-poles. Soil disturbance is expected to be limited in area to those areas associated with the pole placements and the development of service support roads or trails and new substation.

Baseline soil map development was based on assigning soil associations to delineated bio-terrain polygons. This approach to mapping enabled individual soil associations to be identified as the receptors for effect analysis. The expected effects during the active phases of development and Operation of the Mine Site, water supply pipeline corridor and transmission line corridor on the local soil associations is variable, but most of the associations within the potential disturbance area will generally be affected to some extent.

The extent of disturbance to topsoil was approximated by calculating the potential area of disturbance to individual mapped terrain units within the LSA. Topsoil change within the potential disturbance area is summarised in Table 6.2-10.

Those associations with the greatest proportional change in distribution will be in SMU 3, with 55% of the potential disturbance area. Chernozem soils (SMUs 1, 2 and 3) have developed where grasses are the dominant vegetation. Surficial textures are typically silt loam; coarse fragment content is variable and average pH of the A horizon is 7.2. Black Chernozems are found in some toe slope areas and imperfect drainage corridors associated with slope wash. In some instances there are accumulations of 1.5 metres of silt textured soil material with little or no coarse fragments. These units (SMU 1, 2, and 3) have a combined disturbance area of 1,127 ha or 67%of the disturbance area. Brunisols (SMU 4 and 5) commonly develop in areas dominated by conifers. They typically

have a fragile, dusty, thin A soil horizon overlying a thicker, compact B soil horizon with loam to silt loam textures and an average pH of 7.2. The effect on this association will be 289 ha or 17% of the disturbance area. In both of these soil associations (SMU's 1, 2, 3, 4, and 5 combined), the mine disturbance area of 91% can yield large amounts of high quality growing medium and must be carefully stripped under the supervision of a soil scientist.

Table 6.2-10. Summary of Disturbance to Topsoil within the Potential Disturbance Area

Soil Map Units	Suitability for Reclamation	Baseline Extent		Project Disturbance Area	
		Area (ha)	% of LSA	Area (ha)	% of Disturbance Area
SMU 1	Good	113	2%	82	5%
SMU 2	Good	516	9%	115	7%
SMU 3	Good - Fair	3,457	63%	931	55%
SMU 3K	Poor	111	2%	111	6%
SMU 4	Fair	721	13%	208	12%
SMU 5	Fair - Good	197	4%	80	5%
SMU 6	Poor - Unsuitable	276	5%	156	9%
SMU 99	Unsuitable	103	2%	23	1%
Total		**5,513**	**100%**	**1,705**	**24%**

The suitability of soils for reclamation purposes was assessed utilizing criteria consistent with the *BC Mines Act* permitting requirements. The reclamation suitability criteria require consideration of several soil chemical properties (pH, electrical conductivity, and sodicity and saturation percentage) and physical properties (texture, moist consistency, and volumetric stone content). SMUs were rated as Good, Fair, Poor, or Unsuitable for the A and B horizon characteristics of their profiles. Preliminary volume estimates of salvageable soil and soil requirements for reclamation have been used to create a quantity of soils expected to be salvaged and stockpiled during the Construction phase, summarised in Table 6.2-11. Limitations observed included elevated saturation percentage, excessive carbonates, high salinity, excessive coarse fragments, thin (shallow) soil profiles, adverse structure and erodibility. Salvageability of SMUs assists in site development and soil handling by determining which soils may present challenges during site Construction, Decommissioning and Closure.

During the Construction phase of the Project, the topsoil from each SMU will be salvaged and stored for Decommissioning and Closure. This topsoil consists of the vegetation litter (needle/leaf/decomposed organic matter accumulations on the surface) and the A and B mineral soil horizons (collectively referred to as topsoil in this document). Where the subsoil C horizon has a favourable texture and does not contain significant accumulations of salts, carbonates or coarse fragments, it will be salvaged as "growth medium". This material can be amended with nutrients and actively managed to create a soil-like material or be blended with topsoil to increase overall volumes without substantially diminishing their quality.

Table 6.2-11. Expected Quantity of Soils Stockpiled

Facility / Original Location	Facility Surface Area Area m²	Salvageable Topsoil Volume m³	Average Topsoil Replacement Depth m	Topsoil Required Based on Surface area Area m³	Surplus / Deficit of Topsoil m³	Overburden Baseline Replacement Depth m	Overburden Required Area m³
Open Pit	3,125,000	475,625	0	0	475,625	0	-
TSF	5,494,400	2,670,218	0.35	1,923,040	747,178	0.5	2,747,200
WMRSF	2,429,126	496,014	0.35	599,330	-354,180	0.5	1,214,563
SMRSF	2,407,534	759,956	0.35	842,637	-82,681	0.5	1,203,767
EMRSF	1,008,885	393,918	0.35	353,110	40,808	0.5	504,443
Ore stockpiles (MG and LG)	554,499	-	0.35	194,075	-194,075	0.5	-
Total	**16,392,172**	**4,795,731**	**0.35**	**4,365,960**	**429,771**	**0.5**	**5,959,837**

[1] *Ore stockpiles located on historic mine rock storage facility with no salvageable soils.*

Within the Project disturbance area, it is estimated that approximately 4,795,731 m³ of salvageable topsoil material will be available. Based on the average replacement depth, there will be a projected conceptual soil balance/surplus of approximately 429,771 m³. Approximately 5,959,837 m³ of subsoil/overburden materials will also be required to establish the 0.5 m thickness basal cover over the various mine facilities requiring reclamation, summarised in Table 6.2-11. See also further discussion in Section 3.17.

Facilities such as linear features (Mine Site roads, diversion ditches, etc.), building sites, parking and laydown/storage areas, and water management ponds which, during Construction, will have the soil windrowed on site rather than removed and stockpiled at another location. For these sites, the soil volume replaced is assumed to be the same as the volume removed, therefore, there will be no soil surplus or shortfall.

Terrain Stability and Accelerated Erosion

Potential effects associated with terrain stability are vegetation clearing, overburden slope failure, berm/dyke/diversion channel slope failure road damage causing slope failure causing accelerated erosion. During baseline characterization, terrain stability ratings were assigned to each terrain polygon through API. In general, the potential for terrain stability issues increase with slope gradient, increased moisture content, and the presence of existing instability features (refer to Section 6.2.2 for the criteria for rating terrain stability). Within the Mine Site, water supply pipeline corridor and transmission line corridor, approximately 98% (7,011 ha, see Table 6.2-4) of the area is rated with Negligible to Low likelihood of landslide initiation, and is considered 'stable'. For those polygons with a 'stable' rating, stability issues may develop if surface or drainage conditions are significantly altered. Terrain stability ratings of 'potentially unstable' with a moderate likelihood of landslide initiation, occupied less than 2% (123 ha, see Table 6.2-4) of the disturbance area. Within the access and transmission line corridor, terrain stability issues are generally the result of over-steepening by gully and fluvial incision or the development of valley bottom meltwater channels.

Localised areas of seepage and slow soil creep processes result in an increase in the terrain stability ratings based on the potential for surface erosion following disturbance in the Mine Site footprint.

Baseline terrain within the Project footprint is generally considered to be stable and, therefore, terrain stability related issues are expected to be associated with Project activities only. Slope failure or slumping resulting from the development of this Project is directly influenced by the Construction and Operation phases. Specifically, the potential for effect is possible during site preparation and infrastructure development, and mining and quarrying components of the Project. During the Decommissioning and Closure phase, instability or accelerated erosion associated with reclaimed terrain is considered to be a potential effect.

Within the Mine Site footprint, three potential effects were identified:

- The potential for overburden slope failure and accelerated erosion is identified for Operations and Construction phases of the Project. This effect is expected to be limited to areas of active quarrying (Open Pit and borrow source areas) during Operations phase of the Project. Pit walls have been designed for stability (Section 6.2.2) so this potential effect is not discussed further below.
- MRSFs and diversion channel slope failure or accelerated erosion has been identified as a potential effect during the Construction and Operations phases of the Project; however, it is expected to have a limited area and MRSFs will be managed in accordance with standard practices.
- Stockpile instability (slope failure) or accelerated erosion was identified as a potential Project effect; however, this effect is not considered likely (stockpiles will be managed in accordance with standard practices) and is therefore not considered further.

The water supply pipeline corridor component of the Project involves the upgrades to an historic mine haul road. Baseline analysis indicates that the existing road was developed on stable topography. Further development of this right-of-way is not expected to change the current stability conditions. This potential effect is not considered further. Within the transmission line corridor, the terrain is considered to be 'stable', and as such, no terrain stability potential effects have been identified for this Project component. All of the preceding potential terrain stability effects are considered to be limited or localised in nature.

Open Pit geotechnical slope design parameters (Appendices 6.2-C and E) were prepared to provide geotechnical pit slope design and recommendations for feasibility mine planning. The stability of Open Pit rock slopes is typically controlled by wall geology, structural geology, rock mass characteristics, and hydrogeological conditions discussed in Section 3.4.2, Project Description – Pit Design.

In an Open Pit mine, some bench scale and even multiple bench scale slope instabilities are acceptable provided that proper worker safety and management measures are implemented during mine operations. Given the conservative slope recommendations, large scale slope layback of entire pit walls is unlikely for the Project. Localized slope instabilities are possible during pit development and should be managed as part of routine pit operations. The common slope remedial measure would be either leaving a stepout in the lower slope or laying back the upper slope around the instability zone.

The calculated global Factor of Safety (FoS) of the ultimate pit walls ranged between 1.3 and 1.6. The potential for pit slope stability to cause facility damage is considered an unlikely effect when managed in accordance with standard engineering practices, and this potential effect is not assessed further.

Terrain Stability – Aberdeen Hills Area

One key issue identified by feedback received on the VC selection process during the pre-Application phase was potential effects of pit blasting vibrations on the Aberdeen Hills area. An assessment has been undertaken of the potential influence of production blasting at the Ajax Pit on slope stability in the Aberdeen Hills area by KP. The stability model was modified to determine the sensitivity of the calculated FoS values to possible increases in porewater pressure (PWP) due to blasting. The results indicated there is expected to be negligible effects of blasting vibrations on slope stability.

This finding is supported by published case histories data set (Charlie, et. al. 1983). Published case identified blasting with Peak Particle Velocity (PPV) of less than 10 mm/s did not result in induced PWP. The PPV from the production blasts is predicted by Stantec (1994) to reduce to less than 10 mm/s at a distance well within 1 km from the Open Pit (i.e., more than 1.9 km from Aberdeen) and is expected to be about 0.6 mm/s at Aberdeen Hills. It is concluded that small and large-scale stability of the slopes in the Aberdeen Hills development are not expected to be affected by production blasting for the Project. Please also refer to the discussion of potential effects related to groundwater at the Aberdeen Hills in Section 6.6.

6.2.4.3 Mitigation Measures for Geology, Landforms and Soils

Mitigation measures for each Geology, Landforms and Soils VC indicator are summarised in Table 6.2-12 and discussed in the following section.

Alteration of Baseline Landforms

The effects on topography and physiography, specifically the alteration of the baseline landscape, can be minimised and managed through mitigation. Proposed mitigation measures include:

- minimisation of Project footprint to limit surface disturbance;
- concurrent reclamation (to the extent possible) during Operations; and
- site reclamation following mine Decommissioning and Closure.

During the Decommissioning and Closure phase the landscape diversity will be achieved by recreating various topographic conditions including, level to gently sloping topography in the center of the reclaimed TSF, undulating terrain with micro-topography along the upper portions of the reclaimed TSF, and higher relief terrain along the outer perimeter of the TSF, MRSFs and along the margins of the Open Pit lake. This variability in reclamation will provide Post Closure landscape diversity. Decommissioning and Closure activities will employ well known and proven Closure approaches and technologies. To the extent possible, concurrent reclamation will be implemented during mining Operations. This approach allows for ongoing monitoring and maintenance of reclamation success. Adaptive management techniques can be implemented during the Project life to respond to reclamation requirements.

Table 6.2-12. Summary of Potential Effects and Mitigation on Geology, Landforms and Soils VC

Valued Component Indicators	Project Phase (timing of effect)	Project Component /Physical Activity	Description of Cause-Effect[1]	Description of Mitigation Measure(s)
Topography and Physiography	Construction, Operation, and Closure	Mine Site footprint	Construction of infrastructure will change landforms	Footprint minimisation, Decommissioning and Closure planning
Surficial Geology	Construction, Operation, and Closure	Mine Site footprint	Footprint minimisation re-distributed surficial materials in Closure	Facility reclamation
Terrain Stability and Accelerated Erosion	Construction	Mine Site footprint	Vegetation clearing causing accelerated erosion	Minimizing disturbed areas, erosion and sediment control
	Construction and Operation	Mine Site footprint	Overburden slope failure and accelerated erosion	Erosion and sediment control
	Operation, Decommissioning and Closure	Pit wall instability	Construction of steep slopes	Engineering design and BMPs
	Construction and Operation	Mine Site footprint	Berm/dam/dyke/ diversion channel slope failure or accelerated erosion	Engineering design and BMPs, erosion control measures
	Construction and Operation	Mine Site	Road damage because of slope failure or accelerated erosion	Engineering design and BMPs, erosion control measures
	Closure	Mine Site footprint	Reclaimed terrain slope failure or accelerated erosion	Erosion and sediment control, Reclamation and Closure planning and activities
Terrain Stability - Aberdeen	Operation	Open Pit blasting	Activation of historic landslides in Aberdeen Hills subdivision	Blasting BMP and seismograph monitoring (by KAM). PWP will continue to be monitored by CoK.
Soils Disturbance	Construction and Operation	Mine Site footprint	Loss of topsoil	Footprint minimisation, soil salvage
	Construction and Operation	Mine Site footprint stockpiling	Soil salvage of baseline soils	Footprint minimisation, soil salvage
	Decommissioning and Closure	Mine Site footprint	Re-distribution of salvaged soils	Decommissioning and Closure planning and activities

[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 VC.*

Best Management Practices (BMPs) and industry standards exist for mining Decommissioning and Closure activities (BC Ministry of Energy and Mines, 2003) and the Project currently incorporates these practices into its overall design. Although some aspects of the original baseline condition will not be re-created with respect to physiography and topography, Decommissioning and Closure planning (Landscape Design and Restoration Plan, Section 11) outlines a functioning Closure landscape. Thus, Decommissioning and Closure as a mitigation measure is anticipated to have a high mitigation success rating.

Surficial Geology

The effects on surficial geology, specifically the removal and re-distribution of surficial materials (overburden), can be minimised and managed through mitigation. Proposed mitigation measures include:

- minimisation of the overall Project footprint, including the use of overburden removed from the Open Pit and other facilities as Construction material;
- site reclamation following mine Decommissioning and Closure;
- facility location planning: grouping facilities in centralized areas and development of a functional Project footprint;
- use of overburden and mine rock as Construction material whenever technically feasible; and
- sourcing aggregate for Construction within areas anticipated to be disturbed during development of additional Project activities or components.

At the Mine Site, administrative buildings, Project infrastructure, Open Pit, and the TSF are all grouped as closely as is feasible to minimize the area occupied. Use of mine rock and overburden from Open Pit stripping in Construction directly reduces the extent of borrow source areas. The Project incorporates these mitigation measures for Construction of the TSF infrastructure, such as berms, embankments, and causeways. These facilities will incorporate the overburden, oxide weathered rock, and not potentially acid generating (NPAG) rock derived from quarrying activities. Section 3.6 Tailing Management and Section 3.8 Waste Rock Storage and Ore Stockpiles, provides further information on mine rock allocation.

The water supply pipeline corridor will be developed using existing roads (historic haul road to New Afton mine) and additional linear developments will be limited to the extent feasible. Borrow source areas are not delineated within the Mine Site footprint. This borrow area will be encompassed within the TSF. This facilitates overlap in the footprint of the TSF and the borrow source area, aiding in minimizing the overall footprint.

Reclamation with respect to the re-distribution of surficial materials is limited. In the case of the Project, the removed materials will not be returned to their baseline distribution. Reclamation and Closure planning has, instead, focused on measures to incorporate the re-distributed surficial materials into the Closure landscape features. The resultant landscape will use this redistributed material as an overburden base upon which reclamation material will be replaced. The overall

mitigation success rating for the Decommissioning and Closure activities proposed for the Project is anticipated to be high.

There will be a re-distribution of surficial materials as a result of Project development. This re-distribution will be localised in extent to development of the Open Pit, MRSFs and TSF. Having been derived from local surficial deposits, this material will be similar in physical and chemical properties to the baseline conditions observed within the Mine Site footprint. Overall, no residual effect is identified for surficial geology.

Soil Disturbance

The potential effects on soil disturbance can be minimised and managed through mitigation. The mitigation measures include:

- minimisation of the overall Project footprint;
- soil salvage plan;
- site reclamation following mine Closure; and
- soil and vegetation monitoring program.

In summary, minimisation of the Project footprint directly correlates to the minimisation of soil disturbance. As noted earlier, the Project achieves this in the current description and the mitigation success rating is anticipated to be high.

Soil reclamation refers to the re-distribution of salvaged soils (referred to as topsoil), and will occur during Closure phase of the Project. Salvaged reclamation material will be re-distributed, graded, and contoured as part of reclamation activities. To the extent possible, concurrent reclamation activities will take place within the Operations phase of the Project. Most of the soil reclamation will take place at the end of Operations and is considered in the Decommissioning and Closure phase of the Project.

During the Decommissioning and Closure phase, topsoil will be placed at a thickness of 0.6 m; greater than the average baseline topsoil thickness of 0.35 m. Table 6.2-11 summarizes the cover soil requirements for the components where reclamation will occur. As noted earlier, 4.79 Mm^3 of topsoil will be salvaged and 4.36 Mm^3 is required for Closure, indicating that there is a topsoil surplus.

The Project Description (Section 3.17, Decommissioning and Closure) is referred to for a detailed description of reclamation activities as it pertains to the salvage and redistribution of soils. BMPs and industry standards exist for mining Decommissioning and Closure activities and the Project currently incorporates these practices into its overall design. Overall, the measures incorporated into the Project to mitigate the potential effects to soils have a high mitigation success rating. The disturbance of soil would have a potential effect throughout the Project and would be adverse. This potential effect could affect other disciplines and is carried forward further into the effects assessment. The redistribution of soil upon Closure would be positive in direction thereby limiting the overall effect to soil disturbance.

Terrain Stability and Accelerated Erosion

The potential effects on terrain stability and accelerated erosion can be minimised and managed through mitigation. The mitigation measures include:

- minimisation of the overall Project footprint;
- erosion and sediment control;
- engineering design and Best Management Practices (BMPs); and
- reclamation and closure planning activities.

The principal mitigation measure for terrain stability related potential effects are standard BMPs for erosion and sediment control. Grading, site contouring, and the maintenance of slope lengths and gradient parameters based upon universal soil loss equation (USLE) guidelines BC Ministry of Forestry (MOF) 2001 reduce wind and water erosion of stockpiled soil materials. During the Construction and Operations phases, stabilization of topsoil stockpiles with erosion control measures and management of surface runoff (snow melt, rainfall) reduces the potential risk of water erosion. Use of erosion control materials (mats, netting, straw, and mulches) can reduce soil surface exposure, and consequently, soil erosion. Long term re-vegetation of stockpile surfaces will be implemented. The incorporation of organic material into coarse-textured (sandy) soils or those deficient in organic matter at the time of salvage, serves as a preventative measure against wind erosion, as well as contributes to the improvement of water-holding capacity.

The Erosion and Sediment Control Plan (Section 11.2) presents a summary of the BMPs and erosion and sediment control techniques designed for the Project. Employment of relevant engineering and construction BMPs during design and Construction of Project facilities such as TSF embankments and MRSFs will further mitigate the potential for terrain stability issues. Mitigation measures along the water supply pipeline will incorporate construction best practices into this management plan. Based on the proposed Construction and management plans, it is expected that potential terrain stability effects within the water supply pipeline corridor will be fully mitigated.

The potential effects related to terrain stability will be fully mitigated by construction and engineering practices identified, including erosion and sediment control and Project design. All potential effects are temporary in nature and are not expected to extend beyond the duration of the Project. The Erosion and Sediment Control Plan developed for the Project is expected to mitigate the effects that erosion may have on other terrestrial disciplines as well as on the loss of surface materials needed for reclamation. For a more detailed description of the Erosion and Sediment Control Plan, refer to Section 11.2. No residual effects related to terrain stability from the Project are anticipated.

Terrain Stability – Aberdeen Hills Area

The potential effects of the Project on terrain stability in Aberdeen Hills area can be minimised and managed through mitigation. The mitigation measures include:

- distance from Ajax pit to Aberdeen Hills area is great enough to not cause significant vibrations;

- use of blasting best practices (reducing borehole diameter, using explosives decks, using lower density explosives and explosives deck delay) to further reduce vibrations;
- continued PWP management in Aberdeen Hills area by CoK; and
- use of a seismograph monitoring network to monitor and record blast vibrations.

The potential effects on re-activation of historic landslides in the Aberdeen Hills area are minimised by the distance from the Ajax pit to the Aberdeen Hills area (2.9 km) which studies have proven is at a reasonable distance to not affect PWP. Additionally, blasting best practices (reducing borehole diameter, using explosives decks, using lower density explosives and explosives delay to further reduce vibrations) minimises vibration to effectively reduce potential negative effects.

The Aberdeen Hills area is managed today by a sophisticated network of pumping wells managed by CoK and Golder Associates. Seismic and air blast monitoring by KAM at strategic locations around the mine is planned. A linear array of permanent seismographs will be set up from the pit edge towards the CoK in the Aberdeen Hills area. All seismographs will operate 24 hrs daily to record blast events, and non-blasting seismic/air blast activities in the community (i.e., ambient levels, electrical storms, local traffic).

6.2.5 Residual Effects and Their Significance

6.2.5.1 Summary of Residual Effects

The residual effects of the Project on the Geology, Landforms and Soils VC that are anticipated to remain after the implementation of mitigation measures are summarised in Table 6.2-13.

Table 6.2-13. Summary of Residual Effects/Predicted Changes after Mitigation on Geology, Landforms and Soils VC

Potential Effect	Project Phase[1]	Project Component/ Physical Activity	Description of Cause-Effect[2]	Description of Mitigation Measure(s)	Description of Residual Effect
Topography and Physiography	Construction, Operation, Decommissioning and Closure	Mine Site footprint	Construction of infrastructure will change landforms	Footprint minimisation, Decommissioning and Closure planning	Alteration of landscape baseline

[1] Project phases are Construction, Operation, Decommissioning and Closure, and Post Closure.
[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 VC.

Alteration of Baseline Landforms

Project development will alter the baseline landscape within the Mine Site footprint. Mitigation measures will minimize the extent of these alterations and will return the site to a functioning state, although different from the baseline condition. The anticipated change to a different landscape is a residual effect with respect to physiography and topography. Restoration to baseline conditions following Project Decommissioning and Closure is not possible. Instead, the Project will incorporate

measures to develop the irreversible alterations in landscape into new features which are physically and functionally integrated in the Post Closure landscape. On the Mine Site, new features will include:

- 237 ha lake with a maximum depth of 545 m (from the top of the highwall to its deepest point) and volume of 1470 Mm^3 within the mined out Pit (note it will take several hundred years for the pit lake to reach this elevation);
- 544 ha of relatively flat plateau on the reclaimed tailings; and
- 54 ha of moderate slopes on the TSF Embankments and MRSFs.

A functioning and variable Closure landscape is proposed for the Project (Volume 3, Section 3.18), although the Closure landscape will be different from pre-Project conditions. The conceptual plan indicates reclamation of the TSF to support upland and wetland landscapes. Residual Effects for the Geology, Landforms and Soils VC were characterized using standard criteria (i.e., the magnitude, geographic extent, duration, frequency, reversibility, and ecological or social context associated with each residual effect must be described). The general definitions of the characterization criteria are provided in Table 6.2-14.

6.2.5.2 Characterization of Residual Effects

The residual effects of Geology, Landforms and Soils VC from the Project are shown in Table 6.2-15 using the definitions from Table 6.2-15 to determine the significance residual effects.

Alteration of Baseline Landforms

Potential residual effects of the Project are expected to occur on alteration of baseline landforms, throughout all phases of the Project. As a result of the Project, change at the landscape level will occur. The Project will affect slope gradients and topographic function of the landscape. The development of a compact Project footprint and the eventual reclamation of the site would reduce the overall effect of the Project. The original distribution of baseline topographic conditions would not be re-established; however, upon reclamation, a fully functional landscape would be developed to support the reclamation goals. Following implementation of mitigation measures, residual effects, in the form of new topographic features and improved or enhanced aquatic habitat, are expected to remain for the alteration of landforms indicator.

6.2.5.3 Significance of Residual Effects

A significance rating was applied to each residual effect for the Geology, Landforms and Soils VC in Table 6.2-13. The anticipated significance ratings assigned to alteration of baseline is rated as not significant (minor) as it is rated minor in magnitude, local in extent, long term in duration. The alteration of baseline landforms is a direct consequence of Project development; however, after mitigation the residual effects are minimised.

6.2.5.4 Characterization of Likelihood and Confidence

A likelihood and confidence rating was applied to each residual effect for the Geology, Landforms and Soils VC in Table 6.2-13. The anticipated likelihood and confidence ratings assigned to alteration

of baseline landforms is rated 'medium' confidence rating as the predicted effect is expected to be low.

6.2.5.5 Summary of Residual Effects Assessment and Significance

The main conclusions for Geology, Landforms and Soils residual effects assessment are summarised in Table 6.2-16.

6.2.6 Cumulative Effects Assessment

6.2.6.1 Introduction

To produce a cumulative effect, the residual effects of the Project must act in combination with the residual effects of one or more other human actions. The residual effects identified for the Geology, Landforms and Soils VC are alteration of landforms. Reclamation will ensure that the irreversible alteration in landscape will be developed into new features which are physically and functionally integrated into the Post Closure landscape.

6.2.6.2 Identification of Other Actions that May Affect Geology, Landforms and Soils

Other projects or activities whose residual effects would overlap spatially and temporarily with the residual effects on the Geology, Landforms and Soils VC were reviewed. A detailed description of the other human activities and foreseeable projects selected for the Cumulative Effects Assessment (CEA) project inclusion list is presented in the Project Description. The screening matrix of other actions for the CEA is presented in Table 6.2-17 and the characterization of residual cumulative effects is in Table 6.2-18.

One project was identified, the Kinder Morgan pipeline, as having a spatial and temporal interaction with the residual effects on the Geology, Landforms and Soils VC. Geology, Landforms and Soils VC are common resources. The Kinder Morgan pipeline will be constructed then buried, similar to the water supply pipeline and a 200 m buffer zone between the Kinder Morgan pipeline and the Ajax Project has been established. Alteration of landforms and removal of soils will occur temporarily during the Construction phase of the Kinder Morgan pipeline realignment; however, these effects will be fully mitigated. There are no common resources and/or Geology, Landforms and Soils VC between the Ajax Project and the Kinder Morgan pipeline and it is not considered further in the cumulative effects assessment.

6.2.7 Conclusion

A summary of the results of the Project-related effects assessment and cumulative residual effects assessment for the Geology, Landforms and Soils VC is presented in Table 6.2-19.

The screening matrix for the Geology, Landforms and Soils VC and other actions identified the Kinder Morgan Pipeline for potential cumulative effects. There are no common resources for the Geology, Landforms and Soils VC between the Ajax Project and the Kinder Morgan pipeline due to 200 m buffer zone. Although there is some spatial and temporal overlap, no interaction is anticipated and no further consideration is warranted.

Table 6.2-14. Definitions of Characterization Criteria for Residual Effects on Geology, Landforms and Soils VC

Magnitude	Duration	Frequency	Geographic Extent (Physical/Biophysical)	Reversibility	Resiliency	Ecological Context	Likelihood of Effects	
							Probability	Confidence Level
How severe will the effect be?	*How long will the effect last?*	*How often will the effect occur?*	*How far will the effect reach?*	*To what degree is the effect reversible?*	*How resilient is the receiving environment or population?*	*What is the current condition of the ecosystem and how commonly is it represented in the LSA?*	*How likely is the effect to occur?*	*How certain is this analysis?*
Negligible: No or very little detectable change from baseline conditions.	**Short-term:** Effect lasts 1 to 5 years.	**Once:** Effect is confined to one discrete period in time during the life of the Project.	**Local:** Effect extends less than 500 m from infrastructure or activity.	**Reversible Short-term:** Effect can be reversed relatively quickly.	**Low:** The receiving environment or population has a low resilience to imposed stresses, and will not easily adapt to the effect.	**Low:** The receptor is considered to have little to no unique attributes or provision of functions is severely degraded.	**High:** It is highly likely that this effect will occur.	**High:** < 80% confidence. There is a good understanding of the cause-effect relationship and all necessary data are available for the Project area. There is a low degree of uncertainty and variation from the predicted effect is expected to be low.
Minor: Differs from the average value for baseline conditions to a small degree.	**Medium-term:** Effect lasts 6 to 25 years.	**Sporadic:** Effect an effect that occurs at sporadic or intermittent intervals during any phase of the Project.	**Landscape:** Effect is limited to the LSA or one watershed (i.e., Sub-area).	**Reversible Long-term:** Effect can be reversed within 20 years of Post Closure.	**Neutral:** The receiving environment or population has a neutral resilience to imposed stresses and may be able to respond and adapt to the effect.	**Neutral:** The receiving environment considered to have some unique attributes and provides most functions that an undisturbed environment would provide.	**Medium:** This effect is likely, but may not occur.	**Medium:** 50 to 80% confidence. The cause-effect relationships are not fully understood, there are a number of unknown external variables, or data for the Project area are incomplete. There is a moderate degree of uncertainty; while results may vary, predictions are relatively confident.
Medium: Differs substantially from the average value for baseline conditions and approaches the limits of natural variation.	**Long-term:** Effect lasts between 26 and 50 years.	**Regular:** Effect occurs on a regular basis during the life span of the Project.	**Regional:** Effect extends across the broader region (e.g., RSA, multiple watersheds, etc.).	**Irreversible:** Effect cannot be reversed (i.e., is permanent).	**High:** The receiving environment or population has a high natural resilience to imposed stresses, and can respond and adapt to the effect.	**High:** The receiving environment or population is uncommon and occurs in a natural state and provides functions at a maximum capacity.	**Low:** This effect is unlikely but could occur.	**Low:** < 50% confidence. The cause-effect relationships are poorly understood, there are a number of unknown external variables, and data for the Project area are incomplete. High degree of uncertainty and final results may vary considerably.
Major: Differs substantially from baseline conditions, resulting in a detectable change beyond the range of natural variation.	**Far Future:** Effect lasts more than 50 years.	**Continuous:** Effect occurs constantly during the life of the Project.	**Beyond Regional:** Effect extends beyond the regional scale, and may extend across or beyond the province.					

Table 6.2-15. Characterization of Residual Effects, Significance, Likelihood, and Confidence on Geology, Landforms and Soils VC

Residual Effect	Residual Effects Characterization Criteria							Significance of Adverse Residual Effects	Likelihood and Confidence	
	Magnitude	Duration	Frequency	Geographic Extent	Reversibility	Resiliency	Context		Probability	Confidence
Alteration of Baseline Landforms	Minor	Medium-term	Once	Local	Reversible Long-term	High	Neutral	Not Significant (minor)	High	Medium

Table 6.2-16. Summary of Project and Cumulative Residual Effects, Mitigation, and Significance for Geology, Landforms and Soils VC

Residual Effects	Project Phase	Mitigation Measures	Significance
Alteration of Baseline Landforms	Construction, Operation and Closure	Footprint minimisation and re-contouring	Not significant (minor)

Table 6.2-17. Screening of Other Actions for Inclusion in the CEA for Geology, Landforms and Soils VC

	Industrial Projects/Activities													Natural Resources and Land Use			Tourism and Commercial Recreation Activities					Community Infrastructure			Transportation					
Residual Effect	Vidette Lake Mine	Afton Mine (Historical)	Iron Mask Mine	Bonaparte Mine	New Afton Mine (New Gold)	Highland Valley Copper Mine (Teck)	Domtar Kamloops Pulp Mill	Tolko-Hefley Creek Plywood and Veneer	LaFarge Cement Plant	Trans Mountain Pipeline System (Kinder Morgan)	Trans Mountain Pipeline System - Expansion (Kinder Morgan)	Harper Creek	Highland Valley Copper – Bethlehem Expansion	Kamloops Forest District	Agriculture	Ranching	Tranquille on the Lake	Lac le Jeune Resort	Tobiano Golf Course	Recreational Hunting, Fishing, Foraging	Recreational Trails	City of Kamloops Wastewater Management	Water Treatment Centre	City Expansion and Growth	Lac le Jeune Road	Highway 1	Highway 5A	Highway 5 (Coquihalla Highway)	Kamloops Airport	Rail Yards and Lines (CP and CN)
Alteration of Baseline Landforms	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O

O – No interaction anticipated, no further consideration is warranted
L – Negligible to minor interaction expected; implementation of best practices, standard mitigation and management measures; no monitoring required, no further consideration warranted.
M – Potential moderate interaction requiring unique active management/monitoring/mitigation; warrants further consideration.
H – Key interaction; warrants further consideration.

Table 6.2-18. Characterization of Residual Cumulative Effects, Significance, Likelihood, and Confidence on Geology, Landforms and Soils VC

Residual Effect	Residual Effects Characterization Criteria							Significance of Adverse Residual Effects	Likelihood and Confidence	
	Magnitude	Duration	Frequency	Geographic Extent	Reversibility	Resiliency	Context		Probability	Confidence
Alteration of Baseline Landforms	Negligible	Short-term	Once	Local	Reversible Short-term	High	Low	Not Significant (minor)	Low	High

Table 6.2-19. Summary of Project and Cumulative Residual Effects, Mitigation, and Significance for Geology, Landforms and Soils

Residual Effects	Project Phase	Mitigation Measures	Residual Effect Significance	Residual Cumulative Effect Significance
Alteration of Baseline Landforms	Construction, Operation, Decommissioning and Closure	Footprint minimisation and re-contouring	Not significant (minor)	N/A

6.3 SURFACE WATER QUALITY

6.3.1 Rationale

The purpose of the scoping process is to allow the Environmental Assessment (EA) to focus on the components that are valued and have the greatest potential for significant adverse effects (Beanlands and Duinker 1983). Valued Components (VCs) are defined as components of the natural and human environment that are considered to be of scientific, ecological, economic, social, cultural, or heritage importance (Environmental Assessment Office and Canadian Environmental Assessment Agency 2013). In addition to being valued, a project must be likely to affect the VC for it to be included in an EA.

A scoping process was used by KGHM Ajax Mining Inc. (KAM) to identify and select Surface Water Quality as a VC for inclusion in the EA of the Ajax Project (the Project). Surface Water Quality is generally considered to be the physical and chemical constituents of water on the surface of the land in the form of streams, rivers, lakes and endorheic basins within the Local Study Area (LSA, see Figure 6.3-2) and Regional Study Area (RSA, see Figure 6.3-2).

Surface Water Quality was identified by government agencies, stakeholders, and Aboriginal communities, during consultations with KAM on the Project as a potential VC because of its importance to fish, wildlife, livestock, use as irrigation water, and for recreation. Concerns that were raised are recorded in the issues tracking tables in Appendix 15B of the Application/Environmental Impact Statement (EIS). Comments that were raised by the Public during the two public consultation periods for the Application Information Requirements (AIR)/ EIS Guidelines are summarized in Table 6.3-1.

In summary, the Stk'emlupsemc te Secwépemc Nation (SSN) have expressed general concerns related to surface water quality and more specifically as it may pertain to water quality of Jacko Lake and the closure of Goose Lake. The Lower Nicola Indian Band (LNIB) has expressed general concerns related to water quality. The Adams Lake Indian Band (AIB) raised questions about the application of the Sustainable Water Quality Act to the Project. Metis Nation BC (MNBC) raised concerns about the closure of Goose Lake, water supply for mine operations and water quality in Jacko Lake. Additional detail on the concerns raised by Aboriginal Group during consultation is in issues tracking tables of Appendix 15B of the Application/EIS.

The Supporting Topic - Jacko Lake, section 8.7, serves to aggregate summaries for all VCs that have potential pathways of effect from the Project on Jacko Lake. The intent of the section's summaries is to provide a snapshot of residual effects, mitigations and the determination of significance for each of the relevant VCs.

Provincial, federal and local governments have raised issues related to ML/ARD potential and downstream water quality effects. The relevant provincial and federal statutory framework, guidance documents, and policies related to potential Project-related surface water quality effects were reviewed for the Project as part of the scoping phase:

- BC *Water Act (1996)*;
- *Canada Water Act (1985)*;

Table 6.3-1. Aboriginal and Public Comments Related to Surface Water Quality

Subject Area	Identified by *				Issue Raised	KAM's Response
	AG	G	P/S	SK		
Surface Water Quality	X	X	X	X	Effects of ML/ARD on water quality	Geochemical source terms for all proposed mine contact sources were developed by Lorax Environmental Services Ltd. (Lorax) and accounted for neutral metal leaching (ML) and potential acid rock drainage (ARD). These source terms were used as primary input parameters to the water quality model used to predict the effects of the mine on water quality. Specific details pertaining to source term development are provided in Section 6.3.4.2.
	X		X	X	Effects of dustfall on water quality	Dustfall effects on water quality have been modeled based on loading terms provided from Stantec Inc. Dustfall composition is based on inputs from mine sources (tailings, mine rock, and ore) and diesel. Specific details pertaining to modelling to support dustfall inputs to the water quality model are provided in Section 6.3.4.2.
	X				Effects of accidental spills of mine contact water, fuels, etc. on surface water quality	Accidental spill are addressed in the Risk Management Plan (Accidents and Malfunctions) (Section 11.12) and Spill Contingency Plan (Section 11.16)
	X	X	X	X	Water quality impacts on fish, wildlife, livestock, human health	Water quality model predictions have been screened against water quality guidelines for all of the potential receptors in the project area as required in the AIR, which are aquatic life, wildlife, livestock, irrigation, drinking water, recreation and aesthetics
	X	X			Effects of increased sediments on water quality	Monitoring programs that have been developed and implemented as part of the Environmental Management System provide measures and controls to minimize the potential for environmental degradation. The following plans described in the AIR/EIS Guidelines relevant to this concern include: • Surface Water Quality Management and Monitoring Plan (Section 11.23) • Groundwater Quality Management and Monitoring Plan (Section 11.24) • Erosion and Sediment Control Plan (Section 11.2) • Metal Leaching/Acid Rock Drainage Management Plan (Section 11.5) • Water Management and Hydrometric Monitoring Plan (Section 11.7) • Fisheries And Aquatic Life Monitoring Plan (Section 11.25)

** A/G = Aboriginal Group; G = Government; P/S = Public/Stakeholder; SK = Scientific/Professional Knowledge*

- *Environmental Management Act (2003)*;
- *Fisheries Act (1985)*;
- *Mines Act (1996)*;
- BC Water Quality Guidelines (BCWQG; Approved and Working; BC MOE 2015a, 2015b);
- CCME Water Quality Guidelines (CCME 2014);
- Guidelines for Canadian Drinking Water Quality (Health Canada 2012);
- Policy for Metal Leaching and Acid Rock Drainage at Minesites in British Columbia (BC MEM and BC MOE 1998);
- Guidelines for Metal Leaching and Acid Rock Drainage in British Columbia (Price and Errington 1998);
- Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials (Price 2009);
- Water and Air Baseline Monitoring Guidance Document for Mine Proponents and Operators (BC MOE 2012);
- Guidelines for Designing and Implementing a Water Quality Monitoring Program in British Columbia (Cavanagh et al., 1998);
- BC Field Sampling Manual (MWLAP, 2003);
- Guidelines for Interpreting Water Quality Data (MELP, 1998);
- Approved Water Quality Guidelines Summary Report (MOE, 2015); and
- Guidance for the Derivation and Application of Water Quality Objectives in British Columbia (BC MOE, 2013).

The information developed to support the analysis of this VC also contributes to other analyses for other VCs, as summarised in Figure 6.3-1. This assessment supports the assessment of wildlife and vegetation VCs, fish and fish habitat, health and social VCs. Surface Water Quality was included as a VC for the EA because Project components and activities have the potential to change surface water quality from baseline conditions during the Construction, Operation, Decommissioning and Closure and Post Closure phases. The potential Project interactions with the Surface Water Quality VC are identified in Table 6.3-7.

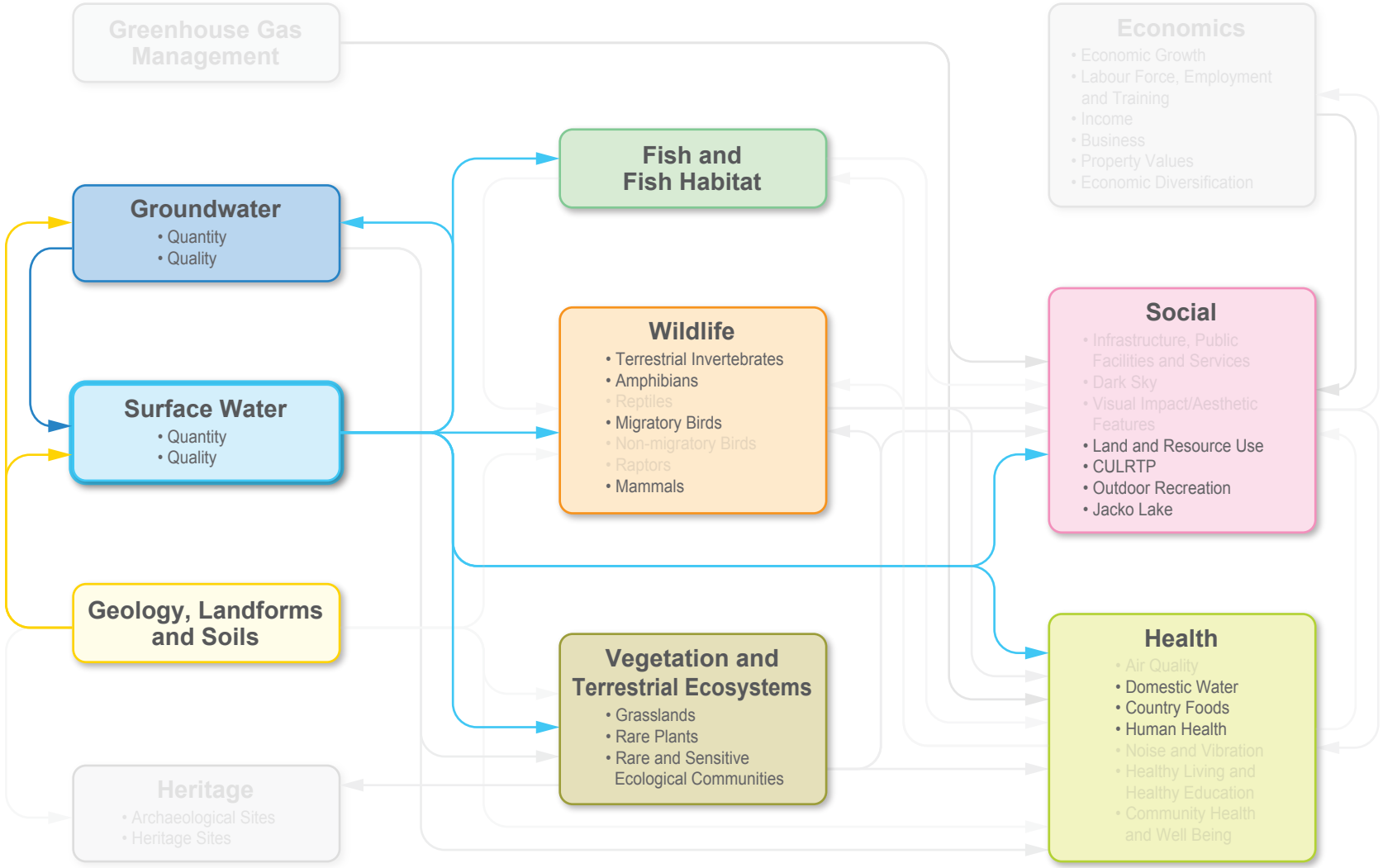
The assessment focuses on potential interactions between the Project and Surface Water Quality that are likely during normal operating conditions; whereas, occurrences such as spills and accidents that are very unlikely to occur because they are considered to be outside of normal operating conditions are addressed in Accidents and Malfunctions Plan as well as in the Spill Contingency Plan in Section 11 of the Application/EIS.

Note that predicted changes in Surface Water Quality from baseline (or pre-Project) conditions will be presented and characterized through comparisons to guidelines, where provincial or federal guidelines exist. Accordingly, potential effects to aquatic resources, human health, wildlife, and other VCs as a result of predicted changes in Surface Water Quality will be assessed and presented in the relevant sections of the Application/EIS:

Figure 6.3-1

Ajax Project Surface Water Quality
Surface Water Quality Pathways of Effects

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- Groundwater Quality (Section 6.5);
- Fish Population and Fish Habitat (Section 6.7);
- Terrestrial Invertebrates (Section 6.11);
- Amphibians (Section 6.12);
- Migratory Birds (Section 6.14);
- Non-migratory Gamebirds (Section 6.16);
- Mammals (Section 6.17);
- Supporting Topic – Jacko Lake, Section 8.7;
- Aboriginal Groups (Part C); and
- Assessment of Potential Health Effects (Section 10):
  - Domestic Water Quality (Section 10.2);
  - Country Foods (Section 10.3); and
  - Community Health and Well-being (Section 10.7).

Through the scoping process, Surface Water Quality was selected for inclusion in the EA as a VC, primarily to inform the effects assessment of other VCs (e.g., aquatic resources, human health etc.). The surface water quality baseline data collected for the Project is presented in Appendix 6.3-A and summarized in Section 6.3.2.3 and the water quality model is presented in Appendix 6.3-B and summarized in Section 6.3.4.2. The Surface Water Quality section follows the effects assessment methodology described in Section 5 of the Application/EIS and conforms to the requirements outlined in Section 5 of the AIR/EIS Guidelines.

6.3.2 Background

6.3.2.1 Regional Overview

The Mine Site is located within the Thompson River watershed, Thompson – Okanagan Plateau Ecoregion of the Southern Interior Ecoprovince of BC, which is within the Interior Plateaus and Highlands Ground Water Region of British Columbia (Province of British Columbia 2013 and Zubel 2001). The Project components are all situated within the Peterson Creek watershed. The RSA is comprised of the entire Peterson Creek watershed as well as Inks Lake. Inks Lake is an evaporative lake within the boundary of the Cherry Creek drainage area, but with no observed connection to Cherry Creek. The LSA is entirely within the boundaries of the Peterson Creek watershed and encompasses all of the Project facilities; the upper and lower portions of the Peterson Creek watershed are excluded from the LSA. A map showing the footprint of the Mine Site, the boundaries of the regional watersheds, the baseline surface water quality sampling sites, and the boundaries of the RSA and the LSA are shown on Figure 6.3-2.

Peterson Creek has a mainstem length of approximately 40 km and a watershed area of approximately 130 km^2 (BGC 2015b). The Peterson Creek headwaters are southwest of the city of Kamloops in a marshy area to the east of Eureka Lake. From the headwaters, the creek flows northeast and forms the sole inlet channel to Jacko Lake, which is the largest water body in the LSA. Peterson Creek continues at the controlled outlet of Jacko Lake, with two major tributaries: Keynes Creek flows north from Goose Lake into Peterson Creek less than 1 km downstream of the outflow of Jacko Lake and Humphrey Creek flows north from the controlled outlet of Edith Lake (the second largest lake in the LSA, after Jacko Lake) into Peterson Creek approximately 2.5 km downstream of the confluence with Keynes Creek. Surface connections between Humphrey Creek and Keynes Creek were not found during the baseline water quality program, and flow from these creeks into Peterson Creek is through the subsurface. The lower reaches run through Peterson Creek Park and an urbanized portion of the City of Kamloops.

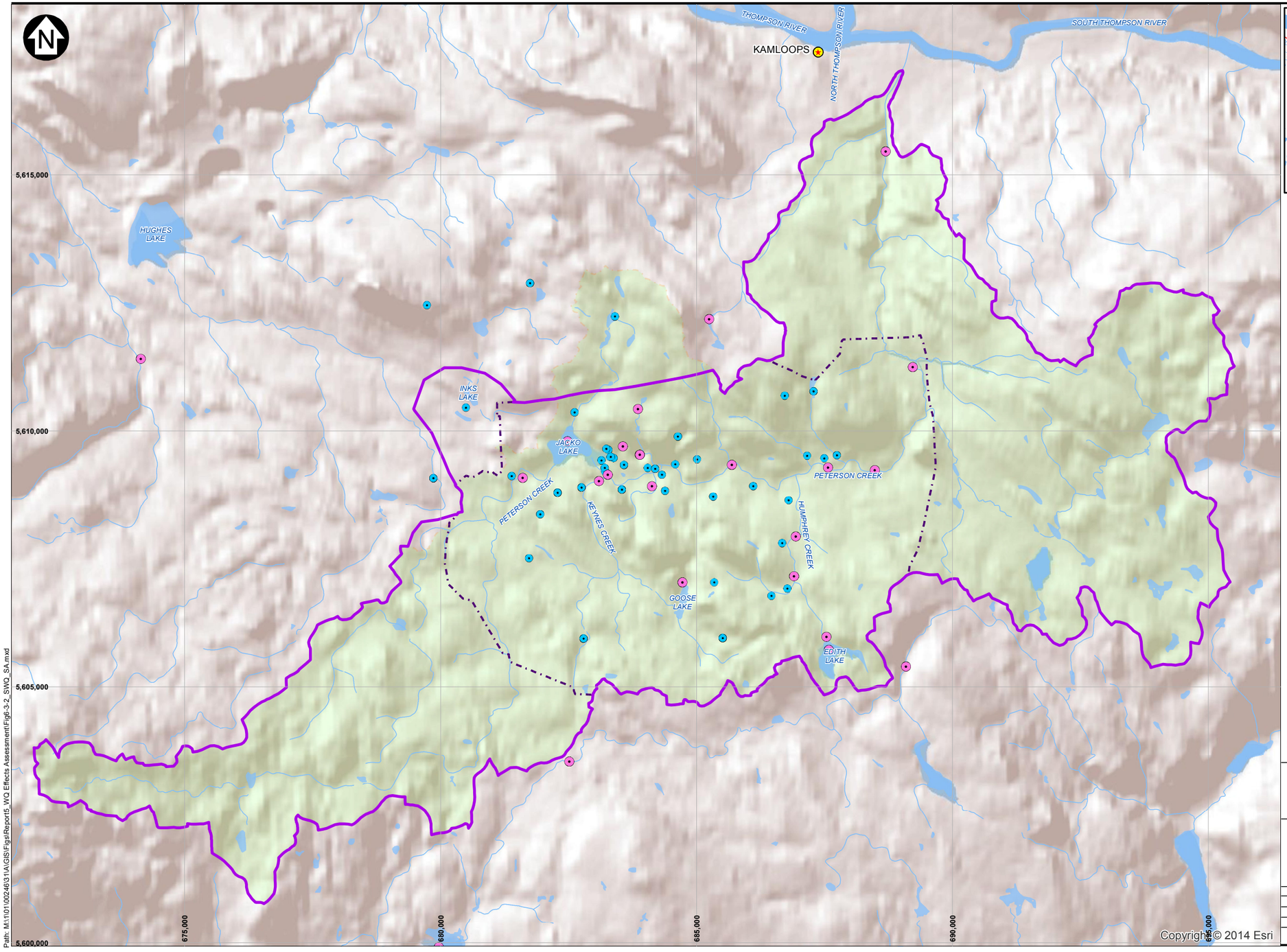
The RSA is characterized by rolling hills, evaporative lakes, and small creeks and all water bodies are influenced by the arid climate conditions. The evaporative lakes are sustained by spring melt, groundwater inflows and precipitation, as there are no surface water connections. The largest of such lakes is Inks Lake (surface area of 13.2 ha), which is located northeast of the Mine Site, within the Cherry Creek watershed. Water levels in the smaller lakes are highly dependent on precipitation, and some remain dry for most months of the year. Creek flows are also dependent on precipitation runoff, but flows outside of spring freshet are dominantly sustained by groundwater recharge. Beaver dams, which have been observed along Peterson Creek during the baseline data collection program also affect surface flow conditions in Peterson Creek. Flows are generally low to dry from late summer (September) through the winter months (up to and including February) with increased flow from early spring (March) through summer (August). Spring freshet generally happens in late April or May and is characterized by higher runoff contributing to creek flow.

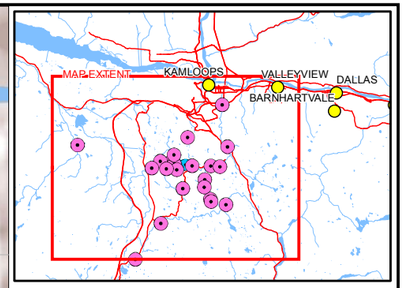
6.3.2.2 Historical Activities

The Project is partially located on a historical mine site and mining activities in the immediate project area began in 1989. Mining operations ceased under Teck Cominco in the Afton, Ajax East and Ajax West open pits in 1997. Previously mined areas on site include two mine rock piles, the partially backfilled Ajax East open pit, and the two lobes in the Ajax West open pit, within which lakes are developing. The water elevation in these historical open pits remains well below the natural ground level and the surrounding measured groundwater levels, therefore there are no suspected discharges from these lake. The lake in the east lobe of the Ajax West Pit is approximately 30 m at its deepest point and has an estimated surface area of 1.7 ha and the high walls along the west, north, and eastern boundaries of the pit are still visible. The lake in the west lobe of the Ajax West Pit, was 9 m at its deepest point measured in 2008, and is intermittently dry. Historical-mined rock was backfilled into Ajax East open pit and the surface was reclaimed and the two other mine rock piles were also covered with a vegetated layer as part of the reclamation. The Trans Mountain Pipeline (Kinder Morgan) cuts across the project area, extending from north to south, immediately east of Jacko Lake and west of the extent of the Ajax West open pit. This pipeline has been in operation since 1953 and is used to transport crude oil and refined petroleum products from Alberta to southern British Columbia and the United States.

Figure 6.3-2
Surface Water Quality Study Area Boundaries

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LEGEND:

GENERAL

- SURFACE WATER QUALITY SITE
- GROUNDWATER QUALITY SITE
- COMMUNITY
- RIVER/CREEK
- LAKE
- PETERSON CREEK WATERSHED
- LOCAL STUDY AREA (LSA)
- REGIONAL STUDY AREA (RSA)

NOTES:

1. BASE MAP: BC TRIM AND CANADA NTS MAPPING.
2. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD 1983 UTM ZONE 10N.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:80,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.

SCALE 0 0.5 1 1.5 Kilometres

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KGHM Ajax Mining Inc.

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Peterson Creek has been used as a source of drinking water, irrigation, and as a drainage channel since the late 1800s. Jacko Lake has been altered due to human activities dating back to the late 1940s when the outlet channel (Peterson Creek) was modified for irrigation purposes. In order to accommodate irrigation requirements the lake was raised in the 1970s leading to the expansion into the northeast and southeast arms and an expansion of the two westerly arms. In 1990 the lake was again altered with the addition of 1 m to the outlet structure at Peterson Creek and the dredging of silt to effectively double the live storage capacity of the lake. At the same time, a 1,000 m portion of the Peterson Creek channel immediately downstream of Jacko Lake was lined with till to help mitigate water losses from the channel due to seepage. Water licences for extraction from Jacko Lake and Peterson Creek date back to the late 1800s and on wetter years the current requirements can be met through effective management, however, these requirements are not met on drier years (Price 1991).

6.3.2.3 Baseline Studies

The surface water quality baseline study for the Project commenced in 2007 and continues to the present day. Baseline surface water samples were collected by Knight Piésold Ltd. from 2007 until 2014 when sample collection was undertaken by KAM under the guidance of Knight Piésold Ltd. The purpose of the baseline study was to:

- Define the characteristics of baseline/pre-Project surface water quality;
- Characterize seasonal and spatial trends in surface water quality; and
- Identify exceedances of relevant guidelines.

Data Sources

The characterization of baseline Surface Water Quality is mainly based on information summarized in the Baseline Water Quality Report (KP 2015), which is provided in Appendix 6.3-A. The baseline water quality report includes an analysis of all surface water quality samples and in situ data, collected from 2007, when the program commenced, to October 31, 2014. The main focus of the effects assessment is on the Peterson Creek watershed, where the project facilities and most of the water quality monitoring sites are located; however, the baseline water quality characterization includes a greater area. Monitoring sites have been established in the following four watersheds: Peterson Creek (including tributaries: Keynes Creek and Humphry Creek), Cherry Creek, the Thompson River (limited to Makaoo Lake and outlet channel), and Anderson Creek.

- In addition to the baseline water quality report, information from the following reports has been used to support the characterization of baseline conditions, as they pertain to water quality:
- Baseline Groundwater Hydrology Assessment – Draft Report (BGC 2015a);
- Climatology Report (KP 2014);
- Testing in support of development of a science based environmental benchmark for sulphate for the Ajax Mine – Nautilus Environmental (Nautilus 2015) (Appendix 6.3-B); and
- Derivation of Protective Water Quality Benchmarks (Stantec 2015) (Appendix 6.3-D).

Methods

The water quality program and sampling protocols were implemented following the general requirements of the following documents:

- Guidelines for Designing and Implementing a Water Quality Monitoring Program in British Columbia. BC Ministry of Environment, Lands and Parks, Wildlife Branch. Resource Inventory Committee. 1998.
- British Columbia Field Sampling Manual for Continuous Monitoring and the Collection of Air, Air-emission, Water, Wastewater, Soil, Sediment and Biological Samples. 2003 Edition. BC Ministry of Water, Land and Air Protection.
- Protocols Manual for Water Quality Sampling in Canada. Canadian Council of Minister of the Environment. 2011.
- Water and Air Baseline Monitoring Guidance Document for Mine Proponents and Operators. Prepared by the Ministry of Environment. October 9, 2012 (MoE 2012).

Surface water quality sites were strategically located in close proximity to and downstream from historical mine features and proposed Project facilities and at reference locations upstream of the Project and in nearby watersheds. A total of 38 sites have been established, five of which are no longer active. A summary of the surface water sample locations in the LSA is provided in Table 6.3-2 and the general arrangements and site locations are shown on Figure 6.3-3.

Table 6.3-2. Surface Water Sampling Locations in the LSA

Site ID	Easting	Northing	Samples Collected	Site Description
JC03	681100	5608717	30	Peterson Creek upstream reference site (superseded by PC10), upstream of Jacko Lake
PC02	689229	5611248	62	Peterson Creek, adjacent to the Princeton-Kamloops Highway
PC02.3	688485	5609232	9	Peterson Creek down-gradient of all project facilities
PC02.5	687573	5609285	50	Peterson Creek down-gradient of the EMRSF
PC02WH	689335	5611224	1	Well house at PC02
PC03	685692	5609339	61	Peterson Creek, down-gradient of all historical mine features
PC08	683266	5609146	63	Peterson Creek, at the outlet of Jacko Lake
PC10	681607	5609088	15	Peterson Creek upstream reference site, upstream of Jacko Lake
PC-EF-04	688617	5614344	5	Peterson Creek, upstream of Bridal Veil Falls
JACL-D	682481	5609804	40	Jacko Lake deep location
JACL-M	682481	5609804	6	Jacko Lake mid-depth location
JACL-S	682481	5609804	41	Jacko Lake shallow location

(continued)

Table 6.3-2. Surface Water Sampling Locations in the LSA (completed)

Site ID	Easting	Northing	Samples Collected	Site Description
C03	683097	5609018	8	Keynes Creek, upstream of the confluence with Peterson Creek
EDITH-01D	687588	5605722	11	Edith Lake deep location
EDITH-01M	687588	5605722	3	Edith Lake mid-depth location
EDITH-01S	687588	5605722	12	Edith Lake shallow location
GOOSE LAKE	684727	5607042	13	Headwaters of Keynes Creek
HUMPH02	686943	5607938	18	Humphrey Creek, upstream of a small tributary outside of the Project footprint
HUMPH-08	686907	5607159	10	Humphrey Creek, down-gradient of the confluence with a tributary within the Project footprint
HUMPH-10	687540	5605977	15	Humphrey Creek at the outflow of Edith Lake
AJWE-D	683896	5609537	11	Ajax west-east pit deep location
AJWE-M	683896	5609537	1	Ajax west-east pit mid-depth location
AJWE-S	683895	5609536	11	Ajax west-east pit shallow location
AJWW-D	683563	5609701	7	Ajax west-west pit deep location
AJWW-S	683562	5609700	8	Ajax west-west pit shallow location
NSP	683859	5610425	25	North seepage collection pond for a historical mine rock pile
S. CATCHMENT	684483	5608316	5	South side of Peterson Creek, in close proximity to the historical mine rock area
WR-SEEP	684133	5608923	19	Historical mine rock seepage collection pond, south of Peterson Creek

Notes:
[1] GPS coordinates are in UTM wgs84 zone 10 u. Ground surface elevations estimated from LIDAR. Coordinates for domestic water sources may not be accurate for the well, but are specific to the property area.

During each sampling event, *in situ* parameters were recorded using a multiparameter probe and water samples were submitted to ALS Environmental in Burnaby for the analysis of physical tests, dissolved anions, nutrients, total and dissolved metals, cyanide, and organics.

A quality assurance/quality control (QA/QC) program was implemented from the on-set of the environmental baseline program to assess the data collection methods and the data collected in comparison to the pre-set data quality objectives (DQOs). The QA/QC program, described in detail in Appendix 6.3-A, encompasses all elements of the data collection program, including staffing the project with experienced/trained individuals, documenting site visits, adhering to standard protocols for sample collection, calibration and maintenance of equipment, and collecting and analyzing duplicate and blank samples. In accordance with the QA/QC program, suspect data were flagged and further examined; data that were determined not to meet the DQOs were rejected.

Baseline water quality analytical and *in situ* data were examined and compared to relevant guidelines with respect to all categories of water use. The guidelines relevant to the water quality data for the Project are as follows:

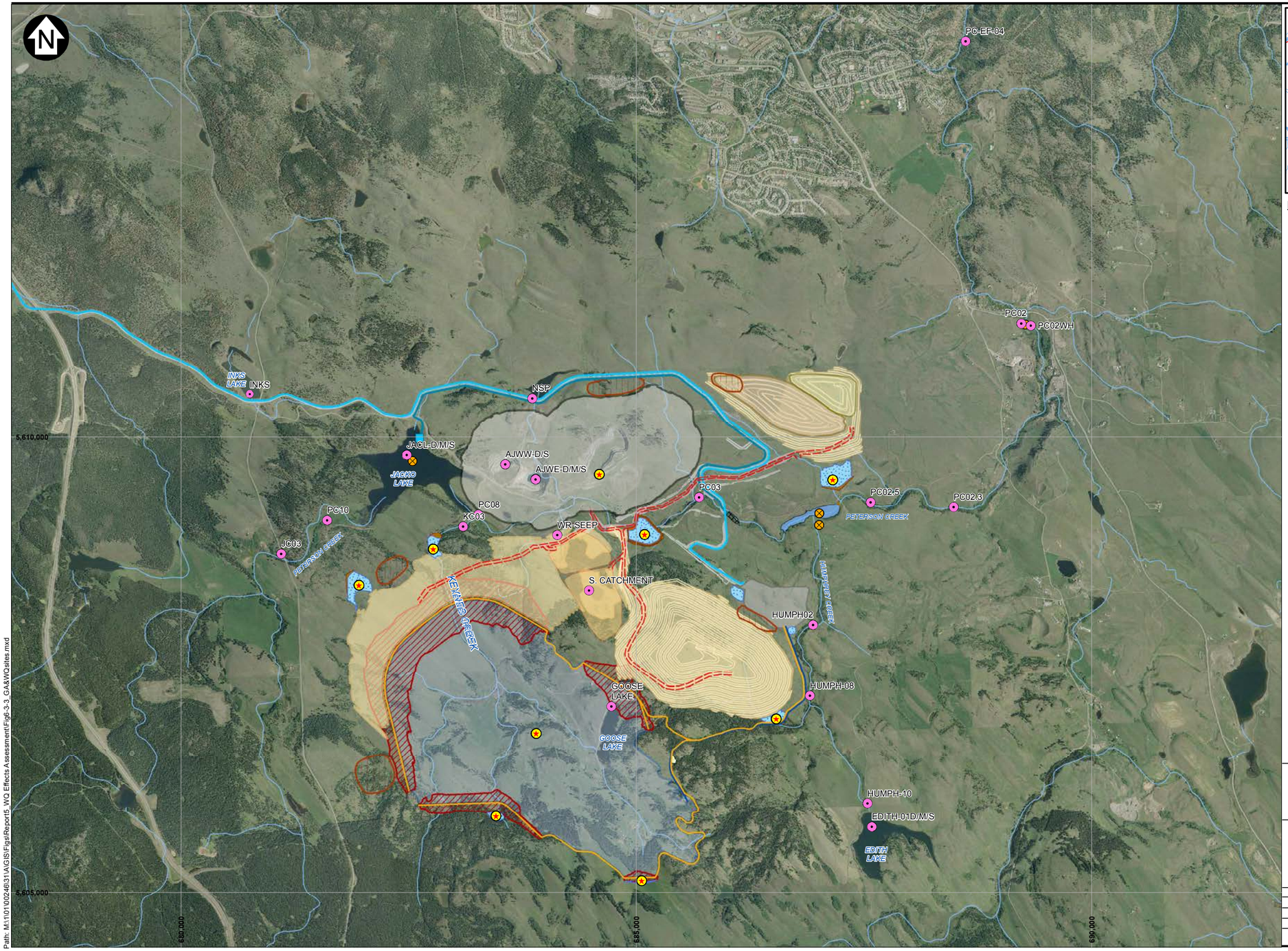
- British Columbia Ministry of Environment Approved and Working Water Quality Guidelines (BCWQG) (BC MOE 2015a and BC MOE 2015b):
- Drinking Water Supply (BCWQG-DW)
- Fresh Water Aquatic Life (BCWQG-Aq)
  - Maximum (BCWQG-Max)
  - 30 Day Average (BCWQG-30 D)
- Livestock Water Supply (BCWQG-Livestock)
- Irrigation (BCWQG-Irrigation)
- Recreation (BCWQG-Rec)
- Canadian Council of Ministers of the Environment (CCME), Canadian Environmental Quality Guidelines (CEQG) (CCME 2015):
- Water Quality Guidelines for the Protection of Aquatic Life (Freshwater) (CEQG-PAL)
- Water Quality Guidelines for the Protection of Agriculture (Livestock) (CEQG-Livestock)
- Water Quality Guidelines for the Protection of Agriculture (Irrigation) (CEQG-Irrigation)
- Water Quality Guidelines for the Protection of Wildlife (CEQG-Wildlife)
- Health Canada (2012):
- Guidelines for Canadian Drinking Water Quality (HC-DW), and
- Guidelines for Canadian Recreational Water Quality (HC-Rec).

The varied terrain of the project area and its proximity to densely populated areas contribute to the multidisciplinary water use and the relevance of many different guidelines. While all types of guideline exceedances are included in the baseline characterization, most exceedances of guidelines are within the subset of those of aquatic life guidelines, which are generally the most stringent.

Physical parameters and nutrients are important for water quality characterization; however guidelines are often not directly applicable. For the following parameters, ranges of parameter concentrations are used to qualitatively describe water types: hardness, pH, TDS, TSS, alkalinity, and phosphate. Many of the aquatic life guidelines are specified as hardness- or pH-dependant equations, which can affect the toxicity of metal parameters. Phosphate is a common limiting nutrient in natural waters and is used to define the trophic status of each water body.

Figure 6.3-3
General Arrangement South Option and Water Quality Sites

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The BCWQG-30 D (aquatic life) for sulphate is dependent on hardness concentrations, with guideline values that are higher for waters of higher hardness. Waters of very high hardness (i.e. greater than 250 mg/L), such as those of the LSA, required site specific toxicity testing. The toxicity testing, documented in *Testing in support of development of a science based environmental benchmark for sulphate for the Ajax Mine* (Nautilus, 2015), resulted in a recommended science based environmental benchmark (SBEB) for a maximum sulphate concentration of 429 mg/L, which is the same as the current BCWQG-30 D, but with the maximum hardness adjusted up to 800 mg/L $CaCO_3$ which is protective of early life stages for trout (present from May through June). An alternative SBEB of 730 mg/L for a hardness of up to 1377 mg/L $CaCO_3$ was recommended for surface waters where early life stages for trout are never present, or for periods of the year when these life stages are not expected to be present in a given reach of Peterson Creek (July through April).

Characterization of Surface Water Quality Baseline Conditions

The surface water quality characterization below is summarized from the *Baseline Water Quality Report* (Knight Piésold Ltd. 2015) which is provided in Appendix 6.3-A. A summary of statistics of water quality can be found in Tables 6.3-3 to Table 6.3-6.

Physical Parameters

All waterbodies in the RSA are neutral to basic, hard to very hard, and alkaline. Measured pH rarely exceeded the upper bound guidelines for aquatic life (6.5-9.0), but occasionally exceeded drinking water guidelines (6.0-8.5). Specific conductance was generally higher (up to 2200 µS/cm) than the normal range for interior streams (500 µS/cm; RISC 1998). Colour exceeded the BC recreational guidelines frequently. TDS concentrations, mainly comprised of calcium, magnesium, sodium, sulphate, and bicarbonate, were elevated throughout the RSA, frequently exceeded drinking water and irrigation guidelines; however, TDS concentrations in all water bodies except Goose Lake and Inks Lake fell within the range of the freshwater classification (TDS less than 1000 mg/L). While the lakes are classified as natural water bodies, Goose Lake and Inks Lake had elevated TDS concentrations that were classified as slightly saline and saline, respectively, likely due to groundwater inflows and evaporation.

All of the creeks show a sharp decrease in total dissolved solids (TDS) and specific conductance in response to dilution from spring freshet. TDS is a key parameter that differentiates the surface water features within the baseline study program. All creeks within the RSA and Jacko Lake qualify as freshwater sources, despite elevated TDS. Inks Lake, a local groundwater discharge zone within a net evaporative climate, tends to have higher concentrations of TDS and other parameters than the surrounding groundwater and surface water. Water temperature in Peterson Creek varied seasonally and spatially, with temperatures ranging from 0.05°C in the wither months (measured in open water amongst iced-over sections) and 20°C during summer. Water temperatures were noted to increase with distance downstream, particularly during the summer months. With the exception of spring freshet, the flow in the creek is generally very low and slow moving, and the creek is generally poorly shaded for long stretches, resulting in significant exposure to ambient conditions.

Within the lakes, profiles were used to measure variations in physical parameters with depth. In Jacko Lake, pH decreased with depth and TDS and SpC increased. In Edith Lake, pH was higher

and more seasonally variable in the shallow samples than deep and TSS decreased with depth. TDS was elevated throughout the water columns of Jacko Lake and Edith Lake and exceeded the HC-DW guideline of 500 mg/L in most samples. A single year of temperature profiles indicated that the spring lake turnover event in Edith Lake occurred in April and the fall turnover event occurred after August. A larger dataset for Jacko Lake indicated that the spring turnover generally occurs in February or March and fall turnover likely occurs between September and November. Dissolved oxygen concentrations in Jacko Lake remain high in the epilimnion throughout the summer, supporting the mesotrophic (moderately biologically productive) conditions. Dissolved oxygen and declines rapidly in the thermocline with depth, and falls more gradually in the hypolimnion where no wind-mixing and little photosynthetic influences occur. Anoxic conditions were commonly observed near bottom-sediments in summer sampling events.

Major Ions

Ion concentrations vary seasonally and are elevated throughout the RSA. Ion concentrations generally decreased during freshet and increased during periods of lower surface runoff, which is consistent with a surface water flow system that is dominantly supported by local groundwater discharge. Surface lake samples generally showed a muted version of the same seasonal trend, though ion concentrations were more stable at depth. The dominant anions present in the RSA were sulphate or bicarbonate and the major cations were typically magnesium, with significant sodium and calcium. Samples from upper watershed sites were dominant in bicarbonate and sulphate became relatively more dominant at sites lower in the watersheds. The ion signatures of the lakes were similar to the corresponding outflowing creeks. Goose Lake does not have a defined outlet channel; however, the Keynes Creek (KC03) water sample ion signatures were indicative of magnesium-bicarbonate-sulphate water type which is comparable to Goose Lake (sodium-sulphate-bicarbonate type), but with influence from other freshwater sources.

Sulphate concentrations were elevated in surface water samples collected from throughout the RSA. Livestock guideline exceedances (1000 mg/L) were observed at Inks Lake and exceedances of the aquatic life SBEB (430 mg/L or 730 mg/L, depending on the site location or the time of year) and the drinking water guideline (500 mg/L) were frequent in Goose Lake and at sites in lower Peterson Creek. Concentrations in Peterson Creek increased from upstream to downstream and varied seasonally, and occasionally exceeded the SBEB at sites further downstream in samples collected during low flow conditions. Sulphate concentrations are elevated in groundwater in the local and regional area, and based on the seasonality in sulphate concentrations groundwater is understood to be the primary source of sulphate in the surface water in the project area. While portions of Peterson Creek are characterized as suitable for fish habitat, the measured sulphate concentrations indicate that fish in the early life stages may be adversely affected by sulphate concentrations under baseline conditions. Sulphate concentrations in Inks Lake were elevated and generally exceeded all applicable guidelines.

Table 6.3-3. Surface Water Quality Summary Statistics

Parameter	In Situ Conductivity µS/cm				In Situ Oxygen Dissolved %				In Situ Oxygen Dissolved				In Situ pH (unitless)				In Situ Redox Potential mV				In Situ Salinity ppt				In Situ Specific Conductivity µS/cm				In Situ Temperature °C				In Situ Total Dissolved Solids			
Statistic	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max
JC03	28	506	644	675	28	81.3	90.4	96.2	28	9.2	12.0	13.1	28	8.07	8.34	8.50	28	103	193	218	22	0.38	0.52	0.59	29	830	1064	1320	29	8.6	14.2	17.8	24	531.5	693.1	859.0
PC02	58	972	1237	1376	59	77.5	92.5	116.0	59	9.0	11.3	12.4	60	7.82	8.33	8.53	59	78	196	326	53	0.74	1.01	1.15	60	1529	1997	2276	61	8.5	17.2	22.1	55	996.0	1298.6	1476.0
PC02.3	7	751	888	933	7	89.3	97.4	97.9	7	8.6	10.4	10.9	8	8.45	8.69	8.74	7	96	148	154	7	0.43	0.54	0.55	7	875	1080	1096	8	16.7	18.8	19.0	7	569.0	702.5	713.0
PC02.5	43	698	949	1111	44	69.3	99.4	110.0	44	8.3	11.4	12.3	46	7.91	8.25	8.32	45	101	195	287	41	0.53	0.78	0.85	45	1033	1435	1573	46	10.0	19.9	24.6	41	698.0	857.0	961.0
PC03	52	668	961	1295	49	85.6	176.8	193.0	52	9.4	15.0	15.9	54	8.11	8.72	9.18	50	80	181	407	42	0.43	0.74	0.96	53	872	1563	1926	54	12.2	25.3	28.7	43	563.0	974.7	1252.0
PC08	55	563	694	907	51	89.1	144.5	169.0	57	9.1	14.1	17.6	58	7.95	8.87	8.97	55	97	208	427	46	0.36	0.43	0.45	58	747	877	969	58	12.5	22.9	24.1	49	492.0	571.8	603.0
PC10	13	491	547	557	13	76.3	95.7	104.0	13	8.5	11.6	11.8	13	8.07	8.31	8.36	13	72	155	171	13	0.32	0.46	0.48	13	657	927	971	13	10.2	15.1	15.8	13	427.0	602.2	631.0
PC-EF-04	3	1268	1852	1917	3	127.0	160.3	164.0	3	13.7	19.6	20.2	3	8.27	8.41	8.42	3	57	111	117	2	1.00	1.01	1.01	3	1399	1933	1992	3	10.9	12.0	12.1	1	1295.0	1295.0	1295.0
JACL-D	38	467	621	804	36	4.7	93.5	129.0	40	0.5	12.1	13.2	39	7.74	8.67	8.84	32	0	224	258	30	0.36	0.41	0.65	40	749	848	1302	40	4.9	18.1	20.5	31	477.0	548.5	846.0
JACL-M	5	530	858	934	5	45.8	64.8	67.6	5	4.9	6.7	7.0	5	8.33	8.41	8.42	5	35	148	161	5	0.36	28.12	35.00	5	721	1103	1195	5	11.1	13.6	13.6	5	469.0	718.0	778.0
JACL-S	39	542	665	934	38	84.4	114.2	129.0	41	8.6	12.1	14.7	41	8.45	8.87	9.21	33	112	228	277	28	0.34	0.37	0.60	40	689	771	1182	41	14.5	22.5	23.0	31	446.0	493.5	778.0
KC03	6	951	996	997	6	60.0	76.5	78.4	6	7.4	9.7	9.8	6	7.97	8.10	8.12	6	113	216	216	6	0.77	0.78	0.78	6	1523	1541	1542	6	5.3	6.6	6.7	6	989.5	1002.5	1003.0
EDITH-01D	11	677	1012	1148	11	76.5	115.0	118.0	11	7.4	12.5	14.2	11	8.12	8.81	8.81	11	1	180	272	11	0.44	0.70	0.89	11	897	1393	1765	11	9.1	19.0	20.0	11	584.0	1062.5	1461.0
EDITH-01M	3	723	1177	1227	3	18.8	24.7	25.4	3	2.0	2.3	2.3	3	8.31	8.48	8.50	3	109	128	130	3	0.48	0.80	0.83	3	978	1574	1640	3	11.8	14.8	15.1	3	634.0	1022.8	1066.0
EDITH-01S	11	782	1035	1236	11	85.1	115.0	118.0	11	8.8	12.5	14.2	11	8.75	8.82	8.82	11	50	146	168	11	0.44	0.64	0.81	11	885	1263	1597	11	16.6	21.1	21.8	11	575.0	820.0	1037.0
GOOSE LAKE	11	5259	6096	6755	11	61.6	91.1	91.8	11	6.3	9.6	10.5	12	9.55	9.67	9.77	11	-64	55	67	11	2.79	3.67	3.85	11	5172	6681	7000	12	20.0	26.2	27.0	11	3362.0	4342.0	4550.0
HUMPH-02	15	840	919	920	15	88.3	343.9	899.0	15	10.0	12.5	13.3	16	8.37	8.58	8.68	15	68	171	217	15	0.62	0.76	0.81	15	1231	4988	12850	16	8.9	14.9	15.3	15	800.0	984.1	1052.0
HUMPH-08	8	737	848	855	8	78.8	89.3	90.9	8	7.9	9.5	10.0	9	8.46	8.58	8.59	8	75	158	171	8	0.48	0.49	0.49	8	953	979	981	9	13.1	20.9	21.4	8	620.0	635.9	638.0
HUMPH-10	14	700	909	930	14	70.8	102.0	114.0	14	7.7	10.4	12.0	15	7.92	8.97	9.11	14	38	115	175	14	0.45	0.49	0.50	14	917	997	1007	15	16.5	24.0	26.9	14	595.5	648.5	655.0
AJWE-D	11	1906	2044	2050	8	88.0	123.3	125.0	11	10.7	13.5	14.4	11	8.19	8.47	8.51	7	115	244	247	5	1.45	1.51	1.52	11	2771	2928	2929	11	9.3	11.1	11.2	5	1806.0	1889.8	1903.0
AJWE-S	11	1906	2044	2050	8	88.0	123.3	125.0	11	10.7	13.5	14.4	11	8.19	8.47	8.51	7	115	244	247	5	1.45	1.51	1.52	11	2771	2928	2929	11	9.3	11.1	11.2	5	1806.0	1889.8	1903.0
AJWW-D	6	2188	2414	2445	4	18.9	58.9	65.7	6	2.1	6.1	7.4	6	7.83	8.03	8.04	4	23	133	137	2	1.76	1.81	1.81	6	3417	3467	3477	6	6.4	10.1	10.1	2	2166.5	2226.4	2233.0
AJWW-S	8	2577	2740	2748	4	74.5	85.5	85.9	7	8.4	9.0	9.1	7	8.08	8.29	8.30	4	26	113	113	2	1.77	1.82	1.83	8	3403	3468	3470	8	12.7	14.1	14.2	2	2183.0	2248.7	2256.0
NSP	18	4352	5531	5732	19	94.9	166.3	178.0	19	8.8	18.6	20.4	21	9.22	9.48	9.50	20	57	142	146	19	2.69	3.71	4.09	20	5043	6940	7629	21	14.8	22.8	24.0	19	3292.0	4528.5	4956.0
S. CATCHMENT	2	2435	3046	3114	1	188.0	188.0	188.0	1	16.3	16.3	16.3	3	9.12	9.63	9.69	2	32	51	53	2	1.53	1.70	1.72	2	2921	3246	3282	3	17.5	21.9	22.4	2	1899.0	2112.3	2136.0
WR-SEEP	13	1674	6611	11220	12	89.9	103.4	105.0	12	7.8	10.0	10.1	13	8.38	8.72	8.83	13	86	177	191	12	1.09	4.31	7.18	13	2363	7225	12500	13	17.2	28.6	29.9	13	1540.0	4694.6	8120.0

Notes

Units are mg/L, unless otherwise stated

n = Number of samples

95th P - 95th Percentile summary statistics

Med - Median (50th Percentile)

Max - Maximum

Table 6.3-3. Surface Water Quality Summary Statistics

Parameter	Acidity to pH 8.3 (as $CaCO_3$)				Alkalinity (Total as $CaCO_3$)				Bicarbonate Alkalinity				Carbonate Alkalinity				Color TCU				Hardness as $CaCO_3$ (Dissolved)				Hydroxide Alkalinity				pH (unitless)				Specific Conductivity µS/cm			
Statistic	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max
JC03	1	0.5	0.5	0.5	29	295.0	423.0	439.0	16	293.5	430.0	439.0	16	1.0	9.7	14.5	29	27.7	51.1	69.0	29	383	484	512	16	0.5	1.0	1.0	28	8.29	8.41	8.48	29	811	989	1020
PC02	5	4.0	6.7	7.2	61	413.0	468.0	481.0	48	408.5	468.0	481.0	48	1.0	19.2	28.1	44	9.7	36.7	63.6	61	711	914	1040	48	1.0	1.0	1.0	60	8.24	8.48	8.54	61	1570	1920	2230
PC02.3	0	-	-	-	8	392.5	433.3	449.0	8	366.0	410.2	428.0	8	23.0	29.1	30.1	0	-	-	-	8	452	517	527	8	0.5	0.5	0.5	8	8.50	8.55	8.55	8	983	1073	1080
PC02.5	4	1.0	2.1	2.2	46	393.0	519.8	606.0	42	389.0	488.7	606.0	42	1.0	20.1	22.8	30	34.1	46.7	100.0	46	507	643	775	42	0.5	1.0	10.0	46	8.31	8.44	8.49	46	1075	1368	1530
PC03	4	1.3	4.2	4.6	54	324.0	496.4	700.0	39	314.0	506.8	700.0	39	8.1	28.7	49.8	39	28.2	38.1	57.7	54	422	790	976	39	0.5	1.9	10.0	53	8.32	8.57	8.78	54	939	1598	1940
PC08	3	2.4	6.5	7.0	57	296.0	333.0	357.0	40	301.5	330.0	351.0	40	1.0	20.6	31.0	42	19.3	23.7	25.9	58	335	380	393	40	0.5	1.0	1.0	57	8.29	8.60	8.79	58	755	845	866
PC10	0	-	-	-	13	286.0	342.8	344.0	13	278.0	342.8	344.0	13	1.0	9.1	9.5	1	30.7	30.7	30.7	13	310	429	429	13	0.5	1.0	1.0	13	8.34	8.39	8.43	13	659	903	906
PC-EF-04	2	0.5	0.5	0.5	4	380.5	407.4	409.0	2	198.8	377.2	397.0	2	6.2	11.2	11.8	4	24.0	34.6	34.9	4	742	862	868	2	0.5	0.5	0.5	4	8.46	8.57	8.57	4	1630	1954	1970
JACL-D	5	4.9	7.2	7.7	40	252.0	280.0	285.0	30	252.0	274.8	285.0	30	1.0	4.1	22.6	27	16.0	17.5	21.3	40	316	336	341	30	1.0	1.0	1.0	40	8.15	8.33	8.64	40	740	801	811
JACL-M	0	-	-	-	5	237.0	247.8	248.0	3	230.0	242.6	244.0	3	3.8	7.3	7.7	2	12.6	14.3	14.5	5	296	310	310	3	0.5	0.5	0.5	5	8.36	8.47	8.47	5	684	750	758
JACL-S	5	0.5	0.5	0.5	40	230.5	252.1	253.0	29	221.0	252.6	253.0	29	8.5	23.5	27.4	28	16.2	22.2	24.5	41	287	322	335	29	0.5	1.0	1.0	41	8.43	8.68	8.71	41	665	732	777
KC03	0	-	-	-	6	559.0	601.5	610.0	6	549.0	601.5	610.0	6	10.0	27.8	28.0	1	32.6	32.6	32.6	6	700	733	739	6	0.5	10.0	10.0	6	8.32	8.43	8.43	6	1485	1498	1500
EDITH-01D	0	-	-	-	11	413.0	497.0	552.0	11	383.0	497.0	552.0	11	18.3	43.7	49.3	0	-	-	-	11	397	415	422	11	0.5	5.5	10.0	11	8.37	8.76	8.77	11	900	962	969
EDITH-01M	0	-	-	-	3	418.0	445.0	448.0	3	418.0	444.1	447.0	3	0.5	29.6	32.8	0	-	-	-	3	400	413	414	3	0.5	0.5	0.5	3	8.37	8.56	8.58	3	917	940	942
EDITH-01S	0	-	-	-	11	402.0	418.5	421.0	11	345.0	373.0	382.0	11	50.3	59.5	60.7	0	-	-	-	11	391	402	408	11	0.5	0.5	0.5	11	8.76	8.82	8.84	11	864	900	901
GOOSE LAKE	0	-	-	-	12	1920.0	2433.5	2450.0	12	1032.0	1321.5	1360.0	12	863.5	1136.0	1180.0	0	-	-	-	12	1035	1197	1230	12	0.5	0.5	0.5	12	9.42	9.49	9.52	12	5430	7208	7290
HUMPH-02	0	-	-	-	16	474.0	498.3	508.0	16	442.5	470.8	476.0	16	32.9	65.2	101.0	1	17.7	17.7	17.7	16	641	799	850	16	0.5	0.6	1.0	16	8.49	8.55	8.56	16	1250	1473	1540
HUMPH-08	0	-	-	-	9	433.0	469.2	472.0	9	410.0	451.0	463.0	9	29.8	44.0	45.3	0	-	-	-	9	447	460	461	9	0.5	0.5	0.5	9	8.54	8.61	8.63	9	970	984	990
HUMPH-10	0	-	-	-	15	419.0	477.9	487.0	15	419.0	477.9	487.0	15	1.0	53.5	55.4	0	-	-	-	15	411	437	437	15	0.5	1.0	1.0	15	8.33	8.78	8.79	15	895	965	978
AJWE-D	2	1.8	3.0	3.1	11	163.0	172.5	177.0	6	163.0	174.3	177.0	6	1.0	1.0	1.0	8	2.5	2.5	2.5	11	1290	1370	1380	6	1.0	1.0	1.0	11	8.29	8.33	8.33	11	2750	2825	2850
AJWE-S	2	1.8	3.0	3.1	11	163.0	172.5	177.0	6	163.0	174.3	177.0	6	1.0	1.0	1.0	8	2.5	2.5	2.5	11	1290	1370	1380	6	1.0	1.0	1.0	11	8.29	8.33	8.33	11	2750	2825	2850
AJWW-D	2	6.8	7.7	7.8	7	162.0	168.5	170.0	4	163.5	169.3	170.0	4	1.0	1.0	1.0	5	2.5	2.5	2.5	7	1750	1900	1930	4	1.0	1.0	1.0	7	8.10	8.20	8.22	7	3410	3527	3530
AJWW-S	2	5.5	6.3	6.4	8	156.5	163.6	165.0	4	156.5	160.4	161.0	4	1.0	1.0	1.0	5	2.5	2.5	2.5	8	1730	1872	1900	4	1.0	1.0	1.0	8	8.15	8.25	8.27	8	3390	3482	3510
NSP	4	0.5	0.5	0.5	22	1210.0	1504.5	1520.0	21	714.0	1040.0	1210.0	21	471.0	615.0	676.0	14	35.4	48.5	50.1	22	2545	3458	3610	21	0.5	0.5	0.5	22	9.18	9.29	9.32	22	5355	7137	7400
S. CATCHMENT	0	-	-	-	4	1080.0	1165.0	1180.0	4	607.5	800.4	823.0	4	379.0	524.7	546.0	1	16.7	16.7	16.7	4	1745	1844	1860	4	0.5	0.5	0.5	4	9.04	9.30	9.34	4	3210	3443	3470
WR-SEEP	0	-	-	-	14	143.5	295.7	386.0	14	138.0	288.7	366.0	14	2.7	40.0	76.4	9	29.3	354.2	566.0	14	1045	2199	2400	14	0.5	1.0	1.0	15	8.26	8.81	8.96	15	2380	4074	4270

Notes

Units are mg/L, unless otherwise stated

n = Number of samples

95th P - 95th Percentile summary statistics

Med - Median (50th Percentile)

Max - Maximum

Table 6.3-3. Surface Water Quality Summary Statistics

Parameter	Total Dissolved Solids				Total Suspended Solids				Turbidity NTU				Bromide				Chloride				Fluoride				Sulphate				Ammonia (Total)				Nitrate (as N)			
Statistic	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max
JC03	28	499	644	650	29	19.4	96.7	116.0	29	8.0	46.7	66.7	29	0.25	0.25	0.50	29	46.5	119.6	123.0	16	0.19	0.32	0.36	29	42.1	67.9	73.7	29	0.023	0.103	0.139	24	0.056	0.171	1.040
PC02	61	1100	1410	1710	61	7.0	61.4	245.0	59	2.3	15.9	75.7	59	0.25	0.50	0.50	61	106.0	133.0	142.0	61	0.21	0.44	0.67	61	359.0	535.0	775.0	60	0.020	0.042	0.268	57	0.180	0.996	1.180
PC02.3	8	629	848	911	8	8.2	15.7	17.8	8	2.9	5.2	5.5	8	0.25	0.25	0.25	8	54.5	59.1	59.9	8	0.27	0.38	0.44	8	113.5	149.5	160.0	8	0.020	0.026	0.028	8	0.025	0.163	0.177
PC02.5	46	699	890	1080	46	5.2	25.6	49.7	45	2.3	12.2	13.1	45	0.25	0.25	0.25	46	55.3	72.4	77.2	46	0.24	0.37	0.42	46	132.5	301.5	442.0	46	0.045	0.200	0.298	43	0.060	0.142	0.211
PC03	54	600	1122	1420	54	3.3	10.5	105.0	50	1.5	6.0	15.3	53	0.25	0.50	0.65	54	52.6	62.8	79.0	53	0.21	0.34	1.10	54	153.5	437.1	568.0	54	0.042	1.074	2.260	44	0.025	0.140	0.760
PC08	58	458	507	531	58	6.8	26.7	42.4	53	7.6	22.1	29.6	58	0.13	0.25	0.25	58	55.9	61.3	65.1	57	0.24	0.38	0.43	58	47.7	74.3	85.0	58	0.040	0.385	0.516	49	0.017	0.065	0.122
PC10	13	413	581	587	13	5.4	18.3	19.1	13	3.0	7.9	8.6	13	0.05	0.25	0.25	13	47.2	81.3	84.5	13	0.22	0.28	0.31	13	30.2	82.2	84.7	13	0.021	0.234	0.440	13	0.067	0.256	0.258
PC-EF-04	4	1135	1338	1350	4	8.0	35.7	40.0	4	1.8	16.3	18.7	4	0.25	0.46	0.50	4	119.6	154.8	157.0	4	0.15	0.23	0.24	4	397.0	500.2	508.0	4	0.013	0.015	0.015	4	0.346	0.786	0.850
JACL-D	40	453	492	507	40	1.5	5.3	7.3	36	1.9	11.5	23.4	40	0.13	0.25	0.25	40	59.5	62.7	65.0	37	0.21	0.30	0.34	40	65.4	83.8	86.4	39	0.390	1.572	1.940	34	0.027	0.522	0.562
JACL-M	5	427	448	448	5	1.5	3.6	4.1	5	1.7	6.2	7.3	5	0.03	0.13	0.13	5	55.8	59.8	59.8	5	0.22	0.24	0.24	5	50.3	73.4	73.7	5	0.087	0.097	0.099	5	0.042	0.081	0.085
JACL-S	41	413	455	465	41	1.5	7.9	11.3	37	1.2	11.1	15.9	40	0.03	0.13	0.25	40	54.0	60.3	61.6	39	0.21	0.23	0.30	40	53.2	83.5	84.5	40	0.034	0.255	0.361	40	0.012	0.276	0.546
KC03	6	999	1048	1060	6	1.5	12.3	15.1	6	0.4	3.0	3.8	6	0.25	0.25	0.25	6	17.5	20.5	21.0	6	0.28	0.30	0.30	6	340.0	350.3	351.0	6	0.009	0.010	0.010	6	0.103	0.189	0.198
EDITH-01D	11	533	567	568	11	1.5	6.4	6.9	11	1.6	24.0	43.3	11	0.25	0.25	0.25	11	50.2	51.8	52.0	11	0.24	0.38	0.42	11	41.2	42.7	42.7	11	0.238	2.145	2.420	11	0.025	0.038	0.051
EDITH-01M	3	549	561	562	3	1.5	5.4	5.8	3	5.2	21.9	23.8	3	0.25	0.25	0.25	3	49.7	50.7	50.8	3	0.25	0.25	0.25	3	40.5	41.9	42.1	3	0.360	1.440	1.560	3	0.025	0.025	0.025
EDITH-01S	11	527	546	547	11	1.5	6.5	7.4	11	1.7	4.9	6.5	11	0.25	0.25	0.25	11	49.8	50.9	51.0	11	0.24	0.41	0.46	11	41.6	42.4	42.4	11	0.024	0.072	0.092	11	0.025	0.025	0.025
GOOSE LAKE	12	4705	6200	6260	12	18.7	125.7	218.0	12	4.7	100.1	161.0	12	1.25	1.45	1.50	12	128.5	165.2	169.0	12	0.04	0.50	0.50	12	1550.0	2148.0	2170.0	12	0.142	0.256	0.341	12	0.125	0.125	0.125
HUMPH-02	16	855	1020	1050	16	11.1	24.1	28.3	16	2.4	7.3	7.6	16	0.25	0.25	0.25	16	33.2	48.0	48.9	16	0.27	0.37	0.40	16	234.5	409.0	478.0	16	0.011	0.020	0.024	16	0.025	0.142	0.180
HUMPH-08	9	578	612	616	9	26.5	60.0	66.8	9	12.9	16.5	17.4	9	0.25	0.25	0.25	9	44.4	49.8	50.3	9	0.24	0.36	0.43	9	68.1	87.1	91.7	9	0.024	0.057	0.065	9	0.066	0.146	0.165
HUMPH-10	15	537	578	592	15	8.3	73.4	84.5	15	2.1	10.3	10.9	15	0.25	0.25	0.25	15	50.2	52.6	52.7	15	0.25	0.38	0.46	15	37.8	45.8	52.6	15	0.086	0.431	0.535	15	0.025	0.071	0.078
AJWE-D	11	2270	2625	2650	11	1.5	5.2	5.2	8	0.2	1.0	1.3	11	0.50	1.88	2.50	11	27.0	32.5	34.0	10	0.20	0.88	1.20	11	1480.0	1600.0	1600.0	11	0.007	0.034	0.041	11	22.000	24.200	24.400
AJWE-S	11	2270	2625	2650	11	1.5	5.2	5.2	8	0.2	1.0	1.3	11	0.50	1.88	2.50	11	27.0	32.5	34.0	10	0.20	0.88	1.20	11	1480.0	1600.0	1600.0	11	0.007	0.034	0.041	11	22.000	24.200	24.400
AJWW-D	7	3010	3342	3390	7	3.6	5.5	6.0	5	0.4	0.6	0.7	7	0.50	1.25	1.25	7	36.0	38.8	39.0	6	0.31	1.10	1.30	7	1770.0	1941.0	1980.0	7	0.012	0.040	0.045	7	74.100	79.630	79.900
AJWW-S	8	2890	3257	3260	8	1.5	5.6	5.7	5	0.3	0.3	0.3	8	0.25	0.99	1.25	8	35.0	35.9	36.0	7	0.22	0.47	0.50	8	1680.0	1942.5	1960.0	8	0.031	0.058	0.063	8	71.850	73.775	74.300
NSP	22	4925	7145	7290	22	9.1	24.2	91.0	21	2.8	21.7	24.8	22	1.25	1.49	1.60	22	50.0	88.2	95.0	22	0.50	0.98	1.20	22	2705.0	3946.5	4010.0	22	0.100	2.693	3.680	22	0.125	0.340	4.320
S. CATCHMENT	4	2785	3074	3120	4	18.2	42.4	45.7	4	4.9	41.1	47.1	4	0.50	0.50	0.50	4	26.5	33.0	34.0	4	0.14	0.20	0.20	4	1350.0	1397.0	1400.0	4	0.079	0.240	0.262	4	0.050	0.050	0.050
WR-SEEP	15	2060	3630	3770	15	7.7	16.3	18.7	14	2.9	16.6	17.7	14	0.50	1.07	1.20	14	53.0	208.0	219.0	14	0.20	0.29	0.42	14	1240.0	2357.5	2390.0	14	0.020	0.304	0.630	14	0.050	2.694	4.130

Notes

Units are mg/L, unless otherwise stated

n = Number of samples

95th P - 95th Percentile summary statistics

Med - Median (50th Percentile)

Max - Maximum

Table 6.3-3. Surface Water Quality Summary Statistics

Parameter	Nitrite (as N)				Nitrogen (Dissolved)				Nitrogen (Total)				Nitrogen Kjeldahl (Total)				Orthophosphate (Dissolved)				Phosphorus - Dissolved				Phosphorus - Total				Cyanide (Free)				Cyanide (Total)			
Statistic	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max
JC03	28	0.005	0.005	0.009	21	0.51	1.01	2.10	27	0.64	1.39	2.09	29	0.60	1.30	2.24	7	0.119	0.175	0.196	25	0.064	0.181	0.206	29	0.161	0.260	0.435	27	0.0025	0.0025	0.0025	27	0.0025	0.0132	0.0136
PC02	36	0.005	0.030	0.035	30	0.83	1.28	1.34	39	0.85	1.40	1.81	61	0.51	1.18	1.67	28	0.071	0.169	0.432	57	0.065	0.179	0.502	58	0.080	0.280	0.671	59	0.0025	0.0025	0.0025	58	0.0025	0.0081	0.0150
PC02.3	8	0.005	0.009	0.011	0	-	-	-	0	-	-	-	8	0.91	1.14	1.16	8	0.092	0.107	0.108	8	0.112	0.140	0.148	8	0.129	0.154	0.161	8	0.0025	0.0025	0.0025	8	0.0025	0.0025	0.0025
PC02.5	42	0.005	0.025	0.063	22	0.89	1.56	2.39	29	0.93	1.53	1.99	46	0.93	1.58	1.84	20	0.081	0.184	0.418	46	0.111	0.247	0.770	44	0.126	0.318	0.965	44	0.0025	0.0025	0.0025	44	0.0025	0.0107	0.0190
PC03	54	0.005	0.026	0.157	24	1.01	2.07	3.27	35	0.93	2.22	3.37	54	0.99	2.09	3.37	27	0.021	0.143	0.171	47	0.043	0.304	0.561	53	0.058	0.247	0.647	50	0.0025	0.0025	0.0025	51	0.0025	0.0101	0.0110
PC08	58	0.005	0.016	0.024	24	0.82	1.37	1.75	37	0.90	1.73	3.68	58	0.93	1.58	3.55	31	0.003	0.010	0.022	50	0.015	0.052	0.136	57	0.050	0.123	0.266	52	0.0025	0.0025	0.0025	55	0.0025	0.0075	0.0078
PC10	13	0.003	0.009	0.014	0	-	-	-	0	-	-	-	13	0.57	1.18	1.77	13	0.090	0.217	0.309	13	0.099	0.264	0.413	13	0.127	0.308	0.451	13	0.0025	0.0025	0.0025	13	0.0025	0.0025	0.0025
PC-EF-04	4	0.005	0.025	0.028	2	1.21	1.34	1.35	4	1.25	1.65	1.70	4	0.67	0.78	0.80	2	0.061	0.067	0.067	4	0.077	0.102	0.105	3	0.074	0.164	0.174	3	0.0025	0.0025	0.0025	3	0.0053	0.0197	0.0213
JACL-D	40	0.005	0.030	0.036	18	1.52	2.93	3.50	23	1.45	2.55	2.77	40	1.31	2.52	3.17	40	0.114	0.336	0.343	33	0.122	0.354	0.392	39	0.140	0.364	0.430	36	0.0025	0.0025	0.0025	38	0.0025	0.0065	0.0117
JACL-M	5	0.003	0.020	0.022	2	1.14	1.21	1.22	2	1.13	1.16	1.16	5	1.06	1.10	1.11	5	0.002	0.022	0.022	5	0.013	0.036	0.036	5	0.018	0.041	0.042	5	0.0025	0.0025	0.0025	5	0.0025	0.0025	0.0025
JACL-S	40	0.003	0.024	0.031	18	0.98	1.57	2.10	23	1.06	1.46	1.99	41	0.94	1.38	1.99	40	0.001	0.075	0.098	33	0.017	0.101	0.135	40	0.033	0.116	0.140	36	0.0025	0.0025	0.0025	39	0.0025	0.0099	0.0106
KC03	6	0.005	0.009	0.010	0	-	-	-	0	-	-	-	6	0.69	0.84	0.87	6	0.118	0.176	0.190	6	0.142	0.208	0.223	6	0.155	0.202	0.209	6	0.0025	0.0025	0.0025	6	0.0025	0.0025	0.0025
EDITH-01D	11	0.005	0.005	0.005	0	-	-	-	0	-	-	-	11	1.61	3.42	3.64	11	0.024	0.377	0.434	11	0.047	0.439	0.502	11	0.073	0.422	0.504	11	0.0025	0.0025	0.0025	11	0.0025	0.0025	0.0025
EDITH-01M	3	0.005	0.005	0.005	0	-	-	-	0	-	-	-	3	2.09	3.07	3.18	3	0.011	0.294	0.325	3	0.030	0.342	0.377	3	0.070	0.373	0.407	3	0.0025	0.0025	0.0025	3	0.0025	0.0025	0.0025
EDITH-01S	11	0.005	0.005	0.005	0	-	-	-	0	-	-	-	11	1.42	1.65	1.66	11	0.001	0.006	0.008	11	0.022	0.029	0.031	11	0.031	0.055	0.070	11	0.0025	0.0025	0.0025	11	0.0025	0.0025	0.0025
GOOSE LAKE	12	0.025	0.043	0.065	0	-	-	-	0	-	-	-	12	10.70	16.82	17.20	12	0.003	0.021	0.022	11	0.086	0.187	0.196	12	0.097	0.389	0.400	12	0.0025	0.0025	0.0025	12	0.0025	0.0025	0.0025
HUMPH-02	16	0.005	0.005	0.005	0	-	-	-	0	-	-	-	16	0.66	0.99	1.05	16	0.086	0.126	0.133	15	0.092	0.150	0.160	16	0.137	0.166	0.166	16	0.0025	0.0025	0.0025	16	0.0025	0.0025	0.0025
HUMPH-08	9	0.005	0.013	0.014	0	-	-	-	0	-	-	-	9	0.91	1.79	1.83	9	0.137	0.173	0.183	8	0.168	0.225	0.242	9	0.222	0.318	0.332	9	0.0025	0.0025	0.0025	9	0.0025	0.0025	0.0025
HUMPH-10	15	0.005	0.019	0.025	0	-	-	-	1	1.25	1.25	1.25	15	1.37	2.20	2.35	15	0.043	0.188	0.401	14	0.063	0.253	0.479	15	0.110	0.346	0.574	15	0.0025	0.0025	0.0025	15	0.0025	0.0025	0.0025
AJWE-D	11	0.031	0.147	0.160	3	28.50	31.11	31.40	3	21.20	22.10	22.20	11	0.18	0.25	0.26	8	0.002	0.003	0.003	5	0.001	0.003	0.003	10	0.003	0.008	0.010	7	0.0025	0.0025	0.0025	10	0.0025	0.0025	0.0025
AJWE-S	11	0.031	0.147	0.160	3	28.50	31.11	31.40	3	21.20	22.10	22.20	11	0.18	0.25	0.26	8	0.002	0.003	0.003	5	0.001	0.003	0.003	10	0.003	0.008	0.010	7	0.0025	0.0025	0.0025	10	0.0025	0.0025	0.0025
AJWW-D	7	0.138	0.176	0.187	0	-	-	-	0	-	-	-	7	0.15	0.35	0.39	6	0.001	0.002	0.002	2	0.001	0.001	0.001	6	0.003	0.006	0.007	4	0.0025	0.0025	0.0025	6	0.0025	0.0025	0.0025
AJWW-S	8	0.131	0.138	0.138	0	-	-	-	0	-	-	-	8	0.03	0.18	0.18	7	0.001	0.002	0.002	2	0.001	0.001	0.001	7	0.003	0.004	0.004	4	0.0025	0.0025	0.0025	7	0.0025	0.0152	0.0207
NSP	22	0.025	0.051	0.060	8	4.83	5.76	6.04	14	5.12	12.20	20.80	22	5.21	12.32	15.30	18	0.303	0.774	0.904	22	0.477	0.968	1.000	22	0.537	1.053	1.100	21	0.0025	0.0025	0.0050	22	0.0025	0.0139	0.0174
S. CATCHMENT	4	0.010	0.010	0.010	0	-	-	-	1	3.10	3.10	3.10	4	2.92	3.34	3.38	4	0.002	0.009	0.010	4	0.043	0.096	0.104	4	0.069	0.119	0.127	4	0.0025	0.0025	0.0025	4	0.0025	0.0025	0.0025
WR-SEEP	14	0.010	0.078	0.091	4	2.26	4.77	5.13	9	2.00	5.28	5.29	14	1.50	2.70	2.85	9	0.001	1.483	2.470	14	0.015	0.033	0.034	15	0.037	0.994	3.160	15	0.0025	0.0025	0.0025	15	0.0025	0.0118	0.0215

Notes

Units are mg/L, unless otherwise stated

n = Number of samples

95th P - 95th Percentile summary statistics

Med - Median (50th Percentile)

Max - Maximum

Table 6.3-3. Surface Water Quality Summary Statistics

Parameter	Cyanide (WAD)				Aluminum - Dissolved				Antimony - Dissolved				Arsenic - Dissolved				Barium - Dissolved				Beryllium - Dissolved				Bismuth - Dissolved				Boron - Dissolved			
Statistic	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max
JC03	27	0.0025	0.0025	0.0025	14	0.0029	0.0070	0.0080	15	0.00005	0.00007	0.00012	26	0.0011	0.0021	0.0023	29	0.0803	0.1010	0.1040	15	0.000050	0.000050	0.000050	26	0.00025	0.10000	0.10000	15	0.005	0.014	0.016
PC02	59	0.0025	0.0025	0.0078	39	0.0013	0.0053	0.0153	45	0.00005	0.00014	0.00016	58	0.0018	0.0030	0.0032	61	0.0540	0.0638	0.0740	45	0.000050	0.000050	0.000050	58	0.00025	0.10000	0.10000	47	0.057	0.091	0.098
PC02.3	8	0.0025	0.0025	0.0025	8	0.0019	0.0055	0.0069	8	0.00008	0.00014	0.00014	8	0.0021	0.0024	0.0025	8	0.0523	0.0575	0.0596	8	0.000050	0.000050	0.000050	8	0.00025	0.00025	0.00025	8	0.033	0.039	0.040
PC02.5	44	0.0025	0.0025	0.0025	34	0.0018	0.0060	0.0119	42	0.00008	0.00014	0.00017	46	0.0016	0.0025	0.0028	46	0.0606	0.0722	0.0756	42	0.000050	0.000050	0.000050	46	0.00025	0.10000	0.10000	42	0.030	0.036	0.037
PC03	50	0.0025	0.0025	0.0025	29	0.0018	0.0036	0.0041	37	0.00011	0.00017	0.00034	53	0.0014	0.0022	0.0034	54	0.0605	0.1114	0.1390	37	0.000050	0.000050	0.000050	48	0.00025	0.10000	0.10000	37	0.034	0.049	0.051
PC08	52	0.0025	0.0025	0.0025	30	0.0019	0.0026	0.0069	38	0.00005	0.00011	0.00011	58	0.0012	0.0015	0.0018	58	0.0544	0.0772	0.0840	38	0.000050	0.000050	0.000050	49	0.00025	0.10000	0.10000	38	0.023	0.030	0.032
PC10	13	0.0025	0.0025	0.0025	13	0.0018	0.0060	0.0095	13	0.00005	0.00013	0.00015	13	0.0017	0.0019	0.0020	13	0.0643	0.0800	0.0814	13	0.000050	0.000050	0.000050	13	0.00025	0.00025	0.00025	13	0.013	0.019	0.022
PC-EF-04	3	0.0025	0.0025	0.0025	4	0.0038	0.0050	0.0050	4	0.00038	0.00050	0.00050	4	0.0026	0.0032	0.0032	4	0.0606	0.0750	0.0760	4	0.000750	0.001000	0.001000	2	0.05013	0.09501	0.10000	4	0.050	0.064	0.066
JACL-D	36	0.0025	0.0025	0.0063	22	0.0005	0.0021	0.0090	27	0.00005	0.00012	0.00012	40	0.0013	0.0014	0.0016	40	0.0672	0.0752	0.0793	27	0.000050	0.000050	0.000050	32	0.00025	0.10000	0.10000	27	0.022	0.026	0.026
JACL-M	5	0.0025	0.0025	0.0025	4	0.0016	0.0067	0.0075	3	0.00005	0.00010	0.00010	5	0.0013	0.0014	0.0014	5	0.0600	0.0620	0.0625	3	0.000050	0.000050	0.000050	5	0.00025	0.10000	0.10000	3	0.022	0.023	0.023
JACL-S	36	0.0025	0.0025	0.0025	22	0.0013	0.0033	0.0093	27	0.00010	0.00012	0.00013	41	0.0013	0.0014	0.0017	41	0.0550	0.0660	0.0714	27	0.000050	0.000050	0.000050	33	0.00025	0.10000	0.10000	27	0.020	0.023	0.025
KC03	6	0.0025	0.0025	0.0025	6	0.0012	0.0017	0.0019	6	0.00019	0.00020	0.00020	6	0.0056	0.0066	0.0068	6	0.0745	0.0784	0.0790	6	0.000050	0.000050	0.000050	6	0.00025	0.00025	0.00025	6	0.111	0.130	0.133
EDITH-01D	11	0.0025	0.0025	0.0025	11	0.0014	0.0039	0.0041	11	0.00011	0.00014	0.00014	11	0.0015	0.0016	0.0017	11	0.0537	0.0670	0.0679	11	0.000050	0.000050	0.000050	11	0.00025	0.00025	0.00025	11	0.018	0.019	0.019
EDITH-01M	3	0.0025	0.0025	0.0025	3	0.0021	0.0032	0.0033	3	0.00012	0.00013	0.00013	3	0.0016	0.0016	0.0016	3	0.0592	0.0665	0.0673	3	0.000050	0.000050	0.000050	3	0.00025	0.00025	0.00025	3	0.018	0.018	0.018
EDITH-01S	11	0.0025	0.0025	0.0025	11	0.0042	0.0111	0.0116	11	0.00013	0.00014	0.00014	11	0.0016	0.0018	0.0018	11	0.0488	0.0542	0.0543	11	0.000050	0.000050	0.000050	11	0.00025	0.00025	0.00025	11	0.016	0.019	0.020
GOOSE LAKE	12	0.0025	0.0025	0.0025	12	0.0025	0.0059	0.0070	12	0.00218	0.00312	0.00319	12	0.0200	0.0312	0.0325	12	0.0153	0.0184	0.0186	12	0.000250	0.000363	0.000500	12	0.00125	0.00181	0.00250	12	0.275	0.333	0.341
HUMPH-02	16	0.0025	0.0025	0.0025	16	0.0017	0.0022	0.0026	16	0.00021	0.00024	0.00026	16	0.0033	0.0037	0.0038	16	0.0611	0.0679	0.0690	16	0.000050	0.000050	0.000050	16	0.00025	0.00025	0.00025	16	0.029	0.038	0.039
HUMPH-08	9	0.0025	0.0025	0.0025	9	0.0020	0.0079	0.0101	9	0.00019	0.00022	0.00022	9	0.0041	0.0051	0.0052	9	0.0689	0.0762	0.0772	9	0.000050	0.000050	0.000050	9	0.00025	0.00025	0.00025	9	0.029	0.033	0.033
HUMPH-10	15	0.0025	0.0025	0.0025	15	0.0026	0.0047	0.0051	15	0.00013	0.00018	0.00019	15	0.0016	0.0033	0.0038	15	0.0879	0.1401	0.1450	15	0.000050	0.000050	0.000050	15	0.00025	0.00025	0.00025	15	0.015	0.024	0.025
AJWE-D	7	0.0025	0.0025	0.0025	11	0.0125	0.0125	0.0125	11	0.02100	0.02420	0.02470	11	0.0691	0.0811	0.0829	11	0.0100	0.0194	0.0201	11	0.002500	0.002500	0.002500	5	0.00025	0.00050	0.00050	11	0.097	0.110	0.114
AJWE-S	7	0.0025	0.0025	0.0025	11	0.0125	0.0125	0.0125	11	0.02100	0.02420	0.02470	11	0.0691	0.0811	0.0829	11	0.0100	0.0194	0.0201	11	0.002500	0.002500	0.002500	5	0.00025	0.00050	0.00050	11	0.097	0.110	0.114
AJWW-D	4	0.0025	0.0025	0.0025	7	0.0125	0.0250	0.0250	7	0.01570	0.01717	0.01720	7	0.0183	0.0208	0.0212	7	0.0100	0.0150	0.0155	7	0.002500	0.005000	0.005000	2	0.00038	0.00049	0.00050	7	0.050	0.071	0.073
AJWW-S	4	0.0025	0.0025	0.0025	8	0.0250	0.0250	0.0250	8	0.01665	0.01914	0.01980	8	0.0211	0.0259	0.0264	8	0.0100	0.0157	0.0157	8	0.005000	0.005000	0.005000	2	0.00025	0.00025	0.00025	8	0.050	0.070	0.073
NSP	21	0.0025	0.0025	0.0050	22	0.0025	0.0246	0.0250	22	0.00093	0.00244	0.00250	22	0.0120	0.0169	0.0186	22	0.0384	0.0960	0.2080	22	0.000250	0.004763	0.005000	21	0.00125	0.00125	0.10000	22	0.025	0.050	0.050
S. CATCHMENT	4	0.0025	0.0025	0.0025	4	0.0017	0.0029	0.0030	4	0.00073	0.00093	0.00095	4	0.0133	0.0149	0.0149	4	0.0099	0.0118	0.0120	4	0.000100	0.000100	0.000100	4	0.00050	0.00050	0.00050	4	0.520	0.588	0.594
WR-SEEP	15	0.0025	0.0025	0.0025	13	0.0032	0.0064	0.0071	14	0.00061	0.00152	0.00162	14	0.0026	0.0041	0.0048	14	0.0426	0.0672	0.0684	14	0.000050	0.000415	0.001000	14	0.00025	0.03533	0.10000	14	0.219	0.359	0.375

Notes

Units are mg/L, unless otherwise stated

n = Number of samples

95th P - 95th Percentile summary statistics

Med - Median (50th Percentile)

Max - Maximum

Table 6.3-3. Surface Water Quality Summary Statistics

Parameter	Cadmium - Dissolved				Calcium - Dissolved				Chromium - Dissolved				Cobalt - Dissolved				Copper - Dissolved				Iron - Dissolved				Lead - Dissolved				Lithium - Dissolved			
Statistic	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max
JC03	16	0.000005	0.000009	0.000021	29	93.2	115.8	118.0	16	0.00017	0.00058	0.00110	16	0.00019	0.00056	0.00062	24	0.00190	0.00432	0.00470	24	0.056	0.189	0.242	15	0.000025	0.000025	0.000025	16	0.00482	0.00592	0.00600
PC02	52	0.000005	0.000048	0.000201	61	111.0	147.0	149.0	45	0.00012	0.00021	0.00029	45	0.00018	0.00027	0.00028	56	0.00210	0.00315	0.00487	50	0.033	0.061	0.107	48	0.000025	0.000171	0.000250	51	0.00853	0.01060	0.01110
PC02.3	8	0.000005	0.000005	0.000005	8	73.5	83.2	83.7	8	0.00012	0.00013	0.00013	8	0.00013	0.00014	0.00014	8	0.00238	0.00304	0.00332	8	0.020	0.026	0.026	8	0.000025	0.000025	0.000025	8	0.00673	0.00819	0.00845
PC02.5	42	0.000005	0.000017	0.000033	46	81.2	101.8	123.0	42	0.00013	0.00017	0.00019	42	0.00017	0.00031	0.00037	46	0.00162	0.00303	0.00539	46	0.046	0.116	0.137	46	0.000025	0.000250	0.000250	45	0.00626	0.00754	0.00828
PC03	36	0.000005	0.000039	0.000143	54	66.1	115.0	143.0	37	0.00012	0.00024	0.00025	38	0.00015	0.00036	0.00050	43	0.00131	0.00217	0.00437	46	0.039	0.163	0.243	37	0.000025	0.000025	0.000025	43	0.00572	0.00785	0.00887
PC08	38	0.000005	0.000005	0.000005	58	65.7	73.9	76.8	39	0.00032	0.00053	0.00120	38	0.00015	0.00030	0.00052	44	0.00095	0.00132	0.00164	47	0.082	0.354	0.751	38	0.000025	0.000025	0.000025	47	0.00510	0.00607	0.00760
PC10	13	0.000005	0.000005	0.000005	13	71.2	98.9	99.2	12	0.00011	0.00014	0.00015	13	0.00014	0.00023	0.00027	13	0.00244	0.00451	0.00591	13	0.036	0.062	0.070	12	0.000025	0.000025	0.000025	13	0.00421	0.00478	0.00480
PC-EF-04	4	0.000027	0.000048	0.000049	4	110.0	130.2	132.0	4	0.00075	0.00270	0.00300	4	0.00023	0.00030	0.00030	4	0.00275	0.00363	0.00370	4	0.015	0.015	0.015	4	0.000375	0.000500	0.000500	4	0.00975	0.01264	0.01300
JACL-D	27	0.000005	0.000005	0.000005	40	56.9	60.4	61.3	27	0.00005	0.00005	0.00010	27	0.00005	0.00005	0.00005	21	0.00060	0.00159	0.00219	21	0.005	0.018	0.019	25	0.000025	0.000025	0.000025	35	0.00593	0.00720	0.00820
JACL-M	3	0.000005	0.000005	0.000005	5	54.0	56.9	57.1	3	0.00005	0.00005	0.00005	3	0.00005	0.00005	0.00005	3	0.00149	0.00262	0.00275	3	0.005	0.005	0.005	3	0.000025	0.000025	0.000025	5	0.00550	0.00613	0.00620
JACL-S	27	0.000005	0.000009	0.000034	41	53.5	58.3	59.0	27	0.00005	0.00005	0.00027	27	0.00005	0.00005	0.00005	32	0.00092	0.00155	0.00160	21	0.005	0.013	0.023	27	0.000025	0.000025	0.000025	37	0.00548	0.00664	0.00690
KC03	6	0.000005	0.000010	0.000011	6	72.0	74.4	74.4	6	0.00045	0.00051	0.00052	6	0.00005	0.00005	0.00005	6	0.00572	0.00662	0.00680	6	0.005	0.005	0.005	6	0.000025	0.000025	0.000025	6	0.01285	0.01413	0.01430
EDITH-01D	11	0.000005	0.000005	0.000005	11	41.7	44.8	45.8	11	0.00005	0.00012	0.00012	11	0.00011	0.00013	0.00014	11	0.00124	0.00321	0.00470	11	0.005	0.014	0.016	11	0.000025	0.000025	0.000025	11	0.01170	0.01250	0.01270
EDITH-01M	3	0.000005	0.000010	0.000011	3	42.1	44.6	44.9	3	0.00005	0.00010	0.00010	3	0.00011	0.00012	0.00012	3	0.00099	0.00120	0.00122	3	0.005	0.014	0.015	2	0.000025	0.000025	0.000025	3	0.01100	0.01217	0.01230
EDITH-01S	11	0.000005	0.000005	0.000005	11	39.8	41.4	42.0	11	0.00005	0.00005	0.00005	11	0.00012	0.00014	0.00014	11	0.00108	0.00132	0.00140	11	0.005	0.005	0.005	11	0.000025	0.000025	0.000025	11	0.01130	0.01270	0.01290
GOOSE LAKE	11	0.000025	0.000054	0.000058	12	6.3	8.1	9.0	12	0.00025	0.00036	0.00050	12	0.00025	0.00036	0.00050	12	0.00050	0.00118	0.00140	12	0.010	0.042	0.058	12	0.000125	0.000181	0.000250	12	0.07410	0.09320	0.09380
HUMPH-02	14	0.000005	0.000005	0.000005	16	100.3	123.8	132.0	16	0.00013	0.00027	0.00044	16	0.00005	0.00012	0.00013	16	0.00638	0.00734	0.00741	16	0.005	0.016	0.028	16	0.000025	0.000025	0.000025	16	0.00709	0.00788	0.00804
HUMPH-08	9	0.000005	0.000005	0.000005	9	64.5	67.1	67.5	9	0.00021	0.00027	0.00027	9	0.00015	0.00029	0.00029	9	0.00515	0.00573	0.00589	9	0.015	0.035	0.041	9	0.000025	0.000025	0.000025	9	0.00698	0.01056	0.01100
HUMPH-10	15	0.000005	0.000005	0.000005	15	45.2	49.0	50.5	15	0.00005	0.00013	0.00016	15	0.00062	0.00141	0.00146	15	0.00296	0.00404	0.00417	15	0.076	0.113	0.151	15	0.000025	0.000025	0.000025	15	0.00760	0.01147	0.01210
AJWE-D	10	0.000490	0.001325	0.001500	11	169.0	176.0	177.0	11	0.00250	0.00250	0.00250	11	0.00134	0.00181	0.00191	11	0.02920	0.03895	0.04140	11	0.015	0.015	0.015	11	0.001250	0.001250	0.001250	11	0.04390	0.05250	0.05300
AJWE-S	10	0.000490	0.001325	0.001500	11	169.0	176.0	177.0	11	0.00250	0.00250	0.00250	11	0.00134	0.00181	0.00191	11	0.02920	0.03895	0.04140	11	0.015	0.015	0.015	11	0.001250	0.001250	0.001250	11	0.04390	0.05250	0.05300
AJWW-D	6	0.000787	0.002125	0.002500	7	225.0	251.4	255.0	7	0.00250	0.00500	0.00500	7	0.00097	0.00150	0.00150	7	0.03100	0.03945	0.03990	7	0.015	0.015	0.015	7	0.001250	0.002500	0.002500	7	0.05000	0.05435	0.05450
AJWW-S	7	0.001000	0.002203	0.002500	8	223.5	246.2	250.0	8	0.00500	0.00500	0.00500	8	0.00150	0.00150	0.00150	8	0.03155	0.03458	0.03500	8	0.015	0.015	0.015	8	0.002500	0.002500	0.002500	8	0.04825	0.05834	0.06100
NSP	22	0.000025	0.000082	0.000360	22	27.5	35.3	54.1	22	0.00025	0.00476	0.00500	22	0.00025	0.00144	0.00150	22	0.00100	0.00489	0.00500	22	0.012	0.025	0.031	22	0.000125	0.002381	0.002500	22	0.00310	0.02405	0.02500
S. CATCHMENT	4	0.000013	0.000024	0.000025	4	11.6	15.2	15.8	4	0.00010	0.00010	0.00010	4	0.00010	0.00010	0.00010	4	0.00036	0.00093	0.00100	4	0.017	0.021	0.021	4	0.000050	0.000050	0.000050	4	0.00930	0.00967	0.00970
WR-SEEP	14	0.000025	0.000436	0.000550	14	141.0	304.4	331.0	14	0.00005	0.00068	0.00100	14	0.00013	0.00047	0.00051	14	0.01360	0.03491	0.06370	13	0.023	0.086	0.162	14	0.000025	0.000208	0.000500	14	0.02675	0.09212	0.09550

Notes

Units are mg/L, unless otherwise stated

n = Number of samples

95th P - 95th Percentile summary statistics

Med - Median (50th Percentile)

Max - Maximum

Table 6.3-3. Surface Water Quality Summary Statistics

Parameter	Magnesium - Dissolved				Manganese - Dissolved				Mercury - Dissolved				Molybdenum - Dissolved				Nickel - Dissolved				Phosphorus - Dissolved				Potassium - Dissolved				Selenium - Dissolved			
Statistic	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max
JC03	29	33.4	51.1	52.9	29	0.0361	0.1458	0.2350	27	0.0000050	0.0000050	0.0000050	24	0.0021	0.0038	0.0038	20	0.0014	0.0025	0.0026	26	0.150	0.150	0.153	29	8.7	14.0	14.4	16	0.00029	0.00062	0.00100
PC02	61	105.0	133.0	163.0	61	0.0836	0.1950	0.2510	57	0.0000050	0.0000050	0.0000050	61	0.0105	0.0147	0.0152	60	0.0030	0.0044	0.0058	58	0.150	0.182	0.528	61	19.4	23.4	26.6	50	0.00043	0.00235	0.00290
PC02.3	8	64.9	75.0	77.2	8	0.0102	0.0320	0.0335	8	0.0000050	0.0000050	0.0000050	8	0.0135	0.0189	0.0192	8	0.0021	0.0024	0.0025	8	0.108	0.123	0.126	8	15.7	18.3	18.7	8	0.00021	0.00036	0.00038
PC02.5	46	73.7	94.8	113.0	46	0.1250	0.5678	0.8260	45	0.0000050	0.0000050	0.0000050	46	0.0091	0.0303	0.0468	46	0.0021	0.0025	0.0030	46	0.150	0.184	0.830	46	15.7	20.0	20.9	42	0.00020	0.00037	0.00054
PC03	54	62.5	123.1	150.0	54	0.0788	1.2290	1.9800	49	0.0000050	0.0000050	0.0000050	54	0.0124	0.0728	0.1030	48	0.0015	0.0021	0.0025	48	0.150	0.285	0.600	54	14.7	20.4	27.5	37	0.00022	0.00072	0.00106
PC08	58	42.0	47.6	48.9	58	0.1135	0.2330	0.2840	52	0.0000050	0.0000050	0.0000050	58	0.0024	0.0032	0.0036	50	0.0017	0.0024	0.0025	49	0.025	0.150	0.150	58	10.9	12.0	13.6	38	0.00013	0.00017	0.00017
PC10	13	32.2	44.6	45.1	13	0.0230	0.0462	0.0550	12	0.0000050	0.0000050	0.0000050	13	0.0026	0.0032	0.0036	13	0.0012	0.0018	0.0022	13	0.099	0.251	0.364	13	9.2	13.3	16.8	13	0.00028	0.00082	0.00142
PC-EF-04	4	113.5	130.6	131.0	4	0.0184	0.0372	0.0394	4	0.0000050	0.0000050	0.0000050	4	0.0138	0.0178	0.0183	4	0.0031	0.0034	0.0034	2	0.150	0.150	0.150	4	21.7	22.7	22.8	4	0.00159	0.00245	0.00250
JACL-D	40	42.4	46.7	49.2	40	0.0501	0.1233	0.1680	34	0.0000050	0.0000050	0.0000050	38	0.0021	0.0028	0.0033	27	0.0007	0.0009	0.0011	32	0.150	0.335	0.364	40	12.3	13.5	14.7	29	0.00015	0.00280	0.01070
JACL-M	5	37.8	42.6	42.7	5	0.0019	0.0038	0.0039	5	0.0000050	0.0000050	0.0000050	5	0.0024	0.0030	0.0032	3	0.0006	0.0006	0.0006	5	0.025	0.150	0.150	5	11.2	12.5	12.5	3	0.00012	0.00014	0.00014
JACL-S	41	36.5	44.3	46.7	41	0.0030	0.0200	0.0273	35	0.0000050	0.0000050	0.0000050	40	0.0024	0.0030	0.0035	28	0.0007	0.0011	0.0015	33	0.111	0.150	0.150	41	11.2	13.2	13.5	28	0.00014	0.00018	0.00110
KC03	6	125.5	132.8	134.0	6	0.0002	0.0005	0.0006	6	0.0000050	0.0000050	0.0000050	6	0.0134	0.0138	0.0138	6	0.0015	0.0017	0.0017	6	0.126	0.179	0.188	6	21.9	22.9	22.9	6	0.00615	0.00817	0.00833
EDITH-01D	11	72.1	74.6	74.6	11	0.0375	0.2135	0.2540	11	0.0000050	0.0000050	0.0000050	11	0.0018	0.0022	0.0025	11	0.0007	0.0009	0.0009	11	0.025	0.425	0.474	11	18.1	20.9	21.3	10	0.00011	0.00044	0.00052
EDITH-01M	3	72.0	73.3	73.4	3	0.2040	0.2139	0.2150	3	0.0000050	0.0000050	0.0000050	3	0.0014	0.0023	0.0024	3	0.0006	0.0007	0.0007	3	0.025	0.311	0.343	3	19.4	19.4	19.4	3	0.00005	0.00017	0.00018
EDITH-01S	11	70.9	73.4	74.5	11	0.0024	0.0071	0.0094	11	0.0000050	0.0000050	0.0000050	11	0.0020	0.0021	0.0022	11	0.0007	0.0007	0.0007	11	0.025	0.025	0.025	11	17.8	20.1	20.9	11	0.00005	0.00012	0.00013
GOOSE LAKE	12	248.0	286.3	294.0	12	0.0011	0.0020	0.0025	12	0.0000050	0.0000050	0.0000050	12	0.0044	0.0051	0.0051	12	0.0013	0.0018	0.0025	12	0.050	0.124	0.140	12	195.5	277.1	287.0	12	0.00025	0.00036	0.00050
HUMPH-02	16	95.7	119.3	126.0	16	0.0100	0.0243	0.0248	16	0.0000050	0.0000050	0.0000050	16	0.0219	0.0246	0.0248	16	0.0013	0.0016	0.0017	16	0.098	0.140	0.145	16	14.5	17.3	18.0	16	0.00211	0.00533	0.00618
HUMPH-08	9	69.6	71.8	72.2	9	0.0308	0.0507	0.0556	9	0.0000050	0.0000050	0.0000050	9	0.0126	0.0156	0.0156	9	0.0017	0.0022	0.0022	9	0.161	0.205	0.221	9	18.1	19.9	20.5	9	0.00085	0.00131	0.00132
HUMPH-10	15	72.3	77.8	78.6	15	0.2620	0.6744	0.6940	15	0.0000050	0.0000136	0.0000150	15	0.0044	0.0077	0.0085	15	0.0046	0.0071	0.0074	15	0.066	0.249	0.504	15	17.1	21.0	21.8	15	0.00013	0.00019	0.00021
AJWE-D	11	212.0	225.5	229.0	11	0.0011	0.0020	0.0020	10	0.0000100	0.0000100	0.0000100	11	2.2000	2.5100	2.6700	11	0.0025	0.0040	0.0042	5	0.025	0.150	0.150	11	20.0	21.8	21.9	11	0.01750	0.02000	0.02050
AJWE-S	11	212.0	225.5	229.0	11	0.0011	0.0020	0.0020	10	0.0000100	0.0000100	0.0000100	11	2.2000	2.5100	2.6700	11	0.0025	0.0040	0.0042	5	0.025	0.150	0.150	11	20.0	21.8	21.9	11	0.01750	0.02000	0.02050
AJWW-D	7	292.0	308.9	314.0	7	0.0234	0.0322	0.0341	7	0.0000100	0.0000100	0.0000100	7	3.3700	4.6210	4.8400	7	0.0140	0.0150	0.0150	2	0.025	0.025	0.025	7	25.4	31.5	31.9	7	0.03210	0.05109	0.05220
AJWW-S	8	285.5	305.8	310.0	8	0.0074	0.0101	0.0111	8	0.0000100	0.0000100	0.0000100	8	3.4450	4.4165	4.5600	8	0.0125	0.0159	0.0170	2	0.025	0.025	0.025	8	26.1	30.6	31.2	8	0.03150	0.04980	0.05050
NSP	22	591.0	821.6	858.0	22	0.0660	0.1368	0.1650	22	0.0000050	0.0000050	0.0000050	22	0.0178	0.0239	0.0250	22	0.0013	0.0048	0.0050	21	0.452	0.790	0.840	22	108.0	142.7	147.0	20	0.00100	0.00186	0.00190
S. CATCHMENT	4	417.5	441.0	445.0	4	0.0110	0.0146	0.0150	4	0.0000050	0.0000050	0.0000050	4	0.0595	0.0750	0.0777	4	0.0013	0.0014	0.0014	4	0.025	0.049	0.053	4	76.7	80.8	81.2	4	0.00073	0.00086	0.00087
WR-SEEP	14	167.5	359.6	383.0	14	0.0159	0.4082	0.9230	14	0.0000050	0.0000050	0.0000050	14	0.1530	1.5880	2.0300	14	0.0024	0.0062	0.0070	14	0.025	0.839	2.120	14	45.3	75.1	86.3	14	0.00214	0.03102	0.03810

Notes

Units are mg/L, unless otherwise stated

n = Number of samples

95th P - 95th Percentile summary statistics

Med - Median (50th Percentile)

Max - Maximum

Table 6.3-3. Surface Water Quality Summary Statistics

Parameter	Silicon - Dissolved				Silver - Dissolved				Sodium - Dissolved				Strontium - Dissolved				Thallium - Dissolved				Tin - Dissolved				Titanium - Dissolved				Uranium - Dissolved			
Statistic	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max
JC03	26	8.8	11.6	12.1	15	0.000005	0.000005	0.000005	29	33.6	43.3	43.9	26	0.4	0.5	0.5	15	0.000005	0.000005	0.000005	15	0.000050	0.000050	0.000050	29	0.0050	0.0050	0.0130	29	0.0014	0.0048	0.0075
PC02	58	8.3	10.4	10.8	45	0.000005	0.000005	0.000005	61	92.6	117.0	154.0	58	1.0	1.3	1.5	44	0.000005	0.000005	0.000025	45	0.000050	0.000050	0.000050	61	0.0050	0.0100	0.0130	61	0.0025	0.0035	0.0044
PC02.3	8	8.1	10.4	10.8	8	0.000005	0.000005	0.000005	8	51.9	56.1	56.8	8	0.6	0.7	0.7	8	0.000005	0.000005	0.000005	8	0.000050	0.000050	0.000050	8	0.0050	0.0050	0.0050	8	0.0012	0.0016	0.0018
PC02.5	46	7.7	13.7	14.5	42	0.000005	0.000005	0.000005	46	55.5	75.2	81.2	46	0.7	0.9	1.0	41	0.000005	0.000005	0.000005	42	0.000050	0.000050	0.000050	46	0.0050	0.0050	0.0120	46	0.0011	0.0031	0.0035
PC03	48	5.6	12.8	13.6	37	0.000005	0.000005	0.000005	54	50.6	77.3	100.0	48	0.6	1.0	1.2	37	0.000005	0.000005	0.000005	37	0.000050	0.000050	0.000050	54	0.0050	0.0050	0.0050	54	0.0012	0.0046	0.0056
PC08	49	8.1	10.1	10.5	38	0.000005	0.000005	0.000005	58	36.0	43.5	46.4	49	0.4	0.5	0.5	38	0.000005	0.000005	0.000005	38	0.000050	0.000050	0.000050	58	0.0050	0.0050	0.0110	58	0.0006	0.0012	0.0014
PC10	13	9.5	10.6	11.0	13	0.000005	0.000005	0.000005	13	29.8	37.2	38.2	13	0.4	0.5	0.5	13	0.000005	0.000005	0.000005	13	0.000050	0.000050	0.000050	13	0.0050	0.0050	0.0050	13	0.0009	0.0020	0.0020
PC-EF-04	2	8.6	8.7	8.7	4	0.000015	0.000020	0.000020	4	98.6	111.9	112.0	2	1.1	1.3	1.4	4	0.000150	0.000200	0.000200	4	0.000375	0.000500	0.000500	4	0.0050	0.0050	0.0050	4	0.0030	0.0038	0.0039
JACL-D	32	4.5	6.8	7.2	27	0.000005	0.000005	0.000005	40	38.9	43.5	47.0	32	0.4	0.4	0.4	27	0.000005	0.000005	0.000005	27	0.000050	0.000050	0.000050	40	0.0050	0.0050	0.0050	40	0.0011	0.0012	0.0013
JACL-M	5	5.4	6.1	6.3	3	0.000005	0.000005	0.000005	5	35.3	40.7	40.7	5	0.4	0.4	0.4	3	0.000005	0.000005	0.000005	3	0.000050	0.000050	0.000050	5	0.0050	0.0050	0.0050	5	0.0011	0.0012	0.0012
JACL-S	33	3.9	6.5	6.8	27	0.000005	0.000005	0.000005	41	34.8	41.0	44.2	33	0.4	0.4	0.4	27	0.000005	0.000005	0.000005	27	0.000050	0.000050	0.000050	41	0.0050	0.0050	0.0050	41	0.0011	0.0013	0.0014
KC03	6	9.6	9.8	9.8	6	0.000005	0.000005	0.000005	6	98.6	100.5	101.0	6	1.2	1.3	1.3	6	0.000005	0.000005	0.000005	6	0.000050	0.000050	0.000050	6	0.0050	0.0050	0.0050	6	0.0053	0.0058	0.0058
EDITH-01D	11	1.1	3.7	3.8	11	0.000005	0.000005	0.000005	11	55.6	58.5	59.5	11	0.3	0.3	0.3	11	0.000005	0.000005	0.000005	11	0.000050	0.000050	0.000050	11	0.0050	0.0050	0.0050	11	0.0016	0.0017	0.0017
EDITH-01M	3	2.0	3.3	3.4	3	0.000005	0.000005	0.000005	3	56.3	58.8	59.1	3	0.3	0.3	0.3	3	0.000005	0.000005	0.000005	3	0.000050	0.000050	0.000050	3	0.0050	0.0050	0.0050	3	0.0015	0.0017	0.0017
EDITH-01S	11	0.3	1.0	1.0	11	0.000005	0.000005	0.000005	11	54.5	60.3	60.8	11	0.3	0.3	0.3	11	0.000005	0.000005	0.000005	11	0.000050	0.000050	0.000050	11	0.0050	0.0050	0.0050	11	0.0016	0.0018	0.0018
GOOSE LAKE	12	0.7	4.0	4.2	12	0.000025	0.000036	0.000050	12	1000.5	1401.5	1440.0	12	0.5	0.6	0.6	12	0.000025	0.000036	0.000050	12	0.000250	0.000363	0.000500	12	0.0250	0.0363	0.0500	12	0.0044	0.0053	0.0053
HUMPH-02	16	8.7	10.3	10.4	16	0.000005	0.000005	0.000005	16	62.5	66.3	68.5	16	0.9	1.1	1.2	16	0.000005	0.000005	0.000005	16	0.000050	0.000050	0.000050	16	0.0050	0.0050	0.0050	16	0.0036	0.0046	0.0047
HUMPH-08	9	8.3	9.1	9.2	9	0.000005	0.000005	0.000005	9	52.9	57.9	58.3	9	0.5	0.6	0.6	9	0.000005	0.000005	0.000005	9	0.000050	0.000050	0.000050	9	0.0050	0.0050	0.0050	9	0.0032	0.0035	0.0035
HUMPH-10	15	4.2	6.6	6.8	15	0.000005	0.000005	0.000005	15	57.4	60.9	61.4	15	0.4	0.4	0.5	15	0.000005	0.000005	0.000005	15	0.000050	0.000050	0.000050	15	0.0050	0.0050	0.0050	15	0.0018	0.0022	0.0022
AJWE-D	5	8.7	9.0	9.0	11	0.000050	0.000050	0.000050	11	208.0	226.5	235.0	5	2.9	3.3	3.3	11	0.000500	0.000500	0.000500	11	0.001250	0.001250	0.001250	11	0.0050	0.0080	0.0110	11	0.0099	0.0108	0.0109
AJWE-S	5	8.7	9.0	9.0	11	0.000050	0.000050	0.000050	11	208.0	226.5	235.0	5	2.9	3.3	3.3	11	0.000500	0.000500	0.000500	11	0.001250	0.001250	0.001250	11	0.0050	0.0080	0.0110	11	0.0099	0.0108	0.0109
AJWW-D	2	7.3	7.3	7.3	7	0.000050	0.000100	0.000100	7	198.0	211.3	214.0	2	4.1	4.4	4.5	7	0.000500	0.001000	0.001000	7	0.001250	0.002500	0.002500	7	0.0050	0.0114	0.0120	7	0.0109	0.0111	0.0111
AJWW-S	2	7.1	7.2	7.2	8	0.000100	0.000100	0.000100	8	199.0	209.3	211.0	2	4.1	4.3	4.4	8	0.001000	0.001000	0.001000	8	0.002500	0.002500	0.002500	8	0.0050	0.0050	0.0050	8	0.0108	0.0117	0.0118
NSP	21	4.5	7.3	7.5	22	0.000025	0.000096	0.000100	22	621.5	841.4	876.0	21	3.5	4.9	5.1	22	0.000025	0.000951	0.001000	22	0.000250	0.002388	0.002500	22	0.0100	0.0250	0.0250	22	0.0055	0.0067	0.0068
S. CATCHMENT	4	4.6	5.7	5.9	4	0.000010	0.000010	0.000010	4	274.5	296.3	300.0	4	0.1	0.2	0.3	4	0.000010	0.000010	0.000010	4	0.000100	0.000100	0.000100	4	0.0100	0.0100	0.0100	4	0.0034	0.0042	0.0044
WR-SEEP	14	3.6	8.7	12.3	14	0.000005	0.000014	0.000020	14	126.0	282.0	293.0	14	2.4	5.9	6.6	14	0.000005	0.000090	0.000200	14	0.000050	0.000240	0.000500	14	0.0050	0.0100	0.0100	14	0.0059	0.0162	0.0237

Notes

Units are mg/L, unless otherwise stated

n = Number of samples

95th P - 95th Percentile summary statistics

Med - Median (50th Percentile)

Max - Maximum

Table 6.3-3. Surface Water Quality Summary Statistics

Parameter	Vanadium - Dissolved				Zinc - Dissolved				Aluminum - Total				Antimony - Total				Arsenic - Total				Barium - Total				Beryllium - Total				Bismuth - Total			
Statistic	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max
JC03	28	0.0024	0.0037	0.0044	14	0.0027	0.0166	0.0312	29	0.3690	2.0060	2.2200	29	0.00021	0.00050	0.00050	29	0.0013	0.0020	0.0024	29	0.0860	0.1174	0.1240	29	0.000050	0.001000	0.001000	26	0.00025	0.10000	0.10000
PC02	58	0.0029	0.0039	0.0047	39	0.0012	0.0037	0.0050	61	0.0810	1.3600	3.4500	61	0.00013	0.00050	0.00125	61	0.0019	0.0031	0.0040	61	0.0550	0.0750	0.1060	61	0.000050	0.001000	0.002500	58	0.00025	0.10000	0.10000
PC02.3	8	0.0027	0.0030	0.0030	8	0.0005	0.0010	0.0013	8	0.1620	0.3213	0.3290	8	0.00013	0.00016	0.00017	8	0.0022	0.0023	0.0023	8	0.0533	0.0598	0.0615	8	0.000050	0.000050	0.000050	8	0.00025	0.00025	0.00025
PC02.5	46	0.0024	0.0034	0.0038	35	0.0014	0.0066	0.0095	46	0.0901	0.4915	0.5120	46	0.00012	0.00025	0.00025	46	0.0016	0.0025	0.0030	46	0.0614	0.0762	0.0816	46	0.000050	0.000500	0.000500	46	0.00025	0.10000	0.10000
PC03	50	0.0026	0.0052	0.0067	33	0.0012	0.0057	0.0083	54	0.0349	0.1778	0.5150	54	0.00014	0.00050	0.00125	54	0.0014	0.0021	0.0031	54	0.0620	0.1122	0.1430	54	0.000050	0.001000	0.002500	48	0.00025	0.10000	0.10000
PC08	54	0.0014	0.0028	0.0030	34	0.0005	0.0053	0.0098	58	0.0903	0.5659	1.2800	58	0.00011	0.00025	0.00050	58	0.0013	0.0019	0.0020	58	0.0577	0.0893	0.1030	58	0.000050	0.000500	0.001000	49	0.00025	0.10000	0.10000
PC10	13	0.0029	0.0036	0.0039	13	0.0005	0.0020	0.0021	13	0.1290	0.5190	0.6990	13	0.00005	0.00014	0.00015	13	0.0017	0.0019	0.0020	13	0.0654	0.0805	0.0806	13	0.000050	0.000050	0.000050	13	0.00025	0.00025	0.00025
PC-EF-04	4	0.0040	0.0045	0.0046	4	0.0031	0.0049	0.0051	4	0.1032	0.7962	0.9030	4	0.00038	0.00050	0.00050	4	0.0025	0.0033	0.0034	4	0.0640	0.0682	0.0682	4	0.000750	0.001000	0.001000	2	0.05013	0.09501	0.10000
JACL-D	35	0.0018	0.0023	0.0026	22	0.0013	0.0039	0.0043	40	0.0050	0.0179	0.0841	40	0.00012	0.00050	0.00050	40	0.0013	0.0014	0.0016	40	0.0675	0.0749	0.0770	40	0.000050	0.001000	0.001000	32	0.00025	0.10000	0.10000
JACL-M	5	0.0023	0.0027	0.0028	3	0.0005	0.0037	0.0040	5	0.0083	0.0096	0.0099	5	0.00010	0.00025	0.00025	5	0.0013	0.0013	0.0013	5	0.0610	0.0620	0.0620	5	0.000050	0.000500	0.000500	5	0.00025	0.10000	0.10000
JACL-S	38	0.0023	0.0028	0.0029	26	0.0012	0.0152	0.0497	41	0.0068	0.0709	0.1910	41	0.00012	0.00025	0.00050	41	0.0013	0.0015	0.0018	41	0.0560	0.0672	0.0702	41	0.000050	0.000500	0.001000	33	0.00025	0.10000	0.10000
KC03	6	0.0072	0.0075	0.0075	6	0.0005	0.0010	0.0011	6	0.0046	0.0285	0.0356	6	0.00020	0.00021	0.00021	6	0.0052	0.0060	0.0061	6	0.0726	0.0769	0.0772	6	0.000050	0.000050	0.000050	6	0.00025	0.00025	0.00025
EDITH-01D	11	0.0021	0.0032	0.0032	11	0.0005	0.0018	0.0022	11	0.0092	0.0194	0.0218	11	0.00013	0.00016	0.00017	11	0.0015	0.0017	0.0019	11	0.0539	0.0627	0.0635	11	0.000050	0.000050	0.000050	11	0.00025	0.00025	0.00025
EDITH-01M	3	0.0021	0.0028	0.0029	3	0.0005	0.0029	0.0032	3	0.0136	0.0162	0.0165	3	0.00012	0.00013	0.00013	3	0.0016	0.0016	0.0017	3	0.0583	0.0637	0.0643	3	0.000050	0.000050	0.000050	3	0.00025	0.00025	0.00025
EDITH-01S	11	0.0028	0.0033	0.0033	11	0.0005	0.0026	0.0034	11	0.0141	0.0228	0.0232	11	0.00014	0.00017	0.00017	11	0.0016	0.0017	0.0017	11	0.0467	0.0513	0.0520	11	0.000050	0.000050	0.000050	11	0.00025	0.00025	0.00025
GOOSE LAKE	12	0.0025	0.0054	0.0058	12	0.0025	0.0052	0.0055	12	0.0155	0.2401	0.4650	12	0.00223	0.00307	0.00323	12	0.0199	0.0301	0.0309	12	0.0176	0.0213	0.0247	12	0.000250	0.000363	0.000500	12	0.00125	0.00181	0.00250
HUMPH-02	16	0.0051	0.0057	0.0059	16	0.0005	0.0013	0.0018	16	0.1810	0.3488	0.3600	16	0.00021	0.00027	0.00028	16	0.0033	0.0034	0.0034	16	0.0633	0.0714	0.0717	16	0.000050	0.000050	0.000050	16	0.00025	0.00025	0.00025
HUMPH-08	9	0.0076	0.0101	0.0103	9	0.0005	0.0024	0.0028	9	0.6040	2.6000	3.4200	9	0.00023	0.00024	0.00024	9	0.0041	0.0051	0.0052	9	0.0781	0.0927	0.0992	9	0.000050	0.000050	0.000050	9	0.00025	0.00025	0.00025
HUMPH-10	15	0.0026	0.0048	0.0055	15	0.0005	0.0019	0.0022	15	0.1210	0.5423	0.7110	15	0.00013	0.00021	0.00021	15	0.0017	0.0036	0.0038	15	0.0918	0.1469	0.1490	15	0.000050	0.000050	0.000050	15	0.00025	0.00025	0.00025
AJWE-D	11	0.0080	0.0150	0.0150	11	0.0025	0.0125	0.0125	11	0.0125	0.0412	0.0699	11	0.02100	0.02375	0.02410	11	0.0693	0.0785	0.0811	11	0.0100	0.0198	0.0205	11	0.002500	0.002500	0.002500	5	0.00025	0.00050	0.00050
AJWE-S	11	0.0080	0.0150	0.0150	11	0.0025	0.0125	0.0125	11	0.0125	0.0412	0.0699	11	0.02100	0.02375	0.02410	11	0.0693	0.0785	0.0811	11	0.0100	0.0198	0.0205	11	0.002500	0.002500	0.002500	5	0.00025	0.00050	0.00050
AJWW-D	7	0.0050	0.0150	0.0150	7	0.0025	0.0213	0.0250	7	0.0125	0.0250	0.0250	7	0.01560	0.01735	0.01750	7	0.0186	0.0207	0.0211	7	0.0100	0.0143	0.0146	7	0.002500	0.005000	0.005000	2	0.00038	0.00049	0.00050
AJWW-S	8	0.0052	0.0150	0.0150	8	0.0031	0.0250	0.0250	8	0.0250	0.0250	0.0250	8	0.01635	0.01905	0.01940	8	0.0214	0.0251	0.0258	8	0.0100	0.0160	0.0163	8	0.005000	0.005000	0.005000	2	0.00025	0.00025	0.00025
NSP	22	0.0025	0.0049	0.0050	22	0.0025	0.0073	0.0075	22	0.0363	0.1321	0.2180	22	0.00108	0.00245	0.00250	22	0.0121	0.0175	0.0181	22	0.0386	0.0867	0.1840	22	0.000250	0.004763	0.005000	21	0.00125	0.00125	0.10000
S. CATCHMENT	4	0.0045	0.0050	0.0050	4	0.0010	0.0027	0.0030	4	0.2144	1.0809	1.2100	4	0.00081	0.00098	0.00101	4	0.0143	0.0247	0.0264	4	0.0131	0.0412	0.0460	4	0.000100	0.000100	0.000100	4	0.00050	0.00050	0.00050
WR-SEEP	14	0.0012	0.0044	0.0056	14	0.0013	0.0073	0.0144	15	0.0465	0.3289	0.4710	15	0.00061	0.00145	0.00146	15	0.0025	0.0058	0.0081	15	0.0413	0.0690	0.0700	15	0.000050	0.000370	0.001000	15	0.00025	0.03035	0.10000

Notes

Units are mg/L, unless otherwise stated

n = Number of samples

95th P - 95th Percentile summary statistics

Med - Median (50th Percentile)

Max - Maximum

Table 6.3-3. Surface Water Quality Summary Statistics

Parameter	Boron - Total				Cadmium - Total				Calcium - Total				Chromium - Total				Cobalt - Total				Copper - Total				Iron - Total				Lead - Total			
Statistic	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max
JC03	29	0.019	0.050	0.050	29	0.000009	0.000028	0.000075	29	93.6	115.4	121.0	29	0.00120	0.00524	0.00571	29	0.00056	0.00169	0.00176	29	0.00500	0.01406	0.01510	29	0.621	3.010	3.270	29	0.000250	0.000500	0.000500
PC02	61	0.051	0.095	0.105	61	0.000012	0.000059	0.000183	61	110.0	144.0	150.0	61	0.00083	0.00367	0.01100	61	0.00030	0.00137	0.00335	61	0.00328	0.00992	0.02040	61	0.184	1.870	4.880	61	0.000087	0.000611	0.001280
PC02.3	8	0.036	0.045	0.047	8	0.000005	0.000010	0.000012	8	71.8	81.7	82.7	8	0.00048	0.00077	0.00080	8	0.00027	0.00038	0.00040	8	0.00389	0.00546	0.00585	8	0.249	0.451	0.477	8	0.000055	0.000100	0.000102
PC02.5	46	0.034	0.050	0.050	45	0.000005	0.000014	0.000026	46	81.0	100.5	117.0	46	0.00039	0.00121	0.00140	46	0.00024	0.00062	0.00073	46	0.00270	0.00470	0.01060	46	0.190	0.769	0.858	46	0.000025	0.000250	0.000250
PC03	54	0.044	0.051	0.053	54	0.000009	0.000041	0.000137	54	64.5	116.1	146.0	54	0.00041	0.00100	0.00250	54	0.00017	0.00058	0.00075	54	0.00204	0.00355	0.00870	54	0.106	0.369	0.797	54	0.000025	0.000500	0.001250
PC08	58	0.030	0.050	0.050	58	0.000005	0.000020	0.000035	58	65.2	73.1	75.2	58	0.00050	0.00168	0.00310	58	0.00020	0.00074	0.00115	58	0.00192	0.00549	0.00930	58	0.924	2.458	3.380	58	0.000056	0.000250	0.000500
PC10	13	0.015	0.020	0.022	13	0.000005	0.000007	0.000011	13	68.0	95.7	95.9	13	0.00049	0.00145	0.00186	13	0.00025	0.00057	0.00077	13	0.00404	0.00721	0.00765	13	0.226	0.850	1.140	13	0.000025	0.000310	0.000543
PC-EF-04	4	0.050	0.071	0.075	4	0.000032	0.000054	0.000056	4	111.2	130.7	132.0	4	0.00100	0.00296	0.00330	4	0.00030	0.00090	0.00100	4	0.00335	0.00694	0.00740	4	0.154	1.163	1.320	4	0.000375	0.000500	0.000500
JACL-D	40	0.026	0.050	0.050	40	0.000005	0.000017	0.000017	40	56.2	60.9	62.1	40	0.00020	0.00100	0.00150	40	0.00005	0.00030	0.00030	40	0.00073	0.00247	0.00589	40	0.015	0.039	0.144	40	0.000043	0.000504	0.000588
JACL-M	5	0.027	0.050	0.050	5	0.000005	0.000016	0.000018	5	54.1	56.9	57.5	5	0.00018	0.00050	0.00050	5	0.00005	0.00015	0.00015	5	0.00119	0.00195	0.00213	5	0.015	0.016	0.016	5	0.000025	0.000250	0.000250
JACL-S	41	0.026	0.050	0.050	41	0.000005	0.000019	0.000043	41	52.7	57.8	59.3	41	0.00017	0.00072	0.00100	41	0.00005	0.00019	0.00030	41	0.00110	0.00226	0.00374	41	0.015	0.075	0.244	41	0.000025	0.000250	0.000500
KC03	6	0.107	0.127	0.129	6	0.000005	0.000005	0.000005	6	70.2	72.3	72.8	6	0.00053	0.00060	0.00060	6	0.00005	0.00021	0.00026	6	0.00579	0.00718	0.00740	6	0.008	0.037	0.045	6	0.000025	0.000105	0.000120
EDITH-01D	11	0.018	0.023	0.024	11	0.000005	0.000005	0.000005	11	41.1	44.5	46.8	11	0.00014	0.00025	0.00031	11	0.00013	0.00016	0.00017	11	0.00242	0.00572	0.00672	11	0.019	0.049	0.053	11	0.000025	0.000182	0.000206
EDITH-01M	3	0.022	0.024	0.024	3	0.000005	0.000005	0.000005	3	42.1	42.6	42.6	3	0.00015	0.00016	0.00016	3	0.00014	0.00014	0.00014	3	0.00155	0.00171	0.00173	3	0.024	0.044	0.046	3	0.000025	0.000025	0.000025
EDITH-01S	11	0.018	0.021	0.022	11	0.000005	0.000005	0.000005	11	38.5	40.3	40.7	11	0.00011	0.00017	0.00018	11	0.00014	0.00017	0.00017	11	0.00128	0.00245	0.00277	11	0.020	0.040	0.049	11	0.000025	0.000051	0.000077
GOOSE LAKE	12	0.267	0.348	0.356	11	0.000025	0.000038	0.000050	12	6.9	9.0	9.8	12	0.00025	0.00102	0.00165	12	0.00025	0.00054	0.00059	12	0.00125	0.00273	0.00300	12	0.033	0.425	0.814	12	0.000125	0.000181	0.000250
HUMPH-02	16	0.032	0.042	0.043	16	0.000010	0.000018	0.000025	16	100.8	119.3	129.0	16	0.00053	0.00088	0.00093	16	0.00028	0.00048	0.00049	16	0.00989	0.01430	0.01430	16	0.284	0.531	0.571	16	0.000068	0.000131	0.000132
HUMPH-08	9	0.031	0.037	0.037	9	0.000013	0.000024	0.000028	9	60.8	65.4	67.2	9	0.00171	0.00587	0.00744	9	0.00068	0.00197	0.00253	9	0.01240	0.02538	0.02950	9	0.811	3.084	3.880	9	0.000150	0.000493	0.000626
HUMPH-10	15	0.015	0.027	0.030	15	0.000005	0.000018	0.000018	15	43.5	47.6	47.7	15	0.00031	0.00099	0.00125	15	0.00073	0.00190	0.00204	15	0.00611	0.01040	0.01330	15	0.266	0.915	1.100	15	0.000053	0.000162	0.000215
AJWE-D	11	0.050	0.128	0.130	10	0.000497	0.001320	0.001500	11	169.0	179.0	182.0	11	0.00250	0.00250	0.00250	11	0.00137	0.00184	0.00198	11	0.03110	0.03895	0.04070	11	0.015	0.051	0.087	11	0.001250	0.001975	0.002700
AJWE-S	11	0.050	0.128	0.130	10	0.000497	0.001320	0.001500	11	169.0	179.0	182.0	11	0.00250	0.00250	0.00250	11	0.00137	0.00184	0.00198	11	0.03110	0.03895	0.04070	11	0.015	0.051	0.087	11	0.001250	0.001975	0.002700
AJWW-D	7	0.050	0.077	0.080	6	0.000729	0.002125	0.002500	7	222.0	242.6	245.0	7	0.00250	0.00500	0.00500	7	0.00094	0.00150	0.00150	7	0.03200	0.04302	0.04380	7	0.015	0.015	0.015	7	0.001250	0.002500	0.002500
AJWW-S	8	0.050	0.078	0.082	7	0.001000	0.002089	0.002500	8	223.0	243.6	245.0	8	0.00500	0.00500	0.00500	8	0.00150	0.00150	0.00150	8	0.03100	0.03593	0.03600	8	0.015	0.015	0.015	8	0.002500	0.002500	0.002500
NSP	22	0.025	0.055	0.057	22	0.000025	0.000082	0.000300	22	28.1	37.8	55.3	22	0.00025	0.00476	0.00500	22	0.00025	0.00144	0.00150	22	0.00125	0.00493	0.00500	22	0.045	0.103	0.212	22	0.000125	0.002381	0.002500
S. CATCHMENT	4	0.531	0.594	0.600	4	0.000013	0.000024	0.000025	4	13.8	21.7	22.8	4	0.00053	0.00228	0.00255	4	0.00018	0.00078	0.00087	4	0.00140	0.00473	0.00530	4	0.208	1.170	1.320	4	0.000050	0.000339	0.000390
WR-SEEP	15	0.229	0.379	0.403	15	0.000050	0.000443	0.000600	15	132.0	294.3	302.0	15	0.00036	0.00118	0.00155	15	0.00023	0.00061	0.00073	15	0.01640	0.03693	0.05030	15	0.100	0.527	0.666	15	0.000025	0.000225	0.000500

Notes

Units are mg/L, unless otherwise stated

n = Number of samples

95th P - 95th Percentile summary statistics

Med - Median (50th Percentile)

Max - Maximum

Table 6.3-3. Surface Water Quality Summary Statistics

Parameter	Lithium - Total				Magnesium - Total				Manganese - Total				Mercury - Total				Molybdenum - Total				Nickel - Total				Phosphorus - Total				Potassium - Total			
Statistic	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max
JC03	29	0.00500	0.00598	0.00620	29	32.8	50.5	53.1	29	0.0886	0.1934	0.2400	29	0.0000050	0.0000080	0.0000100	29	0.0020	0.0040	0.0043	29	0.0026	0.0053	0.0059	26	0.150	0.162	0.223	29	8.8	13.9	14.8
PC02	61	0.00815	0.01070	0.01250	61	105.0	137.0	160.0	61	0.1090	0.2800	0.6200	60	0.0000050	0.0000100	0.0000250	61	0.0111	0.0148	0.0162	61	0.0042	0.0082	0.0197	58	0.150	0.267	0.661	61	19.5	23.9	27.7
PC02.3	8	0.00678	0.00770	0.00785	8	64.4	73.9	75.2	8	0.0399	0.0623	0.0701	8	0.0000050	0.0000050	0.0000050	8	0.0138	0.0198	0.0204	8	0.0027	0.0028	0.0028	8	0.116	0.137	0.140	8	15.3	17.6	17.7
PC02.5	46	0.00625	0.00776	0.00818	46	72.3	92.9	107.0	46	0.1425	0.6785	0.8490	45	0.0000050	0.0000050	0.0000050	46	0.0098	0.0323	0.0484	46	0.0023	0.0037	0.0041	46	0.150	0.353	0.910	46	15.5	19.6	20.2
PC03	54	0.00568	0.00805	0.01250	54	61.0	119.1	151.0	54	0.0864	1.2430	2.0400	54	0.0000050	0.0000100	0.0000100	54	0.0131	0.0753	0.1110	54	0.0017	0.0031	0.0039	48	0.150	0.331	0.670	54	14.5	20.3	27.5
PC08	58	0.00495	0.00650	0.00710	58	41.5	46.2	48.2	58	0.1275	0.2702	0.2830	58	0.0000050	0.0000100	0.0000100	58	0.0026	0.0038	0.0042	58	0.0019	0.0034	0.0044	49	0.111	0.150	0.192	58	10.7	12.4	13.3
PC10	13	0.00405	0.00476	0.00486	13	31.1	43.4	43.6	13	0.0335	0.0793	0.1100	13	0.0000050	0.0000130	0.0000250	13	0.0027	0.0034	0.0038	13	0.0015	0.0026	0.0033	13	0.108	0.296	0.387	13	8.9	12.9	15.9
PC-EF-04	4	0.01060	0.01370	0.01400	4	113.9	130.0	130.0	4	0.0353	0.0829	0.0896	4	0.0000050	0.0000050	0.0000050	4	0.0147	0.0186	0.0191	4	0.0040	0.0069	0.0073	2	0.150	0.150	0.150	4	21.4	23.1	23.3
JACL-D	40	0.00588	0.00742	0.00770	40	42.0	46.1	48.2	40	0.0590	0.1310	0.1720	40	0.0000050	0.0000100	0.0000100	40	0.0022	0.0031	0.0033	40	0.0008	0.0010	0.0016	32	0.150	0.346	0.370	40	12.3	13.9	13.9
JACL-M	5	0.00538	0.00663	0.00680	5	37.2	43.1	43.3	5	0.0046	0.0075	0.0076	5	0.0000050	0.0000050	0.0000050	5	0.0027	0.0028	0.0029	5	0.0006	0.0008	0.0008	5	0.025	0.150	0.150	5	11.8	12.7	12.7
JACL-S	41	0.00543	0.00690	0.00750	41	36.1	44.0	46.9	41	0.0050	0.0253	0.0338	41	0.0000050	0.0000100	0.0000100	41	0.0025	0.0035	0.0040	41	0.0007	0.0011	0.0012	33	0.118	0.150	0.150	41	11.1	12.9	13.4
KC03	6	0.01225	0.01343	0.01350	6	120.5	128.8	129.0	6	0.0006	0.0032	0.0039	6	0.0000050	0.0000050	0.0000050	6	0.0134	0.0143	0.0143	6	0.0016	0.0018	0.0018	6	0.133	0.188	0.201	6	21.5	22.4	22.6
EDITH-01D	11	0.01090	0.01215	0.01230	11	68.8	74.5	76.2	11	0.0918	0.2115	0.2350	11	0.0000050	0.0000050	0.0000050	11	0.0018	0.0022	0.0024	11	0.0008	0.0009	0.0009	11	0.076	0.447	0.518	11	17.5	20.3	21.6
EDITH-01M	3	0.01140	0.01167	0.01170	3	71.9	72.0	72.0	3	0.1980	0.2223	0.2250	3	0.0000050	0.0000050	0.0000050	3	0.0016	0.0023	0.0024	3	0.0008	0.0008	0.0009	3	0.075	0.303	0.328	3	18.1	19.1	19.2
EDITH-01S	11	0.01110	0.01160	0.01180	11	68.7	73.0	73.4	11	0.0057	0.0219	0.0232	11	0.0000050	0.0000050	0.0000050	11	0.0021	0.0022	0.0022	11	0.0007	0.0008	0.0008	11	0.025	0.052	0.078	11	17.5	19.9	20.2
GOOSE LAKE	12	0.07320	0.09066	0.09500	12	245.5	290.8	293.0	12	0.0018	0.0145	0.0271	12	0.0000050	0.0000050	0.0000050	12	0.0045	0.0054	0.0054	12	0.0013	0.0018	0.0025	12	0.114	0.348	0.370	12	196.0	269.2	278.0
HUMPH-02	16	0.00686	0.00796	0.00802	16	93.1	113.0	122.0	16	0.0427	0.0766	0.0848	16	0.0000050	0.0000050	0.0000050	16	0.0224	0.0252	0.0253	16	0.0019	0.0024	0.0025	16	0.119	0.145	0.158	16	13.9	16.7	17.4
HUMPH-08	9	0.00727	0.01126	0.01250	9	68.1	71.2	71.6	9	0.0491	0.1306	0.1600	9	0.0000050	0.0000050	0.0000050	9	0.0128	0.0162	0.0167	9	0.0035	0.0086	0.0102	9	0.198	0.353	0.425	9	17.5	18.6	18.7
HUMPH-10	15	0.00699	0.01050	0.01230	15	69.6	73.6	73.8	15	0.2780	0.8076	1.0400	15	0.0000190	0.0000317	0.0000380	15	0.0047	0.0075	0.0089	15	0.0050	0.0086	0.0100	15	0.107	0.340	0.630	15	16.0	20.6	20.9
AJWE-D	11	0.04190	0.04990	0.05080	11	215.0	231.5	239.0	11	0.0012	0.0027	0.0030	10	0.0000100	0.0000100	0.0000100	11	2.2000	2.6050	2.7300	11	0.0025	0.0039	0.0039	5	0.025	0.150	0.150	11	20.0	21.9	21.9
AJWE-S	11	0.04190	0.04990	0.05080	11	215.0	231.5	239.0	11	0.0012	0.0027	0.0030	10	0.0000100	0.0000100	0.0000100	11	2.2000	2.6050	2.7300	11	0.0025	0.0039	0.0039	5	0.025	0.150	0.150	11	20.0	21.9	21.9
AJWW-D	7	0.05100	0.05622	0.05700	7	287.0	304.6	310.0	7	0.0235	0.0333	0.0357	7	0.0000100	0.0000100	0.0000100	7	3.4300	4.7120	4.9700	7	0.0140	0.0152	0.0153	2	0.025	0.025	0.025	7	25.0	30.3	30.3
AJWW-S	8	0.03450	0.06254	0.06600	8	286.5	300.9	304.0	8	0.0084	0.0105	0.0107	8	0.0000100	0.0000100	0.0000100	8	3.3550	4.6520	4.7500	8	0.0120	0.0154	0.0160	2	0.025	0.025	0.025	8	26.2	30.1	30.3
NSP	22	0.00335	0.02399	0.02500	22	590.0	859.8	883.0	22	0.0818	0.1447	0.1790	22	0.0000050	0.0000050	0.0000050	22	0.0188	0.0250	0.0267	22	0.0013	0.0049	0.0050	21	0.479	0.860	0.900	22	107.0	147.4	155.0
S. CATCHMENT	4	0.00965	0.01064	0.01070	4	409.5	434.1	438.0	4	0.0228	0.0772	0.0866	4	0.0000050	0.0000050	0.0000050	4	0.0713	0.0838	0.0842	4	0.0017	0.0037	0.0040	4	0.079	0.377	0.426	4	75.0	77.3	77.4
WR-SEEP	15	0.02410	0.09216	0.10000	15	176.0	329.4	349.0	15	0.0242	0.3564	0.9080	15	0.0000050	0.0000080	0.0000150	15	0.1670	1.6460	2.0100	15	0.0029	0.0072	0.0078	15	0.025	0.870	2.550	15	39.2	74.9	90.9

Notes

Units are mg/L, unless otherwise stated

n = Number of samples

95th P - 95th Percentile summary statistics

Med - Median (50th Percentile)

Max - Maximum

Table 6.3-3. Surface Water Quality Summary Statistics

Parameter	Selenium - Total				Silicon - Total				Silver - Total				Sodium - Total				Strontium - Total				Thallium - Total				Tin - Total				Titanium - Total			
Statistic	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max
JC03	29	0.00050	0.00100	0.00100	26	10.7	12.9	12.9	29	0.000010	0.000020	0.000020	29	33.2	44.6	45.6	26	0.4	0.5	0.5	29	0.000011	0.000200	0.000200	29	0.000050	0.000500	0.000500	29	0.0200	0.0846	0.0930
PC02	61	0.00059	0.00250	0.00300	58	8.9	12.0	16.1	61	0.000005	0.000033	0.000050	61	94.8	118.0	152.0	58	1.0	1.3	1.5	61	0.000005	0.000200	0.000500	61	0.000050	0.000500	0.001250	61	0.0050	0.0550	0.1400
PC02.3	8	0.00024	0.00033	0.00037	8	8.3	10.5	10.9	8	0.000005	0.000005	0.000005	8	50.9	58.7	59.5	8	0.6	0.7	0.7	8	0.000005	0.000005	0.000005	8	0.000050	0.000050	0.000050	8	0.0050	0.0130	0.0130
PC02.5	46	0.00022	0.00050	0.00052	46	7.9	15.2	15.8	46	0.000005	0.000015	0.000094	46	54.1	73.8	80.5	46	0.7	0.9	0.9	46	0.000005	0.000100	0.000100	46	0.000050	0.000250	0.000250	46	0.0050	0.0225	0.0270
PC03	54	0.00031	0.00100	0.00250	48	5.7	13.1	14.2	54	0.000005	0.000020	0.000050	54	49.3	75.8	99.4	48	0.6	1.0	1.2	54	0.000005	0.000200	0.000500	54	0.000050	0.000500	0.002980	54	0.0050	0.0117	0.0220
PC08	58	0.00016	0.00050	0.00100	49	8.5	10.9	11.7	58	0.000005	0.000014	0.000032	58	36.1	42.1	45.5	49	0.4	0.5	0.5	58	0.000005	0.000100	0.000200	58	0.000050	0.000250	0.000500	58	0.0050	0.0262	0.0610
PC10	13	0.00030	0.00075	0.00128	13	9.3	11.5	11.5	13	0.000005	0.000005	0.000005	13	29.1	37.7	39.0	13	0.4	0.5	0.5	13	0.000005	0.000005	0.000005	13	0.000050	0.000050	0.000050	13	0.0050	0.0190	0.0250
PC-EF-04	4	0.00147	0.00242	0.00250	2	9.8	11.2	11.3	4	0.000015	0.000020	0.000020	4	98.4	114.0	114.0	2	1.1	1.4	1.4	4	0.000150	0.000200	0.000200	4	0.000375	0.000500	0.000500	4	0.0050	0.0458	0.0530
JACL-D	40	0.00015	0.00112	0.01710	32	4.6	6.7	7.3	40	0.000005	0.000020	0.000020	40	39.1	43.9	44.8	32	0.4	0.4	0.5	40	0.000005	0.000200	0.000200	40	0.000050	0.000500	0.000500	40	0.0050	0.0050	0.0050
JACL-M	5	0.00015	0.00050	0.00050	5	5.5	5.9	5.9	5	0.000005	0.000010	0.000010	5	35.6	41.2	41.2	5	0.4	0.4	0.4	5	0.000005	0.000100	0.000100	5	0.000050	0.000250	0.000250	5	0.0050	0.0050	0.0050
JACL-S	41	0.00016	0.00050	0.00100	33	3.9	6.4	6.7	41	0.000005	0.000010	0.000033	41	35.1	41.0	44.5	33	0.4	0.4	0.4	41	0.000005	0.000100	0.000200	41	0.000050	0.000250	0.000500	41	0.0050	0.0050	0.0170
KC03	6	0.00517	0.00816	0.00859	6	9.5	9.8	9.8	6	0.000005	0.000005	0.000005	6	95.6	99.9	100.0	6	1.2	1.2	1.3	6	0.000005	0.000005	0.000005	6	0.000050	0.000050	0.000050	6	0.0050	0.0050	0.0050
EDITH-01D	11	0.00005	0.00016	0.00019	11	1.5	3.7	3.9	11	0.000005	0.000005	0.000005	11	53.7	60.8	61.3	11	0.3	0.3	0.3	11	0.000005	0.000005	0.000005	11	0.000050	0.000050	0.000050	11	0.0050	0.0050	0.0050
EDITH-01M	3	0.00005	0.00005	0.00005	3	2.0	3.1	3.2	3	0.000005	0.000005	0.000005	3	56.4	56.5	56.5	3	0.3	0.3	0.3	3	0.000005	0.000005	0.000005	3	0.000050	0.000050	0.000050	3	0.0050	0.0050	0.0050
EDITH-01S	11	0.00005	0.00012	0.00012	11	0.3	1.0	1.0	11	0.000005	0.000005	0.000005	11	54.4	57.9	58.1	11	0.3	0.3	0.3	11	0.000005	0.000005	0.000005	11	0.000050	0.000050	0.000050	11	0.0050	0.0050	0.0050
GOOSE LAKE	12	0.00025	0.00036	0.00050	12	0.9	4.8	5.6	12	0.000025	0.000036	0.000050	12	1041.0	1322.5	1350.0	12	0.5	0.6	0.6	12	0.000025	0.000036	0.000050	12	0.000250	0.000363	0.000500	12	0.0250	0.0363	0.0500
HUMPH-02	16	0.00185	0.00497	0.00510	16	9.1	11.0	11.0	16	0.000005	0.000020	0.000030	16	60.2	65.5	67.2	16	0.9	1.1	1.2	16	0.000005	0.000005	0.000005	16	0.000050	0.000065	0.000110	16	0.0050	0.0135	0.0150
HUMPH-08	9	0.00082	0.00130	0.00133	9	10.1	12.1	12.7	9	0.000013	0.000075	0.000103	9	50.2	54.1	54.3	9	0.5	0.6	0.6	9	0.000005	0.000014	0.000016	9	0.000050	0.000050	0.000050	9	0.0270	0.0992	0.1300
HUMPH-10	15	0.00012	0.00019	0.00021	15	4.3	7.1	7.2	15	0.000016	0.000046	0.000061	15	55.5	59.1	59.2	15	0.4	0.4	0.4	15	0.000005	0.000005	0.000005	15	0.000050	0.000050	0.000050	15	0.0050	0.0190	0.0260
AJWE-D	11	0.01760	0.01955	0.02000	5	8.9	9.3	9.3	11	0.000050	0.000050	0.000050	11	213.0	232.0	244.0	5	3.0	3.3	3.4	11	0.000500	0.000500	0.000500	11	0.001250	0.001250	0.001250	11	0.0050	0.0075	0.0100
AJWE-S	11	0.01760	0.01955	0.02000	5	8.9	9.3	9.3	11	0.000050	0.000050	0.000050	11	213.0	232.0	244.0	5	3.0	3.3	3.4	11	0.000500	0.000500	0.000500	11	0.001250	0.001250	0.001250	11	0.0050	0.0075	0.0100
AJWW-D	7	0.03100	0.04931	0.05000	2	7.2	7.3	7.3	7	0.000050	0.000100	0.000100	7	198.0	211.6	217.0	2	4.2	4.5	4.5	7	0.000500	0.001000	0.001000	7	0.001250	0.002500	0.002500	7	0.0050	0.0107	0.0110
AJWW-S	8	0.03070	0.04943	0.05020	2	7.2	7.4	7.4	8	0.000100	0.000100	0.000100	8	199.0	211.9	215.0	2	4.2	4.3	4.3	8	0.001000	0.001000	0.001000	8	0.002500	0.002500	0.002500	8	0.0050	0.0050	0.0050
NSP	22	0.00099	0.00484	0.00500	21	4.7	7.6	7.9	22	0.000025	0.000096	0.000100	22	620.5	853.3	905.0	21	3.8	4.8	5.5	22	0.000025	0.000951	0.001000	22	0.000250	0.002388	0.002500	22	0.0100	0.0250	0.0250
S. CATCHMENT	4	0.00074	0.00106	0.00110	4	5.7	6.1	6.2	4	0.000010	0.000010	0.000010	4	249.5	304.4	312.0	4	0.2	0.5	0.5	4	0.000010	0.000010	0.000010	4	0.000100	0.000100	0.000100	4	0.0100	0.0389	0.0440
WR-SEEP	15	0.00193	0.02773	0.03270	15	3.6	8.6	12.7	15	0.000010	0.000035	0.000070	15	137.0	272.2	282.0	15	2.2	5.6	5.9	15	0.000005	0.000078	0.000200	15	0.000050	0.000220	0.000500	15	0.0050	0.0167	0.0230

Notes

Units are mg/L, unless otherwise stated

n = Number of samples

95th P - 95th Percentile summary statistics

Med - Median (50th Percentile)

Max - Maximum

Table 6.3-3. Surface Water Quality Summary Statistics

Parameter	Uranium - Total				Vanadium - Total				Zinc - Total				Dissolved Organic Carbon				Total Organic Carbon			
Statistic	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max	n	Med	95th P	Max
JC03	29	0.0015	0.0047	0.0076	29	0.0039	0.0089	0.0094	29	0.0025	0.0077	0.0084	29	12.00	16.32	16.50	25	12.30	16.96	17.90
PC02	61	0.0026	0.0037	0.0046	61	0.0036	0.0061	0.0134	61	0.0025	0.0074	0.0182	61	8.69	16.50	18.10	57	9.03	17.88	24.70
PC02.3	8	0.0012	0.0016	0.0017	8	0.0033	0.0038	0.0040	8	0.0015	0.0015	0.0015	8	14.95	17.17	17.20	8	15.05	17.07	17.10
PC02.5	46	0.0011	0.0031	0.0035	46	0.0029	0.0040	0.0045	46	0.0015	0.0054	0.0065	46	14.50	18.10	25.40	46	14.85	19.00	28.80
PC03	54	0.0013	0.0047	0.0061	54	0.0028	0.0068	0.0150	54	0.0015	0.0040	0.0222	53	14.40	17.92	24.50	48	14.55	18.87	25.40
PC08	58	0.0006	0.0013	0.0016	58	0.0030	0.0085	0.0150	58	0.0015	0.0039	0.0085	57	12.80	16.04	17.40	49	13.60	17.62	19.40
PC10	13	0.0009	0.0020	0.0020	13	0.0037	0.0046	0.0049	13	0.0015	0.0025	0.0041	13	10.80	14.48	16.40	13	10.80	15.24	17.10
PC-EF-04	4	0.0032	0.0040	0.0041	4	0.0045	0.0071	0.0075	4	0.0025	0.0056	0.0061	4	10.48	15.96	16.60	2	12.70	16.30	16.70
JACL-D	40	0.0012	0.0013	0.0014	40	0.0020	0.0150	0.0150	40	0.0015	0.0026	0.0050	40	14.35	15.91	16.80	32	14.85	16.42	18.00
JACL-M	5	0.0012	0.0014	0.0014	5	0.0026	0.0027	0.0027	5	0.0015	0.0025	0.0025	5	14.20	14.94	15.10	5	14.40	15.10	15.10
JACL-S	41	0.0012	0.0013	0.0016	41	0.0025	0.0150	0.0150	41	0.0025	0.0295	0.0590	41	14.10	16.00	16.80	32	14.35	17.17	17.70
KC03	6	0.0053	0.0059	0.0061	6	0.0073	0.0078	0.0078	6	0.0015	0.0015	0.0015	6	13.20	16.68	17.50	6	13.55	17.33	18.20
EDITH-01D	11	0.0017	0.0018	0.0018	11	0.0022	0.0032	0.0039	11	0.0015	0.0036	0.0041	11	19.40	20.65	20.80	11	19.70	20.85	21.50
EDITH-01M	3	0.0016	0.0018	0.0018	3	0.0025	0.0030	0.0031	3	0.0015	0.0015	0.0015	3	19.70	20.69	20.80	3	20.30	20.84	20.90
EDITH-01S	11	0.0018	0.0019	0.0019	11	0.0030	0.0036	0.0036	11	0.0015	0.0015	0.0015	11	19.10	20.05	20.20	11	20.00	20.40	20.40
GOOSE LAKE	12	0.0047	0.0051	0.0051	12	0.0025	0.0057	0.0063	12	0.0075	0.0109	0.0150	12	133.50	190.75	199.00	12	142.00	191.05	196.00
HUMPH-02	16	0.0037	0.0047	0.0048	16	0.0058	0.0065	0.0067	16	0.0015	0.0019	0.0031	16	10.60	17.13	17.20	16	12.35	17.90	20.60
HUMPH-08	9	0.0033	0.0036	0.0037	9	0.0112	0.0132	0.0133	9	0.0033	0.0069	0.0087	9	11.10	20.00	20.20	9	12.60	20.70	21.10
HUMPH-10	15	0.0019	0.0022	0.0023	15	0.0031	0.0067	0.0068	15	0.0015	0.0057	0.0062	15	18.00	19.60	19.60	15	18.30	20.92	21.90
AJWE-D	11	0.0102	0.0111	0.0111	11	0.0084	0.0150	0.0150	11	0.0025	0.0125	0.0125	11	1.46	1.73	1.74	5	1.16	1.36	1.40
AJWE-S	11	0.0102	0.0111	0.0111	11	0.0084	0.0150	0.0150	11	0.0025	0.0125	0.0125	11	1.46	1.73	1.74	5	1.16	1.36	1.40
AJWW-D	7	0.0111	0.0117	0.0118	7	0.0050	0.0150	0.0150	7	0.0025	0.0213	0.0250	7	2.40	2.57	2.59	2	1.50	1.56	1.57
AJWW-S	8	0.0108	0.0117	0.0117	8	0.0053	0.0150	0.0150	8	0.0025	0.0250	0.0250	8	2.27	2.61	2.67	2	1.40	1.41	1.41
NSP	22	0.0057	0.0070	0.0071	22	0.0025	0.0049	0.0050	22	0.0075	0.0075	0.0075	22	54.75	74.07	85.40	21	54.70	75.20	79.90
S. CATCHMENT	4	0.0039	0.0046	0.0047	4	0.0051	0.0064	0.0065	4	0.0030	0.0030	0.0030	4	32.80	33.24	33.30	4	33.05	35.77	36.10
WR-SEEP	15	0.0059	0.0137	0.0186	15	0.0022	0.0084	0.0139	15	0.0030	0.0068	0.0128	13	14.60	26.82	27.60	14	17.10	27.82	28.40

Notes

Units are mg/L, unless otherwise stated

n = Number of samples

95th P - 95th Percentile summary statistics

Med - Median (50th Percentile)

Max - Maximum

Table 6.3-4. Summary of Aquatic Life Guideline Exceedences

Watershed	Guidelines	
Site	BCWQG-30 D[2]	BCWQG-MAX [3]
Number of Samples [1]		
In Situ Parameters		
pH (unitless)		6.5 to 9
Physical Tests		
pH (unitless)		6.5 to 9
Dissolved Anions		
Chloride	150	600
Fluoride		0.4 to 0.01(-51.73+92.57(Log(H))) [6]
Sulphate	SITE SPECIFIC [11]	
Nutrients		
Ammonia (Total)	0.102 to 2.08 [7,8]	0.681 to 28.7 [7,8]
Nitrate (as N)	3	32.8
Nitrite (as N)	0.02 to 0.2 [7]	0.06 to 0.6 [7]
Cyanide		
Cyanide (WAD)		0.01
Dissolved Metals		
Aluminum	0.05 to $e^{(1.6-3.327*[pH]+0.402*([pH] \wedge [(2)]))}$ [7,10]	0.1 to $e^{(1.209-2.426*[pH]+0.286*[pH] \wedge [(2)])}$ [7,10]
Antimony		0.02
Arsenic		0.005
Cadmium	0.0000176 to $e^{(0.736*\ln(H)-4.943)}$/1000 to 0.000457 [6]	0.0000380 to $e^{(1.03*\ln(H)-5.274)}$/1000 to 0.00280 [6]
Chromium	0.001 (Cr VI)/0.0089 (Cr III)	
Copper	(0.04*H)/1000 to 0.010 [6]	(0.094*H+2)/1000 TO 0.010 [6]
Iron		0.35 [10]/1 [9]
Molybdenum	1	2
Selenium	0.002	
Uranium	0.0085	
Zinc	(7.5+0.75*(H-90))/1000 to 0.0075 [6]	(33+0.75*(H-90))/1000 to 0.033 [6]
Total Metals		
Aluminum		
Antimony		0.02
Arsenic		0.005
Cadmium		
Chromium	0.001 (Cr VI)/0.0089 (Cr III)	
Cobalt	0.004	0.11
Copper	(0.04*H)/1000 to 0.010 [6]	(0.094*H+2)/1000 TO 0.010 [6]
Iron		0.35 [10]/1 [9]
Mercury	0.00002	
Molybdenum	1	2
Selenium	0.002	
Silver	0.00005 to 0.0015 [6]	0.0001 to 0.003 [6]
Uranium	0.0085	
Zinc	(7.5+0.75*(H-90))/1000 to 0.0075 [6]	(33+0.75*(H-90))/1000 to 0.033 [6]

(continued

Notes:

1. *Guidelines are presented in mg/L unless otherwise stated; sample counts are in integer vaues. All other units are %.*
2. *British Columbia Water Quality Guidelines (Approved and Working) - 30-day average limits (BCWQG-30 D) - Freshwater Aquatic Life.*
3. *British Columbia Water Quality Guidelines (Approved and Working) - Maximum limits (BCWQG-MAX) - Freshwater Aquatic Life*
4. *Canadian Environmental Quality Guidelines - Water Quality Guideline for the Protection of Aquatic Life (CEQG-PAL) - Freshwater.*
5. *Values represent percentages of samples collected at each site that exceed one or more aquatic life guidelines.*
6. *Hardness (H) Dependent Guideline Limit (Dissolved).*
7. *pH-dependent guideline limit (in situ value preferred).*
8. *Temperature-dependent guideline limit.*
9. *Guideline is specific to total concentration only.*
10. *Guideline is specific to dissolved concentration only.*
11. *Guideline is applied only for waters of dissolved hardness >250 mg/L and is dependent on toxicity testing.*
12. *The percentage is based on the number of samples that exceed the lowest applicable guideline.*

Table 6.3-4. Summary of Aquatic Life Guideline Exceedences (continued)

Watershed	Guidelines *(cont'd)*	Peterson Creek Watershed											
		Peterson Creek									Jacko Lake		
Site	CEQG-PAL [4]	JC03	PC10	PC08	PC03	PC02.5	PC02.3	PC02WH	PC02	PC-EF-04	JACL-D	JACL-M	JACL-S
Number of Samples [1]		29	13	58	54	46	8	1	61	4	40	5	41
In Situ Parameters													
pH (unitless)	6.5 to 9	-	-	-	2%	-	-	-	-	-	-	-	2%
Physical Tests													
pH (unitless)	6.5 to 9	-	-	-	-	-	-	-	-	-	-	-	-
Dissolved Anions													
Chloride	120 (long-term) / 640 (short-term)	7%	-	-	-	-	-	100%	28%	50%	-	-	-
Fluoride	0.12	55%	69%	91%	59%	80%	100%	100%	49%	25%	90%	100%	93%
Sulphate		-	-	-	-	-	-	-	23%	50%	-	-	-
Nutrients													
Ammonia (Total)	0.017 to 192 [7,8]	-	-	12%	2%	-	-	-	-	-	15%	-	2%
Nitrate (as N)	3	-	-	-	-	-	-	-	-	-	-	-	-
Nitrite (as N)	0.06	-	-	-	2%	2%	-	-	-	-	-	-	-
Cyanide													
Cyanide (WAD)		-	-	-	-	-	-	-	3%	-	3%	-	-
Dissolved Metals													
Aluminum	0.005 to 0.1 [7]	-	-	-	-	-	-	-	-	-	-	-	-
Antimony		-	-	-	-	-	-	-	-	-	-	-	-
Arsenic	0.005	-	-	-	-	-	-	-	-	-	-	-	-
Cadmium	$10^{(0.83*(\log(H)-2.46)}/1000$ (min 0.000036 mg/L; max 0.000373 mg/L) [6,18] $10^{(1.016*(\log(H)-1.71)}/1000$ (min 0.000106 mg/L; max 0.0077 mg/L) [6,19]	-	-	2%	2%	-	-	-	3%	-	-	-	-
Chromium	0.001 (Cr VI)/0.0089 (Cr III)	3%	8%	2%	-	-	-	-	-	-	-	-	-
Copper	$e^{(0.8545*\ln(H)-1.465)}$ 0.2/1000 to 0.004 [6]	7%	8%	-	2%	4%	-	-	2%	-	-	-	-
Iron	0.3	-	-	9%	-	-	-	-	-	-	-	-	-
Molybdenum	0.073	-	-	-	6%	-	-	-	-	-	-	-	-
Selenium	0.001	-	8%	-	2%	-	-	-	26%	25%	10%	-	2%
Uranium	0.015	-	-	-	-	-	-	-	-	-	-	-	-
Zinc	0.03	3%	-	-	-	-	-	-	-	-	-	-	7%
Total Metals													
Aluminum	0.005 to 0.1 [7]	86%	69%	48%	15%	48%	63%	-	48%	50%	-	-	2%
Antimony		-	-	-	-	-	-	-	-	-	-	-	-
Arsenic	0.005	-	-	-	-	-	-	-	-	-	-	-	-
Cadmium	$10^{(0.83*(\log(H)-2.46)}/1000$ (min 0.000036 mg/L; max 0.000373 mg/L) [6,18] $10^{(1.016*(\log(H)-1.71)}/1000$ (min 0.000106 mg/L; max 0.0077 mg/L) [6,19]	3%	-	-	2%	-	-	-	5%	-	-	-	-
Chromium	0.001 (Cr VI)/0.0089 (Cr III)	62%	23%	24%	2%	11%	-	-	28%	25%	-	-	-
Cobalt		-	-	-	-	-	-	-	-	-	-	-	-
Copper	$e^{(0.8545*\ln(H)-1.465)}$ 0.2/1000 to 0.004 [6]	62%	54%	12%	4%	13%	50%	100%	34%	50%	3%	-	-
Iron	0.3	79%	46%	64%	11%	30%	38%	100%	34%	25%	-	-	-
Mercury	0.000026	-	-	-	-	-	-	-	2%	-	-	-	-
Molybdenum	0.073	-	-	-	9%	-	-	-	-	-	-	-	-
Selenium	0.001	-	8%	-	-	-	-	-	23%	25%	5%	-	-
Silver	0.0001	-	-	-	-	-	-	-	-	-	-	-	-
Uranium	0.015	-	-	-	-	-	-	-	-	-	-	-	-
Zinc	0.03	-	-	-	-	-	-	-	-	-	-	-	5%

(continued

Notes:

1. *Guidelines are presented in mg/L unless otherwise stated; sample counts are in integer vaues. All other units are %.*
2. *British Columbia Water Quality Guidelines (Approved and Working) - 30-day average limits (BCWQG-30 D) - Freshwater Aquatic Life.*
3. *British Columbia Water Quality Guidelines (Approved and Working) - Maximum limits (BCWQG-MAX) - Freshwater Aquatic Life*
4. *Canadian Environmental Quality Guidelines - Water Quality Guideline for the Protection of Aquatic Life (CEQG-PAL) - Freshwater.*
5. *Values represent percentages of samples collected at each site that exceed one or more aquatic life guidelines.*
6. *Hardness (H) Dependent Guideline Limit (Dissolved).*
7. *pH-dependent guideline limit (in situ value preferred).*
8. *Temperature-dependent guideline limit.*
9. *Guideline is specific to total concentration only.*
10. *Guideline is specific to dissolved concentration only.*
11. *Guideline is applied only for waters of dissolved hardness >250 mg/L and is dependent on toxicity testing.*
12. *The percentage is based on the number of samples that exceed the lowest applicable guideline.*

Table 6.3-4. Summary of Aquatic Life Guideline Exceedences (completed)

Watershed	Peterson Creek Watershed (*cont'd*)															
	Keynes Creek Watershed		Humphrey Creek Watershed						Historical Mine Features							
Site	GOOSE LAKE	KC03	EDITH-01D	EDITH-01M	EDITH-01S	HUMPH-10	HUMPH-08	HUMPH02	WR-SEEP	S. CATCHMENT	NSP	AJWW-D	AJWW-S	AJWE-D	AJWE-M	AJWE-S
Number of Samples [1]	12	6	11	3	11	15	9	16	15	4	22	7	8	11	1	11
In Situ Parameters																
pH (unitless)	100%	-	-	-	-	7%	-	-	-	50%	86%	-	-	-	-	9%
Physical Tests																
pH (unitless)	100%	-	-	-	-	-	-	-	-	100%	73%	-	-	-	-	-
Dissolved Anions																
Chloride	50%	-	-	-	-	-	-	-	33%	-	-	-	-	-	-	-
Fluoride	-	100%	100%	100%	100%	100%	100%	100%	27%	-	5%	57%	50%	45%	100%	45%
Sulphate	100%	-	-	-	-	-	-	6%	87%	100%	100%	100%	100%	100%	100%	100%
Nutrients																
Ammonia (Total)	100%	-	55%	100%	9%	20%	11%	-	-	75%	95%	-	-	-	-	-
Nitrate (as N)	-	-	-	-	-	-	-	-	7%	-	5%	100%	100%	100%	100%	100%
Nitrite (as N)	8%	-	-	-	-	-	-	-	20%	-	-	71%	100%	27%	100%	82%
Cyanide																
Cyanide (WAD)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dissolved Metals																
Aluminum	-	-	-	-	-	-	-	-	7%	-	-	-	-	-	-	-
Antimony	-	-	-	-	-	-	-	-	-	-	-	100%	100%	100%	100%	100%
Arsenic	100%	100%	-	-	-	-	11%	-	-	100%	100%	100%	100%	100%	100%	100%
Cadmium	-	-	-	-	-	-	-	-	-	-	5%	29%	38%	36%	-	27%
Chromium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Copper	-	100%	9%	-	-	7%	78%	94%	93%	-	-	100%	100%	91%	100%	100%
Iron	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Molybdenum	-	-	-	-	-	-	-	-	87%	25%	-	100%	100%	100%	100%	100%
Selenium	-	100%	9%	-	-	-	44%	63%	87%	-	41%	100%	100%	100%	100%	100%
Uranium	-	-	-	-	-	-	-	-	-	-	-	-	-	100%	100%	91%
Zinc	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Metals																
Aluminum	8%	-	-	-	-	53%	100%	69%	27%	50%	14%	-	-	-	-	-
Antimony	-	-	-	-	-	-	-	-	-	-	-	100%	100%	100%	100%	100%
Arsenic	100%	67%	-	-	-	-	11%	-	7%	100%	100%	100%	100%	100%	100%	100%
Cadmium	-	-	-	-	-	-	-	-	-	-	5%	29%	38%	36%	-	27%
Chromium	8%	-	-	-	-	7%	78%	-	13%	25%	-	-	-	-	-	-
Cobalt	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Copper	-	100%	27%	-	-	73%	100%	100%	93%	25%	-	100%	100%	91%	100%	100%
Iron	8%	-	-	-	-	47%	100%	31%	13%	50%	-	-	-	-	-	-
Mercury	-	-	-	-	-	47%	-	-	-	-	-	-	-	-	-	-
Molybdenum	-	-	-	-	-	-	-	-	93%	50%	-	100%	100%	100%	100%	100%
Selenium	-	100%	-	-	-	-	33%	63%	93%	25%	32%	100%	100%	100%	100%	100%
Silver	-	-	-	-	-	-	11%	-	-	-	-	-	-	-	-	-
Uranium	-	-	-	-	-	-	-	-	-	-	-	-	-	100%	100%	91%
Zinc	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Notes:

1. *Guidelines are presented in mg/L unless otherwise stated; sample counts are in integer vaues. All other units are %.*
2. *British Columbia Water Quality Guidelines (Approved and Working) - 30-day average limits (BCWQG-30 D) - Freshwater Aquatic Life.*
3. *British Columbia Water Quality Guidelines (Approved and Working) - Maximum limits (BCWQG-MAX) - Freshwater Aquatic Life*
4. *Canadian Environmental Quality Guidelines - Water Quality Guideline for the Protection of Aquatic Life (CEQG-PAL) - Freshwater.*
5. *Values represent percentages of samples collected at each site that exceed one or more aquatic life guidelines.*
6. *Hardness (H) Dependent Guideline Limit (Dissolved).*
7. *pH-dependent guideline limit (in situ value preferred).*
8. *Temperature-dependent guideline limit.*
9. *Guideline is specific to total concentration only.*
10. *Guideline is specific to dissolved concentration only.*
11. *Guideline is applied only for waters of dissolved hardness >250 mg/L and is dependent on toxicity testing.*
12. *The percentage is based on the number of samples that exceed the lowest applicable guideline.*

Table 6.3-5. Summary of Drinking Water Guideline Exceedances

Watershed	Drinking Water Guidelines		Peterson Creek Watershed																											
			Peterson Creek									Jacko Lake			Keynes Creek Watershed		Humphrey Creek Watershed						Historical Mine Features							
Site			JC03	PC10	PC08	PC03	PC02.5	PC02.3	PC02WH	PC02	PC-EF-04	JACL-D	JACL-M	JACL-S	GOOSE LAKE	KC03	EDITH-01D	EDITH-01M	EDITH-01S	HUMPH-10	HUMPH-08	HUMPH02	WR-SEEP	S. CATCHMENT	NSP	AJWW-D	AJWW-S	AJWE-D	AJWE-M	AJWE-S
Number of Samples	BCWQG [3]	HC [4]	29	13	58	54	46	8	1	61	4	40	5	41	12	6	11	3	11	15	9	16	15	4	22	7	8	11	1	11
In Situ Parameters																														
pH (unitless)		6.5 to 8.5	-	-	26%	15%	-	25%	-	2%	-	15%	-	44%	100%	-	36%	-	82%	20%	33%	13%	27%	100%	105%	-	-	9%	-	9%
Temperature °C	15	15	3%	8%	36%	33%	30%	75%	-	13%	-	8%	-	46%	75%	-	27%	33%	55%	53%	33%	6%	53%	50%	45%	-	-	-	-	45%
Total Dissolved Solids		500	45%	38%	34%	54%	76%	88%	-	89%	25%	15%	20%	2%	92%	100%	100%	100%	100%	87%	89%	94%	87%	50%	91%	29%	25%	36%	100%	36%
Physical Tests																														
Color TCU	15	15	93%	8%	64%	70%	65%	-	-	26%	75%	45%	-	46%	-	17%	-	-	-	-	-	6%	47%	25%	64%	-	-	-	-	-
pH (unitless)		6.5 to 8.5	-	-	24%	13%	-	38%	-	2%	50%	3%	-	37%	100%	-	27%	33%	100%	20%	56%	31%	13%	100%	100%	-	-	-	-	-
Total Dissolved Solids		500	48%	38%	9%	70%	83%	88%	100%	98%	100%	3%	-	-	100%	100%	91%	100%	73%	73%	89%	94%	100%	100%	100%	100%	100%	100%	100%	100%
Turbidity NTU		0.1	100%	100%	91%	93%	98%	100%	100%	97%	100%	90%	100%	90%	100%	100%	100%	100%	100%	100%	100%	100%	93%	100%	95%	71%	63%	73%	100%	73%
Dissolved Anions																														
Bromide	0.05		-	8%	-	2%	-	-	-	7%	-	-	-	2%	-	-	-	-	-	-	-	-	7%	-	18%	-	-	-	-	-
Chloride	250		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fluoride	1.5	1.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sulphate	500	500	-	-	-	4%	-	-	-	10%	25%	-	-	-	100%	-	-	-	-	-	-	-	87%	100%	100%	100%	100%	100%	100%	100%
Nutrients																														
Nitrate (as N)			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100%	100%	100%	100%	100%
Nitrite (as N)	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dissolved Metals																														
Antimony	0.014	0.006	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100%	100%	100%	100%	100%
Arsenic	0.025	0.01	-	-	-	-	-	-	-	-	-	-	-	-	100%	-	-	-	-	-	-	-	-	75%	77%	100%	100%	100%	100%	100%
Iron		*0.05*	-	-	*9%*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Manganese		*0.05*	*41%*	*8%*	*60%*	*65%*	*70%*	-	-	*69%*	-	*50%*	-	-	-	-	*45%*	*100%*	-	*87%*	*11%*	-	*20%*	-	*59%*	-	-	-	-	-
Molybdenum	0.25		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	33%	-	-	100%	100%	100%	100%	100%
Selenium	0.01	0.01	-	-	-	-	-	-	-	-	-	3%	-	-	-	-	-	-	-	-	-	-	33%	-	-	100%	100%	100%	100%	100%
Sodium		*200*	-	-	-	-	-	-	-	-	-	-	-	-	*100%*	-	-	-	-	-	-	-	*33%*	*75%*	*100%*	*29%*	*38%*	*91%*	*100%*	*27%*
Uranium		0.02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*7%*	-	-	-	-	-	-	-
Total Metals																														
Antimony	0.014	0.006	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100%	100%	100%	100%	100%
Arsenic	0.025	0.01	-	-	-	-	-	-	-	-	-	-	-	-	100%	-	-	-	-	-	-	-	-	75%	77%	100%	100%	100%	100%	100%
Iron		*0.3*	*79%*	*46%*	*64%*	*11%*	*30%*	*38%*	*100%*	*34%*	*25%*	-	-	-	*8%*	-	-	-	-	*47%*	*100%*	*31%*	*13%*	*50%*	-	-	-	-	-	-
Manganese		*0.05*	*79%*	*15%*	*60%*	*76%*	*83%*	*13%*	-	*93%*	*25%*	*53%*	-	-	-	-	*55%*	*100%*	-	*87%*	*44%*	*38%*	*27%*	*25%*	*68%*	-	-	-	-	-
Molybdenum	0.25		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	40%	-	-	100%	100%	100%	100%	100%
Selenium	0.01	0.01	-	-	-	-	-	-	-	-	-	3%	-	-	-	-	-	-	-	-	-	-	40%	-	-	100%	100%	100%	100%	100%
Sodium		*200*	-	-	-	-	-	-	-	-	-	-	-	-	*100%*	-	-	-	-	-	-	-	*33%*	*75%*	*100%*	*14%*	*25%*	*91%*	*100%*	*45%*
Organics																														
Carbon Organic (Total)	4		86%	100%	84%	89%	100%	100%	100%	93%	50%	80%	100%	78%	100%	100%	100%	100%	100%	100%	100%	100%	93%	100%	95%	-	-	-	-	-

Notes:

1. *Guidelines are presented in mg/L unless otherwise stated; sample counts are integer values. All other units are %.*
2. *Values represent percentages of samples collected at each site that exceed one or more drinking water guideline.*
3. *BCWQG: BC Water Quality Guidelines for Drinking Water.*
4. *HC: Health Canada Drinking Water Guidelines.*
5. *Italicized values represent guidelines based on aesthetic objectives (e.g., taste, odour, colour), rather than health-based effects.*
6. *The percentage is based on the number of samples that exceed the lowest applicable guideline.*

Table 6.3-6. Summary of Agricultural Guideline Exceedences

Watershed	Guidelines				Peterson Creek Watershed																									
					Peterson Creek									Jacko Lake			Keynes Creek Watershed		Humphrey Creek Watershed						Historical Mine Features							
Site					JC03	PC10	PC08	PC03	PC02.5	PC02.3	PC02WH	PC02	PC-EF-04	JACL-D	JACL-M	JACL-S	GOOSE LAKE	KC03	EDITH-01D	EDITH-01M	EDITH-01S	HUMPH-10	HUMPH-08	HUMPH02	WR-SEEP	S. CATCHMENT	NSP	AJWW-D	AJWW-S	AJWE-D	AJWE-M	AJWE-S
Number of Samples	BCWQG-Irrigation[3]	BCWQG-Livestock[4]	CCME-Irrigation[5]	CCME-Livestock[6]	30	14	62	59	50	9	1	62	4	40	6	41	12	7	11	3	12	15	10	18	19	5	24	7	8	11	1	11
Physical Tests																																
Conductivity (µS/cm)	700	1400			2%	3%	1%	1%	2%	10%	100%	2%	25%	2%	6%	1%	8%	12%	9%	33%	8%	6%	9%	5%	4%	16%	4%	14%	13%	9%	100%	9%
Total Dissolved Solids	500	1000	500	3000	2%	3%	-	1%	2%	9%	100%	2%	25%	0%	-	-	8%	12%	8%	33%	6%	5%	8%	5%	4%	16%	4%	14%	13%	9%	100%	9%
Turbidity (NTU)	10	5			2%	3%	1%	-	-	1%	100%	0%	6%	0%	3%	0%	4%	-	1%	22%	1%	2%	9%	1%	1%	8%	1%	-	-	-	-	-
Dissolved Anions																																
Chloride	100	600	100		-	-	-	-	-	-	100%	1%	13%	-	-	-	7%	-	-	-	-	-	-	-	2%	-	-	-	-	-	-	-
Fluoride	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0%	2%	-	1%	-	1%
Sulphate		1000		1000	-	-	-	-	-	-	-	-	-	-	-	-	8%	-	-	-	-	-	-	-	2%	16%	4%	14%	13%	9%	100%	9%
Dissolved Metals																																
Arsenic	0.1	0.025	0.1	0.025	-	-	-	-	-	-	-	-	-	-	-	-	2%	-	-	-	-	-	-	-	-	-	-	2%	9%	100%	9%
Boron	0.5	5	0.5		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8%	-	-	-	-	-	-
Chromium III	0.0049	0.05	0.0049	0.05	-	-	-	-	-	-	-	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0%	6%	8%	-	-	-
Manganese	0.2		0.2		0%	-	0%	0%	1%	-	-	0%	-	-	-	-	-	-	1%	22%	-	5%	-	-	0%	-	-	-	-	-	-	-
Molybdenum	0.02	0.05	0.01	0.5	-	-	-	1%	1%	6%	-	1%	25%	-	-	-	-	12%	-	-	-	-	7%	5%	4%	16%	4%	14%	13%	9%	100%	9%
Selenium	0.01	0.03	0.02	0.05	-	-	-	-	-	-	-	-	-	0%	-	-	-	-	-	-	-	-	-	-	1%	-	-	14%	13%	9%	100%	9%
Uranium	0.01	0.2	0.01	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1%	-	-	14%	13%	4%	-	3%
Vanadium	0.1	0.1	0.1	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Metals																																
Arsenic	0.1	0.025	0.1	0.025	-	-	-	-	-	-	-	-	-	-	-	-	2%	-	-	-	-	-	-	-	-	4%	-	-	2%	9%	100%	9%
Boron	0.5	5	0.5	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12%	-	-	-	-	-	-
Chromium III	0.0049	0.05	0.0049	0.05	-	-	-	-	-	-	-	0%	-	-	-	-	-	-	-	-	-	-	1%	-	-	-	0%	6%	8%	-	-	-
Manganese	0.2		0.2		-	-	-	-	1%	-	-	0%	-	-	-	-	-	-	1%	11%	-	5%	-	-	0%	-	-	-	-	-	-	-
Molybdenum	0.02	0.05	0.01	0.5	-	-	-	1%	1%	7%	100%	1%	25%	-	-	-	-	12%	-	-	-	-	7%	5%	4%	16%	4%	14%	13%	9%	100%	9%
Selenium	0.01	0.03	0.02	0.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2%	-	-	14%	13%	9%	100%	9%
Uranium	0.01	0.2	0.01	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1%	-	-	14%	13%	6%	-	3%
Vanadium	0.1	0.1	0.1	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Notes:

1. Guidelines are presented in mg/L unless otherwise stated; sample counts are integer values. All other units are %.

2. Values represent percentages of samples collected at each site that exceed one or more drinking water guideline.

3. BCWQG-Irrigation: BC Water Quality Guidelines for Irrigation.

4. BCWQG-Livestock: BC Water Quality Guidelines for Livestock.

5. CCME-Irrigation: CCME Guidelines for Irrigation.

6. CCME-L CCME Guidelines for Irrigation.

6. The percentage is based on the number of samples that exceed the lowest applicable guideline.

Chloride concentrations were elevated seasonally in samples collected from surface water sites in the LSA that were downstream of highways (Highways 5, 5A and Lac La Jeune) and samples occasionally exceeded aquatic life guidelines. Road salt application is the likely source, as groundwater sample concentrations from monitoring wells in the immediate project area were all low in chloride. Samples from residential water well sources in the vicinity of the Davidson Creek Aquifer (parallel to Highway 5A) were also elevated in chloride. Seasonal increases typically occurred between August and October, and sites upstream of the highways were not affected. Fluoride surface water concentrations did not tent to exceed the BC aquatic life guideline (hardness dependent), and concentrations did not show consistent increasing trends with distance downstream, but tended to be elevated in the samples from Humphrey Creek, and Keynes Creek and samples from the mid-reaches of Peterson Creek, which are downstream of Humphrey Creek and Keynes Creek. Fluoride concentrations were elevated above the 0.12 mg/L CEQG-PAL in most samples collected from Peterson Creek and the tributaries (Keynes Creek and Humphrey Creek), with the highest concentrations generally occurring in late summer and fall.

Nutrients

Nutrient loading within the RSA is dominantly phosphorus related. Total phosphorus (TP) in the creeks varied on a seasonal basis, resulting in a range of trophic classifications from eutrophic to hyper-eutrophic. Lake TP concentrations within the LSA varied with depth and season. Surface concentrations of total phosphorous (TP) in Jacko, Inks, Goose, and Edith lakes decreased during freshet and increased through the summer, while at the depths of Jacko Lake, this trend was reversed: TP typically remained stable during freshet and increase in the summer, with highest concentrations observed in the fall season. The median TP concentrations observed along the surface of the lake were in the eutrophic range in winter and spring and in the upper range of meso-eutrophic in the summer and fall, while concentrations at depth were generally in the upper eutrophic and hyper-eutrophic ranges. TP in Goose Lake increased during the late summer, well into the hyper-eutrophic category. In the samples collected from the mid- and deep depths of Edith Lake, TP was in the eutrophic range during freshet and increased during the summer and fall, peaking in the hyper-eutrophic range. In contrast, the shallow samples collected from Edith Lake were classified as meso-eutrophic to eutrophic throughout the season.

Concentrations of nitrogen based inorganics (nitrite, nitrate, and ammonia) were somewhat variable in the creeks and aquatic life guideline exceedances were infrequent; however, ammonia exceeded the temperature- and pH-dependent CEQG-PAL occasionally in lake samples collected from within the LSA and frequently in the samples collected from Inks Lake. Sporadic ammonia guideline exceedances were also observed in samples collected from upper Humphrey Creek, likely affected by seepage losses and flow from Edith Lake, where ammonia concentrations were noted to increase in the deeper lake samples throughout the summer and fall (when most samples exceeded the CEQG-PAL). Guideline exceedances were also observed in some samples collected from Goose Lake and Jacko Lake (deep lake samples only). There were no exceedances of the BCWQG-30 D for ammonia.

Metals

Seasonal trends were apparent for most metal and metalloid parameters. Parameters that were measured at higher concentrations in samples collected during spring freshet are primarily driven by runoff and sediment mobilization and parameters that were higher in samples collected during periods of lower flow are primarily associated with groundwater inflows. Dissolved metals concentrations tended to remain very low in samples collected through spring freshet and guideline exceedances were predominant for total metals concentrations only. Spatially, concentrations of most parameters tended to increase with distance downstream in the watershed or based on proximity to the historical mine site, as is noted for molybdenum and manganese.

Metal and metalloid exceedances of the aquatic life, agricultural, wildlife, and drinking water guidelines were reported for some surface water samples from the LSA. Total aluminum, total copper, and total iron sample concentrations frequently exceeded the aquatic life guidelines whereas dissolved exceedances were infrequent to rare, and manganese concentrations seasonally exceeded the guidelines for irrigation and/or livestock water uses and molybdenum concentrations seasonally exceeded the water quality guidelines for livestock and wildlife. Aluminum, copper, and iron were generally elevated in samples collected during higher flow periods (spring freshet) and manganese and molybdenum were elevated in samples collected during non-freshet periods when surface water flows are understood to be sustained by groundwater inflows. Manganese and molybdenum concentrations were elevated in local groundwater samples and in samples collected from seepage collections ponds downstream of historical waste rock. Molybdenum sample concentrations seasonally exceeded the wildlife and livestock water quality guideline (both 0.05 mg/L) in Peterson Creek downstream of the historical mine site area but were below this guideline further downstream and upstream of this area. Molybdenum concentrations were consistently below the BC aquatic life guidelines (BCWQG-30 D 1 mg/L and BCWQG-Max 2 mg/L), but samples from one site (PC03) seasonally exceeded the CCME-PAL (0.073 mg/L). Selenium aquatic life and wildlife guideline (both 0.002 mg/L) exceedances were also noted within the project area creeks, generally in association with late winter low flow periods, and although concentrations tended to decrease through spring freshet, guidelines were still exceeded for some samples collected during this period. Selenium concentrations were highest in samples from Keynes Creek and lower Humphrey Creek and were also high in the lower reaches of Peterson Creek. Arsenic surface water sample concentrations were highest in the Keynes Creek samples and in samples collected from Peterson Creek site PC02; samples from Keynes Creek generally exceeded the BCWQG-Max (0.005 mg/L) but did not exceed guidelines in Peterson Creek.

Metal concentrations were low in Jacko Lake compared to the local creek sites and concentrations were typically below guidelines. Isolated aquatic life guideline exceedances (i.e. fewer than 5% of samples) were observed for selenium (deeper lake samples only), copper, and zinc, and manganese frequently exceeded the aesthetic objective for drinking water in the deep lake samples.

Metal concentrations in Inks Lake were generally higher than those observed in natural water bodies within the LSA, which likely result from groundwater inflows, which comprise the inflow to the lake and are concentrated by evaporation, since there is no surface water outflow. The following metal concentrations observed in Inks Lake suggest that the water may pose a risk to human-, fish-,

and wildlife health: aluminum, antimony, arsenic, boron, chromium, copper, iron, manganese, molybdenum, selenium, and silver.

6.3.3 Assessment Boundaries

The assessment boundaries for the Surface Water Quality VC define the maximum limit within which the effects assessment on Surface Water Quality is conducted. The assessment boundaries encompass the areas within, and times during which, the Project components and activities are expected to interact with the Surface Water Quality VC, as well as the constraints that are placed on the assessment of those interactions due to political, social, and economic realities (administrative boundaries), and limitations in predicting or measuring changes (technical boundaries). The assessment boundaries are integral in scoping for Surface Water Quality, and encompasses possible direct, indirect, and induced effects of the Project on Surface Water Quality, as well as the trends in processes that may be relevant.

6.3.3.1 Spatial Boundaries

Local Study Area

The LSA for the Surface Water Quality VC includes the spatial area where potential direct effects of the Project are anticipated on Surface Water Quality and extends to the first baseline site downstream of where all potential mine seepage may have the potential to surface in Peterson Creek and is upstream of the influence of urban runoff from the city of Kamloops. The LSA focuses on the Mine Site and immediate surrounding area within which there is a potential for direct effects on Surface Water Quality due to an interaction with Project components and activities.

The Surface Water Quality LSA includes Jacko Lake and a section of the Peterson Creek watershed that flows into Jacko Lake to the west, the Peterson Creek watershed to the south of Peterson Creek to the watershed boundary that separates it from the Anderson Creek watershed, and the Peterson Creek watershed to the north of Peterson Creek to the watershed divide, and to the east in the Peterson Creek watershed to baseline monitoring site PC02, which is just within the limits of the City of Kamloops. The LSA for the Surface Water Quality VC is shown on Figure 6.3-2.

Regional Study Area

The Surface Water Quality RSA was selected as the spatial area within which the potential exists for a residual effect of the Project to interact with a residual effect of another project or activity and cause a cumulative residual effect. The RSA for the Surface Water Quality VC encompasses the LSA and includes the entire Peterson Creek Watershed. The RSA for the Surface Water Quality VC is shown on Figure 6.3-2.

6.3.3.2 Temporal Boundaries

The temporal boundaries of the assessment are the time periods (Project phases) during which proposed Project activities and components are expected to interact with the Surface Water Quality VC. The temporal phases of the Project are:

- **Construction**: 2 years;
- **Operation**: 23 years;
- **Decommissioning and Closure**: 5 years; and
- Post Closure: 5+ years.

The focus of the Surface Water Quality VC assessment is on the Operation, Decommissioning and Closure and Post Closure phases of the Project as the project components have the potential to interact with surface water quality on a continuous basis through all mine phases. Modelling to support the EA for the Surface Water Quality VC extends out to 97 years in the Post Closure phase of the mine.

6.3.3.3 Administrative Boundaries

Administrative boundaries did not influence the assessment of the Surface Water Quality VC.

6.3.3.4 Technical Boundaries

Technical boundaries were considered with respect to the extent to which the potential effects of the Project on Surface Water Quality could be defensibly predicted through modelling and the water quality guidelines against which the predicted changes would be assessed.

The physical boundaries of the surface water quality model are downstream of all expected seepage pathways because direct effects of the Project on surface water quality are anticipated in Peterson Creek. However, Peterson Creek flows through the City of Kamloops, where the influence of urban runoff on surface water quality cannot be determined, creating a technical boundary for the effects assessment of the Surface Water Quality VC. As a result of the technical boundary, the furthest downstream modelling node used for the effects assessment is located before the influence of increased urban runoff.

Guidelines and standards for comparison with the model output data and baseline data are available under both federal (CEQG and HC) and provincial (BCWQG) jurisdictions and are specific to relevant receptors, including drinking water for human health, wildlife, agriculture, and aquatic life (section 6.3.2.3). The effects of the Project on surface water quality were determined with respect to the most sensitive known receptors in the downstream environment, which are typically aquatic life, though wildlife and livestock were considered if water quality guidelines were lower for these receptors. With few exceptions, the most relevant guidelines for comparison of the predictive surface water quality data are the BCWQG for chronic exposure (BCWQG-30 D). The surface water quality predictions have been screened against the HC and CEQG; however, these guidelines were superseded in the effects assessment if they were lower than the BCWQGs. Predicted changes in Surface Water Quality were not screened against effluent regulations (MMER Schedule 4 - Authorized Limits of Deleterious Substances), which are relevant only to end-of-pipe contact water that is released to the environment through a surface water connection. Surface contact water discharges are not anticipated from any of the mine facilities during Operations; rather, the only relevant pathways for surface water quality effects in the downstream environment during the Operation Phase are seepage and dustfall deposition.

Air dispersion modelling results show that dust deposition from the mine decreases rapidly with distance from mine infrastructure/activity. Thus dust is not expected to have measurable effects on water quality in the Cherry Creek watershed. Groundwater modelling results indicate that the groundwater divide between Peterson Creek Watershed and Cherry Creek Watershed will be maintained, and thus any seepage losses from the mine facilities would not migrate towards the Cherry Creek watershed. Direct and indirect effects on surface water quality in the Cherry Creek watershed from dust deposition and seepage are not expected and as a result the water quality model was limited to the Peterson Creek watershed.

6.3.4 Potential Effects of the Project and Proposed Mitigation for Surface Water Quality

6.3.4.1 Identifying Potential Effects on Surface Water Quality

The purpose of this section is to identify the potential effects of the Project on Surface Water Quality that can result from interactions between proposed Project components or activities for each Project phase within the LSA and RSA. Of the potential effects identified, key Project-Surface Water Quality VC interactions that are more likely to require assessment as a residual effect are identified and carried forward for assessment in Section 6.3.4.2.

Preliminary Screening for Potential Effects to Surface Water Quality

Project components and activities that have a reasonable potential to affect Surface Water Quality during Construction, Operations, Decommissioning and Closure, and Post Closure are listed in Table 6.3-7.

The interactions matrix ranks Project components and activities by phase on a four-point scale for the potential to interact with the Surface Water Quality VC and cause a potential effect, as follows:

- Zero (0): No interaction anticipated
- Low (L): Negligible to minor interaction expected; implementation of best practices, standard mitigation and management measures; no monitoring required, no further consideration warranted.
- Moderate (M): Potential moderate interaction requiring unique active management/ monitoring/mitigation; warrants further consideration.
- High (H): Key interaction; warrants further consideration.

Table 6.3-7. Identifying Potential Project Interactions and Effects on Surface Water Quality

Phase	Project Activities	Change in Surface Water Quality
Construction	Clearing and Grubbing	L
	Earthworks	L
	Overburden/Topsoil Stockpile	M
	Laydown Areas and Storage Yards	O
	Project Lighting	O
	Site Security and Fencing	O
	Fuel Storage and Filling Area	O

Phase	Project Activities	Change in Surface Water Quality
Construction (*cont'd*)	Hazardous Wastes Transport, Storage, and Disposal	O
	Construction Wastes Transport, Storage, and Disposal	O
	Sewage Infrastructure and Disposal	O
	Public Road Realignment, Use, and Maintenance	L
	Site Road Construction, Use and Maintenance	L
	Peterson Creek Bridge Construction, Use, and Maintenance	L
	Site Buildings and Process Plant	O
	Explosives Magazine and Storage Facilities	O
	Open Pit Development	M
	Drilling and Blasting	M
	Crushing Mine Rock	L
	Loading, Hauling, and Deposition of Mine Rock	H
	Temporary Ore Stockpile	H
	Tailing Storage Facility Development	H
	Power Transmission, Distribution	O
	Natural Gas Line	O
	Pipeline Utility Corridor (Potable Water, Sewage, and Site Water)	O
	Water Intake from Kamloops Lake	O
	Fire Suppression Infrastructure	O
	Contact Water	H
	Non-contact Water	O
	Peterson Creek Diversion	L
	Water Management Dams	L
	Mine Staffing (Direct Employment)	O
	Contracted Employment	O
	Taxation	O
Operation	Open Pit Development	M
	Drilling and Blasting	M
	Hauling Mine Rock and Ore from Pit	L
	Crushing and Conveying Ore	L
	Temporary Ore Stockpile	H
	Development of Mine Rock Management Facilities	H
	Stripping, Loading, Hauling, Deposition, and Contouring of Topsoil and Overburden	M

Phase	Project Activities	Change in Surface Water Quality
Operation (*cont'd*)	Revegetation through Progressive Reclamation	L
	Process Plant Operation	O
	Deposition to Tailing Storage Facility	H
	Site Road Use and Maintenance (Materials, Personnel, Supplies)	L
	Concentrate Transport and Storage	O
	Explosives Magazine and Storage Facilities	O
	Fire Suppression Infrastructure	O
	Fuel Storage and Filling Area	O
	Hazardous Wastes Transport, Storage, and Disposal	O
	General Wastes Transport, Storage, and Disposal	O
	Sewage Infrastructure and Disposal	O
	Laydown Areas and Storage Yards	O
	Power Transmission, Distribution	O
	Project Lighting	O
	Site Access, Security and Fencing	O
	Water Intake from Kamloops Lake	O
	Contact Water	H
	Non-contact Water	O
	Potable Water Treatment and Use	O
	Peterson Creek Diversion	L
	Mine Staffing (Direct Employment)	O
	Contracted Employment	O
	Taxation	O
Decommissioning and Closure	Dismantling of Ancillary Buildings	O
	Pit Lake Development	M
	Site Road/Bridge Decommissioning	L
	Tailing Storage Facility Decommissioning and Reclamation	H
	Mine Rock Management Facilities Reclamation	H
	Fuel Storage and Filling Area	O
	Hazardous Wastes Transport, Storage, and Disposal	O
	General Wastes Transport, Storage, and Disposal	O
	Sewage Infrastructure and Disposal	O
	Laydown Areas and Storage Yards	O

Phase	Project Activities	Change in Surface Water Quality
Decommissioning and Closure (*cont'd*)	Power Transmission, Distribution	O
	Project Lighting	O
	Site Access, Security and Fencing	O
	Contact Water	H
	Non-contact Water	O
	Potable Water Treatment and Use	O
	Peterson Creek Diversion	L
	Road use to the Project (Materials, Personnel, Supplies)	O
	Mine Staffing (Direct Employment)	O
	Contracted Employment	O
	Taxation	O
Post Closure	General Site Inspections and Maintenance	O
	Contact Water	H
	Non-contact Water	O
	Road use to the Project (Materials, Personnel, Supplies)	O
	Mine Staffing (Direct Employment)	O
	Contracted Employment	O

Project components and activities for which zero interaction (0) is anticipated, or for which there is a potential negligible to minor interaction (L) are not carried forward in the assessment. Project components and activities with the potential to have a moderate (M) or key interaction (H) with the Surface Water Quality VC are carried forward for further analysis in the effects assessment.

Based on the preliminary screening exercise for potential effects on Surface Water Quality, the Project has the potential to change baseline surface water quality throughout the life of the Project from Construction to Post Closure.

Construction Phase Potential Effects

The Construction phase will occur over the first two years (Yr -2 and Yr -1) of the Project life. The proposed Project components and associated activities that will take place during the Construction phase are described in detail in Section 3.0 Project Description of the Application/EIS.

Based on the preliminary screening exercise and interactions matrix (Table 6.3-7), the potential interactions that are anticipated to contribute to a change in Surface Water Quality can occur through the following key pathways of interactions:

- Clearing, grubbing and earthworks activities (stripping, stockpiling overburden and topsoil) for the development of Project facilities (TMF, Peterson Creek Diversion), access roads, and the power transmission line could increase soil erosion and contribute sediments to existing surface water ways.

- The operation of construction equipment, vehicles and development of the open pit by drilling, blasting, transporting and crushing mine rock will contribute dust to the atmosphere.
- Contact Water - has the potential to change the concentrations of key parameters through interactions as follows:
  - Metal leaching and seepage from the materials used to construct the TSF.
  - Metal leaching from MRSFs and temporary stockpiles.
  - Accidental release of contact water (spill).

Operation Phase Potential Effects

The Operations phase will occur over a 23 year period of the Project life. The proposed Project components and associated activities that will take place during the Operation phase are described in detail in Section 3.0 Project Description of the Application/EIS.

Based on the preliminary screening exercise and interactions matrix (Table 6.3-7), the potential interactions that are anticipated to contribute to a change in Surface Water Quality can occur through the following key pathways of interactions:

- Clearing, grubbing and earthworks activities (stripping, stockpiling overburden and topsoil) for the continued development of Project facilities (TMF, Peterson Creek Diversion and Bridge), access roads, and the power transmission line could increase soil erosion and contribute sediments to existing surface water ways.
- The operation of construction equipment, vehicles and development of the open pit by drilling, blasting, transporting and crushing mine rock will contribute dust to the atmosphere.
- Contact Water - has the potential to change the concentrations of key parameters through interactions as follows:
  - Metal leaching and seepage from the embankment mine rock materials.
  - Seepage losses from the TSF.
  - Metal leaching from MRSFs and ore stockpiles.

Decommissioning and Closure Phase Potential Effects

The Decommissioning and Closure phase will occur over a five year period, immediately following the Operation phase. The proposed Project components and associated activities that will take place during the Decommissioning and Closure phase are described in detail in Section 3.0 Project Description of the Application/EIS.

Based on the preliminary screening exercise and interactions matrix (Table 6.3-7), the potential interactions that are anticipated to contribute to a change in Surface Water Quality can occur through the following key pathways of interactions:

- Reclamation activities for the TSF and MRSFs could temporarily increase soil erosion and contribute sediments to existing surface water ways.
- The operation of equipment, vehicles and for the reclamation activities will contribute dust to the atmosphere.
- Contact Water - has the potential to change the concentrations of key parameters through interactions as follows:
  - Metal leaching and seepage from the TSF and the embankment mine rock materials.
  - Metal leaching from MRSFs.

Post Closure Phase Potential Effects

The Post Closure phase will occur from the end of the Decommissioning and Closure phase and for the purposes of the Surface Water Quality VC effects assessment this phase is limited to 97 years, but is acknowledged to extend continuously into the future. The proposed Project components and associated activities that will take place during the Post Closure phase are described in detail in Section 3.0 Project Description of the Application/EIS.

Based on the preliminary screening exercise and interactions matrix (Table 6.3-7), the potential interactions that are anticipated to contribute to a change in Surface Water Quality can occur through the following key pathways of interactions:

- Contact Water - has the potential to change the concentrations of key parameters through interactions as follows:
  - Metal leaching and seepage from the TSF and the embankment mine rock materials.
  - Metal leaching from MRSFs.

6.3.4.2 Effects on Surface Water Quality

Changes in Surface Water Quality

Water Quality Model

A water quality model was developed for the Project to estimate parameter concentrations within the various mine water management ponds and in the downstream surface water features (Jacko Lake, Peterson Creek, and Humphrey Creek) over time. The model was developed in Microsoft® Excel using a mass balance approach. A mass balance approach is a generally accepted water quality modelling practice for mining projects in BC (BC MOE 2012). Alternative modelling software is available for water quality models, such as GoldSim®; however, the basis for the mass balance calculations remains the same, independent of the software. The water balance model for the Project was developed in Microsoft® Excel by BGC Engineering Inc. (BGC) and was used by KP to develop

the surface water quality model. Further detail on the development of the Water Quality Model can be found in Appendix 6.3-C *Water Quality Model Report.*

Objectives

The objectives of water quality modelling were to identify aspects of the Project that may result in changes to parameters concentrations in the receiving water, quantify the expected changes, and quantify the effects of mitigation measures on potential adverse effects. The water quality model was developed iteratively in order to optimize engineering design and water management and avoid or mitigate for the adverse residual effects of the Project on Surface Water Quality. Key changes to project design to minimize effects to Surface Water Quality are listed in Section 6.3.4.3. It is important to note that the results of the model that are presented in the effects assessment represent the potential residual effects to Surface Water Quality, based on the assumed effectiveness of mitigation measures which have been incorporated into the engineering design and water management strategies.

Model Inputs

Information from hydrological, geochemical, dustfall deposition, and baseline inputs were combined in a water quality model in order to predict the resulting concentrations of parameters in the Mine Site water and receiving water. Each category of model inputs is described in detail below.

Water Balance Model Inputs

The baseline and life of mine (LOM) water balance models developed by BGC Engineering Inc. were used as the basis for all flows for the development of the water quality model (baseline calibration and LOM). The water balance model development is documented in the *Water Balance Model* report (BGC 2015b) attached as Appendix 6.4-C of the Application/EIS; the following is an overview of the development of the water balance model as it pertains to the water quality model.

The water balance model for the Project was developed with the water quality model flow inputs and was based on consistent spatial assessment boundaries. The water balance model was developed maintaining consistency with the water management plan and the specific methods and assumptions are documented in the Water Balance Model report (BGC 2015b). The Vanderwiele et al. monthly model was selected and implemented in a Microsoft® Excel spreadsheet for predicting existing and future conditions in the Project area. Inputs to the model include monthly precipitation and potential evapotranspiration, and outputs include monthly runoff. Water flow through Project facilities was explicitly modelled in the LOM water balance model. For example, precipitation on a facility was modelled as runoff or infiltration to the facility, with infiltration further separated into discharge at the base and recharge to deep groundwater along seepage pathways. Stream discharge is divided into slow runoff and fast runoff. Slow runoff depends on the storage in the catchment in the previous month and is approximately similar to baseflow/groundwater flow, whereas fast runoff is similar to surface runoff and interflow in the unsaturated zone (BGC 2015b).

The reported flows in the water balance model were categorized by their specific area of origin (i.e. precipitation over specific project facilities and undisturbed areas) and were reported separately as surface flow or groundwater baseflow. This distinction is important in water quality modelling because the water quality associated with a given flow is dependent on its area of origin and flow

path. Modelled flows were calibrated to historic and synthetic streamflow records based on historic temperature and precipitation inputs.

Water Management Plan Inputs

The water management plan was used to guide the water balance model in an iterative approach to determining an optimal strategy for water use at the Mine Site. The objectives of the water management plan were to maximize containment of mine contact waters and minimize freshwater requirements for mine operations (i.e. mineral processing, dust control, etc.).

Flows originating from precipitation over Project facilities, including MRSFs, the Open Pit, and the TSF, are considered to be contact water and will be collected at a number of water management ponds around the Mine Site. These water management ponds include:

- North Embankment Pond 1 and 2 – collect runoff and seepage from a portion of the West MRSF and seepage from the TSF;
- South and Southeast Embankment Ponds – collect runoff and seepage from the south and southeast TSF embankments and undisturbed areas located up-gradient of these ponds;
- SMRSF Pond – collect seepage and surface runoff from the southeast portion of the South MRSF
- EMRSF Pond – collect seepage and surface runoff from the southeast portion of the South MRSF
- Plant Site Pond; and
- Central Pond – all of the above ponds, with the exception of the South and Southeast Embankment Ponds, are pumped to the Central Pond, which also receives runoff from a portion of the West MRSF and South MRSF. Groundwater inflows and surface runoff to the open pit are also collected and pumped to the Central Pond. Water from the Central Pond is an input source to the mill.

Additional detail on the water management ponds is located in the *Water Management and Hydrometric Monitoring Plan*, Section 11.7.3.6

The TSF was modelled as a conventional tailings facility, receiving inputs that include direct precipitation and undisturbed catchment runoff, water in the tailings slurry, and water from the South and Southeast Embankment Ponds. The water management plan indicates the use of reclaim water from the TSF in the process plant; however, due to high evaporative losses, low runoff volumes within the Mine Site and void losses to tailings, the Project is expected to be operated with a water deficit and will therefore require make-up water, sourced from Kamloops Lake. The Kamloops Lake water will also be used for dust control and potable water.

A reclamation cover will be placed over the MRSFs and the TSF to reduce the amount of water (precipitation and runoff) in contact with the materials stored in these facilities during Decommissioning and Closure. The TSF supernatant pond remaining at the end of Operations will be pumped to the Open Pit during the Decommissioning and Closure phase to facilitate a dryer base

for the closure cover. The TSF closure cover system is intended to convey runoff from that facility to the Humphrey Creek watershed; the phreatic surface in the underlying TSF will be below the elevation of the cover system and as a result, surface drainage off the TSF towards the Humphrey Creek watershed is not affected by TSF seepage; however, small amounts of seepage towards the SMRSF are expected and uncontained seepage from this facility is accounted for in the loading to Humphrey Creek. Active management of the Open Pit is not anticipated for the Post Closure phase and this facility will be allowed to slowly fill due to the influx of groundwater and seepage inflows, surface runoff, and direct precipitation. The Open Pit lake water level is expected to stabilize well below the surrounding groundwater elevation and at equilibrium all inflows will be lost to evaporation.

Geochemical Source Terms Inputs

Lorax developed geochemical source terms for all potential sources of mine contact water from the Project. Source terms are considered to be expected concentrations of parameters in water that comes in contact with materials that may be altered or exposed as a result of Project activities, including excavation and stockpiling. Details regarding the development of the contact water source terms are provided under in the Ajax Project Derivation of Geochemical Source Terms report (Lorax 2015a, Appendix 3-B) and the geochemical characterization for the Project is provided in Section 3.4 of the Application/EIS. The source terms were developed based on the assumption of average infiltration (average climate LOM water balance) and are therefore directly applicable to water quality models based on average climate conditions. Therefore, the loading associated with these source terms may be over-predicted when unusually wet conditions are applied to the model and the reverse is true for dryer conditions.

The geochemical source terms include the following:

- Mine Rock Storage Facilities (MRSFs):
  - West MRSF (WMRSF) and Main Dam: for Years 5, 10, and 20 of mining, and Post Closure.
  - South MRSF (SMRSF) and East Dam: for Years 5, 10, and 20 of mining, and Post Closure.
  - East MRSF (EMRSF): for Years 5, 10, and 20 of mining, and Post Closure.
- Open pit backfill.
- Open pit walls: with the exception of Sugarloaf Diorite, these source terms were applied to water in contact with both mine rock and ore, and include the following geochemical units:
  - Iron Mask Hybrid (IMH) unit: for Operations.
  - Mafic Volcanic (MAFV) unit: for Operations.
  - Picrite (PICR) unit: for Operations.
  - Sugarloaf Diorite (SLD) unit: for Operations and water in contact with mine rock. Other geochemical units grouped under this unit include Sugarloaf Diorite weak albite alteration (SLDWA), Sugarloaf Diorite moderate albite alteration (SLDMA), Sugarloaf Diorite strong albite alteration (SLDSA), Pyroxene Plagioclase Porphyry (PXPP), and Sugarloaf Volcanic Hybrid (SVHYB).

  - Pit wall ore: this unit has the same geochemical characteristics as SLD, with the difference that the source term was applied to water in contact with ore.
- Ore stockpile.
- Tailings Storage Facility (TSF).
- Beach runoff active.
- Beach runoff inactive.
- Saturated pore-water seepage active.
- Saturated pore-water seepage inactive.
- Process water.
- Base concentration.

Natural solubility constraints were assessed by Lorax, in addition to the development of the source terms. The solubility constraints limit the dissolved concentrations for specific parameters, above which they are expected to precipitate out of solution as solid particulates. Loads in excess of these constraints are assumed to settle out of solution as insoluble solids within the given facility.

The geochemical source terms and solubility limits are provided in the *Water Quality Model Report* (KP 2015) in Appendix 6.3-A.

Baseline Water Quality Inputs

Baseline surface water and groundwater quality source terms were developed from the database of baseline water quality inclusive of samples collected through September 2014. The baseline surface water quality assessment study and results are described in Section 6.3.2.3 and the groundwater quality baseline characterization is in Section 6.6 of the Application/EIS. The baseline water quality datasets were first grouped by season, in order to increase the statistical power of the data, and then were reduced to monthly inputs (95th percentile (P), average, median, and 5th P), with months within a season having identical values. Seasons were defined as winter (December, January, February, and March), spring (April and May), summer (June, July, and August), and fall (September, October, and November). High non-detect values were excluded from the baseline summary statistics for input to the model. All included non-detect values were reduced to half the method detection limit (MDL) value for inclusion in the monthly summary statistics generated for each baseline chemistry input node, which is standard practice for handling MDLs. The baseline sites and baseline inputs to the model are documented in the *Water Quality Model Report* (Knight Piésold 2015) in Appendix 6.3-C.

Dustfall Inputs

Stantec Inc. developed the predictive air quality model for the Project from which the dustfall inputs for the water quality model were extracted. Dustfall inputs for the water quality model included average monthly deposition rates (in units of $\mu g/m^2/s$) in grid points located at:

- Peterson Creek: From about 10 km upstream of Jacko Lake to Jacko Lake, on a strip of land of 50 m at each side of the creek channel (for the Base Case water quality model), and a combined grid spacing of 50 m and 100 m.
- Jacko Lake: Over Jacko Lake, on a combined grid spacing of 50 m and 100 m.
- Humphrey Creek: From the headwaters of Humphrey Creek at Edith Lake to its confluence with Peterson Creek, on a strip of land of 50 m at each side of the creek channel (for the base case water quality model), and a grid spacing of 100 m.
- Peterson Creek Downstream Pond (PCDP): Over the area of the proposed PCDP, downstream of the PC03 site, on a grid spacing of 100 m.
- Dust deposition rates were discriminated for the following sources:
  - Diesel: Total particulate matter (PM) deposition resulting from diesel emission sources only.
  - Ore: Total PM deposition resulting from ore sources only.
  - Tailings: Total PM deposition resulting from tailings sources only.
  - Other: All other emissions that are not diesel, ore, or tailings, including mine rock, overburden, and others.

Different chemical compositions were assigned to each of these sources. The speciation profiles of ore, tailings, and other sources were determined from the geochemical characterization of drill hole data, while the speciation profile of diesel was determined from California Air Resources Board (CARB) data and the U.S. Environmental Protection Agency (US EPA, 2002). Further details on the air quality model are presented in the Ajax Mine Project – Air Quality Technical Data Report (Stantec 2015a).

Mass Balance Equations

The water quality model was developed using a mass balance approach in Microsoft Excel®, to predict monthly water quality for dissolved parameters at select locations within and downstream of the Project area. This approach to water quality prediction is an accepted method for quantifying expected changes to concentrations of dissolved constituents and is described in detail in Appendix 6.3-C. A simple mass balance equation was used throughout the model to calculate concentrations of dissolved parameters resulting from the mixing of two flows. This equation was applied to all stream nodes (i.e. where water is flowing) in the model and is shown below:

$$C_{New} = \frac{C_A \times Q_A + C_B \times Q_B}{(Q_A + Q_B)}$$

Where C_{New} = mixed concentration (mg/L)
C_A = concentration of stream A (mg/L)
Q_A = flow rate of stream A (m^3/s)
C_B = concentration of stream B (mg/L)
Q_B = flow rate of stream B (m^3/s)

Model nodes in reservoirs were assessed using a modified version of the equation above, which included direct precipitation and evaporation on the stored waterbodies. Reservoir components in the model include the TSF, Upper Pond, Central Pond, Peterson Creek Downstream Pond (PCDP), and Jacko Lake, in addition to the water management ponds (WMPs) located at the TSF south and southeast embankments, West MRSF, South MRSF, and East MRSF. The monthly reservoir concentrations are a function of the volumes and loads associated with storage and inflowing/outflowing components of the system, and are based on the integration of three basic calculations:

1. The monthly reservoir concentrations are equal to the sum of the previous months' stored load and the input loads from the current time step (monthly loading), divided by the previous months' stored volume plus the new incoming volume, minus evaporation.
2. Loads removed from each reservoir are determined using the monthly reservoir concentration multiplied by the volume of water being removed from the reservoir in that time step.
3. The stored load for each monthly time step is calculated as the sum of the previous months' load plus new loads, minus the outgoing loads.

Model Assumptions

Assumptions are required to define the boundaries of predictive water quality models. Assumptions in the form of estimates can be used as inputs to models in lieu of specific data that are not available and can also be used to predict the behavior of a system for which the outcome is uncertain. In cases where model results were significantly affected by assumptions that were made with a low level of certainty, sensitivity case models were prepared to test the extent of the variability of results with respect to a range of reasonable assumptions. For example, the variable climate case sensitivity models were used to define a range of predicted water quality results that could be expected for a given range of climate scenarios that were considered to be within a realistic range. The specific assumptions used in the predictive water quality model are listed in Appendix 6.3-C and the more general assumptions are shown in the following bullet points, to provide context for the water quality model applicability:

- Precipitation and evaporation have no associated chemical loads.
- Mixing for each model component is instantaneous and complete. Thermal stratification and the effects that would result on surface water reservoirs were not modelled.
- Dissolved components remain in solution, with the exception of those parameters for which solubility limits were applied.
- Parameter loads that exceed the solubility limits are assumed to form particulate and settle out of the water column (no longer available in the mass balance model).

- Baseline water quality data that were below the MDL were applied to the model as background concentrations equal to half the detection limit.
- The TSF pond is a fully mixed system.
- The TSF will be covered during Closure and there will be no pond remaining in Post Closure.
- Water in the Open Pit is a flow-through system during Operations when it is actively dewatered (i.e. the concentrations in the pit dewatering are assumed to equal the combined concentration of the Open Pit inflows from all loading sources in any given time-step).
- Dustfall is assumed to contribute to loading in lakes and creeks if deposited directly on it or on a strip of land that extends to 50 m on each side of a watercourse. A sensitivity analysis was conducted to assess predicted concentrations based on an assumption that half the area on each side of a watercourse contributes to loading.
- Dustfall loads are conservatively assumed to be 100% available for each individual parameter was not considered. However, a sensitivity analysis was performed to consider predicted water quality if dustfall was not available as a surface water loading source given the conservative nature of the Base Case model assumption.
- Dustfall accumulates during winter and spring (Dec thru May) and reaches the open water as in May when spring conditions are modelled under average conditions.
- Seepage delays and the percentage of total seepage losses predicted to arrive in the fast, medium, or slow categories were informed by groundwater modelling inputs from BGC.
- Seepage delays between the TSF, SMRSF, WMRSF, and EMRSF and the seepage collection ponds for these facilities were predicted in the groundwater modelling but were not modelled on a delay in the water quality model (conservative assumption).

Model Sensitivity Cases

The Base Case model results were calculated using average monthly climate inputs in combination with median monthly baseline water quality inputs. Sensitivity analyses were conducted in order to assess the ranges of predicted water chemistry resulting from changes to six main groupings of assumptions that included 13 scenarios, which are described below. It is important to understand that sensitivity analyses tend to represent extremes in model input assumptions in order to reliably quantify the sensitivity to variation in the model input assumptions and that the resulting predicted concentrations tend to exceed the expected ranges and are not representative of expected water quality. The results of the sensitivity scenarios modeled and comparison to applicable water quality guidelines are contained in Water Quality Model Report (Appendix 6.3-C),

Sensitivity analyses are conducted in order to assess the differences in predicted water chemistry due to changes to a single model input assumption. A single change doesn't necessarily result in the same variation in downstream concentrations for all parameters modelled and through the assessment of changes to multiple variables it can be determined which parameters are more sensitive to specific assumptions and which are not. It is important to understand that sensitivity analyses tend to represent extremes in model input assumptions in order to reliably quantify the sensitivity to

variation in the model input assumptions and that the resulting predicted concentrations tend to exceed the expected ranges and are not representative of expected water quality.

Thirteen sensitivity cases have been modelled:

- One case based on the historical precipitation record (Variable Climate Case);
- One case based on the quality of the cover material in the MRSFs footprints (Mine Rock Storage Facilities Case);
- Five cases based on the variation of hydrogeologic assumptions (Groundwater Assumptions Cases);
- Three cases based on variation of baseline input chemistry (Baseline Water Quality Inputs Cases);
- Two cases based on dustfall assumptions (Dustfall Assumptions Cases); and
- One case based on the variation of transit times of mine seepage (Seepage Delays Case).

Variable Climate Case

The precipitation inputs to the Base Case water quality model were based on the average monthly temperature and precipitation calculated from the 115-year climate record (1897 through 2011) for the Project. Variable climate case (VCC) water quality predictions were generated by stepping the water quality model through the historic climate record on 5 year increments to evaluate the sensitivity of water quality predictions to climatic variation. Baseline water chemistry loading in the models are calibrated to the average conditions baseline water balance and as a result can be under or over represented in the VCC model. The 95th percentile (P), 75th P, 50th P (median), mean, 25th P, and 5th P monthly results were summarized for the large set of VCC model output data.

Conservative assumptions regarding seepage interactions with groundwater were made for the sake of modelling; however, these assumptions result in some extreme (unrealistic) high and low concentrations in the VCC models and in the Base Case for some parameters. These extremes are due to the influence of seepage, seepage delays, and the associated timing of monthly model precipitation inputs that generate the loading at the sources (MRSFs) and the runoff in the receiving water node. Source loading for wetter than average months is much greater than would be expected, given the range of infiltration considered in the development of the geochemical source terms. In the model it is not uncommon for a higher than average month for source loading (wet month in historical climate record) to reach a receiving water node on a time delay associated with a lower than average receiving water flow month (due to drier conditions in the historic climate record) and the combined model outcome is much higher concentrations than would realistically be expected to occur. Mine source seepage to groundwater is not mixed with local groundwater in mixing cells along the flow pathway, it is dealt with in terms of timing delays, so receiving water loads are equivalent to source loading for the same calendar month for a set time earlier in the model. In reality, groundwater discharge to local creeks would be a combination of small amounts of mine seepage with larger amounts of local groundwater, resulting in a more diffuse loading than is currently modelled and concentrations are not likely to reach those predicted in the upper percentile VCC summary results.

Repetitive spikes in predicted concentrations were predicted in the VCC models due to model input assumptions with respect to timing of the release of dustfall stored in the snowpack through the winter months. This stored dustfall load is timed to be released in May, when freshet conditions are expected in an average year. The transport mechanism for load that accumulates through the winter months to be carried into the creeks is runoff with snow meltwaters and spring rains, resulting in higher loading when flows would also be higher. Historical climate variability accounts for the onset of spring earlier or later than May in some years, but the model timing results in the release of the stored dustfall load independent of these conditions, resulting in predicted concentrations that are much higher than would realistically be expected to occur.

Based on these very conservative factors, the upper and lower percentile summary results of the VCC models are considered on an individual parameter basis and rationale for exclusion of concentrations summarized for the upper percentiles are provided where applicable. Conversely, higher confidence should be placed on the results for parameters that are predicted to remain below applicable guidelines in the VCC models. This higher confidence is because there are no predicted exceedances, despite these ultra-conservative model interactions combined with conservative changes in the model input assumptions.

Mine Rock Storage Facilities Case

Unsaturated flow modelling predictions indicate that 7.6 mm of water infiltrates the engineered closure cover on the MRSFs on an annual basis, which was assigned as the base case value for groundwater recharge (BGC 2015b). MRSF groundwater recharge values evaluated for sensitivity analysis were two times higher than base case values and the sensitivity case was run to assess the effects of mine rock closure cover performance on water quality predictions.

Groundwater Assumptions Cases

The Base Case hydraulic conductivity values used as inputs to the water balance model were obtained from BGC groundwater modelling results (BGC 2015b). Increasing and decreasing the hydraulic conductivity by a factor of 5 should result in an increase/decrease in groundwater flows, and should be reflected in the sensitivity of water quality predictions to changes in hydraulic conductivity. The Base Case TSF conductance used as input to the water balance model was calculated based on groundwater modelling by BGC (2015b). Increasing the TSF conductance by a factor of 10 increases the TSF seepage estimates; this sensitivity assessment was undertaken to assess the sensitivity of the predicted water concentrations to increased TSF seepage. Another Base Case model groundwater assumption is that 20% of the macro flow in the MRSFs reports to the groundwater table and bypasses the downstream water management pond. The sensitivity assessment around this assumption included an increase of 20% in the macro flow bypassing the WMP in order to assess the sensitivity of the water quality predictions to this condition.

Baseline Water Quality Inputs Cases

Base case water quality predictions were generated using median monthly baseline water quality inputs. Baseline monthly inputs were varied to better constrain the potential effects of natural variability in baseline conditions on predicted water quality. Baseline monthly inputs to the model were incorporated at the 95th percentile (P), average (mean), and 5th P. The baseline calibration model was re-calibrated with the data associated with each of these statistics and the results were

used in the corresponding Life of Mine (LOM) water quality models. Baseline water chemistry inputs and calibration results are presented in detail in Appendix 6.3-C, Section 4.4.

Dustfall Assumptions Cases

Dustfall for the base case was determined from the air quality model results at peak Operations during the combined Years 4 and 8 of mining (Stantec 2015a). The two main assumptions for the incorporation of dustfall into the base case of the water quality model are that dustfall is 100% available (soluble) for all the parameters modelled, and that all dustfall that falls within 100 m of a creek (50 m on either side of the creek) reports as loading to the first downstream water quality model node. The sensitivity of the water quality predictions to dustfall assumptions was assessed by assuming that dustfall is not available for all the parameters modelled, and the second sensitivity assessment reduced the area contributing to surface loading by half to within 50 m of the creeks (25 m on either side of the creek).

Seepage Delays Case

Seepage delays were compressed to fit within a shorter model time frame. Base case model delay time frames were obtained from particle tracking from groundwater hydrological modelling and were input to the water quality model as follows:

- Modelled flow lines less than or equal to 20 years were assigned no delay (0 years),
- Modelled flow lines greater than 20 years but less than or equal to 200 years were assigned a 30-year delay,
- Modelled flow lines greater than 200 years were assigned an 80-year delay.
- The sensitivity of the water quality predictions to seepage delays from mine facilities was evaluated on a less compressed time-frame to account for loading along seepage pathways that was closer to those predicted in the groundwater modelling. Seepage delay inputs to the sensitivity cases were adjusted as follows:
  - Modelled flow lines less than or equal to 20 years were assigned a 10-year delay,
  - Modelled flow lines greater than 20 years but less than or equal to 200 years were assigned a 110-year delay,
  - Modelled flow lines greater than 200 years were outside of the range captured in the model.

Model Results

Water quality model results were used to assess changes in water quality as a result of the Project. The model was then used as a tool to assess the effects of mitigation options and to guide the engineering design and water management plan in ways that minimized adverse effects to water quality. The iterative approach to developing the model included inputting mitigation measures developed through changes in mine design and water management. These changes in the Project design, (further discussed in Section 6.3.4.3) have resulted in improvements to the predicted water quality. The final results of the model are considered to represent the residual effects of the Project on Surface Water Quality VC, after the application of mitigation measures.

Results of the predictive water quality model under the Base Case and sensitivity cases are presented in the *Water Quality Model Report* in Appendix 6.3-C; the results presented in the effects assessments are intended to highlight the parameters and reported values that are relevant to the key effects on Surface Water Quality. The Base Case model results have been included in Tables 6.3-8 through Table 6.3-12 with a comparison to the baseline median, 95th P, and maximum concentration data for all of the modelled parameters.

Table 6.3-8. Jacko Lake – Maximum Predicted Base Case Concentrations

		Baseline			Base Case		
Parameters	Units	Median	95th P	Maximum	Operations	Decommissioning and Closure	Post-Closure
Conventional Parameters and Major Ions							
Hardness - Dissolved	mg/L $CaCO_3$	300	333	341	418	421	424
Bromide (Br^-)	mg/L	0.025	0.25	0.25	0.13	0.13	0.13
Chloride (Cl^-)	mg/L	56	62	65	66	66	67
Fluoride (F^-)	mg/L	0.21	0.29	0.34	0.25	0.25	0.25
Sulphate (SO_4^{2-})	mg/L	58	84	86	65	65	66
Calcium (Ca)	mg/L	56	60	61	94	95	96
Magnesium (Mg)	mg/L	40	46	49	45	45	45
Potassium (K)	mg/L	12	14	15	13	13	13
Sodium (Na)	mg/L	36	43	47	41	41	41
Nutrients							
Ammonia	mg/L N	0.083	0.98	1.9	0.098	0.065	0.065
Nitrate	mg/L N	0.013	0.49	0.56	0.19	0.11	0.10
Nitrite	mg/L	0.0028	0.025	0.036	0.0050	0.0049	0.0048
Phosphorus - Dissolved (P)	mg/L	0.085	0.33	0.39	0.096	0.096	0.096
Dissolved Metals							
Aluminum (Al)	mg/L	0.0011	0.0032	0.0093	0.0062	0.0062	0.0058
Antimony (Sb)	mg/L	0.000050	0.00012	0.00013	0.00010	0.000095	0.000092
Arsenic (As)	mg/L	0.0013	0.0014	0.0017	0.0016	0.0017	0.0017
Barium (Ba)	mg/L	0.060	0.074	0.079	0.082	0.082	0.082
Boron (B)	mg/L	0.021	0.025	0.026	0.023	0.023	0.023
Cadmium (Cd)	mg/L	0.0000050	0.0000050	0.000034	0.0000090	0.0000090	0.0000085
Chromium (Cr)	mg/L	0.000050	0.000050	0.00027	0.00046	0.00046	0.00042
Cobalt (Co)	mg/L	0.000050	0.000050	0.000050	0.00022	0.00022	0.00021
Copper (Cu)	mg/L	0.00091	0.0016	0.0022	0.0031	0.0031	0.0030
Iron (Fe)	mg/L	0.0050	0.018	0.023	0.060	0.060	0.059
Lead (Pb)	mg/L	0.000025	0.000025	0.000025	0.000070	0.000071	0.000064
Lithium (Li)	mg/L	0.0057	0.0069	0.0082	0.0064	0.0064	0.0064
Manganese (Mn)	mg/L	0.014	0.11	0.17	0.044	0.044	0.044
Molybdenum (Mo)	mg/L	0.0023	0.0030	0.0035	0.0035	0.0039	0.0044
Nickel (Ni)	mg/L	0.00070	0.00099	0.0015	0.0016	0.0016	0.0016

Parameters	Units	Baseline			Base Case		
		Median	95th P	Maximum	Operations	Decommissioning and Closure	Post-Closure
Selenium (Se)	mg/L	0.00015	0.00043	0.00068	0.00034	0.00035	0.00036
Silicon (Si)		4.1	6.6	7.2	9.6	9.7	9.7
Silver (Ag)	mg/L	0.0000050	0.0000050	0.0000050	0.0000060	0.0000060	0.0000060
Strontium (Sr)	mg/L	0.37	0.43	0.45	0.43	0.44	0.44
Thallium (Tl)	mg/L	0.0000050	0.0000050	0.0000050	0.0000074	0.0000076	0.0000073
Tin (Sn)		0.000050	0.000050	0.000050	0.000071	0.000071	0.000070
Uranium (U)	mg/L	0.0011	0.0012	0.0014	0.0014	0.0015	0.0015
Vanadium (V)	mg/L	0.0020	0.0028	0.0029	0.0031	0.0031	0.0031
Zinc (Zn)	mg/L	0.0012	0.014	0.050	0.0029	0.0019	0.0019

Table 6.3-9. PDCP – Maximum Predicted Base Case Concentrations

Parameters	Units	Baseline			Base Case		
		Median	95th P	Maximum	Operations	Decommissioning and Closure	Post-Closure
Conventional Parameters and Major Ions							
Hardness - Dissolved	mg/L $CaCO_3$	489	642	775	637	736	655
Bromide (Br^-)	mg/L	0.25	0.25	0.25	0.26	0.33	0.29
Chloride (Cl^-)	mg/L	55	71	77	70	66	65
Fluoride (F^-)	mg/L	0.24	0.37	0.44	0.31	0.29	0.29
Sulphate (SO_4^{2-})	mg/L	125	293	442	170	319	269
Calcium (Ca)	mg/L	80	101	123	117	127	119
Magnesium (Mg)	mg/L	71	95	113	84	103	88
Potassium (K)	mg/L	16	20	21	17	20	17
Sodium (Na)	mg/L	54	73	81	61	71	63
Nutrients							
Ammonia	mg/L N	0.035	0.19	0.30	0.091	0.12	0.14
Nitrate	mg/L N	0.058	0.16	0.21	0.23	0.26	0.22
Nitrite	mg/L	0.0050	0.022	0.063	0.0099	0.014	0.017
Phosphorus - Dissolved (P)	mg/L	0.11	0.24	0.77	0.16	0.16	0.14
Dissolved Metals							
Aluminum (Al)	mg/L	0.0018	0.0068	0.012	0.021	0.020	0.019
Antimony (Sb)	mg/L	0.000075	0.00014	0.00017	0.00043	0.00047	0.00058
Arsenic (As)	mg/L	0.0017	0.0025	0.0028	0.0026	0.0034	0.0036
Barium (Ba)	mg/L	0.056	0.072	0.076	0.081	0.090	0.088
Boron (B)	mg/L	0.031	0.036	0.040	0.030	0.045	0.038
Cadmium (Cd)	mg/L	0.0000050	0.000015	0.000033	0.000015	0.000015	0.000014
Chromium (Cr)	mg/L	0.00013	0.00017	0.00019	0.0014	0.0013	0.0013
Cobalt (Co)	mg/L	0.00016	0.00031	0.00037	0.00038	0.00040	0.00039

Parameters	Units	Baseline			Base Case		
		Median	95th P	Maximum	Operations	Decommissioning and Closure	Post-Closure
Copper (Cu)	mg/L	0.0018	0.0032	0.0054	0.0059	0.0060	0.0059
Iron (Fe)	mg/L	0.042	0.11	0.14	0.090	0.093	0.094
Lead (Pb)	mg/L	0.000025	0.00025	0.00025	0.00017	0.00017	0.00016
Lithium (Li)	mg/L	0.0063	0.0079	0.0085	0.0077	0.0086	0.0078
Manganese (Mn)	mg/L	0.080	0.49	0.83	0.11	0.17	0.16
Molybdenum (Mo)	mg/L	0.0099	0.030	0.047	0.014	0.045	0.039
Nickel (Ni)	mg/L	0.0021	0.0025	0.0030	0.0031	0.0031	0.0031
Selenium (Se)	mg/L	0.00020	0.00038	0.00054	0.0016	0.0018	0.0016
Silicon (Si)		7.9	13	15	12	12	12
Silver (Ag)	mg/L	0.0000050	0.0000050	0.0000050	0.0000066	0.0000069	0.0000066
Strontium (Sr)	mg/L	0.65	0.87	0.96	0.80	0.97	0.85
Thallium (Tl)	mg/L	0.0000050	0.0000050	0.0000050	0.000012	0.000012	0.000011
Tin (Sn)		0.000050	0.000050	0.000050	0.00011	0.00011	0.00010
Uranium (U)	mg/L	0.0011	0.0030	0.0035	0.0022	0.0029	0.0026
Vanadium (V)	mg/L	0.0026	0.0033	0.0038	0.0044	0.0057	0.0054
Zinc (Zn)	mg/L	0.0011	0.0060	0.0095	0.0028	0.0027	0.0024

Table 6.3-10. PC02.3 – Maximum Predicted Base Case Concentrations

Parameters	Units	Baseline			Base Case		
		Median	95th P	Maximum	Operations	Decommissioning and Closure	Post-Closure
Conventional Parameters and Major Ions							
Hardness - Dissolved	mg/L $CaCO_3$	489	642	775	689	756	675
Bromide (Br^-)	mg/L	0.25	0.25	0.25	0.29	0.33	0.30
Chloride (Cl^-)	mg/L	55	71	77	70	66	65
Fluoride (F^-)	mg/L	0.24	0.37	0.44	0.31	0.29	0.32
Sulphate (SO_4^{2-})	mg/L	125	293	442	295	358	307
Calcium (Ca)	mg/L	80	101	123	115	126	122
Magnesium (Mg)	mg/L	71	95	113	103	108	91
Potassium (K)	mg/L	16	20	21	20	21	19
Sodium (Na)	mg/L	54	73	81	83	81	69
Nutrients							
Ammonia	mg/L N	0.035	0.19	0.30	0.17	0.20	0.18
Nitrate	mg/L N	0.058	0.16	0.21	0.23	0.25	0.25
Nitrite	mg/L	0.0050	0.022	0.063	0.010	0.013	0.016
Phosphorus - Dissolved (P)	mg/L	0.11	0.24	0.77	0.17	0.17	0.14
Dissolved Metals							
Aluminum (Al)	mg/L	0.0018	0.0068	0.012	0.019	0.019	0.018

Parameters	Units	Baseline			Base Case		
		Median	95th P	Maximum	Operations	Decommissioning and Closure	Post-Closure
Antimony (Sb)	mg/L	0.000075	0.00014	0.00017	0.00047	0.00054	0.0010
Arsenic (As)	mg/L	0.0017	0.0025	0.0028	0.0031	0.0042	0.0047
Barium (Ba)	mg/L	0.056	0.072	0.076	0.079	0.089	0.086
Boron (B)	mg/L	0.031	0.036	0.040	0.029	0.044	0.040
Cadmium (Cd)	mg/L	0.0000050	0.000015	0.000033	0.000014	0.000013	0.000013
Chromium (Cr)	mg/L	0.00013	0.00017	0.00019	0.0013	0.0012	0.0012
Cobalt (Co)	mg/L	0.00016	0.00031	0.00037	0.00037	0.00037	0.00074
Copper (Cu)	mg/L	0.0018	0.0032	0.0054	0.0056	0.0055	0.0054
Iron (Fe)	mg/L	0.042	0.11	0.14	0.090	0.091	0.55
Lead (Pb)	mg/L	0.000025	0.00025	0.00025	0.00016	0.00015	0.00015
Lithium (Li)	mg/L	0.0063	0.0079	0.0085	0.0076	0.0082	0.0088
Manganese (Mn)	mg/L	0.080	0.49	0.83	0.11	0.16	0.69
Molybdenum (Mo)	mg/L	0.0099	0.030	0.047	0.014	0.043	0.040
Nickel (Ni)	mg/L	0.0021	0.0025	0.0030	0.0030	0.0031	0.0030
Selenium (Se)	mg/L	0.00020	0.00038	0.00054	0.0016	0.0017	0.0019
Silicon (Si)		7.9	13	15	12	12	13
Silver (Ag)	mg/L	0.0000050	0.0000050	0.0000050	0.0000069	0.0000071	0.0000068
Strontium (Sr)	mg/L	0.65	0.87	0.96	0.88	0.99	0.89
Thallium (Tl)	mg/L	0.0000050	0.0000050	0.0000050	0.000011	0.000014	0.000014
Tin (Sn)		0.000050	0.000050	0.000050	0.00010	0.000099	0.000098
Uranium (U)	mg/L	0.0011	0.0030	0.0035	0.0022	0.0028	0.0032
Vanadium (V)	mg/L	0.0026	0.0033	0.0038	0.0043	0.0056	0.0060
Zinc (Zn)	mg/L	0.0011	0.0060	0.0095	0.0028	0.0028	0.0028

Table 6.3-11. PC02 – Maximum Predicted Base Case Concentrations

Parameters	Units	Baseline			Base Case		
		Median	95th P	Maximum	Operations	Decommissioning and Closure	Post-Closure
Conventional Parameters and Major Ions							
Hardness - Dissolved	mg/L $CaCO_3$	711	914	1,040	1,056	1,027	1,029
Bromide (Br^-)	mg/L	0.25	0.50	0.50	0.82	0.80	0.79
Chloride (Cl^-)	mg/L	106	133	142	182	176	175
Fluoride (F^-)	mg/L	0.21	0.44	0.67	0.27	0.27	0.27
Sulphate (SO_4^{2-})	mg/L	359	535	775	696	667	658
Calcium (Ca)	mg/L	111	147	149	159	156	158
Magnesium (Mg)	mg/L	105	133	163	161	156	155
Potassium (K)	mg/L	19	23	27	30	29	29
Sodium (Na)	mg/L	93	117	154	166	161	159

Parameters	Units	Baseline			Base Case		
		Median	95th P	Maximum	Operations	Decommissioning and Closure	Post-Closure
Nutrients							
Ammonia	mg/L N	0.020	0.042	0.27	0.093	0.11	0.12
Nitrate	mg/L N	0.18	1.00	1.2	1.2	1.2	1.2
Nitrite	mg/L	0.0050	0.030	0.035	0.024	0.023	0.024
Phosphorus - Dissolved (P)	mg/L	0.065	0.18	0.50	0.16	0.16	0.16
Dissolved Metals							
Aluminum (Al)	mg/L	0.0013	0.0053	0.015	0.0084	0.0080	0.0063
Antimony (Sb)	mg/L	0.000050	0.00014	0.00016	0.00033	0.00044	0.00094
Arsenic (As)	mg/L	0.0018	0.0030	0.0032	0.0031	0.0039	0.0045
Barium (Ba)	mg/L	0.054	0.064	0.074	0.073	0.080	0.079
Boron (B)	mg/L	0.057	0.091	0.098	0.16	0.15	0.15
Cadmium (Cd)	mg/L	0.0000050	0.000048	0.00020	0.000019	0.000018	0.000016
Chromium (Cr)	mg/L	0.00012	0.00021	0.00029	0.00067	0.00067	0.00048
Cobalt (Co)	mg/L	0.00018	0.00027	0.00028	0.00032	0.00032	0.00045
Copper (Cu)	mg/L	0.0021	0.0031	0.0049	0.0046	0.0046	0.0039
Iron (Fe)	mg/L	0.033	0.061	0.11	0.057	0.062	0.16
Lead (Pb)	mg/L	0.000025	0.00017	0.00025	0.000090	0.000087	0.000070
Lithium (Li)	mg/L	0.0085	0.011	0.011	0.013	0.013	0.013
Manganese (Mn)	mg/L	0.084	0.20	0.25	0.063	0.088	0.21
Molybdenum (Mo)	mg/L	0.011	0.015	0.015	0.014	0.035	0.035
Nickel (Ni)	mg/L	0.0030	0.0044	0.0058	0.0068	0.0066	0.0066
Selenium (Se)	mg/L	0.00043	0.0024	0.0029	0.0036	0.0033	0.0032
Silicon (Si)		8.3	10	11	11	11	11
Silver (Ag)	mg/L	0.0000050	0.0000050	0.0000050	0.0000061	0.0000065	0.0000063
Strontium (Sr)	mg/L	1.0	1.3	1.5	1.5	1.5	1.5
Thallium (Tl)	mg/L	0.0000050	0.0000050	0.000025	0.0000083	0.000011	0.000012
Tin (Sn)		0.000050	0.000050	0.000050	0.000077	0.000079	0.000072
Uranium (U)	mg/L	0.0025	0.0035	0.0044	0.0050	0.0050	0.0055
Vanadium (V)	mg/L	0.0029	0.0039	0.0047	0.0050	0.0058	0.0063
Zinc (Zn)	mg/L	0.0012	0.0037	0.0050	0.0035	0.0029	0.0029

Table 6.3-12. Humphrey Creek – Maximum Predicted Base Case Concentrations

Parameters	Units	Baseline			Base Case		
		Median	95th P	Maximum	Operations	Decommissioning and Closure	Post-Closure
Conventional Parameters and Major Ions							
Hardness - Dissolved	mg/L $CaCO_3$	641	799	850	770	774	851
Bromide (Br^-)	mg/L	0.25	0.25	0.25	0.25	0.29	0.30

Parameters	Units	Baseline			Base Case		
		Median	95th P	Maximum	Operations	Decommissioning and Closure	Post-Closure
Chloride (Cl^-)	mg/L	33	48	49	43	47	43
Fluoride (F^-)	mg/L	0.27	0.37	0.40	0.28	0.29	0.29
Sulphate (SO_4^{2-})	mg/L	235	409	478	380	382	529
Calcium (Ca)	mg/L	100	124	132	119	124	141
Magnesium (Mg)	mg/L	96	119	126	115	116	121
Potassium (K)	mg/L	15	17	18	15	16	19
Sodium (Na)	mg/L	63	66	69	65	65	79
Nutrients							
Ammonia	mg/L N	0.011	0.020	0.024	0.018	0.13	0.48
Nitrate	mg/L N	0.025	0.14	0.18	0.13	0.58	0.77
Nitrite	mg/L	0.0050	0.0050	0.0050	0.0049	0.026	0.089
Phosphorus - Dissolved (P)	mg/L	0.092	0.15	0.16	0.13	0.13	0.12
Dissolved Metals							
Aluminum (Al)	mg/L	0.0017	0.0022	0.0026	0.049	0.047	0.0023
Antimony (Sb)	mg/L	0.00021	0.00024	0.00026	0.00028	0.0010	0.0010
Arsenic (As)	mg/L	0.0033	0.0037	0.0038	0.0035	0.0047	0.0043
Barium (Ba)	mg/L	0.061	0.068	0.069	0.065	0.066	0.065
Boron (B)	mg/L	0.029	0.038	0.039	0.033	0.052	0.075
Cadmium (Cd)	mg/L	0.0000050	0.0000050	0.0000050	0.000024	0.000023	0.000010
Chromium (Cr)	mg/L	0.00013	0.00027	0.00044	0.0030	0.0029	0.00067
Cobalt (Co)	mg/L	0.000050	0.00012	0.00013	0.00056	0.00054	0.00051
Copper (Cu)	mg/L	0.0064	0.0073	0.0074	0.012	0.012	0.0069
Iron (Fe)	mg/L	0.0050	0.016	0.028	0.11	0.11	0.28
Lead (Pb)	mg/L	0.000025	0.000025	0.000025	0.00035	0.00034	0.000033
Lithium (Li)	mg/L	0.0071	0.0079	0.0080	0.0075	0.0084	0.012
Manganese (Mn)	mg/L	0.010	0.024	0.025	0.026	0.026	0.35
Molybdenum (Mo)	mg/L	0.022	0.025	0.025	0.024	0.097	0.10
Nickel (Ni)	mg/L	0.0013	0.0016	0.0017	0.0042	0.0040	0.0027
Selenium (Se)	mg/L	0.0021	0.0053	0.0062	0.0048	0.0052	0.0070
Silicon (Si)		8.7	10	10	10.0	9.9	13
Silver (Ag)	mg/L	0.0000050	0.0000050	0.0000050	0.0000066	0.0000070	0.0000064
Strontium (Sr)	mg/L	0.89	1.1	1.2	0.99	1.1	1.3
Thallium (Tl)	mg/L	0.0000050	0.0000050	0.0000050	0.000017	0.000018	0.000012
Tin (Sn)		0.000050	0.000050	0.000050	0.00016	0.00016	0.000075
Uranium (U)	mg/L	0.0036	0.0046	0.0047	0.0045	0.0045	0.0054
Vanadium (V)	mg/L	0.0051	0.0057	0.0059	0.0069	0.0069	0.0049
Zinc (Zn)	mg/L	0.00050	0.0013	0.0018	0.0015	0.0035	0.0055

For ease of review, the parameters that were modelled have been grouped into three categories based on their predicted potential for adverse effects.

Category 1 Parameters are defined as parameters for which BC water quality guideline exceedances were predicted at multiple nodes, during multiple phases, under the Base Case water quality model scenario. The potential effects of the Project on the concentrations of these parameters are considered in this section and the residual adverse effects are assessed in Section 6.3.5.

Category 2 Parameters are those that are predicted to exceed an applicable BC water quality guideline in the Base Case at only one node and during a single mine phase, or those that are predicted to exceed a guideline under a sensitivity case but not in the Base Case. The discussion of Category 2 parameters in this section is focused on parameters for which effects are predicted under less probable circumstances. The assessment of potential effects to these parameters is discussed in this section; however, these parameters are not carried forward to the assessment of residual effects because of the low probability and limited extent of the predicted concentration changes as a result of the Project.

Category 3 Parameters includes all parameters that were modelled, but do not fit within the definitions of Category 1 or Category 2; and they are not predicted to exceed any guidelines.

The parameters identified for discussion in this section are limited to Category 1 and Category 2 parameters; predicted changes in concentrations of Category 3 parameter results are presented in the *Water Quality Model Report* (Appendix 6.3-C), but are not carried forward in the effects assessment because they either have no water quality guidelines or have not been predicted to exceed any guidelines. Each modelled parameter and predicted category is listed in Table 6.3-13.

Category 1 Parameters

Parameters included in Category 1 are those for which concentrations predicted in the Base Case water quality model exceeded guidelines at multiple nodes, during multiple mine phases and include sulphate, chloride, copper, molybdenum, and selenium. The parameters discussed in this section are considered to have a high potential for adverse effects due to the Project and are carried forward in the assessment of residual effects. The order of discussion is not intended imply relative importance, but are listed similar to how they are presented in Table 6.3-13 in the following order: major ions, nutrients, and dissolved metals.

Time-series graphs of predicted Base Case concentrations for the Category 1 parameters are presented for one year periods through the progression of the project development. All downstream sites are presented on the same graphs in order to compare concentrations between sites. The baseline concentrations have not been included on these graphs to prevent confusion; however, baseline concentrations are presented on the time-series graphs for each parameter in the *Water Quality Model Report* (Appendix 6.3-C). Time-series graphs for all of the sensitivity cases are also presented in the appendices to the *Water Quality Model Report* (Appendix 6.3-C).

Table 6.3-13. Modelled Parameters and Assigned Categories

Parameter	Parameter Category			Parameter	Parameter Category		
	1	2	3		1	2	3
Physical Parameters				**Dissolved Metals** (*cont'd*)			
Hardness			x	Cu	x		
Alkalinity			x	Fe		x	
Major Ions				Hg			x
SO_4	x			K			x
Cl	x			Li			x
F		x		Mg			x
Br			x	Mn			x
Nutrients				Mo	x		
Ammonia		x		Na			x
Nitrate		x		Ni			x
Dissolved Metals				P			x
Ag			x	Pb			x
Al		x		Sb		x	
As		x		Se	x		
B			x	Si			x
Ba			x	Sr			x
Be			x	Tl			x
Ca			x	U		x	
Cd			x	V			x
Co		x		Zn			x
Cr		x					

Note: Category 1 and Category 2 parameters are presented and discussed in the effects assessment. Please refer to Appendix 6.3-B for information Category 3 parameters.

Chloride – Major Ion

Modelled chloride concentrations are similar to baseline concentrations at all of receiving water model nodes, and predicted concentrations are not greatly affected by mine loading sources. Modelled chloride concentrations at Jacko Lake, PCDP, PC02.3, and Humphrey Creek remain fairly constant throughout all phases of the Project, with only a slight increase in May for Jacko Lake, PCDP, and PC02.3, and in June for Humphrey Creek during all mine phases. Baseline chloride concentrations at PC02 are higher than at all the other nodes, as are modelled concentrations, and are predicted to exceed the BCWQG-30 D (150 mg/L) seasonally under lower flow conditions during all phases of the model. Highest chloride concentrations are predicted during the Operation phase at PC02, due to incremental loading from mine site runoff and seepage.

Unlike the other water quality nodes, peak chloride concentrations in PC02 usually appear in September and remain elevated through February, and steadily decrease from March through June

during all Project phases. Higher chloride concentrations in PC02 are attributed to proximity to Highway 5A, where road salting activities would be common practice for winter conditions. Higher baseline sodium concentrations were also observed at PC02 than at the other nodes, with seasonality identical to that of chloride, which further supports the understanding that chloride, although not naturally elevated, is a background source. Modelled chloride concentrations for specific annual time-frames are provided on Figure 6.3-4.

A water quality benchmark (WQB) protective of the most sensitive aquatic life was developed because of the predicted chloride concentrations exceeded the BCWQG-30 D at PC02. The WQB of 388 mg/L was developed for chloride specific to conditions in the Project area, which is protective of the majority of aquatic biota including rainbow trout (Stantec 2015b). No predicted chloride concentrations exceed the WQB at any node for the base case model. The VCC model results were the only that exceeded the WQB, with seasonal peak concentrations at PC02 up to 600 mg/L in May, predicted concentrations for all other months remained below the WQB.

The range of predicted chloride concentrations on a monthly basis is fairly uniform at all water quality nodes for all sensitivity cases, though in PC02.3 concentration drops are observed in June and September, which are more pronounced for the lower VCC percentiles (5th P and 25th P) and likely due to unseasonable wet weather for those months in the climate history. Chloride is also sensitive to variation in the baseline inputs to the model, although to a lesser degree in Humphrey Creek. Chloride predictions did not vary much from Base Case results for sensitivity models related to groundwater assumptions, dustfall assumptions, and seepage delay assumptions, confirming that chloride loading in the models is not related to mine sources. The annual range in predicted chloride concentrations is greatest during Operations in PC02.

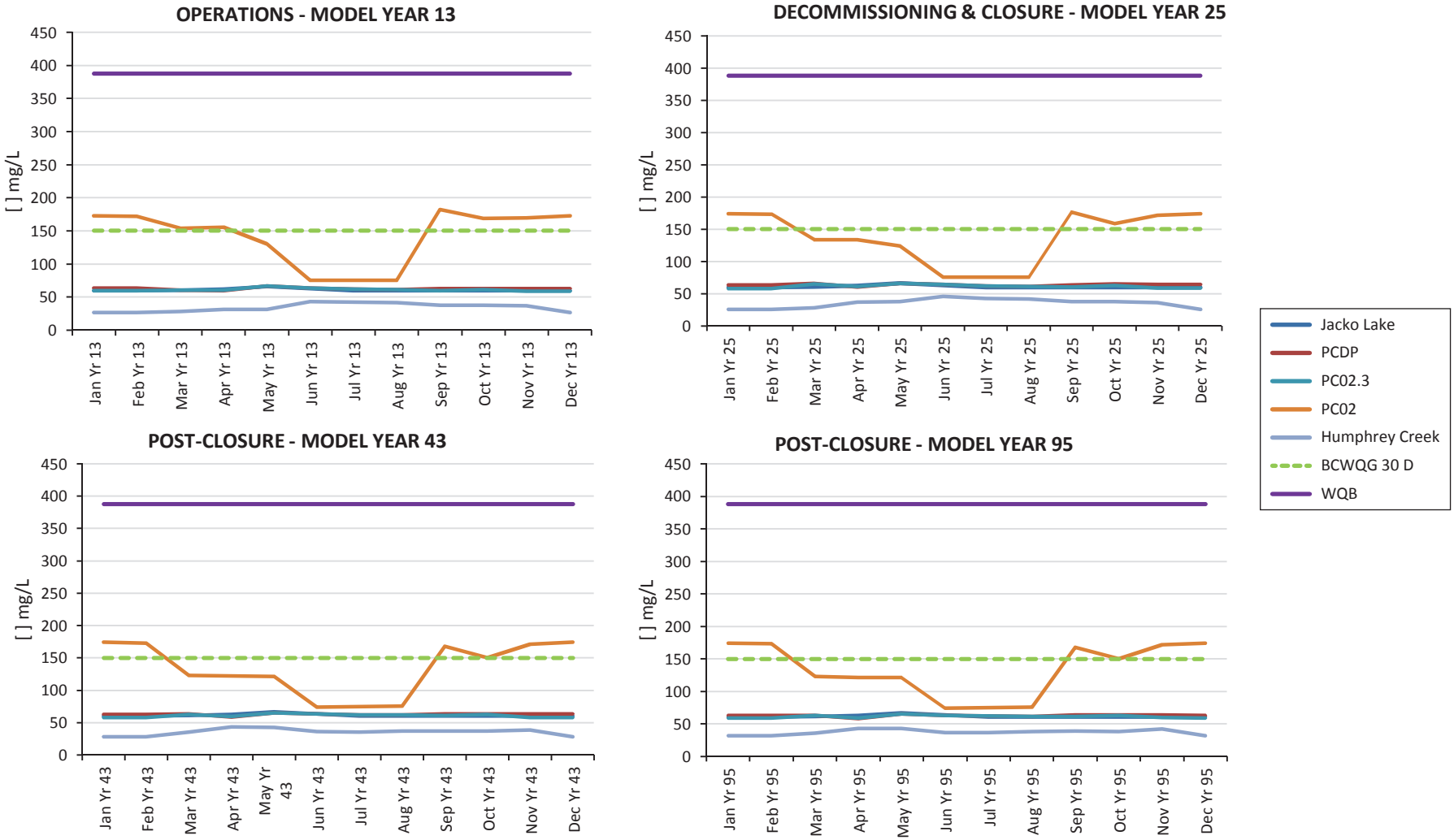
Sulphate – Major Ion

The lowest receiving water sulphate concentrations are predicted for Jacko Lake and seasonality is not emphasized at this model node. Highest receiving water sulphate concentrations are predicted for Peterson Creek model node PC02, with maximum concentrations at this site predicted for Construction and early Operations, during the filling of the PCDP due to slight flow reductions and greater influence from higher concentration groundwater sources. Baseline sulphate concentrations were higher at PC02 compared to upstream locations and the seasonality in sulphate concentrations is indicative of loading primarily due to groundwater baseflow contributions, with higher concentrations measured under low flow conditions. Predicted sulphate ranges are fairly constant at all model nodes, with slight increases in concentration upon arrival of delayed seepage loads, which is most emphasized in Humphrey Creek. The seasonality in predicted sulphate concentrations is different for the PCDP and the downstream site PC02.3 compared to Humphrey Creek and PC02; sulphate concentrations at the PCDP and PC02.3 are lower through the winter months with highest concentrations predicted from March through May, whereas higher concentrations are predicted through the low flow months at PC02 and Humphrey Creek; this discrepancy is because the PCDP is a reservoir and not dominated by the influence of groundwater inflows during low flow periods and outflow from the PCDP has a moderating influence on predicted low flow concentrations at PC02.3, whereas Humphrey Creek and the Peterson Creek site PC02 are subject to greater extremes.

Figure 6.3-4

Ajax Project Surface Water Quality
Chloride - Predicted Seasonality in Peterson Creek Watershed - Base Case

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NOTES:

1. MODEL RESULTS DISPLAYED FOR DISSOLVED CONCENTRATIONS.
2. BASE CASE - MEDIAN MONTHLY BASELINE WATER QUALITY AND AVERAGE MONTHLY WATER BALANCE MODEL INPUTS.
3. HARDNESS DEPENDENT GUIDELINES HAVE BEEN CALCULATED USING BASELINE MONTHLY HARDNESS.
4. BRITISH COLUMBIA APPROVED AND WORKING WATER QUALITY GUIDELINES (BCWQG): FRESH WATER AQUATIC LIFE (BCWQG 30 D AND BCWQG MAX) AND WILDLIFE (BCWQG WILDLIFE); LOWEST APPLICABLE GUIDELINES LISTED ON GRAPHS. SOME GUIDELINES MAY BE EXCLUDED.
5. WATER QUALITY BENCHMARK (WQB).

Predicted Base Case sulphate concentrations are below the SBEB at all receiving water model nodes, with the exception of PC02. Predicted Base Case sulphate concentrations seasonally exceed the 429 mg/L SBEB at PC02 in May of each year in Closure and Post Closure, though predicted Base Case concentrations never exceed the baseline monthly 95th P concentration (736 mg/L) in May (based on 95th P concentration for PC02 for the combined seasonally representative dataset for April and May) and are therefore assumed to be within the range of natural variability for that month. Humphrey Creek is not identified as a fish-bearing stream and the higher SBEB (730 mg/L) would be applicable to sulphate concentrations in this creek; Base Case sulphate concentrations in Humphrey Creek are not been predicted to exceed the SBEB. Modelled sulphate concentrations for specific annual time-frames are provided on Figure 6.3-5.

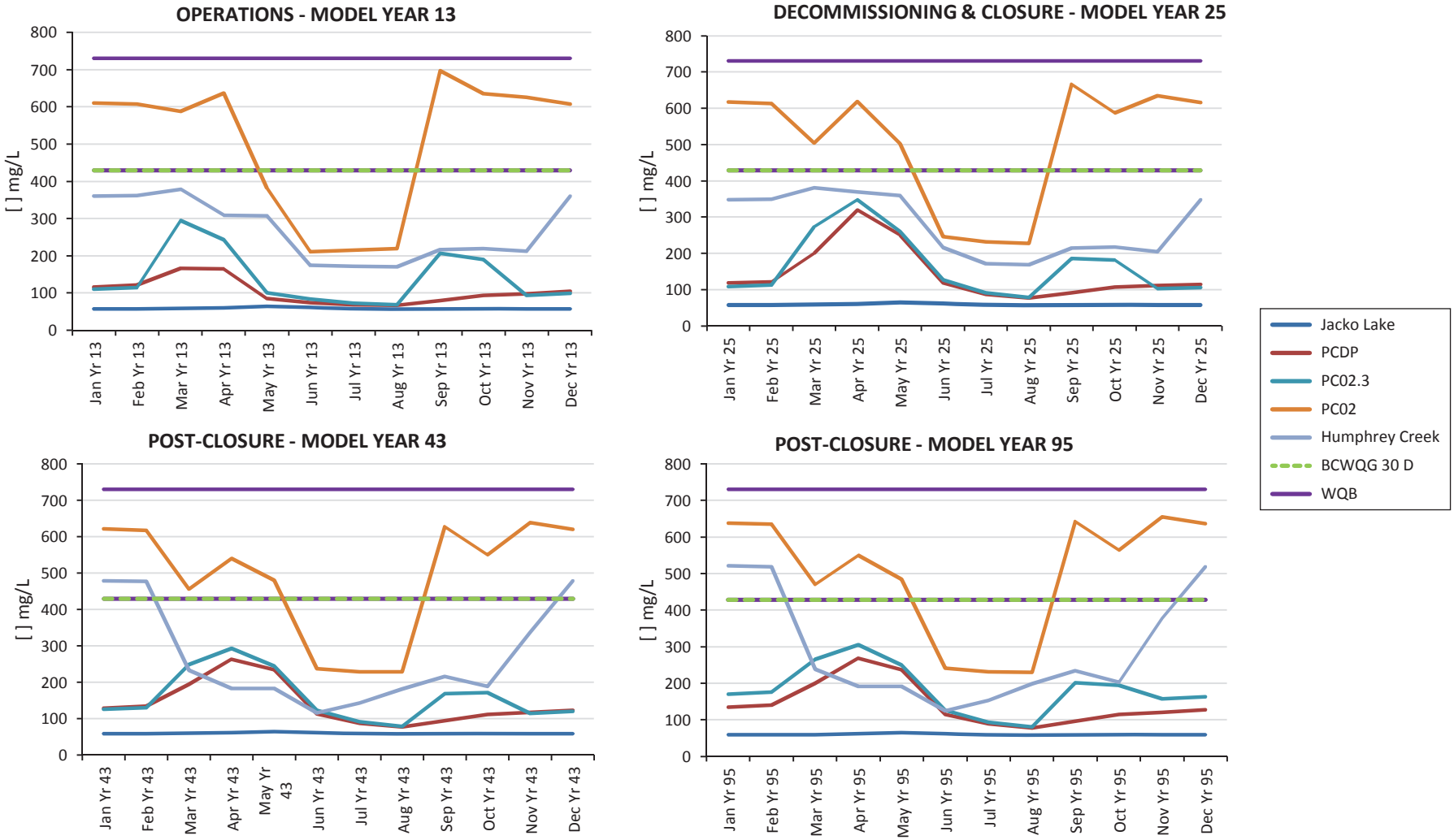
Highest sulphate concentrations at most nodes were predicted for the VCC models; the exceptions being the Jacko Lake model node for all mine phases and the Humphrey Creek model node during Operations and Closure. Jacko Lake predicted sulphate concentrations are most sensitive to variation in baseline inputs, resulting in the highest predicted concentrations during Operations and Closure, though in Post Closure, the highest predicted concentrations resulted from the sensitivity modelling for higher hydraulic conductivity. Highest predicted sulphate concentrations for Humphrey Creek during Operations and Closure resulted from the baseline sensitivity case modelling but transitioned to VCC model results in Post Closure, due to the combined effect of variation in climate inputs with the arrival of loads associated with long-delay seepage pathways. Similar to all other parameters that are predicted to be loaded through seepage pathways from the MRSFs, higher VCC model results are predominantly due to the influence of seepage, seepage delays, and the associated timing of monthly model precipitation inputs that generate the loading at the sources (MRSFs) and the runoff in the receiving water node. Source loading for wetter than average months is much greater than would be expected, given the range of infiltration considered in the development of the geochemical source terms. In the model it is not uncommon for a higher than average month for source loading (wet month in historical climate record) to reach a Peterson Creek receiving water node on a time delay associated with a lower than average receiving water flow month (due to drier conditions in the historic climate record) and the combined model outcome results in much higher predicted concentrations than would realistically be expected. Conservative assumptions regarding seepage interactions with groundwater were made. Mine source seepage to groundwater was modelled in such a way that receiving water loads are equivalent to source loading for the same calendar month for a set time earlier in the model. In reality, groundwater discharge to local creeks would be a combination of small amounts of mine seepage with larger amounts of local groundwater, resulting in a more diffuse loading than is currently modelled and concentrations are not likely to reach those predicted in the upper percentile VCC summary results. Dustfall contributions to sulphate loading are proportionally very low at all nodes and the sensitivity model results for dustfall assumptions were similar to Base Case results.

As mentioned previously, sulphate is naturally elevated in the project area and as a result is sensitive to variation in the baseline inputs to the model, especially 95th P baseline inputs. Sulphate predictions are not as sensitive to other types of assumptions, with the exception of higher hydraulic conductivity for groundwater. In all cases, the annual range in predicted parameter concentrations is greatest at PC02, particularly during Operations.

Figure 6.3-5

Ajax Project Surface Water Quality
Sulphate- Predicted Seasonality in Peterson Creek Watershed - Base Case

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NOTES:

1. MODEL RESULTS DISPLAYED FOR DISSOLVED CONCENTRATIONS.
2. BASE CASE - MEDIAN MONTHLY BASELINE WATER QUALITY AND AVERAGE MONTHLY WATER BALANCE MODEL INPUTS.
3. HARDNESS DEPENDENT GUIDELINES HAVE BEEN CALCULATED USING BASELINE MONTHLY HARDNESS.
4. BRITISH COLUMBIA APPROVED AND WORKING WATER QUALITY GUIDELINES (BCWQG): FRESH WATER AQUATIC LIFE (BCWQG 30 D AND BCWQG MAX) AND WILDLIFE (BCWQG WILDLIFE); LOWEST APPLICABLE GUIDELINES LISTED ON GRAPHS. SOME GUIDELINES MAY BE EXCLUDED.
5. SCIENCE BASED ENVIRONMENTAL BENCHMARK (SBEB - WQB); HIGHER SBEB (730 mg/L) FOR PERIODS OF YEAR WHEN EARLY LIFE STAGES OF FISH ARE ABSENT FROM WATER COURSE (TYPICALLY FROM JULY THROUGH APRIL).

Copper - Metal

Baseline copper concentrations in Peterson Creek tended to increase slightly with distance downstream in the watershed and seasonal variation was evident with concentrations tending to increase between May and June or July and then decreasing again from July through October. This seasonal pattern suggests that copper loading under the current site conditions is typically associated with increased surface runoff in response to spring freshet. Highest baseline concentrations were reported for samples collected from Humphrey Creek and although these samples didn't exceed the BCWQG-30 D, they often exceeded the Canadian Environmental Quality Guidelines for the protection of aquatic life (CEQG-PAL).

The copper aquatic life guidelines are hardness dependent and surface waters in the project area are hard to very hard, resulting in higher calculated guideline values.

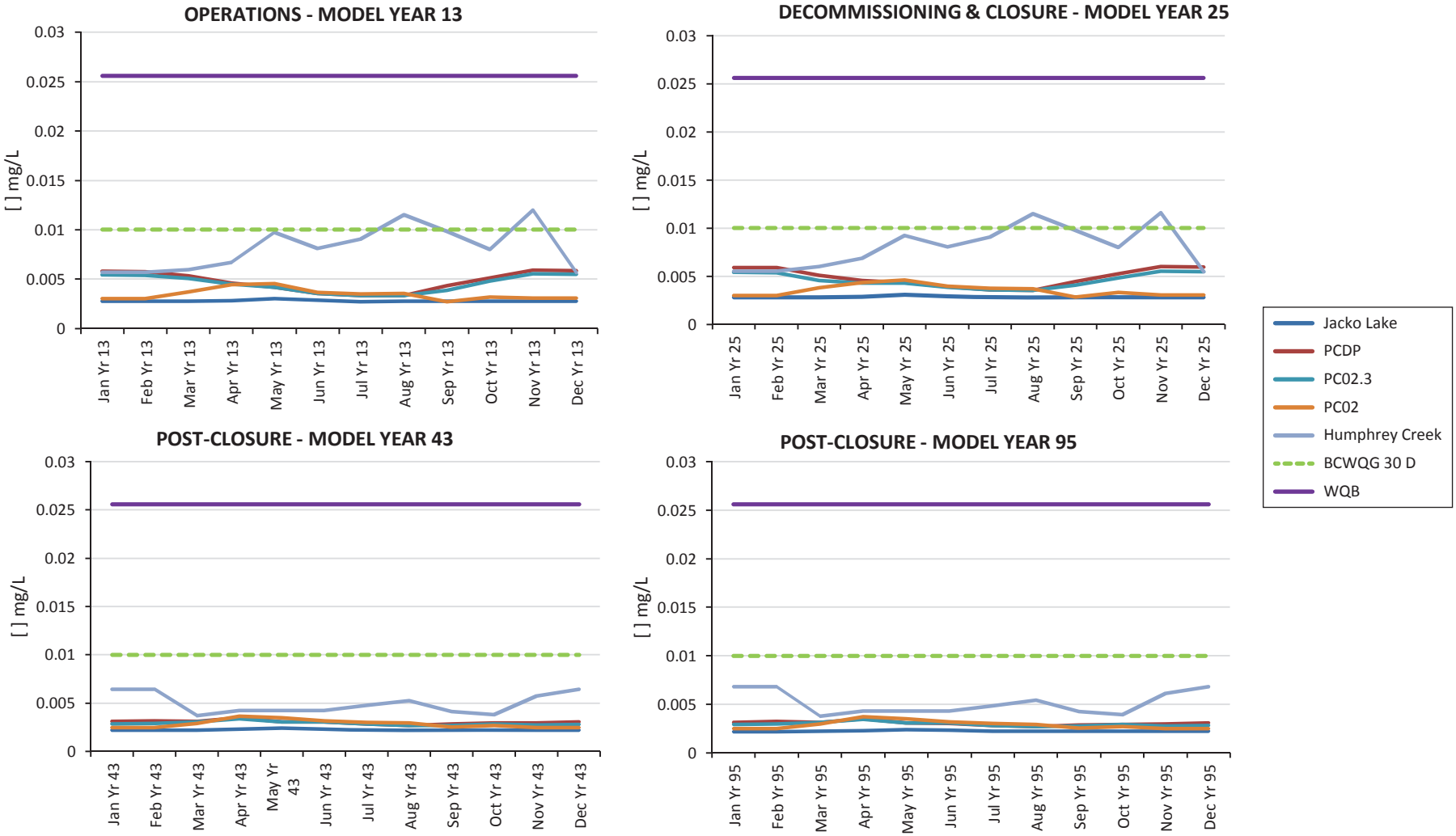
Predicted copper concentrations are affected by dustfall loading from the MRSF and TSF. Predicted copper concentrations decrease in Post Closure when the TSF and MRSFs are reclaimed and the sources of dustfall are no longer exposed. Dustfall that is deposited in the winter months (December through April) is accumulated in the model, based on the assumption that it is held up in the snowpack, and is made available at the nearest surface water quality model node in May in association with the average timing of spring freshet and ice break-up on Jacko Lake. The seasonality in predicted copper concentrations is affected by this load accumulation, with an increase in concentrations in May at all nodes in Operations and Closure, though maximum concentrations are not predicted in May at any node except PC02 during these mine phases. Base Case copper concentrations are highest in Humphrey Creek in Operations and Closure as this creek is most affected by the dustfall deposition due to proximity to the loading sources (TSF and SMRSF) and due to the natural low flow volumes in this creek. The highest copper concentrations are predicted for Humphrey Creek in Post Closure as well, but due to seepage loading from the SMRSF, resulting in higher concentrations in the low flow winter months compared to all other receiving water quality model nodes. Modelled copper concentrations for specific annual time-frames are provided on Figure 6.3-6.

A WQB protective of the most sensitive aquatic biota was derived for copper in order to effectively assess the effects of the predicted concentrations for this parameter in Humphrey Creek. Since the hardness dependent BCWQG-30 D derived for copper does not account for the effects of other parameters (pH, dissolved organic carbon) on copper toxicity, the WQB was developed using a biotic ligand model (BLM), which accounts for the effects of site specific water chemistry on copper toxicity and bioavailability. Based on the results of this model, a WQB of 0.0256 mg/L was determined for copper in the Project area, which is protective of sensitive species such as water fleas, Chinook salmon, and rainbow trout (Stantec 2015b). No Base Case copper concentrations are predicted to exceed the WQB in any receiving water node.

Figure 6.3-6

Ajax Project Surface Water Quality
Copper - Predicted Seasonality in Peterson Creek Watershed - Base Case

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NOTES:

1. MODEL RESULTS DISPLAYED FOR DISSOLVED CONCENTRATIONS.
2. BASE CASE - MEDIAN MONTHLY BASELINE WATER QUALITY AND AVERAGE MONTHLY WATER BALANCE MODEL INPUTS.
3. HARDNESS DEPENDENT GUIDELINES HAVE BEEN CALCULATED USING BASELINE MONTHLY HARDNESS.
4. BRITISH COLUMBIA APPROVED AND WORKING WATER QUALITY GUIDELINES (BCWQG): FRESH WATER AQUATIC LIFE (BCWQG 30 D AND BCWQG MAX) AND WILDLIFE (BCWQG WILDLIFE); LOWEST APPLICABLE GUIDELINES LISTED ON GRAPHS. SOME GUIDELINES MAY BE EXCLUDED.
5. WATER QUALITY BENCHMARK (WQB).

With the exception of Humphrey Creek, all predicted copper concentrations in the sensitivity analyses were below the WQB. The 95th P summary VCC model results exceed the WQB in almost every May during Operations and Closure in Humphrey Creek. This repetitive spike in the model results is due to model input assumptions with respect to timing of the release of dustfall stored in the snowpack through the winter months combined with lower than average May flows in Humphrey Creek due to lower flow spring conditions based on the historical climate record for the Project that could result from a lighter snowpack, longer drawn out spring freshet periods, whereby peak flows tend to be lower and extend over two months (April/May or May/June), or variation in the onset of freshet conditions. The deposition is the same in all models and lower flows in Humphrey Creek in May results in higher than expected chromium concentrations. Dustfall deposited along the creeks is conservatively assumed to be available from a 100 m corridor (50 m on both sides) and the transport mechanism for load that accumulates through the winter months to be carried into the creeks is runoff with snow meltwaters and spring rains, resulting in higher loading when flows would also be higher. Predicted model copper concentrations during Post Closure were always below the WQB and only once exceeded the BCWQG-30 D (at PC02.3 in model year 84). Predicted copper concentrations on a monthly basis have a fairly uniform range in all model nodes and for all sensitivity analyses, though the range in Humphrey Creek in Operations, Closure, and early Post Closure is larger than in the other nodes for the VCC. Like chromium, copper concentrations are sensitive to the variation in the baseline inputs to the model, and are less sensitive to other types of assumptions.

Dustfall is an important source of copper loading in Operations to PCDP and Humphrey Creek; however, natural catchment contributions are the primary loading source at all downstream model node in all mine phases.

Molybdenum - Metal

Seasonal and spatial trends in baseline molybdenum concentrations are evident in the Peterson Creek watershed. Seasonally, molybdenum concentrations were typically highest in March, were sustained at comparable but slightly lower concentrations for a couple of months and then decreased quickly to lower concentrations that were sustained through the fall and winter months. Spatially, molybdenum baseline concentrations were highest at PC03 through the lower flow months and through freshet and steadily decreased with distance downstream. However, molybdenum concentrations at PC03 were generally lower than the downstream sites from late May through October. Humphrey Creek molybdenum concentrations were also higher in March and the following months, but the concentrations in this creek were higher under low flow conditions than in Peterson Creek, indicating that molybdenum loading from surface runoff and groundwater baseflow contributions in Humphrey Creek is similar. Samples from PC03, collected in March through May, typically exceeded BCWQG-Wildlife and BCWQG-Livestock (0.05 mg/L) but remained well below the 1 mg/L BCWQG-30 D (aquatic life).

Predicted molybdenum concentrations are affected by seepage from the TSF and MRSFs and due to seepage delay assumptions, the majority of the seepage loads from infiltration through the un-reclaimed (Operations) MRSFs to Peterson Creek and Humphrey Creek affect water quality in Closure and Post Closure, resulting in higher predicted concentrations in these later mine phases. Highest Base Case concentrations are predicted for Humphrey Creek, though during Operations, the

predicted concentrations are similar to baseline concentrations. The seasonality is similar for all of the Peterson Creek water quality nodes, with slightly higher concentrations predicted in April of each year and lowest in August. Seasonality in Humphrey Creek predicted molybdenum concentrations differs between Closure and Post Closure, with higher concentrations through the winter months that are sustained by seepage from the SMRSF and a sharp drop in concentration in March due to increase runoff to the Humphrey Creek catchment from the reclaimed surface of the TSF. Modelled molybdenum concentrations for specific annual time-frames are provided on Figure 6.3-7.

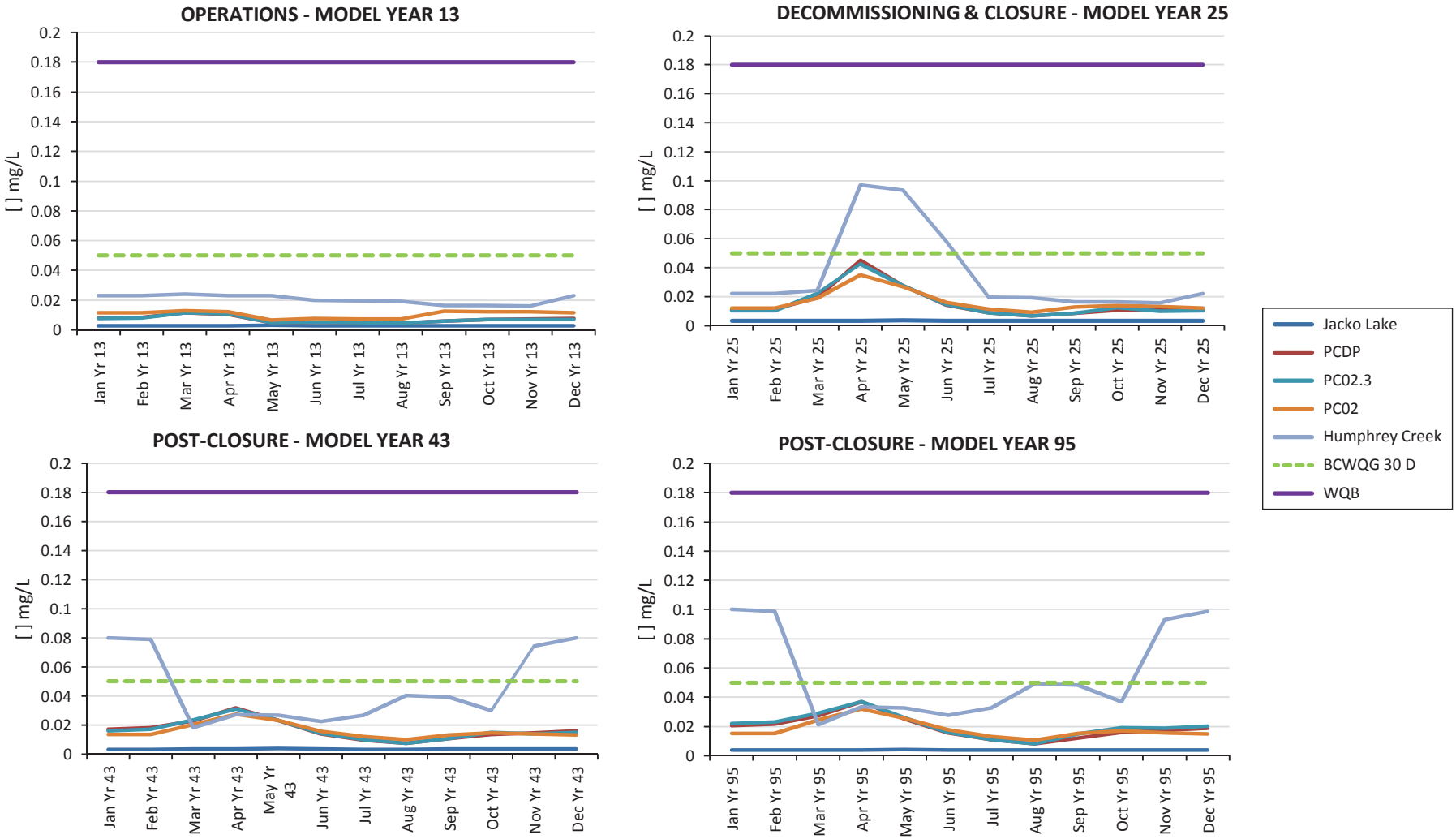
Peak molybdenum Base Case model concentrations in Humphrey Creek exceed the BCWQG-Wildlife and BCWQG-Livestock and are predicted to remain below this guideline at all other receiving water quality model nodes. Although predicted molybdenum concentrations do not exceed the BCWQG-30 D at any node, a WQB protective of sensitive wildlife and livestock was developed for molybdenum, considering the baseline exceedances of these guidelines and the predicted exceedances of the BCWQG–Wildlife and BCWQG-Livestock in Humphrey Creek. Based on the estimated maximum water consumption of beef cow, which are present on the Project area, a WQB of 0.18 mg/L was determined for molybdenum, which is also protective of other wildlife species that have lower water requirements and forage over a larger area (Stantec 2015b). No molybdenum concentrations are predicted to exceed the WQB in any node for the Base Case model.

Predicted molybdenum concentrations at all nodes are sensitive to variation in model assumptions that result in changes to seepage loads and baseline inputs. A comparison of sensitivity model molybdenum concentrations revealed that the highest concentrations for each node were predicted during Post Closure, but the sensitivity case that resulted in those peak concentrations varied between nodes and was often different between mine phases. The WQB was exceeded for the 95th P VCC summary results for one month in Post Closure at PC02.3 and four months in Humphrey Creek, which is very low considering the Post Closure model phase is 97 years. Similar to all other parameters that are predicted to be loaded through seepage pathways from the MRSFs, higher VCC model results are predominantly due to the influence of seepage, seepage delays, and the associated timing of monthly model precipitation inputs that generate the loading at the sources (MRSFs) and the runoff in the receiving water node. Source loading for wetter than average months is much greater than would be expected, given the range of infiltration considered in the development of the geochemical source terms. In the model it is not uncommon for a higher than average month for source loading (wet month in historical climate record) to reach a Peterson Creek receiving water node on a time delay associated with a lower than average receiving water flow month (due to drier conditions in the historic climate record) and the combined model outcome is much higher concentrations than would be expected. Conservative assumptions regarding seepage interactions with groundwater were made for the sake of modelling. Mine source seepage to groundwater is not mixed with local groundwater in mixing cells along the flow pathway, it is dealt with in terms of timing delays, so receiving water loads are equivalent to source loading for the same calendar month for a set time earlier in the model. In reality, groundwater discharge to local creeks would be a combination of small amounts of mine seepage with larger amounts of local groundwater, resulting in a more diffuse loading than is currently modelled and concentrations are not likely to reach those predicted in the upper percentile VCC summary results.

Figure 6.3-7

Ajax Project Surface Water Quality
Molybdenum - Predicted Seasonality in Peterson Creek Watershed - Base Case

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NOTES:
1. MODEL RESULTS DISPLAYED FOR DISSOLVED CONCENTRATIONS.
2. BASE CASE - MEDIAN MONTHLY BASELINE WATER QUALITY AND AVERAGE MONTHLY WATER BALANCE MODEL INPUTS.
3. HARDNESS DEPENDENT GUIDELINES HAVE BEEN CALCULATED USING BASELINE MONTHLY HARDNESS.
4. BRITISH COLUMBIA APPROVED AND WORKING WATER QUALITY GUIDELINES (BCWQG): FRESH WATER AQUATIC LIFE (BCWQG 30 D AND BCWQG MAX) AND WILDLIFE (BCWQG WILDLIFE); LOWEST APPLICABLE GUIDELINES LISTED ON GRAPHS. SOME GUIDELINES MAY BE EXCLUDED.
5. WATER QUALITY BENCHMARK (WQB).

Jacko Lake water quality predictions were assessed to be most sensitive (highest concentrations predicted) to adjustments related to higher hydraulic conductivity (High HC SC) in Closure and Post Closure, with greater seepage loads reaching the lake. Baseline sensitivity modelling resulted in the maximum concentrations in Jacko Lake during Operations. It should be noted that the range in predicted molybdenum concentrations in Jacko Lake is very narrow and are often barely discernable on the graphs. Humphrey Creek maximum predicted sensitivity case molybdenum concentrations resulted from baseline adjustments in Operations, higher hydraulic conductivity in Closure, and VCC models in Post Closure.

Sources of molybdenum loading in Operations are predominantly natural sources, although mining sources (seepage) account for an important portion of molybdenum loading to Jacko Lake. In Post Closure, mining sources (seepage and runoff from reclaimed areas) account for a larger portion of molybdenum loading to Jacko Lake and make up the majority of molybdenum loading to Humphrey Creek, but natural catchment contributions are still predominant at all nodes in this mine phase.

Selenium - Metalloid

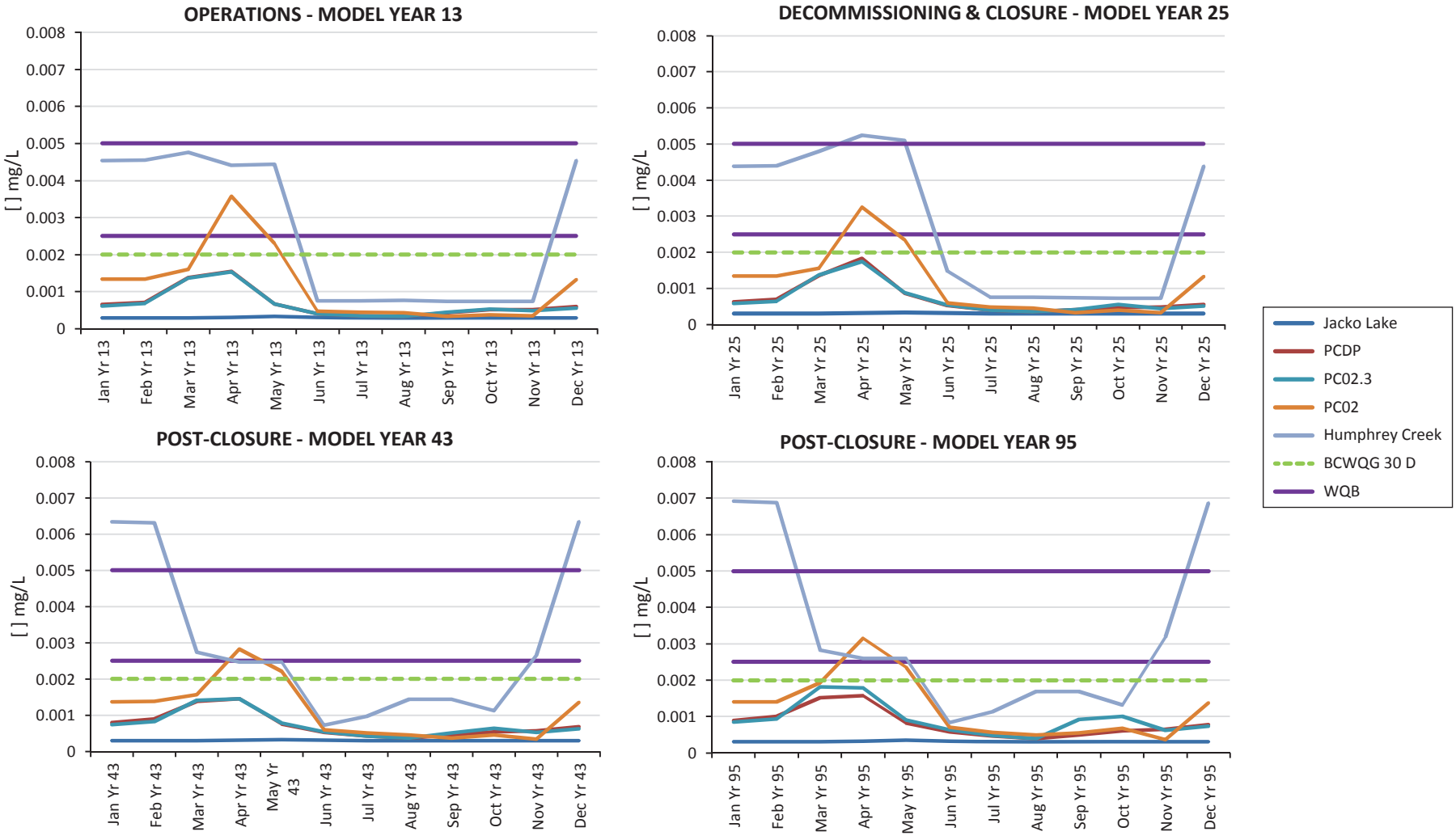
Seasonal and spatial trends for baseline selenium concentrations in Peterson Creek and Humphrey Creek were evident; concentrations were typically higher in samples collected in late winter/early spring, under lower flow conditions and concentrations increased with distance downstream. Peak concentrations were typically measured in samples collected in March in Humphrey Creek and in April in Peterson Creek. Baselines sample concentrations frequently exceeded the BCWQG-30 D at PC02 and lower Humphrey Creek. The highest baseline concentrations were reported for samples from lower Humphrey Creek and some samples exceeded the WQB developed for selenium. Selenium was one of the parameters that was often represented by negative concentrations in the baseline calibration model; and as a result, the baseline contributions in the model are higher than would be expected, particularly in April and May at PC02 and in March and April at PC02.3, adding a conservative factor to predictions for this parameter.

Spatial and seasonal trends predicted for selenium concentrations were similar to baseline trends at the Peterson Creek watershed model nodes. Higher selenium concentrations were predicted to be sustained through the duration of the low flow winter months in Humphrey Creek as opposed to the Peterson Creek nodes where concentrations predicted through these months were typically lower than the peak achieved just prior to spring freshet. Predicted selenium concentrations for Humphrey Creek during Operations were very similar to baseline concentrations (model inputs), indicating that mine seepage and dustfall do not contribute to loading for this parameter. A slight change in the seasonality of predicted selenium concentrations is of note in Humphrey Creek between Closure and Post Closure and in Post Closure predicted concentrations are lower in May and June than in previous mine phases. This is due to the influence of spring freshet runoff from the reclaimed TSF, which is directed to the Humphrey Creek watershed in Post Closure. Background (non-mine) loading sources were the dominant influence on selenium concentrations at all nodes, though the influence of seepage is apparent, particularly in Humphrey Creek. The highest predicted Base Case selenium concentrations are in Humphrey Creek in Post Closure as a result of long-delay seepage influence from the SMRSF. Selenium was not predicted to exceed the BCWQG-30 D or the WQB under any model scenario in Jacko Lake. Modelled selenium concentrations for specific annual time-frames are provided on Figure 6.3-8.

Figure 6.3-8

Ajax Project Surface Water Quality
Selenium - Predicted Seasonality in Peterson Creek Watershed - Base Case

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NOTES:

1. MODEL RESULTS DISPLAYED FOR DISSOLVED CONCENTRATIONS.
2. BASE CASE - MEDIAN MONTHLY BASELINE WATER QUALITY AND AVERAGE MONTHLY WATER BALANCE MODEL INPUTS.
3. HARDNESS DEPENDENT GUIDELINES HAVE BEEN CALCULATED USING BASELINE MONTHLY HARDNESS.
4. BRITISH COLUMBIA APPROVED AND WORKING WATER QUALITY GUIDELINES (BCWQG): FRESH WATER AQUATIC LIFE (BCWQG 30 D AND BCWQG MAX) AND WILDLIFE (BCWQG WILDLIFE); LOWEST APPLICABLE GUIDELINES LISTED ON GRAPHS. SOME GUIDELINES MAY BE EXCLUDED.
5. WATER QUALITY BENCHMARK (WQB).

A WQB was developed for selenium as a result of baseline surface water sample concentrations that exceeded the BCWQG-30 D (0.002 mg/L). A WQB of 0.0025 mg/L was developed for lentic systems (Jacko Lake and the PCDP) with consideration of higher bioavailability in slow flowing systems and a WQB of 0.005 mg/L was developed for lotic systems (Humphrey Creek and Peterson Creek) (Stantec 2015b). Base Case selenium concentrations are not predicted to exceed the WQB in any node other than Humphrey Creek and Base Case concentrations in the PCDP (next node downstream of Humphrey Creek) are predicted to remain below the BCWQG-30 D and the WQB for the duration of the model. It should be noted that the 95th P baseline concentration for the lower Humphrey Creek is 0.0051 mg/L, which also exceeds the WQB. Peak Base Case concentrations are predicted to seasonally exceed the BCWQG-30 D at PC02 (April and May of each year), but remain below the WQB.

Predicted selenium concentrations are sensitive to variation in baseline inputs to the models but are most sensitive to variable climate (VCC) inputs. Jacko Lake selenium water quality predictions were not sensitive to VCC inputs, but were most sensitive to the high hydraulic conductivity groundwater assumptions, which result in greater loading from the TSF and WMRSF. The Base Case and sensitivity case ranges in predicted concentrations are much greater at Peterson Creek watershed nodes below the PCDP than above. This is predominantly due to the influence of seepage, seepage delays, and the associated timing of monthly model precipitation inputs that generate the loading at the sources (MRSFs) and the runoff in the receiving water node. Source loading for wetter than average months is much greater than would be expected, given the range of infiltration considered in the development of the geochemical source terms. In the model it is not uncommon for a higher than average month for source loading to reach a Peterson Creek receiving water node on a time delay associated with a lower than average receiving water flow month (due to drier conditions in the historic climate record) and the combined model outcome is much higher concentrations than would be expected. Conservative assumptions regarding seepage interactions with groundwater were made. Mine source seepage to groundwater is not mixed with local groundwater in mixing cells along the flow pathway, it is dealt with in terms of timing delays, so receiving water loads are equivalent to source loading for the same calendar month for a set time earlier in the model. In reality, groundwater discharge to local creeks would be a combination of small amounts of mine seepage with larger amounts of local groundwater, resulting in a more diffuse loading than is currently modelled and concentrations will not likely reach those predicted in the VCC summary results. There are predicted exceedances of the WQB for selenium at PC02 regularly in May in the 95th P summary results for the VCC models and occasionally at PC02.3 due to delayed seepage loading in Post Closure; as stated above, these maximum predicted concentrations are not expected, and are considered very conservative. Baseline sensitivity case (BSC) model results for the 95th P baseline inputs are also very conservative, given that these concentrations assume that all baseline contributions are at their near maximum for the duration of the model. They provide a valuable understanding of potential sensitivities but are not likely representative of future water concentrations.

The primary sources of selenium loading at all model nodes are natural catchment runoff and baseflow contributions. Seepage from proposed mine facilities is the second important source and is most dominantly noted for Jacko Lake, though the influence of seepage does not result in a predicted concentrations that exceed the BCWQG-30 D in the lake. In Post Closure, mining sources (seepage and runoff from reclaimed areas) account for a slightly larger portion of selenium loading

to Jacko Lake, PCDP, and Humphrey Creek. Selenium loading sources to the PCDP are predominantly Humphrey Creek, though there is a shift between Closure and Post Closure and Jacko Lake becomes an important loading source for water quality predictions in the PCDP.

Category 2 Parameters

Parameters defined in Category 2 are those for which concentrations were not predicted to exceed a relevant BC water quality guideline in the Base Case at multiple nodes or over multiple mine phases but were predicted to exceed a relevant guideline at only one node, during one phase, or under a sensitivity case only. These parameters include ammonia, nitrate, aluminum, antimony, arsenic, chromium, cobalt, iron, and uranium. The predicted changes in concentrations of these parameters are discussed in this section; however, these parameters are not carried forward in the discussion of residual effects because of the limited extent and low probability of the predicted changes. The order of discussion is not intended to imply relative importance, but is listed similar to how they are presented in results summary tables, in the following order: Major ions, nutrients, and metals/metalloids.

Sensitivity analyses were conducted in order to assess the differences in predicted water chemistry from the Base Case due to changes to a single model input assumption. A single change doesn't necessarily result in the same variation in downstream concentrations for all parameters modelled and through the assessment of changes to multiple variables it can be determined which parameters are more sensitive to specific assumptions and which are not. It is important to understand that sensitivity analyses tend to represent extremes in model input assumptions in order to reliably quantify the sensitivity to variation in the model input assumptions and that the resulting predicted concentrations tend to exceed the expected ranges and are not representative of expected water quality. The parameter that are summarized in this Category 2 section tend to be here due to predicted concentrations that exceed water quality guideline and are outside of the expected range. Most of these predicted exceedances are associated with summary results for the VCC models or due to baseline sensitivity case result for the 95th P baseline inputs. The follow introduction paragraphs have been presented as explanations for the higher than expected concentrations predicted in the sensitivity cases for the Category 1 parameters and are valid explanations for the Category 2 parameters as well.

Variable climate case (VCC) model results tended to produce the more extreme (unrealistic) high and low concentrations as a result of conservative model assumptions regarding seepage interactions with groundwater and receiving water. In some cases these model assumptions have also resulted in some Base Case concentrations that are outside of the expected range. These extremes are due to the influence of seepage, seepage delays, and the associated timing of monthly model precipitation inputs that generate the loading at the sources (MRSFs) and the runoff in the receiving water node. Source loading for wetter than average months is much greater than would be expected, given the range of infiltration considered in the development of the geochemical source terms. In the model it is not uncommon for a higher than average month for source loading (wet month in historical climate record) to reach a receiving water node on a time delay associated with a lower than average receiving water flow month (due to drier conditions in the historic climate record) and the combined model outcome is much higher concentrations than would be expected. Mine source seepage to groundwater is not mixed with local groundwater in mixing cells along the flow pathway, it is dealt with in terms of timing delays, so receiving water loads are equivalent to

source loading for the same calendar month for a set time earlier in the model. In reality, groundwater discharge to local creeks would be a combination of small amounts of mine seepage with larger amounts of local groundwater, resulting in a more diffuse loading than is currently modelled and concentrations are not likely to reach those predicted in the upper percentile VCC summary results.

Repetitive spikes in predicted concentrations were predicted in the VCC models due to model input assumptions with respect to timing of the release of dustfall stored in the snowpack through the winter months. This stored dustfall load is timed to be released in May, when freshet conditions are expected in an average year. The transport mechanism for load that accumulates through the winter months to be carried into the creeks is runoff with snow meltwaters and spring rains, resulting in higher loading when flows would also be higher. Historical climate variability accounts for the onset of spring earlier or later than May in some years, but the model timing results in the release of the stored dustfall load independent of these conditions, resulting in predicted concentrations that are much higher than expected.

Baseline sensitivity models are intended to assess the extremes in baseline conditions, but result in the over- or under-prediction of concentrations based on the assumption that all of the baseline inputs are at their near highest (95th P) or near lowest (5th P) for all nodes for the duration of the model. The probability that all baseline sources would be at the 95th P for the duration of the mine life is very low and as such these results provide insight into the potential for concentrations to be sensitive to baseline variability, but are not necessarily a good indicator of potential guideline exceedances particularly for assessing chronic exposure risks.

Ammonia - Nutrient

Ammonia is not predicted to exceed the relevant water quality guidelines in the Base Case model at any node, the lowest of which is the BCWQG-30 D. The BCWQG-30 D for ammonia is *in situ* temperature and pH dependent and ranges from 0.102 mg/L to 2.08 mg/L, with the lower threshold typical for higher pH and temperature conditions. None of the predicted ammonia concentrations exceeded the BCWQG-Max. The pH in the creeks and Jacko Lake is not expected to change as a result of the project and baseline pH ranges have been used to as the basis for the ammonia guideline interpretation and at most sites this range is typically from 8.0 to 8.5. Water temperature is predominantly affected by local air temperature, and due to the relative low flows in the project area creeks, water temperatures are often high in the summer months. It is understood that water temperatures will be somewhat affected by the PCDP and the diversion of Peterson Creek, but it is not likely to change significantly from baseline conditions. Baseline water temperatures have been used to assess the ammonia guidelines for comparison with future predicted concentrations.

Ammonia BCWQG-30 D exceedances were predicted at the following nodes for the sensitivity case models:

- Humphrey Creek – 95th P, 75th P, and Mean VCC summary results in Post Closure due to arrival of medium- and long-delayed seepage from the SMRSF. Seasonal exceedances for low flow periods from late summer through winter.

- PCDP - 95th P Baseline Inputs sensitivity case – seasonally (July) for Construction through Post Closure. Predicted concentration is just above the guideline (1.3 times higher);
- PC02.3 – VCC summary results and 95th P Baseline Inputs sensitivity case:
  - 95th P and Mean VCC summary results – exceeds the BCWQG-30 D three times in Post Closure when long-delayed seepage from the EMRSF arrives at this node.
  - 95th P Baseline Inputs sensitivity case – seasonally (July) for Construction through Post Closure. Predicted concentration is just above the guideline (1.3 times higher).
- PC02 – 95th P Baseline Inputs sensitivity case – seasonally (July) for Construction through Post Closure. Predicted concentrations in July are equal to or just above the guideline (1.0 to 1.1 times higher).

Ammonia loading is predominantly from background sources, with the exception of Humphrey Creek, which is dominantly loaded by seepage from the SMRSF. Proportional loading at all sites varies seasonally, with loading from seepage more dominant in the low flow periods (summer through winter). All of the 95th P Baseline Input sensitivity analysis exceedances were predicted in July when baseline pH and temperature were typically highest and the exceedances were minor (less than 1.5 times the guideline). A slight drop in temperature or pH in July would result in these predicted values being below the guideline. Baseline sensitivity case model results tend to be very conservative in that the model assumes that all inputs are at the percentile being modelled. The probability that all baseline sources would be at the 95th P for the duration of the mine life is very low and as such these results provide insight into the potential for concentrations to be sensitive to baseline variability, but are not an indication of expected ammonia concentrations.

All of the exceedances for ammonia are predicted as a result of these unrepresentative model interactions and these predictions exceed the range of expected concentrations for the receiving water in the project area. What is apparent from the sensitivity model results is that parameter concentrations are sensitive to variation in streamflow conditions, which is evident under baseline conditions, with higher concentrations for most parameters measured under low flow conditions, when groundwater is the primary source for surface flows.

Nitrate - Nutrient

Nitrate is not predicted to exceed the relevant water quality guidelines in the Base Case model at any node, the lowest of which is the BCWQG-30 D (3 mg/L) and predicted ammonia concentrations remain below the BCWQG-Max (32.8 mg/L) in all of the sensitivity cases. There were some exceedances of the BCWQG-30 D predicted in the VCC models as follows:

- Humphrey Creek – 95th P VCC summary results in Post Closure due to arrival of medium- and long-delayed seepage from the SMRSF. Eleven exceedances in total.
- PC02.3 – 95th P and Mean VCC summary results – six exceedances in late Post Closure due to arrival of long-delayed seepage from the EMRSF.
- PC02 – 95th P VCC summary results – seven exceedances in Construction through Closure and four in Post Closure due to seepage.

Nitrate loading in Humphrey Creek is dominated by background sources in Operations and by seepage from the SMRSF in Post Closure and the PCDP nitrate loading is dominated by seepage from the EMRSF Pond in Operations and Closure, but by background sources in Post Closure. All other model nodes have minor loading contributions from seepage source and the majority of the loads are from background sources. Proportional loading at all sites varies seasonally, with loading from seepage more dominant in the low flow periods (summer through winter).

All of the exceedances for nitrate are predicted as a result of these unrepresentative model interactions and these predictions exceed the range of expected concentrations for the receiving water in the project area. What is apparent from the sensitivity model results is that parameter concentrations are sensitive to variation in streamflow conditions, which is evident under baseline conditions, with higher concentrations for most parameters measured under low flow conditions, when groundwater is the primary source for surface flows.

Aluminum - Metal

Aluminum is not predicted to exceed the relevant water quality guidelines in the Base Case model at any node, the lowest of which is the BCWQG-30 D (0.05 mg/L). Base Case aluminum concentrations approach the BCWQG-30 D in Humphrey Creek seasonally in Operations and Closure due to loading associated with dustfall deposition. Aluminum exceedances are predicted in the VCC models at the following nodes, but remained below the BCWQG-30 D in all sensitivity cases in Jacko Lake and at the most downstream model node in Peterson Creek (PC02):

- Humphrey Creek – for the 95th P, 75th P, 50th P, Mean, 25th P, and 5th P VCC summary results as follows:
  - 95th P VCC summary results – seasonally (May through September and November) in Construction and Operations, and seasonally (May through September) in Closure;
  - 75th P VCC summary results – seasonally (May through September) in Construction through Closure (variation in total number of months that is predicted to exceed from year to year);
  - 50th P (Median) summary results – seasonally (typically July through September) in Construction through Closure;
  - Mean VCC summary results – seasonally in Construction through Closure (May and then August/September);
  - 25th P VCC summary results – once in Construction and seasonally (August/September) in Operations and Closure;
  - 5th P VCC summary results – once only in Operations; and
  - All VCC cases – there were no exceedances predicted in Post Closure in Humphrey Creek.
- PCDP - 95th P VCC summary results – seasonally (May or May/June) for Construction through Closure; and
- PC02.3 - 95th P VCC summary results – once in Closure.

All of the aluminum exceedances summarized above result from these conservative and unrepresentative model assumption issues and are therefore not expected exceedances.

Antimony - Metalloid

Antimony is not predicted to exceed the relevant water quality guidelines in the Base Case model at any node, the lowest of which is the BCWQG-30 D (0.009 mg/L). Changes in receiving water antimony concentrations are due to seepage losses from the MRSFs and the sensitivity case BCWQG-30 D exceedances were only predicted during Post Closure in the VCC sensitivity models, for the 95th P summary results for Humphrey Creek and Peterson Creek nodes PC02.3 and PC02. There were also exceedances noted at PC02.3 for the Mean VCC summary results in Post Closure. The VCC summary result exceedances were as follows:

- Humphrey Creek – 95th P VCC summary results – five times in Post Closure (March, June, August or October in random years when delayed seepage arrives in the creek);
- Peterson Creek node PC02.3 – 95th VCC summary results – seasonally in Post Closure when delayed seepage arrives at the node.
- Peterson Creek node PC02.3 – Mean VCC summary results – four times in Post Closure when long-delayed seepage arrives at the node (occurs every five years in late Post Closure, due to cycling of one specific dry June in the historical record which results in very low flows in Peterson Creek).
- Peterson Creek node PC02 – 95th VCC summary results – eight times in Post Closure when long-delayed seepage arrives at the node.

All of the antimony exceedances summarized above result from these conservative and unrepresentative model assumption issues and are therefore not expected exceedances.

Arsenic - Metalloid

Base Case arsenic concentrations predicted for the Peterson Creek watershed nodes were consistently below the BCWQG-Max (0.005 mg/L); however, arsenic concentrations are predicted to exceed the BCWQG-Max in the VCC and High MRSF Recharge sensitivity case models at various nodes. A WQB of 0.032 mg/L was derived for arsenic to protect the most sensitive aquatic organism found in the Project area (*Cyclops vernalis* in Jacko Lake) (Stantec 2015b). Arsenic concentrations are not predicted to exceed the WQB at any node in any of the sensitivity cases, except at PC02.3 in the VCC model results.

Arsenic WQB exceedances are summarized as follows:

- PC02.3 – 95th P and Mean VCC summary results - WQB was exceeded eight times in the 95th P VCC summary results and three times in the Mean VCC summary results and all were in later Post Closure when long-delayed seepage from the EMRSF arrives at this node.

Arsenic BCWQG-30 D exceedances were predominantly predicted in later Post Closure when long-delayed seepage loads were accounted for at the downstream nodes for the VCC models, the High MRSF Recharge, and the 95th P Baseline Inputs sensitivity cases. The exceedances typically occur in

March and April when flow conditions are lower. These results indicate that arsenic receiving water concentrations are sensitive to flow conditions, seepage rates, and baseline conditions.

All of the exceedances for arsenic are predicted as a result of unrepresentative model interactions and these predictions exceed the range of expected concentrations for the receiving water in the project area. What is apparent from the sensitivity model results is that parameter concentrations are sensitive to variation in streamflow conditions, which is evident under baseline conditions, with higher concentrations for most parameters measured under low flow conditions, when groundwater is the primary source for surface flows.

Chromium - Metal

Water quality model predictions under the Base Case scenario indicated screening level exceedances of the most stringent guideline, specific to the more toxic form of chromium; however, further assessment of the speciation and sources of the chromium predicted in the water quality model has indicated that the predicted species and concentrations of chromium are not likely to have a significant effect on aquatic life receptors. Chromium generally exists in two forms in the natural environment, depending on the conditions: hexavalent (Cr VI) and trivalent (Cr III), the latter of which is the less toxic of the two forms. Understanding the species of chromium is critical to understand the potential effects of chromium sources on aquatic biota. The assessment of the effects of elevated chromium concentrations requires an understanding of the expected forms of chromium in each of the contributing loading sources. Chromium has been identified as a parameter that could potentially be affected by the project, but has been classified as a Category 2 parameter in order to present the discussion related to speciation and the selection of the trivalent chromium guideline (BCWQG-30 D – 0.0089 mg/L) as the relevant guideline for the effects assessment.

Dustfall is the primary loading source in Operations and Closure and natural catchment loading as the primary loading source in Post Closure and delayed seepage from the MRSFs as the secondary loading source during this model phase. The species present in the mine rock and tailings from which the dustfall is generated was identified by Lorax, based on the geochemical characterization of the mine rock and tailings, as the less toxic Cr III form (Lorax 2015b). Based on this characterization, the predicted Base Case chromium concentrations remain below the relevant guideline during all mine phases at all nodes in the Peterson Creek watershed.

The seasonal distribution of predicted chromium concentrations is dependent on the loading source of chromium, which change between phases. Dustfall that is deposited in the winter months (December through April) is accumulated in the model, based on the assumption that it is held up in the snowpack, and is made available at the nearest surface water quality model node in May in association with the average timing of spring freshet and ice break-up on Jacko Lake. The seasonality in predicted chromium concentrations is affected by this load accumulation, with an increase in concentrations in May at all nodes in Operations and Closure. Base Case chromium concentrations are highest in Humphrey Creek in Operations and Closure as this creek is most affected by the dustfall deposition due to proximity to the loading sources (TSF and SMRSF) and due to the natural low flow volumes in this creek.

Predicted Base Case chromium concentrations in Humphrey Creek seasonally exceed the BCWQG-30 D for Cr VI of 0.001 mg/L during Operations, Closure, and for a few years in early Post Closure, but remain below the BCWQG-30 D for Cr III of 0.0089 mg/L. Predicted winter low flow chromium concentrations exceed the BCWQG-30 D for Cr VI (but not the Cr III guideline) at the PCDP and PC02.3 during Operations and Closure, but predicted concentrations decrease at these nodes and remain below the guideline in Post Closure.

With the exception of Humphrey Creek, all predicted chromium concentrations in the sensitivity analyses were below the BCWQG-30 D for Cr III. The 95th P summary VCC model results exceeded the BCWQG-30 D every May during Operations and Closure in Humphrey Creek. This repetitive spike in the model results is due to model input assumptions with respect to timing of the release of dustfall stored in the snowpack through the winter months combined with lower than average May flows in Humphrey Creek due to lower flow spring conditions based on the historical climate record for the Project that could result from a lighter snowpack, longer drawn out spring freshet periods, whereby peak flows tend to be lower and extend over two months (April/May or May/June), or variation in the onset of freshet conditions. The deposition is the same in all models and lower flows in Humphrey Creek in May results in higher than expected chromium concentrations. Dustfall deposited along the creeks is conservatively assumed to be available from a 100 m corridor (50 m on both sides) and the transport mechanism for load that accumulates through the winter months to be carried into the creeks is runoff with snow meltwaters and spring rains, resulting in higher loading when flows would also be higher.

Cobalt - Metal

Cobalt is not predicted to exceed the relevant water quality guidelines in the Base Case model at any node, the lowest of which is the BCWQG-30 D (0.004 mg/L). Exceedances of the BCWQG-30 D for cobalt are predicted in the VCC models at the Humphrey Creek and PC02.3 nodes; however, it is important to note that there were no exceedances of the BCWQG-Max (0.11 mg/L) in any scenario. Exceedances were not predicted at any other node under any other sensitivity scenario. The cobalt BCWQG-30 D exceedances are as follows:

- Humphrey Creek – 95th P VCC summary results – five times in Construction through Closure as a result of dustfall loading; and
- Peterson Creek node PC02.3 – 95th VCC summary results – three times in Post Closure when delayed seepage arrives at the node.

Cobalt is primarily loaded through dustfall during Construction, Operations, and Closure and then through seepage from the MRSFs in Post Closure, with dustfall having the greatest effect on Humphrey Creek due to natural low flow conditions in that watershed. Repetitive spikes in predicted concentrations were predicted in the VCC models due to model input assumptions with respect to timing of the release of dustfall stored in the snowpack through the winter months. This stored dustfall load is timed to be released in May, when freshet conditions are expected in an average year. The transport mechanism for load that accumulates through the winter months to be carried into the creeks is runoff with snow meltwaters and spring rains, resulting in higher loading when flows would also be higher. Historical climate variability accounts for the onset of spring earlier or later than May in some years, but the model timing results in the release of the stored

dustfall load independent of these conditions, resulting in predicted concentrations that are much higher than expected.

All of the exceedances for cobalt are predicted for the VCC models and are a result of unrepresentative model interactions and these predictions exceed the range of expected concentrations for the receiving water in the project area. What is apparent from the sensitivity model results is that parameter concentrations are sensitive to variation in streamflow conditions, particularly for those parameters that are predicted to be affected by seepage from the mine facilities and that are elevated in local groundwater, thus contributing to loading through baseflow.

Iron - Metal

Iron concentrations are predicted to exceed the BCWQG-Max (0.035 mg/L) at the Peterson Creek model node PC02.3 in Post Closure in the Base Case model and in some of the majority of the sensitivity case models. Some sensitivity models, however, did not indicate iron concentrations in excess of any guideline, including the 5th P Baseline Inputs and long delayed seepage sensitivity cases. The high predicted iron concentrations in PC02.3 in Post Closure result from the arrival of seepage from the EMRSF, which is expected to take in excess of 200 years to arrive at the receiving node, but was conservatively modelled to arrive on an 80 year delay. Conservative assumptions related to seepage loading have been made for the purposes of modelling. Mine source seepage to groundwater is not mixed with local groundwater in mixing cells along the flow pathway, it is dealt with in terms of timing delays, so receiving water loads are equivalent to source loading for the same calendar month for a set time earlier in the model. In reality, groundwater discharge to local creeks would be a combination of small amounts of mine seepage with larger amounts of local groundwater, resulting in a more diffuse loading than is currently modelled and concentrations are not likely to reach those predicted in the water quality models. The default seepage assumptions have led to conservatively high predictions of the iron concentrations at PC02.3 (and other nodes), when the actual concentrations are likely to be lower. These same assumptions result in higher than expected predicted concentrations for the sensitivity case models as well at all nodes.

The iron BCWQG-30 D exceedances are as follows:

- Humphrey Creek – VCC summary results – seasonal exceedances in Construction through Closure as a result of dustfall loading;
- PC02.3 – Base Case and most sensitivity cases; and
- PC02 – VCC summary results and 95th P Baseline Inputs:
  - 95th P and 75th P VCC summary results – one exceedance predicted in Post Closure.
  - 95th P Baseline Inputs sensitivity case – seasonal (November through February) exceedances in late Post Closure, upon arrival of long-delayed seepage from the EMRSF.

Humphrey Creek iron loading is primarily through dustfall during Construction, Operations, and Closure and then through seepage from the MRSFs in Post Closure, with dustfall having the greatest effect on Humphrey Creek due to natural low flow conditions in that watershed. Repetitive spikes in predicted concentrations were predicted in the VCC models due to model input assumptions with respect to timing of the release of dustfall stored in the snowpack through the winter months. This

stored dustfall load is timed to be released in May, when freshet conditions are expected in an average year. The transport mechanism for load that accumulates through the winter months to be carried into the creeks is runoff with snow meltwaters and spring rains, resulting in higher loading when flows would also be higher. Historical climate variability accounts for the onset of spring earlier or later than May in some years, but the model timing results in the release of the stored dustfall load independent of these conditions, resulting in predicted concentrations that are much higher than expected.

All of the exceedances for iron are predicted as a result of unrepresentative model interactions and these predictions exceed the range of expected concentrations for the receiving water in the project area. What is apparent from the sensitivity model results is that parameter concentrations are sensitive to variation in streamflow conditions, particularly for those parameters that are predicted to be affected by dustfall and seepage from the mine facilities and that are elevated in local groundwater, thus contributing to loading through baseflow.

Uranium - Metal

Predicted uranium concentrations do not exceed the BCWQG-30 D (0.0085 mg/L) at any node in the Base Case model scenario; however, some exceedances were noted for the VCC models for PC02.3 and PC02. The uranium BCWQG-30 D exceedances are as follows:

- Peterson Creek node PC02.3 – 95th P, 75th P, Mean, and 50th P VCC summary results in Post Closure only – seasonal (September) exceedances when long-delayed seepage arrives at the node; and
- Peterson Creek node PC02 – 95th P and 75th P VCC summary results for all mine phases – seasonal (May) exceedances.

Uranium loading is dominated by background sources at all model nodes with very minor loading from MRSF and TSF seepage. All of the exceedances for uranium are predicted as a result of these unrepresentative model interactions and these predictions exceed the range of expected concentrations for the receiving water in the project area. What is apparent from the sensitivity model results is that parameter concentrations are sensitive to variation in streamflow conditions, which is evident under baseline conditions, with higher concentrations for most parameters measured under low flow conditions, when groundwater is the primary source for surface flows.

Category 3 Parameters

Category 3 parameters are those parameters that do not fit into Category 1 or Category 2 because they either don't have a relevant water quality guideline (BCWQG for the protection of aquatic life, wildlife, or livestock) or the predicted concentrations in the Base Case and the sensitivity cases don't exceed any guidelines. The parameters that do not have guidelines are hardness, bromide, potassium, lithium, magnesium, sodium, silicon, strontium, and vanadium. The Category 3 parameters that have guidelines are nitrite, phosphorus, barium, beryllium, boron, cadmium, manganese, mercury, nickel, lead, thallium, and zinc. The water quality model results for all of these parameters are presented in the Water Quality Model Report (Appendix 6.3-C).

Changes in Erosion and Sedimentation

- Soil erosion is a natural process where gravity, wind and water wear away the soil surface. This process can be accelerated by activities like quarrying, earthworks construction and subdividing land. Sediment erosion can impact water quality by increasing the suspended solids content, which can affect aquatic life and wildlife.
- The potential effects of soil erosion on surface water quality were not modelled using the mass balance model as suspended particulate are not well represented in these types of models; mass balance models are more applicable for the prediction of dissolved parameter concentration change. Furthermore, the accuracy of mass balance models diminishes when used to predict concentrations of suspended parameters, due to sediment transport and deposition.
- The potential adverse effects to Surface Water Quality as a result of erosion and sedimentation are generally well understood and mitigated through the implementation of best management practices (BMPs) and mitigation measures.

6.3.4.3 Mitigation Measures for Surface Water Quality

Mitigation measures are proposed by KAM for the Project to avoid, minimize, compensate, restore-on-site, off-set or otherwise mitigate for adverse effects to Surface Water Quality as result of Project components and activities. Mitigation measures for the protection of surface water quality have been applied in the engineering of all aspects of the Project design and water management plan. Note that the development of the water quality model was an iterative approach and included mitigation measures that were developed through changes in mine design and water management strategies to avoid or minimize adverse effects to Surface Water Quality. The assumptions regarding the effectiveness of these mitigation measures has been provided in other sections of the Application/EIS. The details are summarized below:

- Dry cover closure for the TSF - At closure, a dry cover will be placed on the TSF. Retention of a pond at closure, while potentially maximizing evaporation losses, would likely result in locally increased TSF seepage rates (i.e., beneath the pond footprint) relative to the dry cover design due to an increased hydraulic head created by the pond. While a majority of the TSF seepage is predicted to report to the Open Pit (Drawing 18, Appendix 6.6-D), there remains the possibility of unforeseen seepage paths toward Peterson Creek (Upper) and Jacko Lake. Thus, this design is considered a prudent mitigative measure in that it would reduce TSF seepage rates;
- Design enhancements to the reclamation covers for the MRSFs to encourage runoff and reduce infiltration - Unsaturated flow modelling (HYDRUS) indicates that infiltration is minimized by placing a cover on the mine rock and tailings (see Appendix A of Appendix 6.4-C). For bare mine rock, the unsaturated modelling indicates that average annual infiltration is on the order of 44 mm, which is about 2 times greater than runoff from undisturbed ground. HYDRUS modelling indicates that annual infiltration into the mine rock is reduced by a small amount when a nominal reclamation cover is placed over the mine rock. This infiltration value is reduced to 8 mm assuming a 0.3 m thick, compacted low permeability till cover is placed between the mine rock and the includes a 0.5 m to 0.6 m

thick layer of till (silty clay) followed by approximately 0.35 m of topsoil. The topsoil will be loosely placed to prevent compaction and allow for better seed and moisture retention. The MRSFs will be seeded with a dry land mix of agronomic and native species. Grading of the engineered cover to minimize the potential development of topographic lows (where surface runoff can accumulate and pond) will also be a key component in reducing infiltration.

- Construction of the EMRSF of entirely Not Potentially Acid Generating (NPAG) material - this will minimize potential impacts to water quality. The EMRSF Pond is well situated in that it is located downgradient of the mine rock at the base of a natural watercourse. However, groundwater modelling indicates that seepage from the EMRSF could bypass the pond and discharge into Peterson Creek (Lower) (Drawing 08 and 09, Appendix 6.6-D). Given that the EMRSF is to be built with NPAG material, the effects of this potential seepage on water quality in Peterson Creek (Lower) would be minimized.
- Optimization of the locations of water management ponds to promote the capture of seepage and surface contact water - Each of the water management ponds (Central Pond, North Embankment Pond 1, North Embankment Pond 2, SMRSF Pond and EMRSF Pond) is well located from the perspective of surface runoff in that the embankments are located in existing drainages. The ponds are also coincident with groundwater discharge zones as demonstrated on Drawing 08 (EMRSF Pond), Drawing 16 (SMRSF Pond) and Drawings 17 and 18 (North Embankment Ponds 1 and 2) of Appendix 6.6-D. The Open Pit also serves as a discharge zone for seepage from the TSF, as illustrated by Drawing 18 of Appendix 6.6-D.

The final results of the model are considered to represent the residual effects of the Project on Surface Water Quality VC, after the application of mitigation measures so the discussion of mitigation measures presents a summary of:

- Proposed mitigation measures for other VCs;
- Environmental Management Plans; and
- Environmental Monitoring Plans.

Note that potential effects to aquatic resources, human health, wildlife, and other VCs as a result of predicted changes in Surface Water Quality have been assessed and presented in the relevant sections of the Application/EIS along with their associated proposed mitigation measures:

- Groundwater Quality, Section 6.3;
- Fish and Fish Habitat, Section 6.7;
- Terrestrial Invertebrates, Section 6.11;
- Amphibians, Section 6.12;
- Migratory Birds, Section 6.14;
- Raptors, Section 6.15;
- Non-Migratory Gamebirds, Section 6.16;
- Mammals, Section 6.17;

- Supporting Topic – Jacko Lake, Section 8.7;
- Domestic Water Quality, Section 10.2;
- Country Foods, Section 10.3; and
- Community Health and Well-being, Section 10.6.

Mitigation and management plans outline a range of measures to reduce Project effects on VCs. Many of the mitigation and management measures work along the interaction pathway between the Project and the VC. In addition to the Surface Water Quality Management and Monitoring Plan (Section 11.23), the following management and monitoring plans will also contain measures that will protect surface water quality during the normal course of mine operations, from Construction through Post Closure:

- Water Management and Hydrometric Monitoring Plan, Section 11.7;
- Construction Waste Management Plan, Section 11.4;
- Solid Waste Management Plan, Section 11.9;
- Soil Salvage and Handling Plan, Section 11.3;
- Hazardous Waste Management Plan, Section 11.10;
- Risk Management Plan (Accidents and Malfunctions), Section 11.12;
- Landscape Design and Restoration Plan, Section 11.26;
- Groundwater Quality Management and Monitoring Plan, Section 11.24;
- Erosion and Sediment Control Plan, Section 11.4;
- Metal Leaching and Acid Rock Drainage Management and Monitoring Plan, Section 11.5; and
- Fisheries and Aquatic Life Monitoring Plan (includes Fish Habitat Offsetting Plan), Section 11.25.

Changes in Surface Water Quality

The mitigation and management measures presented in this section are specific to those that are proposed to reduce the effects of the Project on receiving water parameter concentrations and include site water management, dust management, and source loading management specific to metal leaching and acid rock drainage (ML/ARD).

Mine Water Management Plan

The objectives of mine water management include the minimization of effects to water quality by maximizing diversion of non-contact water sources around mine infrastructure, maximizing reclaim use of contact waters within the mine footprint, and minimizing seepage losses and runoff from mine facilities and infrastructure. There must be sufficient water to meet the mine water demand (process requirements (reclaimed and freshwater sources), potable water, explosives mixing, fire protection, truck shop, dust control, etc.) and sufficient water sources to sustain surface water flows and quality in the lakes and creeks downstream of the project facilities. The water source is via a pipeline from Kamloops Lake and the reclaim (recycled) water sources are the process water from

the mill, reclaim from the TSF pond, water from open pit dewatering, water collected at the WMRSF Ponds, EMRSF Pond, and SMRSF Pond, and contact water from the Plant Site. Recycled water sources are the primary source for most mine operations and any deficit will be made up with the Kamloops Lake water supply.

Peterson Creek Diversion and the Peterson Creek Downstream Pond (PCDP)

Key aspects of the water management design include the Peterson Creek Diversion and the Peterson Creek Downstream Pond (PCDP). The Peterson Creek Diversion is required to manage the conveyance of excess water from Jacko Lake to the PCDP around major mining activities and infrastructure and maintain flow requirements for water licence holders. This will be achieved via the construction of the Peterson Creek Diversion System (PCDS), which will allow for excess water from Jacko Lake to be pumped around the mine site and re-introduced upstream of the PCDP. This system will be decommissioned in Closure and a new channel will be established from the outlet of Jacko Lake, along the southern extent of the Open Pit and into the existing Peterson Creek channel, upstream of the PCDP. The PCDP will be constructed during the Construction phase and is intended to provide ease of access for a province-appointed water bailiff to manage outflows to meet the requirements of the downstream water licences.

Mine Rock Storage Facility (MRSF) Water Management Overview

Contact water (runoff and seepage) from the MRSFs will be collected and managed in down-gradient water management ponds. Runoff and seepage from the TSF, WMRSF, and TSF North Embankment will be collected and managed in the North Embankment Pond 1 and North Embankment Pond 2. Runoff and seepage from the southern portion of the SMRSF will be collected and managed in the SMRSF Pond and to the north in the Central Pond and Open Pit. Runoff and seepage from the EMRSF will be collected and managed in the EMRSF Pond, to the south and the Open Pit (seepage) to the west.

Water intercepted in the North Embankment Pond 1 and 2 and the EMRSF will be pumped to the Central Pond and then directed to the mill for process makeup water during Operations and water intercepted at the SMRSF Pond will be routed to the Plant Site Pond and ultimately pumped to the mill for process makeup water during Operations. The EMRSF Pond, SMRSF Pond, and North Embankment Ponds 1 and 2 will all be retained during Decommissioning and Closure and Post Closure with the intention of functioning as either evaporation ponds (North Embankment Ponds 1 and 2) or as semi-evaporative ponds with some surface discharge to Humphrey Creek (SMRSF Pond) and Peterson Creek (EMRSF Pond) during periods of the year when runoff is greatest (i.e. spring freshet). The MRSFs will be reclaimed progressively during Operations and fully reclaimed during Decommissioning and Closure. The objective of the closure cover design is to minimize infiltration (thus minimizing contact water load generation) by maximizing evapotranspiration and runoff. The proposed cover includes a 0.6 m layer of till, followed by approximately 0.35 m of topsoil.

Tailings Storage Facility Water Management Overview

TSF water management features include water management ponds, surface water diversion ditches, and French drains. Prior to construction of the TSF embankments, an underdrain system will be installed to manage seepage. Seepage through the embankments is expected to be managed through

the application of a liner system in the embankment along with a low-permeability glacial till basin liner. Stage expansion of the TSF embankments will be on-going through Operations at a schedule required to maintain freeboard and meet storage requirements. The following are key aspects of TSF water management during Operations:

- Runoff from undisturbed areas in the TSF will be collected within the TSF Pond;
- Tailings supernatant will be reclaimed to the mill through the water reclaim pipeline and water requirements made up through the pipeline from Kamloops Lake ;
- Embankment seepage and runoff along the South and Southeast Embankments will be collected in the South and Southeast Embankments Ponds;

The TSF embankments, which are constructed of non-potentially acid generating (NPAG) mine rock, will be progressively reclaimed during Operations and will be fully reclaimed during Decommissioning and Closure. The TSF supernatant pond that remains at the end of Operations will be pumped to the Open Pit and mine rock will be deposited onto the surface of the tailings in order to facilitate reclamation. The TSF surface will be reclaimed with a cover system designed to minimize infiltration and thus decrease seepage flows into the underlying tailings solids. There will be no pond in the TSF in Post Closure and the surface will be re-contoured to shed excess water from the surface into Humphrey Creek via a constructed spillway channel. Details specific to the closure and reclamation of the TSF are provided in the Water Management and Hydrometric Monitoring Plan (Section 11.7).

Metal Leaching / Acid Rock Drainage Management Plan (Section 11.5)

The Metal Leaching /Acid Rock Drainage (ML/ARD) Management Plan is provided in Section 11.5. Mine rock will be managed in accordance with this plan. The TSF North Embankment and the West MRSF will be constructed with non-potentially acid generating (Non-PAG) mine rock only. Any mine rock that is identified as potentially acid generating (PAG) will be co-mingled with mine rock that has sufficient neutralizing potential such that there will be no acidic drainage from the stored mine rock.

Air Quality Monitoring and Dust Control Plan (Section 11.6)

The Air Quality Monitoring and Dust Control Plan is provided in Section 11.6. Dust fall has the potential to affect surface water quality and management of dustfall is addressed, along with air emissions, in the Air Quality Management Plan. Air emissions and dustfall will be managed through Project design and application of best management practices. Specific protective measures include covering sources of dust emissions (e.g. crusher, haul trucks, and stockpiles), installing dust collectors, using coarse material to construct roads, watering and grading roads, and minimizing exposed soil and rock. Dustfall and air quality will be monitored throughout all phases of the Project and results will be reviewed to assess the effectiveness of the air quality mitigation measures in the context of key performance indicators summarized in the BC EMA Air Discharge Permit. Reporting will occur according to the schedule determined in the permit.

Changes in Erosion and Sedimentation

The Erosion and Sedimentation Control Management Plan (Section 11.2). Sediment loading due to erosion and construction activities has the potential to result changes to TSS and turbidity and parameter concentrations in the surface waters downstream of the Project. Best management practices for mitigating erosion and sedimentation are outlined in the Erosion and Sedimentation Control Management Plan and these will be implemented to reduce potential adverse effects. Residual effects on surface water quality as a result of erosion and sedimentation are not anticipated after the implementation of mitigation measures and are therefore not carried forward into the assessment. Erosion and sediment control will be accomplished by applying the following principles:

- Minimize surface disturbance and restrict access to undisturbed areas;
- Preserve and enhance existing vegetation;
- Mine for Closure; i.e., practice progressive reclamation of disturbed areas;
- Separate runoff from disturbed areas where practicable;
- Maintain riparian buffers on permanent, seasonal, and ephemeral waterways (as per Wildlife and Vegetation Monitoring Plan Section 11.27);
- Establish vegetation to increase residency times and allow for natural removal of silt from water column;
- Emphasize natural erosion controls (e.g., slope micro-diversity, mulching, revegetation), which provide multiple environmental benefits if a disturbance or potential sediment source can be managed over the short-term without the need for further Best Management Practice (BMP) intervention;
- Construct interceptor ditches and sediment dams or use existing/modified water storage facilities to contain runoff; engineered structures will meet design parameters consistent with statistical runoff events identified in the water management plan (e.g. 1-in-200-year flood or a 1-in-10-year, 24 hr rainfall event);
- Time potentially erosion / sediment generating operations to avoid wet weather, when working in environmentally sensitive areas, to minimize storm water runoff and erosion risk; and
- Avoid handling soil during prolonged periods of dry and windy weather to minimize wind erosion and generation of dust.

The ESC Plan will be implemented by contractors under the supervision of KGHM Ajax Mining Inc. (KAM) and will be subject to monitoring by KAM's Environment Manager or other qualified professionals, as appropriate. Erosion prevention efforts associated with soil salvage, storage, and handling are discussed in the Soil Salvage and Handling Plan (Section 11.3). ESC planning specific to watercourses is also included in the Water Management and Hydrometric Monitoring Plan (Section 11.7).

Residual effects related to contaminate loading and increases TSS and turbidity are not anticipated to remain after the implementation of mitigation measures for erosion and sedimentation, and this potential effect on Surface Water Quality has not been carried forward into the effects assessment.

6.3.5 Residual Effects and Their Significance

6.3.5.1 Summary of Residual Effects

The water quality model, described in section 6.1.4 and in Appendix 6.1-B, was run under a Base Case scenario and sensitivity scenarios to predict potential effects of the Project on water quality, which are described by parameter in section 6.1.4.2. For ease of review, the parameters discussed in section 6.1.4.2 were grouped into two categories of potential effects: Category 1 parameters include parameters for which guideline exceedances were predicted at multiple nodes, during multiple phases, under the Base Case water quality model scenario and Category 2 parameters include parameters for which effects were predicted under less probable circumstances (i.e. parameters that were predicted to exceed guidelines at only one node, during one phase, or under a sensitivity case only). The same categories are relevant in the current discussion on residual effects, which include parameters classified in Category 1 only; Category 2 parameters are discussed in section 6.1.4.2 and in Appendix 6.1-B, but are not carried forward in the discussion on residual effects. The current discussion is organized by node in order to highlight the expected residual effects to Category 1 parameters in each area. A summary of the Category 1 parameters, for which residual effects have been predicted, is shown in Table 6.3-14 and a summary of the timing, causes, and mitigation measures of the effects predicted at each model node is summarized in Table 6.3-15. The following subsections, organized by node, explain the context of the information shown on the tables. While there are no parameters that have been carried forward in the evaluation of residual effects for Jacko Lake and PCDP, these nodes are included in the discussion for consistency in describing the effects throughout the study area.

Table 6.3-14. Summary of Category 1 Parameters with Predicted Residual Effects

	British Columbia Water Quality Guidelines for the Protection of Freshwater Aquatic Life [1]			Wildlife Water Quality Guidelines [2]		
Model Node	Operations	Closure	Post Closure	Operations	Closure	Post Closure
Jacko Lake	-	-	-	-	-	-
PCDP	-	-	-	-	-	-
PC02.3	SO_4	-	-	-	-	-
PC02	**SO_4,** Cl, Se	SO_4, Cl, Se	SO_4, Se	Se	Se	Se
Humphrey Creek	Cu, Se	Cu, **Se**	SO4, Cu, **Se**	Se	Mo, **Se**	Mo, **Se**

Notes:

[1] Water quality guidelines for the protection of freshwater aquatic life - BC Water Quality Guidelines (BCWQG) maximum and 30 day average; approved and working water quality guidelines.

[2] Wildlife water quality guidelines were only exceeded for molybdenum (0.05 mg/l) and selenium (0.002 mg/l).

[3] Bold indicates that at least one predicted concentration in the mine phase specified exceeds the water quality benchmark (WQB) or science base environmental benchmark (SBEB).

[4] Category 1 parameters include only those parameters for which guideline exceedances were predicted in the base case model results at more than one node, for more than one phase of the project.

[5] Category 2 and category 3 parameters are not listed in this table.

Table 6.3-15. Summary of Residual Effects on Surface Water Quality

Project Phase (timing of effect)	Project Component/ Physical Activity	Description of Cause-Effect [1]	Description of Mitigation Measure(s)	Description of Residual Effect
C, O, CD, PC	Contact Water (TMF, WMRSF), Dustfall	Seepage from the TSF and WMRSF and associated WMPs	Mine Site Water Management Plan • TSF Design which includes an underdrain system in the embankment foundation, a seepage reduction liner system on the upstream face of the embankment overlying a low permeability glacial till basin liner. • Operations – North Embankment Pond 1 – interception of seepage from TSF and seepage and runoff from North Embankment and WMRSF, reclaimed for Operations water demand • North Embankment Pond 1 is converted to an evaporation pond in Closure and Post Closure • Reclamation on WMRSF in Decommissioning and Closure with a low permeability till layer overlain with topsoil to reduce infiltration and maximize evapotranspiration and runoff • Dry cover on TSF to reduce infiltration into the underlying tailings solids and increase non-contact runoff. Air Quality Management Plan	Change in Surface Water Quality in Jacko Lake
CD, PC	Contact Water (TMF, SMRSF), Dustfall	Seepage from the SMRSF and runoff from the reclaimed SMRSF and reclaimed TSF	Mine Site Water Management Plan • SMRSF Pond – manage seepage and runoff from the southern extent of the SMRSF • Reclamation on SMRSF in Decommissioning and Closure with a low permeability till layer overlain with topsoil to reduce infiltration and maximize evapotranspiration and runoff • Dry cover on TSF to reduce infiltration into the underlying tailings solids and increase non-contact runoff Air Quality Management Plan	Change in Surface Water Quality in Humphrey Creek
C, O, CD, PC	Contact Water (SMRSF, WMRSF), Dustfall	Runoff from SMRSF and WMRSF, seepage from SMRSF, WMRSF and associated WMPs	Mine Site Water Management Plan • Operations – interception of seepage from the SMRSF and WMRSF with associated water management ponds, reclaimed to mill for Operations water demand • Reclamation of SMRSF and WMRSF in Decommissioning and Closure with a low permeability till layer overlain with topsoil to reduce infiltration and maximize evapotranspiration and runoff Air Quality Management Plan	Change in Surface Water Quality in Peterson Creek at the PCDP

Project Phase (timing of effect)	Project Component/ Physical Activity	Description of Cause-Effect [1]	Description of Mitigation Measure(s)	Description of Residual Effect
C, O, CD, PC	Contact Water (EMRSF)	Seepage and runoff from the EMRSF	Mine Site Water Management Plan • Operations – interception of seepage from the EMRSF at EMRSF Pond, reclaimed to mill for Operations water demand • Reclamation of EMRSF in Decommissioning and Closure with a low permeability till layer overlain with topsoil to reduce infiltration and maximize evapotranspiration and runoff	Change in Surface Water Quality in Peterson Creek at PC02.3
C, O, CD, PC	Contact Water (EMRSF)	Seepage and runoff from the EMRSF	Mine Site Water Management Plan • Operations – interception of seepage from the EMRSF, reclaimed for Operations water demand • Reclamation of EMRSF in Decommissioning and Closure with a low permeability till layer overlain with topsoil to reduce infiltration and maximize evapotranspiration and runoff	Change in Surface Water Quality in Peterson Creek at PC02

Notes:
[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 VC.
[2] (C) Construction Phase, (O) Operation Phase, (CD) Decommissioning and Closure Phase and (PC) Post Closure Phase

Residual Effects

Humphrey Creek Changes in Sulphate, Copper, Molybdenum, and Selenium Concentrations

The Humphrey Creek water quality model node is located immediately upstream of the confluence with Peterson Creek and is used to assess predicted changes to the Humphrey Creek watershed. Water quality predictions at Humphrey Creek are based on the following source contributions: Natural catchment, including the surface and baseflows from the upstream catchment; seepage and reclaimed runoff from the SMRSF, reclaimed runoff from the TSF, and dustfall on the creek.

The parameters that were identified as having residual effects at Humphrey Creek are limited to sulphate, copper, molybdenum, and selenium; those that were predicted to exceed the relevant water quality guidelines in the Base Case model (Category 1 parameters), which are shown in Table 6.3-16. Category 2 and 3 parameters are not carried forward to the assessment of residual effects because of the low probability and limited extent of the predicted concentration changes as a result of the Project.

Base case water quality model predictions indicated potential exceedances of the BCWQG for copper and selenium during Operations, Closure, and Post Closure and for sulphate during Post Closure only; molybdenum is predicted to exceed wildlife/livestock water quality guidelines during Decommissioning and Closure and Post Closure.

Table 6.3-16. Residual Effects and Sensitivity Summary at Humphrey Creek

Case	British Columbia Water Quality Guidelines for the Protection of Freshwater Aquatic Life [1]			Wildlife Water Quality Guidelines [2]		
	O	CD	PC	O	CD	PC
Residual Effects	**Cu, Se**	**Cu, Se**	**SO_4, Cu, Se**	**Se**	**Mo, Se**	**Mo, Se**
Model Cases						
VCC - 95th Percentile	Al, As, Co, Cu, Fe, Se	Al, As, Cd, Co, Cu, Fe, Se	SO_4, NH_3, NO_3, Al, Sb, As, Cu, Fe, Se	Se	Mo, Se	Mo, Se
VCC - 75th Percentile	Al, Cu, Se	Al, Cu, Fe, Se	SO_4, NH_3, Al, As, Cu, Se	Se	Mo, Se	Mo, Se
VCC - 50th Percentile	Al, Cu, Se	Al, Cu, Se	SO_4, Al, Cu, Se	Se	Se	Mo, Se
VCC - Mean	Al, Cu, Se	Al, Cu, Fe, Se	SO_4, NH_3, As, Cu, Se	Se	Se	Mo, Se
VCC - 25th Percentile	Al, Cu, Se	Al, Cu, Se	SO_4, Cu, Se	Se	Se	Mo, Se
VCC - 5th Percentile	Al, Cu, Se	Cu, Se	SO_4, Cu, Se	Se	Se	Mo, Se
Higher MRSF Recharge	Cu, Se	As, Cu, Se	SO_4, As, Cu, Se	Se	Mo, Se	Mo, Se
Higher Hydraulic Conductivity	Cu, Se	Cu, Se	SO_4, Cu, Se	Se	Mo, Se	Mo, Se
Lower Hydraulic Conductivity	Cu, Se	Cu, Se	SO_4, Cu, Se	Se	Mo, Se	Mo, Se
Higher TSF Conductance	Cu, Se	Cu, Se	SO_4, Cu, Se	Se	Mo, Se	Mo, Se
Seepage Bypass of WMPs	Cu, Se	Cu, Se	SO_4, Cu, Se	Se	Mo, Se	Mo, Se
Edith Lake Thrust Fault Zone	Cu, Se	Cu, Se	SO_4, Cu, Se	Se	Mo, Se	Mo, Se
Insoluble/Unavailable Dustfall	Se	Se	SO_4, Se	Se	Mo, Se	Mo, Se
Dustfall Contributing Width - 25 m	Se	Se	SO_4, Se	Se	Mo, Se	Mo, Se
95th Percentile Baseline Inputs	SO_4, Cu, Se	SO_4, As, Cu, Se	SO_4, Cu, Fe, Se	Se	Mo, Se	Mo, Se
Mean Baseline Inputs	Cu, Se	Cu, Se	SO_4, Cu, Se	Se	Mo, Se	Mo, Se
5th Percentile Baseline Inputs	Cu, Se	Cu, Se	SO_4, Cu, Se	Se	Mo, Se	Mo, Se
Long Delayed Seepage	Cu, Se	Cu, Se	SO_4, Cu, Se	Se	Mo, Se	Mo, Se

Notes:
[1] Water quality guidelines for the protection of freshwater aquatic life - BC Water Quality Guidelines (BCWQG) maximum and 30 day average; approved and working water quality guidelines.
[2] Wildlife water quality guidelines were only exceeded for molybdenum (0.05 mg/l) and selenium (0.002 mg/l).
[3] Bold indicates that at least one predicted concentration in the mine phase specified exceeds the water quality benchmark (WQB) or science base environmental benchmark (SBEB).
[4] Category 1 parameters (residual effects) include only those parameters for which guideline exceedances were predicted in the base case model results at more than one node, for more than one phase of the project.
[5] "O": operations; "CD": decommissioning and closure; "PC": post closure.

Peterson Creek - PC02.3 Changes in Sulphate Concentrations

Water quality predictions at the Peterson Creek PC02.3 model node include loading from the following sources: the PCDP; seepage and reclaimed runoff from the EMRSF (west and east tributaries in the vicinity of that facility); and natural catchment. Loads associated with the natural catchment between PC02.5 and PC02.3 were assessed in the baseline calibration model.

Sulphate was the only parameter that was identified as having residual effects at PC02.3 during the Operation phase. The Base Case Category 1 parameters are summarized in Table 6.3-17 and the Category 2 parameters are also provided in this table. The Category 2 parameters are not carried forward to the assessment of residual effects because of the low probability and limited extent of the predicted concentration changes as a result of the Project.

Table 6.3-17. Residual Effects and Sensitivity Summary at PC02.3

	British Columbia Water Quality Guidelines for the Protection of Freshwater Aquatic Life [1]			Wildlife Water Quality Guidelines [2]		
Case	O	CD	PC	O	CD	PC
Residual Effects	**SO_4**	**-**	**-**	**-**	**-**	**-**
Model Cases						
Base Case	SO_4	-	Fe	-	-	-
VCC - 95th Percentile	**SO_4**, Cu, Se	SO_4, Al, As, Cu, Se	**SO_4**, NH_3, NO_3, Sb, **As**, Co, Cu, Fe, Mn, **Se**, U	Se	Mo, Se	F, **Mo**, **Se**
VCC - 75th Percentile	SO_4, Cu	SO_4, Cu	SO_4, As, Fe, Mn, Se, U	-	-	Mo, Se
VCC - 50th Percentile	SO_4	-	SO_4, As, Fe, Mn, Se, U	-	-	Se
VCC - Mean	SO_4	-	SO_4, NH_3, NO_3, Sb, As, Fe, Mn, **Se**, U	-	-	Mo, **Se**
VCC - 25th Percentile	-	-	Fe	-	-	-
VCC - 5th Percentile	-	-	Fe	-	-	-
Higher MRSF Recharge	SO_4	As, Se	As, Fe, Se	-	Mo, Se	Mo, Se
Higher Hydraulic Conductivity	SO_4	-	Fe	-	-	-
Lower Hydraulic Conductivity	SO_4	-	As, Fe, Se	-	-	Mo, Se
Higher TSF Conductance	SO_4	-	Fe	-	-	-
Seepage Bypass of WMPs	SO_4	-	Fe	-	-	-
Edith Lake Thrust Fault Zone	SO_4	-	Fe	-	-	-
Insoluble/Unavailable Dustfall	SO_4	-	Fe	-	-	-
Dustfall Contributing Width -25m	SO_4	-	Fe	-	-	-
95th Percentile Baseline Inputs	SO_4, NH_3	SO_4, NH_3, Se	SO_4, As, Fe, Se	-	Mo, Se	Mo, Se
Mean Baseline Inputs	SO_4	-	Fe	-	-	-
5th Percentile Baseline Inputs	SO_4	-	-	-	-	-
Long Delayed Seepage	SO_4	-	-	-	-	-

Notes:

[1] Water quality guidelines for the protection of freshwater aquatic life - BC Water Quality Guidelines (BCWQG) maximum and 30 day average; approved and working water quality guidelines.

[2] Wildlife water quality guidelines were only exceeded for molybdenum (0.05 mg/l) and selenium (0.002 mg/l).

[3] Bold indicates that at least one predicted concentration in the mine phase specified exceeds the water quality benchmark (WQB) or science base environmental benchmark (SBEB).

[4] Category 1 parameters (residual effects) include only those parameters for which guideline exceedances were predicted in the base case model results at more than one node, for more than one phase of the project.

[5] "O": operations; "CD": decommissioning and closure; "PC": post closure.

Peterson Creek – PC02 Changes in Sulphate, Chloride, and Selenium Concentrations

Project effects on sulphate, chloride, and selenium were identified for the residual effects assessment at PC02, based on the assessment of potential effects. The Base Case Category 1 parameters are summarized in Table 6.3-18 and the Category 2 parameters are also provided in this table. The Category 2 parameters are not carried forward to the assessment of residual effects because of the low probability and limited extent of the predicted concentration changes as a result of the Project.

Table 6.3-18. Residual Effects and Sensitivity Summary at PC02

	British Columbia Water Quality Guidelines for the Protection of Freshwater Aquatic Life [1]			Wildlife Water Quality Guidelines [2]		
Case	O	C	P-C	O	C	P-C
Residual Effects	**SO_4, Cl, Se**	**SO_4, Cl, Se**	**SO_4, Se**	**Se**	**Se**	**Se**
Model Cases						
Base Case	**SO_4**, Cl, Se	SO_4, Cl, Se	SO_4, Se	Se	Se	Se
VCC - 95th Percentile	**SO_4**, **Cl**, NO_3, As, **Se**, U	**SO_4**, **Cl**, NO_3, As, **Se**, U	**SO_4**, **Cl**, NO_3, Sb, As, Fe, **Se**, U	**Se**	**Se**	Mo, **Se**
VCC - 75th Percentile	**SO_4**, Cl, As, Se, U	SO_4, Cl, As, Se, U	SO_4, Cl, As, Fe, Se, U	**Se**	**Se**	**Se**
VCC - 50th Percentile	**SO_4**, Cl, Se	SO_4, Cl, Se	SO_4, Cl, Se	Se	Se	Se
VCC - Mean	**SO_4**, Cl, Se	SO_4, Cl, Se	SO_4, Cl, As, Se	**Se**	**Se**	**Se**
VCC - 25th Percentile	**SO_4**, Cl, Se	SO_4, Cl, Se	**SO_4**, Cl, Se	Se	Se	Se
VCC - 5th Percentile	**SO_4**, Se	SO_4, Se	SO_4, Se	Se	Se	Se
Higher MRSF Recharge	**SO_4**, Cl, Se	SO_4, Cl, Se	SO_4, As, Se	Se	Se	Mo, Se
Higher Hydraulic Conductivity	**SO_4**, Cl, Se	**SO_4**, Cl, Se	SO_4, Cl, Se	Se	Se	Se
Lower Hydraulic Conductivity	**SO_4**, Cl, Se	SO_4, Cl, Se	SO_4, Se	Se	Se	Mo, Se
Higher TSF Conductance	**SO_4**, Cl, Se	SO_4, Cl, Se	SO_4, Se	Se	Se	Se
Seepage Bypass of WMPs	**SO_4**, Cl, Se	SO_4, Cl, Se	SO_4, Se	Se	Se	Se
Edith Lake Thrust Fault Zone	**SO_4**, Cl, Se	SO_4, Cl, Se	SO_4, Se	Se	Se	Se
Insoluble/Unavailable Dustfall	**SO_4**, Cl, Se	SO_4, Cl, Se	SO_4, Se	Se	Se	Se
Dustfall Contributing Width-25 m	**SO_4**, Cl, Se	SO_4, Cl, Se	SO_4, Se	Se	Se	Se
95th Percentile Baseline Inputs	**SO_4**, Cl, **Se**	SO_4, Cl, **Se**	**SO_4**, Cl, As, Fe, Se	**Se**	Mo, **Se**	Mo, Se
Mean Baseline Inputs	**SO_4**, Cl, Se	SO_4, Cl, Se	SO_4, Se	Se	Se	Se
5th Percentile Baseline Inputs	**SO_4**	SO4	SO4	-	-	-
Long Delayed Seepage	**SO_4**, Cl, Se	SO_4, Cl, Se	SO_4, Se	Se	Se	Se

Notes:

[1] Water quality guidelines for the protection of freshwater aquatic life - BC Water Quality Guidelines (BCWQG) maximum and 30 day average; approved and working water quality guidelines.

[2] Wildlife water quality guidelines were only exceeded for molybdenum (0.05 mg/l) and selenium (0.002 mg/l).

[3] Bold indicates that at least one predicted concentration in the mine phase specified exceeds the water quality benchmark (WQB) or science base environmental benchmark (SBEB).

[4] Category 1 parameters (residual effects) include only those parameters for which guideline exceedances were predicted in the base case model results at more than one node, for more than one phase of the project.

[5] "O": operations; "CD": decommissioning and closure; "PC": post closure.

Sulphate and selenium were predicted to exceed the relevant water quality guidelines in the Base Case model during all mine phases and chloride during Operations and Closure only. Selenium was also identified as a parameter predicted to exceed wildlife/livestock water quality guidelines throughout the duration of the Base Case model.

Source contributions to the Peterson Creek PC02 model node considered for water quality predictions include: predicted water quality at PC02.3; see page and runoff from the EMRSF and EMRSF Pond; and natural catchment, including surface runoff and baseflow from undisturbed areas, and baseflow from Separation Lake. Loading associated with the natural catchment between PC02.3 and PC02 was assessed in the baseline calibration model as the difference in loads in Peterson Creek between these two sites.

Other Effects

Jacko Lake

The Jacko Lake water quality assessment node has been considered throughout the assessment of the effects to water quality and no residual effects have been identified. The current discussion of Jacko Lake has been included in this section on residual effects because of the importance for aquatic life habitat and because of its cultural and recreational importance. Large changes in seepage loading were modelled in several of the sensitivity cases; however, there are no parameters that are predicted to exceed the water quality guidelines, water quality benchmarks (WQBs), or science based environmental benchmark (SBEB) in Jacko Lake, in the Base Case or in any of the sensitivity case models.

Source contributions to Jacko Lake include loading from the natural catchment, which include Peterson Creek surface water and baseflows, and drainage from the upstream catchment; mining sources include dustfall on Peterson Creek, upstream of the lake, and Jacko Lake, and seepage from North Embankment WMP1 of the West MRSF. Loads leave Jacko Lake through surface discharge (managed through pumping in Operations and Closure until the outlet channel is re-constructed and through natural outflow in Post Closure) and seepage to the Open Pit. Water quality predictions for the lake are based on these sources, since no other sources were identified by the hydrological and hydrogeological studies. Loading associated with Peterson Creek surface and baseflow, and the natural upstream catchment was determined in the baseline calibration model as the difference in loads in Jacko Lake (considering the combined water quality dataset at shallow and deep locations) and the incoming loads (based on the combined datasets for baseline sites JC03 and PC10).

Peterson Creek – PCDP

The assessment of the potential effects of the Project to water quality at PCDP did not indicate any parameters to be carried forward in the assessment of residual effects. Water quality changes at this node have been predicted under the Base Case and sensitivity cases; however, there were no exceedances of relevant water quality guidelines at this node in the Base Case model. The Base Case Category 1 residual effects are summarized in Table 6.3-19 and the Category 2 parameters are also provided in this table. The Category 2 parameters are not carried forward to the assessment of residual effects because of the low probability and limited extent of the predicted concentration changes as a result of the Project.

Table 6.3-19. Residual Effects and Sensitivity Summary at PCDP

	British Columbia Water Quality Guidelines for the Protection of Freshwater Aquatic Life [1]			Wildlife Water Quality Guidelines [2]		
Classification	O	CD	PC	O	CD	PC
Residual Effects	-	-	-	-	-	-
Model Cases						
Base Case	-	-	-	-	-	-
VCC - 95th Percentile	Al, Cu, Se	**SO_4**, Al, Cu, Se	**SO_4**, As, Cu, Se	Se	Mo, Se	Mo, Se
VCC - 75th Percentile	Cu	**SO_4**, Cu	**SO_4**, Cu	-	-	Mo
VCC - 50th Percentile	-	-	-	-	-	-
VCC - Mean	-	-	-	-	-	-
VCC - 25th Percentile	-	-	-	-	-	-
VCC - 5th Percentile	-	-	-	-	-	-
Higher MRSF Recharge	-	Se	As, Se	-	Mo, Se	Mo, Se
Higher Hydraulic Conductivity	-	-	-	-	-	-
Lower Hydraulic Conductivity	-	-	**Se**	-	Mo	Mo, **Se**
Higher TSF Conductance	-	-	-	-	-	-
Seepage Bypass of WMPs	-	-	-	-	-	-
Edith Lake Thrust Fault Zone	-	-	-	-	-	-
Insoluble/Unavailable Dustfall	-	-	-	-	-	-
Dustfall Contributing Width -25 m	-	-	-	-	-	-
95th Percentile Baseline Inputs	-	**SO_4**, NH_3, Se	**SO_4**, NH_3, Se	-	Mo, Se	Mo, Se
Mean Baseline Inputs	-	-	-	-	-	-
5th Percentile Baseline Inputs	-	-	-	-	-	-
Long Delayed Seepage	-	-	-	-	-	-

Notes:

[1] Water quality guidelines for the protection of freshwater aquatic life - BC Water Quality Guidelines (BCWQG) maximum and 30 day average; approved and working water quality guidelines.

[2] Wildlife water quality guidelines were only exceeded for molybdenum (0.05 mg/l) and selenium (0.002 mg/l).

[3] Bold indicates that at least one predicted concentration in the mine phase specified exceeds the water quality benchmark (WQB) or science base environmental benchmark (SBEB).

[4] Category 1 parameters (residual effects) include only those parameters for which guideline exceedances were predicted in the base case model results at more than one node, for more than one phase of the project.

[5] "O": operations; "CD": decommissioning and closure; "PC": post closure.

Water quality predictions at Peterson Creek in the PCDP are based on the following source contributions to the node: Jacko Lake; natural catchment contributions, including surface and baseflows; Humphrey Creek (which includes natural catchment contributions, mine loading from the SMRSF and the SMRSF WMP, and runoff from the TSF area in Post Closure); and mining sources

including seepage and runoff from the SMRSF, and direct deposition of dustfall on the pond. Load losses from the pond include outflows through the spillway. Seepage and reclaimed runoff from the EMRSF are assumed to reach Peterson Creek downstream of the PCDP, in accordance with the water balance model.

6.3.5.2 Criteria for Characterization of Residual Effects

The criteria that are used to characterize the residual effects of the Project to Surface Water Quality are described in this section. The standard criteria (i.e., the magnitude, geographic extent, duration, frequency, reversibility, and ecological or social context) are described in detail in Section 5 Assessment Methodology of the Application/EIS.

The general definitions of the characterization criteria that are used are provided below and the ratings for Surface Water Quality are outlined in Table 6.3-20:

- Magnitude. This refers to the expected magnitude or severity of the residual effect.
- Geographic Extent. This refers to the spatial scale over which the residual effect is expected to occur. The geographic extent can be local, landscape/watershed, regional or beyond regional.
- Duration. This refers to the length of time the effect lasts; the duration of an effect can be short-term to long-term. Short-term effects may have a lower impact than long-term effects.
- Frequency. This refers to how often the effect occurs; the frequency of an effect can be frequent to infrequent. Infrequent effects may have a lower impact than frequent effects.
- Reversibility. This refers to the degree to which the effect is reversible. Effects can be fully reversible, partially reversible, or permanent.
- Resilience. This refers to the predicted concentrations relative to water quality guidelines, WQBs, and SBEBs. The water quality guidelines, WQBs, and SBEBs have been developed based on the most sensitive relevant receptors (i.e., fish, benthics, wildlife, cattle) and as a result the resiliency and ecological context has been assessed in their development.

Table 6.3-20. Definitions of Characterization Criteria for Residual Effects on Surface Water Quality

Magnitude	Duration	Frequency	Geographic Extent (Physical/Biophysical)	Reversibility	Resiliency	Ecological Context	Likelihood of Effects	
							Probability	Confidence Level
How severe will the effect be?	*How long will the effect last?*	*How often will the effect occur?*	*How far will the effect reach?*	*To what degree is the effect reversible?*	*How resilient is the receiving environment or population?*	*What is the current condition of the ecosystem and how commonly is it represented in the LSA?*	*How likely is the effect to occur?*	*How certain is this analysis?*
Negligible: Predicted concentration change is very low (likely undetectable), similar to baseline ranges, and is below applicable water quality guidelines.	**Short-term:** Effect lasts 1 to 5 years, regardless of when the effect begins	**Once:** Effect is confined to one discrete period in time during the life of the Project.	**Local:** Effect extends less than 500 m from infrastructure or activity.	**Reversible:** Effect can be reverse.	**Low:** The receiving environment or population has a low resilience to imposed stresses, and will not easily adapt to the effect.	Considered in the development of water quality guidelines, water quality benchmarks, and science based environmental benchmarks. Ecological context to specific receptors will be assessed in the receptor VCs.	**High:** It is highly likely that this effect will occur.	**High:** < 80% confidence. There is a good understanding of the cause-effect relationship and all necessary data are available for the Project area. There is a low degree of uncertainty and variation from the predicted effect is expected to be low.
Low: Predicted concentration exceeds baseline concentration ranges, but is below applicable water quality guidelines.	**Medium-term:** Effect lasts 6 to 31 years, regardless of when the effect begins.	**Sporadic:** Effect that occurs at sporadic or intermittent intervals during any phase of the Project.	**Landscape:** Effect is limited to the LSA or one watershed (i.e., Sub-area).	**Partially Reversible:** Effect can be partially reversed.	**Neutral:** The receiving environment or population has a neutral resilience to imposed stresses and may be able to respond and adapt to the effect.		**Medium:** This effect is likely, but may not occur.	**Medium:** 50 to 80% confidence. The cause-effect relationships are not fully understood, there are a number of unknown external variables, or data for the Project area are incomplete. There is a moderate degree of uncertainty; while results may vary, predictions are relatively confident.
Medium: Predicted concentrations exceed baseline range and applicable water quality guidelines but are below WQBs or SBEBs, or exceeds a WQB or SBEB but remains within the range of baseline concentrations specific to the monthly time-step.	**Long-term:** Effect lasts between 32 and 50 years, regardless of when the effect begins.	**Regular:** Effect occurs on a regular / seasonal basis during any or all of the phases on the Project.	**Regional:** Effect extends across the broader region (e.g., RSA, multiple watersheds, etc.).	**Irreversible:** Effect cannot be reversed (i.e., is permanent).	**High:** The receiving environment or population has a high natural resilience to imposed stresses, and can respond and adapt to the effect.		**Low:** This effect is unlikely but could occur.	**Low:** < 50% confidence. The cause-effect relationships are poorly understood, there are a number of unknown external variables, and data for the Project area are incomplete. High degree of uncertainty and final results may vary considerably.
High: Predicted concentrations exceed baseline range, applicable water quality guidelines, WQBs or SBEBs.	**Far Future:** Effect lasts more than 50 years, regardless of when the effect begins	**Continuous:** Effect occurs constantly during the life of the Project.	**Beyond Regional:** Effect extends beyond the regional scale, and may extend across or beyond the province.					

The characterization of residual effects is based on comparison to the baseline conditions at each assessment node, water quality guidelines, water quality benchmarks (WQBs), and science based environmental benchmarks (SBEBs). The water quality guidelines applied to the characterization of residual effects included, but were not limited to, the BC water quality guidelines for the protection of aquatic life, livestock, and wildlife; the relevant guideline thresholds vary based on the expected receptor and the lowest guideline (i.e. conservative for all parameters) was used for each given parameter. The WQBs and SBEBS have been developed based on the specific conditions for the Project area creeks and lakes, based on the most sensitive identified common receptors. The residual effects were identified based on the predicted changes in water quality relative to these guidelines and benchmarks. The preparation of WQBs was required where guideline exceedances were observed under baseline conditions. For the Ajax Project, this criterion applies to chloride, arsenic, copper, molybdenum, and selenium. For these parameters, specific protective WQBs were researched and prepared, based on the site specific conditions and the most sensitive species specific to the project area. The process of the development of these WQBs and rationale for selected values are provided in Appendix 6.3-D in the Derivation of Protective Water Quality Benchmarks (Stantec 2015). Exceedances of a 250 mg/L $CaCO_3$ hardness threshold, specified in the BCWQG-30 D, trigger a requirement for site specific toxicity testing for sulphate. This criterion is applicable throughout the Project area under baseline conditions. A science based environmental benchmark (SBEB) was developed for sulphate for the characterization of the baseline and modelled water quality. Testing in support of development of a science based environmental benchmark for sulphate for the Ajax Mine (Nautilus 2015), resulted in the development of two SBEB values. The lower is 429 mg/L, which is the same as the current BCWQG-30 D, but with the maximum hardness adjusted up to 800 mg/L $CaCO_3$ which is protective of early life stages for trout. The alternative SBEB of 730 mg/L for hardness up to 1377 mg/L $CaCO_3$ was developed for surface waters where early life stages for trout are never present (Humphrey Creek), or for periods of the year when these life stages are not expected to be present in a given reach of Peterson Creek (July through April on an average year). The sulphate SBEB document is provided in Appendix 6.3-B.

Ecological context and resiliency cannot be assessed independent of the receptors. The water quality guidelines, WQBs, and SBEBs have been developed based on the most sensitive relevant receptors (i.e., fish, benthics, wildlife, cattle) and as a result the resiliency and ecological context has been assessed in their development. Baseline and predicted future water quality was provided as inputs to the relevant receptor VCs and have been considered with respect to the most sensitive receptors that may not be specifically addressed in the guideline and benchmark development. Resilience is an important indicator in the development of guidelines and chronic effects are considered in their development, as well as safety factors that result in the development of thresholds that are protective. Resilience is carried through the assessment specifically in reference to these guidelines and benchmarks and if concentrations remain below the guidelines or benchmarks. The resilience of the species to specific parameter concentrations specified in the guidelines and benchmarks has been implied through their protective considerations.

6.3.5.3 Characterization of Residual Effects

The residual effects of the Project have been characterized based on the criteria established in Table 6.3-21 to determine the significance of the residual effect, likelihood of the potential residual effect and confidence in the assessment. The outcome of this assessment is discussed below and summarized in Table 6.3-22

Table 6.3-21. Characterization of Residual Effects, Significance, Likelihood and Confidence on Surface Water Quality

Residual Effect	Residual Effects Characterization Criteria						Significance of Adverse Residual Effects	Likelihood and Confidence	
	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Resiliency		Probability	Confidence
Humphrey Creek Changes in Sulphate, Copper, Molybdenum, and Selenium Concentrations									
Sulphate	Medium	Local	Long-term	Regular	Partially Reversible	High	Not Significant (Moderate)	High	High
Copper	Medium	Local	Medium-term	Regular	Fully Reversible	High	Not Significant (Moderate)	High	High
Molybdenum	Medium	Local	Long-Term	Regular	Partially Reversible	High	Not Significant (Moderate)	High	High
Selenium	High	Local	Long-term	Regular	Partially Reversible	Neutral	Not Significant (Moderate)	High	High
Peterson Creek PC02.3 Changes in Sulphate Concentrations	Low	Landscape	Short-term	Once	Partially Reversible	High	Not Significant (Minor)	High	High
Peterson Creek PC02 Changes in Sulphate, Chloride, and Selenium Concentrations									
Sulphate	Medium	Landscape	Far Future	Regular	Partially Reversible	Neutral	Not Significant (Moderate)	High	High
Chloride	Medium	Landscape	Far Future	Regular	Partially Reversible	High	Not Significant (Moderate)	High	High
Selenium	Medium	Landscape	Far Future	Regular	Partially Reversible	High	Not Significant (Moderate)	High	High

Table 6.3-22. Summary of Residual Effects, Mitigation, and Significance on Surface Water Quality

Residual Effects	Project Phase	Project Component/ Physical Activity	Description of Cause-Effect1	Mitigation Measures	Significance
Humphrey Creek Changes in Sulphate, Copper, Molybdenum, and Selenium Concentrations	C, O, CD, PC	Contact Water (TMF, SMRSF), Dustfall	Seepage from the SMRSF and runoff from the reclaimed SMRSF and reclaimed TSF	Mine Site Water Management Plan SMRSF Pond – manage seepage and runoff from the southern extent of the SMRSF Reclamation on SMRSF in Decommissioning and Closure with a low permeability till layer overlain with topsoil to reduce infiltration and maximize evapotranspiration and runoff Dry cover on TSF to reduce infiltration into the underlying tailings solids and increase non-contact runoff Air Quality Management Plan	Not Significant (moderate)
Peterson Creek at PC02.3 Changes in Sulphate Concentrations	C, O, CD, PC	Contact Water (EMRSF) and cumulative loading from all other upstream sources	Seepage and runoff from the EMRSF	Mine Site Water Management Plan Operations – interception of seepage from the EMRSF at EMRSF Pond, reclaimed to mill for Operations water demand Reclamation of EMRSF in Decommissioning and Closure with a low permeability till layer overlain with topsoil to reduce infiltration and maximize evapotranspiration and runoff	Not Significant (minor)
Peterson Creek at PC02 Changes in Sulphate, Chloride, and Selenium Concentrations	C, O, CD, PC	Contact Water (EMRSF)	Seepage and runoff from the EMRSF	Mine Site Water Management Plan Operations – interception of seepage from the EMRSF, reclaimed for Operations water demand Reclamation of EMRSF in Decommissioning and Closure with a low permeability till layer overlain with topsoil to reduce infiltration and maximize evapotranspiration and runoff	Not Significant (moderate)

Notes:
[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 VC.
[2] (C) Construction Phase, (O) Operation Phase, (CD) Decommissioning and Closure Phase and (PC) Post Closure Phase

Humphrey Creek changes in Sulphate, Copper, Molybdenum and Selenium Concentrations

- Magnitude.
  - Sulphate: Sulphate concentrations are predicted to exceed baseline concentration ranges but are not predicted to exceed the SBEB (730 mg/L). The magnitude is **medium**.
  - Copper: Copper concentrations are predicted to exceed baseline concentration ranges, generic aquatic life water quality guidelines (BCWQG-30 D), but are not predicted to exceed the WQB (0.0256 mg/L). The magnitude is **medium**.
  - Molybdenum: Molybdenum concentrations are predicted to exceed baseline concentration ranges and generic wildlife and livestock water quality guidelines (0.05 mg/L), but are not predicted to exceed the protective WQB (0.18 mg/L) or the BCWQG-30 D (1 mg/L). The magnitude is **medium**.
  - Selenium: Selenium concentrations in Humphrey Creek are predicted to slightly exceed the baseline concentration range, generic water quality guidelines (BCWQG-30 D, BCWQG-Wildlife), and the WQB (0.005 mg/L). The magnitude is **high** because it is predicted to exceed both the WQB and the baseline range.
- Geographic Extent.
  - Sulphate, Copper, Molybdenum, and Selenium: Humphrey Creek is within 500 m of infrastructure and activities and the LSA and the geographic extent is **local**.
- Duration.
  - Sulphate: Sulphate is predicted to exceed the baseline range in Post Closure, seasonally for 21 years in early Post Closure and then again for 23 years in later Post Closure (due to delayed seepage loading). The duration is **long-term**.
  - Copper: Copper is predicted to seasonally exceed the baseline range and the generic water quality guideline for the protection of aquatic life through Construction, Operations, and Decommissioning and Closure, but drops below the baseline range in Post Closure due to cessation of dustfall loading due to reclamation of sources. The duration is **medium-term**.
  - Molybdenum: Molybdenum is predicted to exceed the baseline range and the generic wildlife and livestock water quality guidelines seasonally under high flow conditions (April and May) for 4 years in Closure, under winter low flow conditions (November through February) for 20 years in early Post Closure and for 24 years in later Post Closure due to delayed seepage loading from the SMRSF. The duration in **long-term**.
  - Selenium: Selenium is predicted to exceed the baseline range, generic water quality guidelines and the WQB once in Operations and seasonally for 22 years in early Post Closure and 23 years in later Post Closure. The duration is **long-term**.
- Frequency.
  - Sulphate: Sulphate is predicted to seasonally exceed the baseline range during winter low flow months for 21 years in early Post Closure and then again for 23 years in later Post Closure (due to delayed seepage loading). The frequency is **regular**.

  - Copper: Copper is predicted to seasonally exceed the baseline range and the generic water quality guideline for the protection of aquatic life through Construction, Operations, and Decommissioning and Closure due to dustfall loading. The frequency is **regular**.
  - Molybdenum: Molybdenum is predicted to seasonally exceed the generic wildlife and livestock water quality guidelines seasonally under high flow conditions (April and May) for 4 years in Closure, under winter low flow conditions (November through February) for 20 years in early Post Closure and for 24 years in later Post Closure due to delayed seepage loading from the SMRSF. The frequency is **regular**.
  - Selenium: Selenium is predicted to seasonally exceed the baseline range, generic water quality guidelines, and the WQB once in Operations and seasonally for 22 years in early Post Closure and 23 years in later Post Closure (due to delayed seepage loading). The frequency is **regular**.
- Reversibility.
  - Sulphate: Surface water quality effects due to changes in sulphate concentrations are **partially reversible** due to reduced seepage effects as a result of reclamation of the SMRSF.
  - Copper: Surface water quality effects due to changes in copper concentrations are **fully reversible** due to reclamation of mine facilities that contribute to dustfall loading.
  - Molybdenum: Surface water quality effects due to changes in molybdenum concentrations are **partially reversible** due to reduced seepage effects as a result of reclamations of the SMRSF.
  - Selenium: Surface water quality effects due to changes in selenium concentrations are **partially reversible** due to reduced seepage effects as a result of reclamation of the SMRSF.
- Resiliency.
  - Sulphate: Predicted sulphate concentrations are below the protective WQB in Humphrey Creek and therefore the resilience of the aquatic life is **high**.
  - Copper: Predicted copper concentrations are below the protective WQB in Humphrey Creek and therefore the resilience of the aquatic life is **high**.
  - Molybdenum: Predicted molybdenum concentrations are below the protective WQB in Humphrey Creek and therefore the resilience of the livestock and wildlife is **high**.
  - Selenium: Predicted selenium concentrations seasonally exceed the WQB, as do the baseline conditions, though predicted concentrations are slightly higher and therefore the resilience is **neutral**.

<u>Peterson Creek at PC02.3 changes in Sulphate Concentrations</u>

- Magnitude.
  - Sulphate: Sulphate concentrations are predicted to exceed baseline concentration ranges but are not predicted to exceed the SBEB (429 mg/L or 730 mg/L; depending on the time of year). The magnitude is **low**.

- Geographic Extent.
  - Sulphate: Peterson Creek node PC02.3 is within the LSA and downstream of most of the project infrastructure and activities in LSA and the geographic extent is **landscape**.
- Duration.
  - Sulphate: Sulphate is predicted to exceed the baseline range in Construction and early Operations seasonally due to slightly reduced flow conditions associated with the filling of the PCDP. The duration is **short-term**.
- Frequency.
  - Sulphate: Sulphate is predicted to seasonally exceed the baseline range during winter low flow months for 3 years in Construction and early Operations. The exceedances are limited to a short period in the early mine development stage and the frequency is **once**.
- Reversibility.
  - Sulphate: Surface water quality effects due to changes in sulphate concentrations are **partially reversible** due to reduced seepage effects as a result of reclamation of the MRSFs and the TSF.
- Resiliency.
  - Sulphate: Predicted sulphate concentrations are below the protective WQB and therefore the resilience of the aquatic life is **high**.

<u>Peterson Creek at PC02 changes in Sulphate, Chloride and Selenium Concentrations</u>

- Magnitude.
  - Sulphate: Sulphate concentrations are predicted to the exceed baseline concentration range in Construction and the first year of Operations due to slight flow reductions as the PCDP fills and are predicted to seasonally exceed baseline concentrations under low flow conditions, due to seepage effects on a continuous basis. Sulphate concentrations are predicted to exceed the SBEB (429 mg/L) in Closure and Post Closure in May of each year, but remain below the baseline 95th P concentration for this month (which also exceeds the SBEB). The magnitude is **medium**.
  - Chloride: Chloride concentrations are predicted to seasonally exceed the baseline concentration range and the generic chronic aquatic life guideline (BCWQG-30 D 150 mg/L) during winter low flow months, but are below the WQB (388 mg/L). The magnitude is **medium**.
  - Selenium: Selenium concentrations are predicted to seasonally exceed the baseline concentration range (April of most years) and the generic water quality guideline (BCWQG-30 D, BCWQG-Wildlife) (April and May of most years), but remain below the (0.005 mg/L). The magnitude is **medium**.
- Geographic Extent.
  - Sulphate, Chloride, and Selenium: Peterson Creek node PC02 is at the maximum extent of the LSA and concentrations are predicted to exceed baseline ranges at this point. Measurable changes to concentrations of sulphate, chloride, and selenium as a result of

the project are not expected in the Thompson River due to the small relative flow contributions and as such the geographic extent is limited to the watershed and is considered **landscape**.

- Duration.
  - Sulphate: Sulphate concentrations are predicted to exceed baseline concentrations under low flow conditions, due to seepage effects on a continuous seasonal basis. The duration is **far future**.
  - Chloride: Chloride concentrations are predicted to exceed baseline concentrations from September through February on a continuous basis. The duration is **far future**.
  - Selenium: Selenium concentrations are predicted to exceed baseline concentration range and generic water quality guideline seasonally (March through May) on a continuous basis, though the WQB is not predicted to be exceeded in the Base Case model. The duration is **far future**.
- Frequency.
  - Sulphate: Sulphate is predicted to seasonally exceed the baseline range during winter low flow months for the duration of the model time-frame (all mine phases). The frequency is **regular**.
  - Chloride: Chloride is predicted to seasonally exceed the baseline range through all mine phases. The frequency **regular**.
  - Selenium: Selenium concentrations are predicted to exceed baseline concentration range and generic water quality guideline seasonally (March through May) on a continuous basis. The frequency **regular**.
- Reversibility.
  - Sulphate: Surface water quality effects due to changes in sulphate concentrations are **partially reversible** due to reduced seepage effects as a result of reclamation of the MRSFs and TSF, which are all upstream of this model node.
  - Chloride: Surface water quality effects due to changes in chloride concentrations are **partially reversible** due to reduced seepage effects as a result of reclamation of the MRSFs and TSF, which are all upstream of this model node.
  - Selenium: Surface water quality effects due to changes in selenium concentrations are **partially reversible** due to reduced seepage effects as a result of reclamation of the MRSFs and TSF, which are all upstream of this model node.
- Resiliency.
  - Sulphate: Predicted sulphate concentrations are below the protective WQB at PC02 through the majority of the year and in May in Closure and Post Closure, when the WQB is exceeded, the concentrations are predicted to be below the baseline range for this month. The resilience of the aquatic life is **neutral**.
  - Chloride: Predicted chloride concentrations are below the protective WQB and therefore the resilience of the aquatic life is **high**.
  - Selenium: Predicted selenium concentrations are below the protective WQB and there for the resilience of aquatic life is **high**.

6.3.5.4 Significance of Residual Effects

A significance conclusion of 'not significant' or 'significant' has been assigned for each residual effect, based on the residual effects characterization detailed above. Jacko Lake is not carried forward to this portion of the effects assessment for the Surface Water Quality VC as residual effects were not predicted based on the residual effects criteria for this VC. Examples of combinations of characterization criteria for the significance ratings are as follows:

Not Significant (Minor): Residual effects have low to medium magnitude, local to landscape (one watershed) geographic extent, short-term duration, and occur one or sporadically. The effects on the Surface Water Quality VC are almost indistinguishable from background conditions (i.e., occur within the range of natural variation as influenced by physical and chemical processes).

Not Significant (Moderate): Residual effects have medium to high magnitude; have local or landscape geographic extent; are short-term to far-future duration; and occur at regular frequency, but the resilience of the Surface Water Quality VC is moderate to high. Residual effects on the Surface Water Quality VC are not likely to be distinguishable at the population, community, and/or ecosystem level.

Significant (Major): Residual effects have high magnitude; have regional or beyond regional geographic extent; are chronic (i.e., persist into the far future); and occur at all frequencies. Residual effects on the Surface Water Quality VC receptors are consequential.

Residual effects on surface water quality in Humphrey Creek with respect to changes in sulphate, copper, molybdenum, and selenium concentrations have medium (sulphate, copper, and molybdenum) to high (selenium) magnitude, local geographic extent, medium-term (copper) to long-term (sulphate, molybdenum, and selenium) duration, are fully (copper) to partially (sulphate, molybdenum, and selenium) reversible, with neutral (selenium) to high (sulphate, copper, and molybdenum) resilience. The significance of the effect to surface water quality at Humphrey Creek is assessed as **not significant (moderate)**.

Residual effects on surface water quality in Peterson Creek at PC02.3 with respect to changes in sulphate concentrations have low magnitude, landscape geographic extent, short-term duration, and are partially reversible, with high resilience. The significance of the effect to surface water quality at Peterson Creek PC02.3 is assessed as **not significant (minor)**.

Residual effects of surface water quality in Peterson Creek at PC02 with respect to changes in sulphate, chloride, and selenium concentrations have medium magnitude, landscape geographic extent, far future duration, regular frequency, are partially reversible through reclamation, and have neutral (sulphate) to high (chloride and selenium) resilience. The significance of the effect to surface water quality at Peterson Creek PC02 is assessed as **not significant (moderate)**.

The significant ratings are summarized in Table 6.3-21.

6.3.5.5 Characterization of Likelihood and Confidence

Once a significance determination is made, the probability (likelihood) of the residual effect occurring and the confidence in the significance predictions and use of mitigation measures are made. The Likelihood and Confidence of each of the adverse residual effects based on these criteria is summarized in Table 6.3-21.

Characterization of likelihood and confidence are based primarily on the findings of the sensitivity case water quality models and the understanding of the level of conservatism inherent in the Base Case water quality model concentration predictions. Sensitivity analyses were conducted in order to assess the differences in predicted water chemistry from the Base Case due to changes to a single model input assumption. A single change doesn't necessarily result in the same variation in downstream concentrations for all parameters modelled and through the assessment of changes to multiple variables it can be determined which parameters are more sensitive to specific assumptions and which are not. It is important to understand that sensitivity analyses tend to represent extremes in model input assumptions in order to reliably quantify the sensitivity to variation in the model input assumptions and that the resulting predicted concentrations tend to exceed the expected ranges and are not representative of expected water quality. Most of these predicted guideline exceedances are associated with summary results for the VCC models or due to baseline sensitivity case result for the 95th P baseline inputs.

The Category 1 parameters have been classified as such due to the likelihood that these parameters will exceed a generic water quality guideline as a result of the development of the mine and these parameters also tended to be elevated in background sources (surface runoff and baseflow). Elevated baseline concentrations means that any incremental change due to seepage, runoff, or dustfall from the mine facilities and infrastructure can result in guideline exceedances where none were previously measured or, where parameter concentrations already exceeded guidelines exceedances, the exceedances may be by a greater factor. High likelihood and high confidence ratings are given to the Category 1 parameters that have been carried forward in the effects assessment, though based on the conservative nature of water quality modelling, it is not likely that future predicted concentrations will reach the concentrations estimated in the sensitivity analyses. The following paragraphs have been presented as explanations for the higher than expected concentrations predicted in the sensitivity cases for the Category 1 parameters and are valid explanations for the Category 2 parameters as well.

Conservative assumptions regarding seepage interactions with groundwater were made; however, these assumptions result in some extreme (unrealistic) high and low concentrations in the VCC models and in the Base Case for some parameters. These extremes are due to the influence of seepage, seepage delays, and the associated timing of monthly model precipitation inputs that generate the loading at the sources (MRSFs) and the runoff in the receiving water node. Source loading for wetter than average months is much greater than would be expected, given the range of infiltration considered in the development of the geochemical source terms. In the model it is not uncommon for a higher than average month for source loading (wet month in historical climate record) to reach a receiving water node on a time delay associated with a lower than average receiving water flow month (due to drier conditions in the historic climate record) and the combined

model outcome is much higher concentrations than would be expected. Mine source seepage to groundwater is not mixed with local groundwater in mixing cells along the flow pathway, it is dealt with in terms of timing delays, so receiving water loads are equivalent to source loading for the same calendar month for a set time earlier in the model. In reality, groundwater discharge to local creeks would be a combination of small amounts of mine seepage with larger amounts of local groundwater, resulting in a more diffuse loading than is currently modelled and concentrations are not likely to reach those predicted in the upper percentile VCC summary results.

Repetitive spikes in predicted concentrations were predicted in the VCC models due to model input assumptions with respect to timing of the release of dustfall stored in the snowpack through the winter months. This stored dustfall load is timed to be released in May, when freshet conditions are expected in an average year. The transport mechanism for load that accumulates through the winter months to be carried into the creeks is runoff with snow meltwaters and spring rains, resulting in higher loading when flows would also be higher. Historical climate variability accounts for the onset of spring earlier or later than May in some years, but the model timing results in the release of the stored dustfall load independent of these conditions, resulting in predicted concentrations that are much higher than expected.

Baseline sensitivity models are intended to assess the extremes in baseline conditions, but result in the over- or under-prediction of concentrations based on the assumption that all of the baseline inputs are at their near highest (95th P) or near lowest (5th P) for all nodes for the duration of the model. The probability that all baseline sources would be at the 95th P for the duration of the mine life is very low and as such these results provide insight into the potential for concentrations to be sensitive to baseline variability, but are not necessarily a good indicator of potential guideline exceedances particularly for assessing chronic exposure risks.

6.3.5.6 Summary of Residual Effects Assessment and Significance

The residual effects and the significance ratings for the Surface Water Quality VC are summarized in Table 6.3-22 along with summary details on key mitigation and management measures.

6.3.6 Cumulative Effects Assessment

6.3.6.1 Introduction

The baseline characterization for surface water quality includes the cumulative effects of loading from activities and natural sources within the Peterson Creek watershed down to the PC02 baseline monitoring location. Modelling to assess potential changes to water quality in Peterson Creek accounted for the baseline conditions and as such are inclusive of all current activities in this watershed. The predicted surface water quality for the effects assessment accounts for the cumulative effects from these sources. Below the PC02 monitoring location, Peterson Creek runs through the City of Kamloops and is influenced by non-point source loading from urban runoff, which would be difficult to characterize from a cumulative effects perspective. The technical boundaries for the predictive surface water quality modelling were constrained by this factor. These technical boundaries do not limit the ability to predict the potential magnitude of the change in

parameter concentrations in the Thomson River, immediately downstream of the RSA as a result of the influence of the Ajax Mine.

Cumulative effects that are captured in the surface water predictions due to inclusion within the upstream environment for the baseline characterization include:

- runoff and baseflow contributions from rangeland in the area;
- runoff and seepage from the sand and gravel quarry adjacent to Peterson Creek (downstream of the Project);
- runoff from residential properties;
- runoff from the roads and highway adjacent to Peterson Creek; and
- runoff and baseflow contributions from the Separation Lake area (Davidson Creek aquifer discharge).

Cumulative effects on water quality from runoff from local roads and highways (Lac Le Jeune Road, Goose Lake Road, Long Lake Road, Highway 5, and Highway 5A) have been accounted for in the surface water quality effects assessment through existing influences on the baseline water quality (both surface and groundwater). Chloride is one of the better understood examples of cumulative effects captured in the baseline characterization. Chloride concentration changes between the PC02.3 and PC02 monitoring locations (and model nodes) are attributed to runoff from road salting activities on the nearby highway and similar trends were noted at other baseline sites adjacent to roads and highways that were outside of the LSA.

Ranching activities in the LSA (Peterson Creek watershed) and the effects on surface water quality are already accounted for in the baseline characterization for the Project and have thus been included in the effects assessment through the use of baseline conditions as inputs to the water quality predictive models.

The magnitude of the predicted change in surface water quality that is attributed to the Project and the cumulative sources that were captured in the water quality model is anticipated to be below the limits of analytical detection in the Thompson River and therefore the cumulative residual effect is considered negligible. The magnitude of the potential change was calculated for each modelled parameter by taking the difference between the predicted loading and the baseline loading for the month with the maximum predicted change in concentration. This load difference was then used to calculate the incremental change in concentration in the Thompson River that would result from the inflow of water from Peterson Creek; the incremental change in parameter concentrations were below the limits of analytical detection for all parameters modelled.

6.3.6.2 Identification of Other Actions that May Affect Surface Water Quality

Past, present, and reasonably foreseeable future projects and activities within the RSA have been considered for the cumulative effects assessment. There are cumulative effects in the LSA that have been accounted for in the effects assessment and, with the exception of urban runoff sources from

the City of Kamloops, there are no additional actions or projects that have been identified within the RSA that would contribute to the residual effects on surface water quality.

Looking beyond the RSA (Peterson Creek watershed) there are other activities and projects (past, present, and reasonable foreseeable future) that may contribute to some degree to residual effects on surface water quality in the Thompson River watershed. These projects or activities and the anticipated interactions are summarized in Table 6.3-23.

6.3.6.3 Interactions between Residual Project Effects and Other Project or Activity Effects

There are no projects or activity effects outside of the RSA that are anticipated to have anything greater than a negligible effect on surface water quality in the Thompson River watershed. The expected interactions with all projects listed in Table 6.3-23 are categorized as either "L" or effects have already been accounted for in the baseline and residual effects assessment (e.g., Lac le Jeune Road, Highway 1, and Highway 5A, agriculture, and ranching). In accordance with the cumulative effects assessment methodology there are no potential adverse effects ranked as moderate or major (yellow or red) before active application of mitigation measures, so none have been carried forward in the cumulative effects assessment.

There is high uncertainty in understanding the contribution of loading to surface water quality from other projects because there is limited available information on discharges from these facilities/projects, and it is difficult to quantify the potential loading associated with future projects.

6.3.6.4 Proposed Mitigation Measures

There are no proposed additional mitigation measures as the cumulative residual effects are assumed to be negligible immediately outside of the RSA and in the greater Thompson River watershed. The Surface Water Quality Management and Mitigation Plan (Section 11.23) and the Fisheries and Aquatic Life Monitoring Plan (Section 11.25) provide framework for monitoring the effects of the Project on surface water quality and fisheries.

6.3.6.5 Evaluation of Significance of Residual Cumulative Effects

There are no residual cumulative effects on surface water quality. As previously stated, the magnitude of the predicted change in surface water quality that is attributed to the Project and the cumulative sources that were captured in the water quality model is anticipated to be below the limits of analytical detection in the Thompson River and therefore the cumulative residual effect is considered negligible. The baseline in the greater Thompson River watershed includes all loading from past and present projects and activities. The understanding is that all other existing and future projects will be required to meet permitted discharge limits which are typically set at levels that are protective of surface water quality.

Table 6.3-23. Screening of Other Actions for Inclusion in the CEA for Surface Water Quality

	Industrial Projects/Activities													Natural Resources and Land Use			Tourism and Commercial Recreation Activities					Community Infrastructure			Transportation					
Residual Effect	Vidette Lake Mine	Afton Mine (Historical)	Iron Mask Mine	Bonaparte Mine	New Afton Mine (New Gold)	Highland Valley Copper Mine (Teck)	Domtar Kamloops Pulp Mill	Tolko-Hefley Creek Plywood and Veneer	LaFarge Cement Plant	Trans Mountain Pipeline System (Kinder Morgan)	Trans Mountain Pipeline System - Expansion (Kinder Morgan)	Harper Creek	Highland Valley Copper – Bethlehem Expansion	Kamloops Forest District	Agriculture	Ranching	Tranquille on the Lake	Lac Le Jeune Resort	Tobiano Golf Course	Recreational Hunting, Fishing, Foraging	Recreational Trails	City of Kamloops Wastewater Management	Water Treatment Centre	City Expansion and Growth	Lac le Jeune Road	Highway 1	Highway 5A	Highway 5 (Coquihalla Highway)	Kamloops Airport	Rail Yards and Lines (CP and CN)
Change in Surface Water Quality	L	L	L	L	L	L	L	L	L	O	O	L	L	L	O	O	O	O	L	O	O	L	L	O	O	O	O	L	O	O

Notes:

(-) *No spatial or temporal overlap.*

O *Spatial or temporal overlap, but no interaction anticipated OR no change from current condition anticipated, and already captured as part of baseline characterization. No further consideration warranted.*

L *Negligible to minor interaction expected; implementation of best practices, standard mitigation and management measures; no monitoring required, no further consideration warranted.*

M *Potential moderate interaction requiring unique active management/monitoring/mitigation; warrants further consideration.*

H *Key interaction; warrants further consideration.*

6.3.7 Conclusion

Surface Water Quality was selected as a VC for consideration in the environmental effects assessment for the Project based on consultation with government agencies, members of the public and stakeholder groups, and Aboriginal Groups. The Project has the potential to affect surface water quality as a result of dustfall deposition and the migration of uncaptured seepage and runoff (contact water) into nearby surface water bodies. Mitigation measures to reduce dustfall, seepage and runoff loading to surface water have been implemented into the development, operation, and reclamation of key mine components which include:

- TSF seepage management features (underdrain system in the embankment foundation, liner system, and water management ponds);
- MRSF water management during all mine phases (maximize seepage and runoff interception at down-gradient water management ponds);
- reclamation of MRSF in Decommissioning and Closure with a low permeability till layer overlain with topsoil to reduce infiltration and maximize evapotranspiration and runoff;
- reclamation of the TSF in Decommissioning and Closure for a dry closure concept which results in limiting infiltration into the underlying tailing solids and thus reducing seepage loading, and the resultant conveyance of non-contact surface runoff off of the facility into the Humphrey Creek watershed; and
- air quality management specifically targeted at reducing dustfall and the reclamation of the TSF and MRSFs thus eliminating long-term dustfall loading from these facilities.

A water quality model was developed for the Project to estimate parameter concentrations within the various mine water management ponds and in the downstream surface water features (Jacko Lake, Peterson Creek, and Humphrey Creek) over time. The objectives of water quality modelling were to identify aspects of the Project that may result in changes to parameter concentrations in the receiving water, quantify the expected changes, and quantify the effects of mitigation measures on potential adverse effects. The water quality model was developed iteratively in order to optimize engineering design and water management and avoid or mitigate for the adverse residual effects of the Project on Surface Water Quality. The final results of the model have been considered to represent the residual effects of the Project on Surface Water Quality VC, after the application of mitigation measures

The parameters that were modelled have been grouped into three categories based on their predicted potential for adverse effects and the Category 1 parameters were carried through for the determination of potential residual effects of surface water quality. The Category 1 parameters are defined as parameters for which BC water quality guideline exceedances were predicted at multiple nodes, during multiple phases, under the Base Case water quality model scenario. Category 2 and 3 parameters were not carried through in the effects assessment. Category 2 parameters are those that were predicted to exceed an applicable BC water quality guideline in the Base Case at only one node and during a single mine phase, or those that are predicted to exceed a guideline under a sensitivity case but not in the Base Case. These parameters are not carried forward to the assessment of residual effects because of the low probability and limited extent of the predicted concentration changes as a

result of the Project. Category 3 parameters include all parameters that were modelled, but do not fit within the definitions of Category 1 or Category 2, meaning they are not predicted to exceed any guidelines or there are no guidelines specified for a specific parameter.

Residual effects were characterized using the criteria of magnitude, duration, geographic extent, duration, frequency, reversibility, resiliency, and ecological context, specific to all of the Category 1 parameters for each of the receiving water quality assessment nodes. The Jacko Lake and PCDP water quality assessment nodes were considered throughout the assessment of the effects to water quality and no residual effects were identified. Category 1 parameters were predicted at the Humphrey Creek and Peterson Creek (PC02.3 and PC02) water quality assessment nodes and these assessment nodes were carried through the residual effects assessment. The residual effects have been characterized as follows:

- **Residual effects on surface water quality in Humphrey Creek** with respect to changes in sulphate, copper, molybdenum, and selenium concentrations have medium (sulphate, copper, and molybdenum) to high (selenium) magnitude, local geographic extent, medium-term (copper) to long-term (sulphate, molybdenum, and selenium) duration, are fully (copper) to partially (sulphate, molybdenum, and selenium) reversible, with neutral (selenium) to high (sulphate, copper, and molybdenum) resilience. The significance of the effect to surface water quality at Humphrey Creek is assessed as **not significant (moderate)**.
- **Residual effects on surface water quality in Peterson Creek at PC02.3** with respect to changes in sulphate concentrations have low magnitude, landscape geographic extent, short-term duration, and are partially reversible, with high resilience. The significance of the effect to surface water quality at Peterson Creek PC02.3 is assessed as **not significant (minor)**.
- **Residual effects of surface water quality in Peterson Creek at PC02** with respect to changes in sulphate, chloride, and selenium concentrations have medium magnitude, landscape geographic extent, far future duration, regular frequency, are partially reversible through reclamation, and have neutral (sulphate) to high (chloride and selenium) resilience. The significance of the effect to surface water quality at Peterson Creek PC02 is assessed as **not significant (moderate)**.

There are no residual cumulative effects on surface water quality. The magnitude of the predicted change in surface water quality that is attributed to the Project and the cumulative sources that were captured in the water quality model is anticipated to be below the limits of analytical detection in the Thompson River and therefore the cumulative residual effect is considered negligible.

The residual project effects, the proposed mitigation measures, and the significance determination for both the residual Project and cumulative effects are summarized in Table 6.3-24.

Table 6.3-24. Summary of Project and Cumulative Residual Effects, Mitigation, and Significance for Surface Water Quality

Residual Effects	Project Phase [1]	Mitigation Measures	Residual Effect Significance	Residual Cumulative Effect Significance
Humphrey Creek Changes in Sulphate, Copper, Molybdenum, and Selenium Concentrations	C, O, CD, PC	Mine Site Water Management Plan SMRSF Pond – manage seepage and runoff from the southern extent of the SMRSF Reclamation on SMRSF in Decommissioning and Closure with a low permeability till layer overlain with topsoil to reduce infiltration and maximize evapotranspiration and runoff Dry cover on TSF to reduce infiltration into the underlying tailings solids and increase non-contact runoff Air Quality Management Plan	Not Significant (moderate)	None
Peterson Creek at PC02.3 Changes in Sulphate Concentrations	C, O, CD, PC	Mine Site Water Management Plan Operations – interception of seepage from the EMRSF at EMRSF Pond, reclaimed to mill for Operations water demand Reclamation of EMRSF in Decommissioning and Closure with a low permeability till layer overlain with topsoil to reduce infiltration and maximize evapotranspiration and runoff	Not Significant (minor)	None
Peterson Creek at PC02 Changes in Sulphate, Chloride, and Selenium Concentrations	C, O, CD, PC	Mine Site Water Management Plan Operations – interception of seepage from the EMRSF, reclaimed for Operations water demand Reclamation of EMRSF in Decommissioning and Closure with a low permeability till layer overlain with topsoil to reduce infiltration and maximize evapotranspiration and runoff	Not Significant (moderate)	None

Notes:
[1] (C) Construction Phase, (O) Operation Phase, (CD) Decommissioning and Closure Phase and (PC) Post Closure Phase

6.4 SURFACE WATER QUANTITY

This section discusses the potential effects of the Ajax Project (the Project) on local and regional hydrologic conditions. Specifically, this section focuses on the potential project effects on water quantity in the Project area. Surface water is a critical component of the biological and physical environment and is protected under both provincial (e.g., *Environmental Management Act* [2004], *Mines Act* [1996]) and federal (e.g., *Canada Water Act* [1985]) legislation.

The significance and likelihood of residual and cumulative effects, due to the Project, on the quantity of surface water in Peterson Creek (including associated tributaries) and Kamloops Lake are presented hereinafter. A predevelopment baseline was conducted to allow for the prediction, assessment, mitigation and management of potential Project-related effects and was incorporated into water management planning. The baseline study reports and data (2008 to 2014) are located in Appendices 6.4-A and 6.4-B. Surface water quantities affected by the Project footprint are managed under the Water Management and Hydrometric Monitoring Plan (Section 11.7), which includes strategies for management of contact water (i.e., water in contact with mining activity) and non-contact water.

6.4.1 Rationale

This section includes a description of the scoping process used to identify surface water quantity for inclusion in the assessment. Scoping is fundamental to focusing the Application/EIS on those issues where there is the greatest potential to cause significant adverse effects. Valued components (VCs) are components of the natural and human environment that are considered to be of scientific, ecological, economic, social, cultural, or heritage importance. To be included in the EA, there must be a perceived likelihood that the VC will be affected by the proposed Project. Valued components are scoped into the environmental assessment based on issues raised during consultation with Aboriginal communities, government agencies, the public and stakeholders. Consideration of certain VCs may also be a legislated requirement, or known to be a concern because of previous project experience.

Surface water quantity 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. From a water resource perspective, an understanding of the surface water runoff characteristics within and downstream of the Project area is critical to support an environmental effects assessment as well as to contribute to engineering analysis and the design of water management features. The location, timing and magnitude of surface water flows have implications for water quantity and quality, and consequently for the organisms that inhabit waterbodies and riparian zones. Surface water quantity is not only of importance to the ecosystem; a component of the runoff within Peterson Creek and several of its tributaries is used for irrigation, stock watering and domestic use through existing water licenses.

Surface Water Quantity was identified by government agencies, stakeholders, and Aboriginal communities, during consultations with KAM on the Project as a potential VC because of its importance to fish, wildlife, livestock, use as irrigation water, and for recreation. Aboriginal communities have expressed general concerns related to surface water quantity and more

specifically as it may pertain to Jacko Lake and Peterson Creek. Concerns that were raised are recorded in the issues tracking tables in Appendix 15B of the Application/Environmental Impact Statement (EIS).

The Supporting Topic - Jacko Lake, section 8.7, serves to aggregate summaries for all VCs that have potential pathways of effect from the Project on Jacko Lake. The intent of the section's summaries is to provide a snapshot of residual effects, mitigations and the determination of significance for each of the relevant VCs.

The assessment of effects to Surface Water Quantity is largely related to direct ground disturbance from Project activities. The information developed to support the analysis of this VC also contributes to other analyses for other VCs, as summarized in Figure 6.4-1. For example, surface water quantity is linked with surface water quality, both of which support habitat modelling for fish and fish habitat VCs.

6.4.2 Background

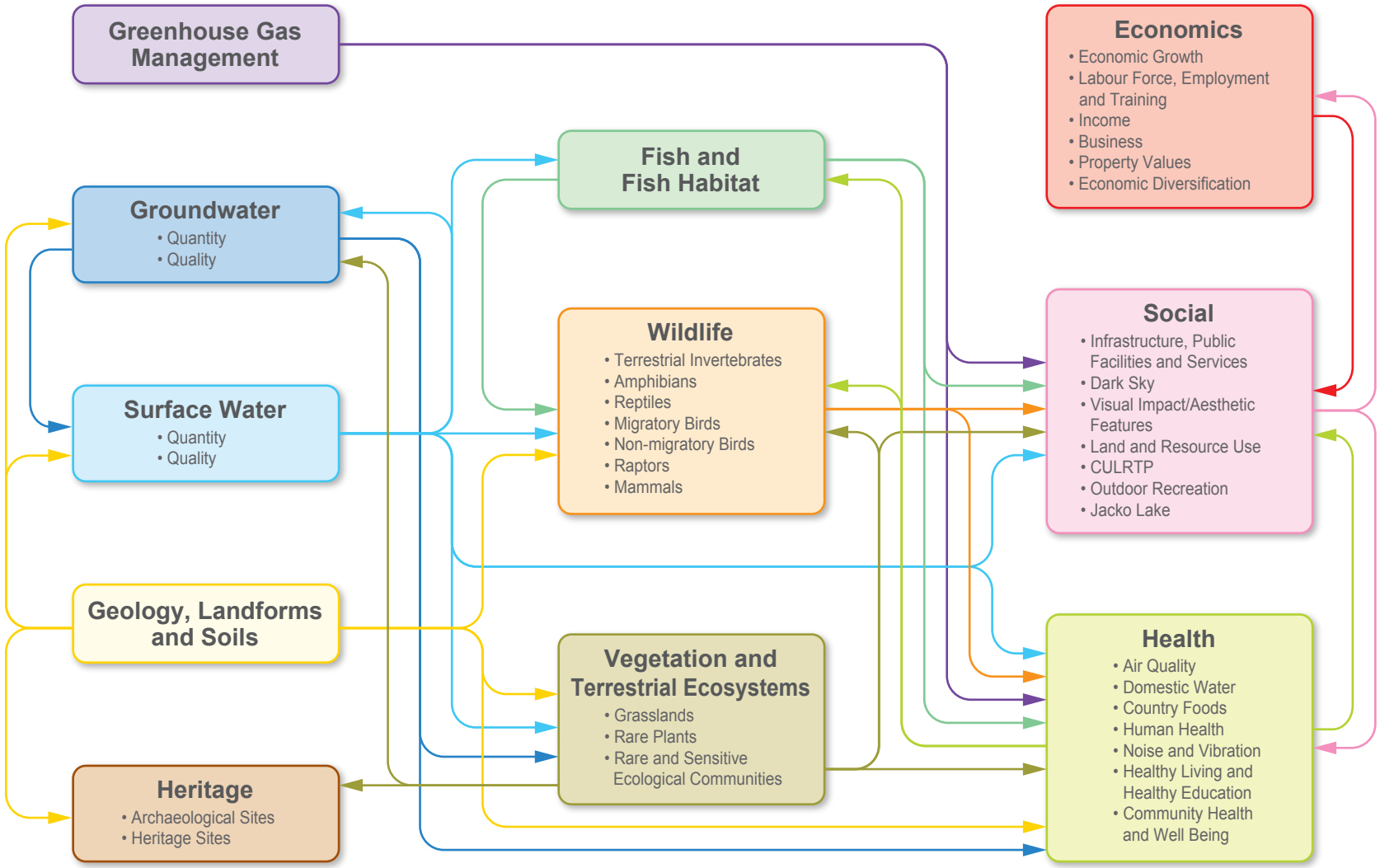
6.4.2.1 Regional Overview

The Project is situated within the Thompson Plateau physiographic region, which is described as a gently rolling upland of low relief, generally between 1,200 m and 1,500 m elevation (Holland 1964). The plateau covers an area of approximately 28,500 km^2 and represents the late Tertiary erosion surface that has been dissected by three major rivers: the Thompson, Similkameen, and Okanagan, and their tributaries. The Project is located in an area of moderate relief with local elevations ranging from 800 m to 1,500 masl. The area is characterized by rolling grasslands with timber at higher elevations. Forested areas consist mainly of Douglas-fir, Lodgepole pine and Ponderosa pine. At lower elevations, vegetation typically consists of bunchgrass, sagebrush and prickly pear cacti (Keystone 2008).

Geomorphic landforms reflect the glacial history of the region. Prominent depositional and erosional features that have resulted from glacial recession include south and southeasterly trending drumlins, successions of melt water channels on sloping surfaces, and kettles. The principal watercourses in the area run northeast and typically consist of north and east flowing sections that follow the principal structural geologic lineation pattern.

The Project lies fully within the Peterson Creek watershed (Figure 6.4-2). The largest water body in the project area is Jacko Lake, which is located west of the proposed Open Pit. Natural drainage of the region is discontinuous, resulting in numerous shallow ponds, some of which are ephemeral and bordered with saline soils and associated mineral deposits. Peterson Creek flows northeast from Chuwels Mountain to Jacko Lake, east through Knutsford, then north to the South Thompson River through downtown Kamloops. The creek has a mainstem length of 40 km and drains a watershed area of approximately 130 km^2. Major tributaries of Peterson Creek are Jacko Creek, Keynes Creek, Humphrey Creek and Davidson Brook.

Figure 6.4-1
Valued Component Interactions



Historical records indicate that Jacko Lake has been managed since the early 1900s, when the outlet to Peterson Creek was raised to impound water for irrigation. This earthfill dam has since been raised on several occasions and is currently about 3 m high, impounding a volume of about 4.2 Mm^3. During periods of high flow, runoff discharges through a spillway, but a low level outlet also allows for lake outflows when lake levels fall below the spillway invert. This low level outlet is managed during the summer months to meet downstream water license requirements. Within the downtown core of Kamloops, the majority of Peterson Creek is contained within culverts and channeled through concrete waterways to its confluence with the South Thompson River.

The South Thompson River and North Thompson River converge at Kamloops to form the Thompson River, which is the largest tributary of the Fraser River. The Thompson River flows approximately 15 km westward from this confluence into Kamloops Lake (a locally enlarged reach of the river). The Thompson River drains an area of 56,000 km^2 from Greenstone Mountain to Kamloops Lake, carrying runoff from the Columbia and Monashee mountains. Kamloops Lake has a catchment area of 29,050 km^2, a surface area of 48 km^2 and is approximately 30 km long (Knight Piésold 2011). From Kamloops Lake, the Thompson River continues to flow westward to Ashcroft, then southwest to the confluence with the Fraser River near Lytton, BC.

The climate of the Ajax mine site is typical of the dry BC Interior with generally low total precipitation and high evaporation, and correspondingly low streamflow rates. Lying within the rain shadow of the Coast Mountains, this area has a semi-arid steppe climate characterized by generally cool dry winters and hot, dry summers, with low humidity. Convective storms are frequent in the summer months, and as a result precipitation is generally highest in June and July.

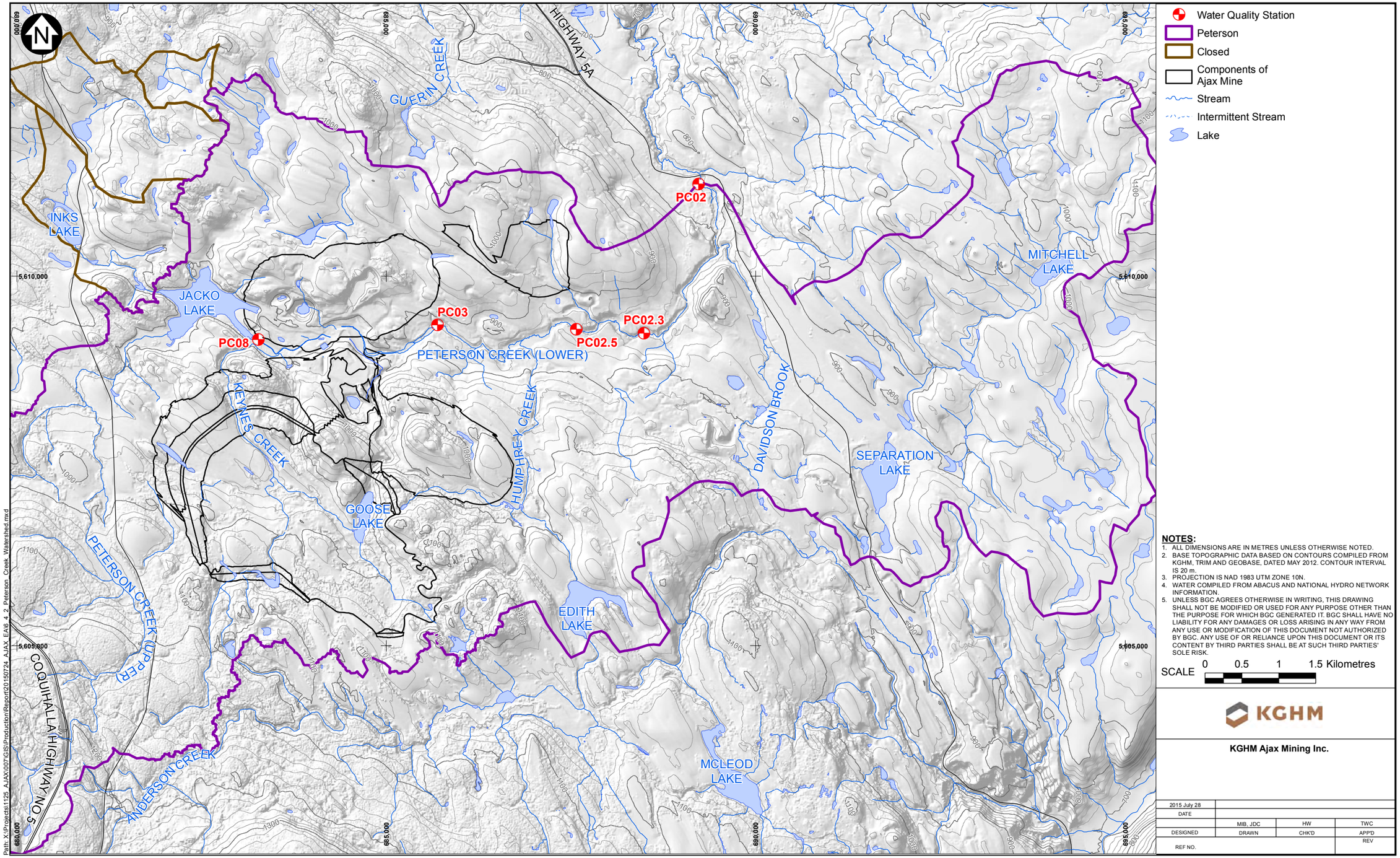
6.4.2.2 Historical Activities

The region surrounding the Project has a long history of human activity that contributes to the current "baseline" condition, which is defined more specifically in the following section of this assessment.

Kamloops derives its name from the Secwepemc word "Tk'emlúps", which refers to the meeting of the North and South Thompson rivers. The area was first inhabited by approximately 3,000 members of the Shuswap tribe, part of the Interior Salish Nation.

British Columbia officially became part of Canada in 1871, and construction of the transcontinental railroad was completed in 1885, encouraging the growth of a small village on the shore of the Thompson River. The village grew rapidly and by 1893 the population had risen to approximately 500 and became incorporated as a city with public works. In the following years, there were a number of infrastructural developments, including bridges that connected villages on either side of the rivers. During this time, the timber industry was growing, and the vegetable and orchard farming industry grew, with most of the land used for this purpose located in the valley. After the Second World War, Kamloops began to grow again, and much of the land that had formerly been used for farming in the valley was used for residential development. Ranching (including cattle grazing) also developed, and is currently ongoing immediately within and adjacent to the Project. Ranching activities have a major influence on Peterson Creek streamflows, as there are a number of existing surface water licenses on Peterson Creek and its tributaries. These licenses are predominantly used for the irrigation of hay crops. Annual surface water licenses for irrigation include:

Figure 6.4-2
Peterson Creek Watershed



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NOTES:

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- 530,396 m^3 on Peterson Creek above Jacko Lake;
- 620,763 m^3 on Peterson Creek below Jacko Lake[1];
- 55,013 m^3 on Keynes Creek;
- 115,947 m^3 on Davidson Brook; and
- 156,035 m^3 in the Separation Lake sub-watershed.

These irrigation licenses total 1,478,154 m^3 on an annual basis or an annual average of 169 m^3/h. Additional details on these licenses are provided in Appendix 6.4-C. Baseline hydrologic conditions established for the Project area account for these licenses, as discussed in Appendix 6.4-C.

Mining activity in the Project area can be traced back over 100 years with exploration in the Project area beginning in the 1880s and continuing intermittently to present. Copper, gold, and iron mineralization was discovered at the Iron Mask Mine near Kamloops in 1896. Nearby properties, including the Wheal Tamar, Ajax, and Monte Carlo claims, were explored in the following years.

The Afton Mine went into operation in 1977. Mining operations were initiated on the Ajax East and Ajax West pits in 1989 and subsequently suspended in 1991 due to depressed metal prices. A second period of production began in 1994 and was again suspended in 1997. The raw ore from the Ajax pits was trucked approximately 10 km west to the processing plant adjacent to the Afton pit. During these periods of production, it is estimated that 17 Mt of ore was mined and 13 Mt of ore was milled. In the late 1990s, the tailings facility and project components were decommissioned and reclaimed by the Afton Mine in accordance with their closure plan. At the Ajax site, this includes reclaimed waste rock facilities adjacent to Peterson Creek (Lower) in the location of the proposed Ore Stockpile.

The New Afton Mine occupies the site of the historic Afton Mine infrastructure. New Afton began underground mining immediately beneath the historic Afton Mine open pit in June 2012. This mine is able to produce up to 13,000 tonnes per day of raw ore though the processing plant. Currently the mine is licenced to draw an annual volume of 1.218 Mm^3 (139 m^3/h) from Kamloops Lake for water supply to the processing plant. An application to withdraw an additional 1.324 Mm^3 (151 m^3/h) is currently in review.

6.4.2.3 Baseline Studies

The Project is located within the Peterson Creek watershed, which drains north through the City of Kamloops and into the South Thompson River. A baseline hydrometeorological report was produced by Knight Piésold in 2013 that incorporates local and regional hydrology assessments to provide estimated long-term water quantity values. The objective of that report was to provide a hydrometeorological characterization of the Project area for the purposes of water balance modelling, engineering design, water rights applications and environmental assessments (Appendix 6.4-A). Results of the 2014 surface water monitoring program in the Project area, completed by BGC Engineering, are presented in Appendix 6.4-B.

[1] Many of these irrigation licenses are supported by upstream storage licenses on Jacko Lake. A conservation license is also held on the lake by the Ministry of Forest, Lands and Natural Resource Operations (MFLNRO) for fish habitat.

Methods

The main objectives of the hydrology baseline program were to:

- identify the drainage basins and channels that will be affected by the Project to determine the hydrometric monitoring sites for collecting flow data;
- review historical data relevant to the Project;
- establish and monitor project-specific hydrometric stations to augment historical datasets, particularly for smaller watersheds;
- generate daily discharges and annual hydrographs for each hydrometric station;
- calculate hydrological indices related to annual runoff, seasonal runoff distribution, monthly flow rates, and peak and low flows; and
- conduct frequency and regional analyses on the historical hydrological data to analyze the regional hydrological characteristics of the Project-related region.

The methods employed in the baseline studies followed guidelines described in the provincial hydrometric standards (RISC 2009) and provincial hydrometeorologic baseline guidelines (BC MOE 2012).

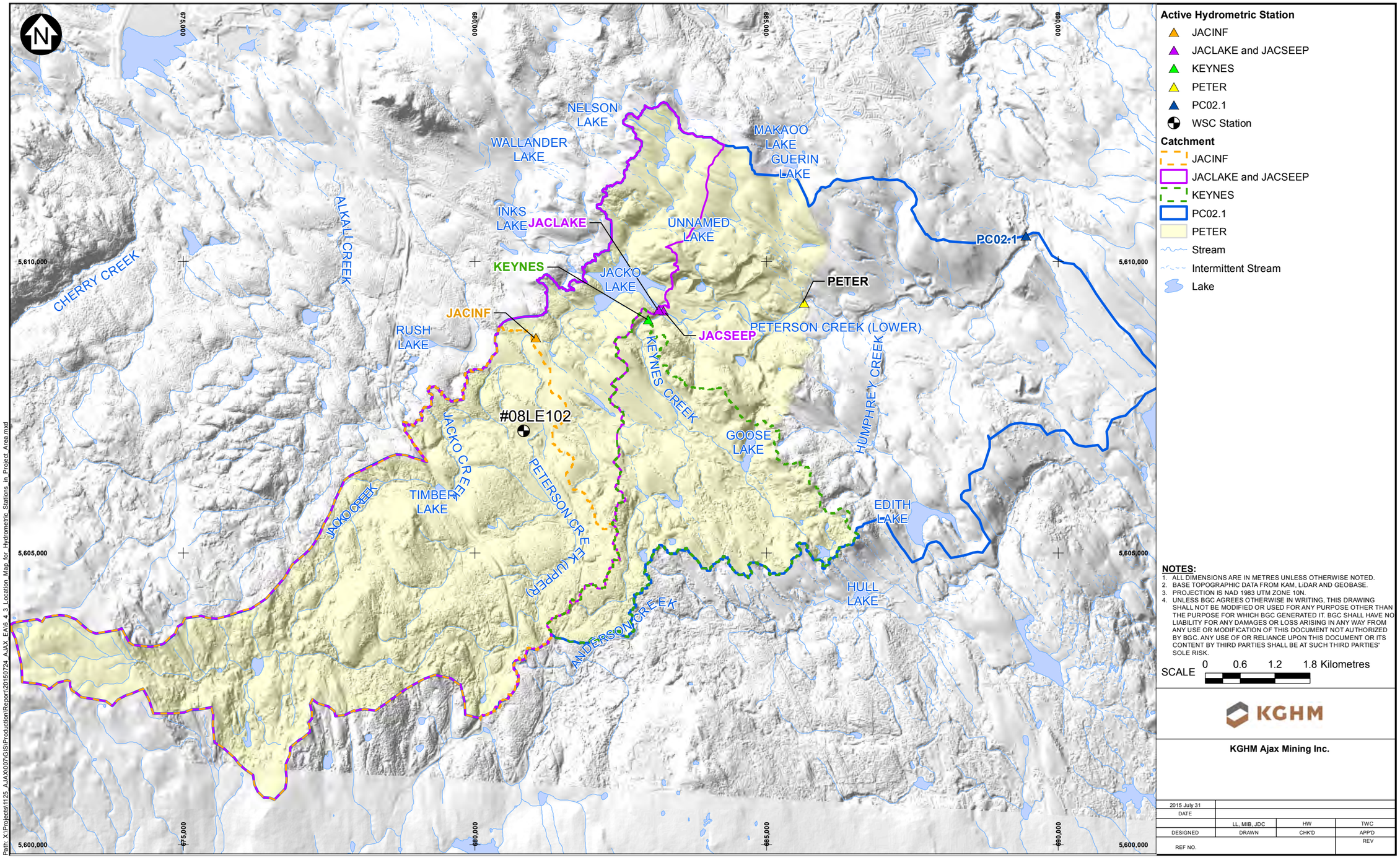
Data Sources

The Project is located in the dry Interior Region of British Columbia, Zone 12 based on Obedkoff (2003), which is typified by low precipitation and high evaporation rates. Hydrometric gauging stations were established in 2008 at five different locations within the Project area to assess local flow conditions. One of these stations, located in the adjacent Cherry Creek watershed, was made inactive following the 2012 monitoring season as Project layout changes made it obsolete. An additional station was subsequently installed in early 2014 at the mouth of Keynes Creek, a south-flowing tributary that discharges into Peterson Creek (Lower) immediately downstream of Jacko Lake. Hydrometric stations were typically operated between March and October from 2008 through 2012 and in 2014. Hydrometric station information is summarized in Table 6.4-1 and a map showing the station locations and watersheds is provided in Figure 6.4-3.

Table 6.4-1. Hydrometric Stations in Project Area

Station ID	Latitude	Longitude	Watershed Area (km^2)	Station Elevation (masl)	Period of Record	Status
JACINF	50.602	-120.441	31	912	April 2008 – present	Active
JACLAKE	50.606	-120.412	41	891	April 2008 – present	Active
JACSEEP	50.605	-120.410	41	883	April 2008 – present	Active
PETER	50.606	-120.376	60	880	April 2008 – present	Active
KEYNES	50.604	-120.414	11	915	March 2014 – present	Active
PC02.1	50.615	-120.322	85	795	June 2015 - present	Active
TSFINF	50.643	-120.535	53	721	April 2008 – October 2012	Inactive

Figure 6.4-3
Location Map for Hydrometric Stations in Project Area



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A brief description of each of the active Project area hydrometric stations is provided below.

Jacko Lake Inflow (JACINF). The JACINF hydrometric station monitors the primary inflows into Jacko Lake from Peterson Creek (Upper). The catchment area to this station is 31 km^2. The station is located in a reach just upstream of a culvert crossing of the Lac Le Jeune Road where the channel is approximately 3.5 m wide. The banks are well-vegetated and the channel bed is comprised primarily of sand with large woody debris scattered throughout. Streamflow recorded at this station represents disturbed conditions due to upstream surface water licenses for irrigation that total 530,396 m^3 on an annual basis (Section 6.4.2.2).

Jacko Lake (JACLAKE). This station monitors the water level in Jacko Lake and any flow over the spillway when occurring. The station is located in the southeast arm of Jacko Lake about 30 m from the entrance to the overflow spillway channel. The bank of the lake is grassy and there is woody debris around the station. The catchment area to this station is 40.9 km^2. The spillway channel is approximately 3 m wide with a gradient of 3%. It is not uncommon for the spillway channel to be dry, as it was during field inspections from July through October 2014.

Jacko Lake Seepage (JACSEEP). During low flow periods in the summer, the water levels in Jacko Lake are controlled by a low-flow outlet. Flows from this outlet, which is operated by a provincially-appointed bailiff when the overflow spillway is dry, are monitored at the JACSEEP hydrometric station. The station is located downstream of the outlet pipe in a concrete outflow channel with a v-notch weir. The catchment area to JACSEEP is the same as that of JACLAKE, 40.9 km^2, as both stations monitor outflow from Jacko Lake. The JACSEEP station has a very low gradient of 0.3% and is often affected by backflow conditions. Peak discharge for this station does not follow the same hydrologic trends as the other stations in the Project area as it generally only operates in July and August.

Peterson Creek (PETER). The PETER station is located 3 km downstream of the Jacko Lake outlet and it has a catchment area of 60 km^2. The channel is 2.5 m wide at the station and the banks are overgrown with small shrubs. The stream bed is comprised of sand with small gravels and cobbles in the centre of the channel.

Keynes Creek (KEYNES). This hydrometric station monitors flows from a small (11 km^2 catchment) tributary of Peterson Creek that discharges to the creek between the Jacko Lake outlet and the PETER station. At the station, the channel is very small (70 cm wide) and flows through a wooded area with thick organic material on the bed. The channel was observed to be dry through most of the summer of 2014 (from mid-June through October) and flow measurements were challenging under such low-flow conditions. The highest measured flow at this station in 2014 was 2 L/s. A lack of surface runoff at this station can be attributed to upstream licensed water use.

PC02.1 (Peterson Creek Lower). Station PC02.1 is located the furthest downstream on Peterson Creek and it receives contributing flows from all the other Project gauging stations. This station was installed in June 2015 with the intent of monitoring baseflows in Peterson Creek (Lower) during periods when Jacko Lake is not spilling or flows are being released from the low level outlet. During periods of low flow, there is typically no surface flow at PETER, due to flow through the subsurface aquifer. However, station PC02.1 is located within a zone of groundwater discharge and it is expected that baseflows can be monitored here.

The Water Survey of Canada (WSC) also maintains and operates hydrometric stations throughout the region. Six regional hydrometric stations within a 60 km radius of the Project area were evaluated as part of the baseline assessment (Appendix 6.4-A). Details of these stations are provided in Table 6.4-2, while station locations are shown on Figure 6.4-4.

From 1981 to 1986 the WSC also operated a station on Peterson Creek above Jacko Creek (08LE102). Flow was measured seasonally at this station, typically from April 1 to September 30. The reported drainage area for this station is 21.2 km^2 and is located upstream of JACINF and irrigation activities. Average annual runoff at this station was 35 mm (for the 1981 to 1986 period).

Characterization of Surface Water Quantity Baseline Condition

Consistent with regional hydrologic patterns typical of the BC Interior Region, peak streamflows in Peterson Creek generally occur in the spring (between April and June) in response to snowmelt and low flows occur during the remainder of the year. Figure 6.4-5 illustrates the regional streamflow pattern plotting average unit runoff hydrographs for the regional WSC stations. Flows remain low in the summer and fall following large rain events, which is attributed to the area's relatively permeable and dry soils that readily absorb rainfall, resulting in limited runoff to the creeks. On Peterson Creek (Upper), there is typically no surface runoff observed at JACINF by late summer.

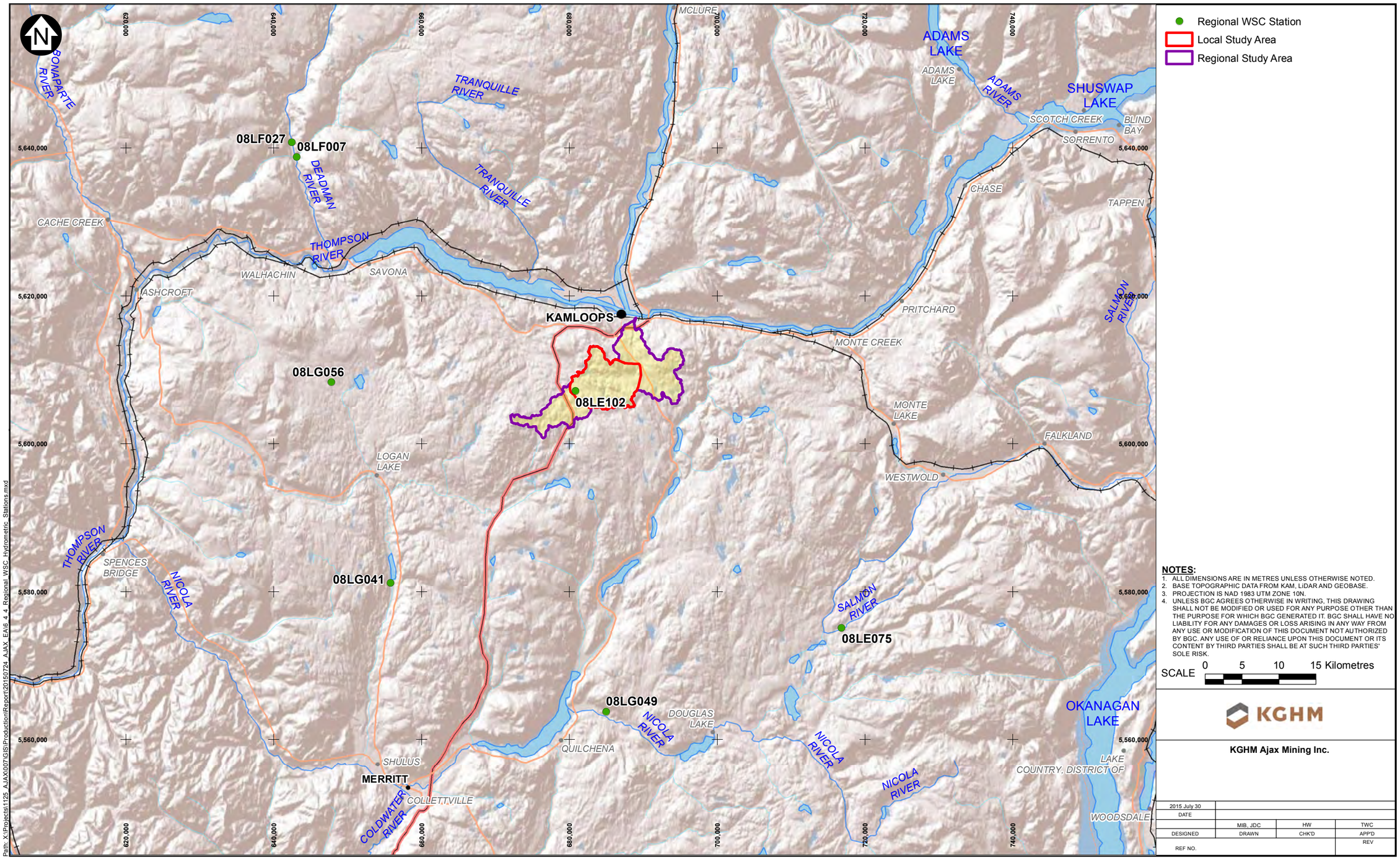
The conceptual model of runoff reaching the JACINF station is a shallow zone of moderately permeable overburden at the surface that becomes saturated during spring melt and contributes rapid runoff to the local stream network. A portion of the snow melt also infiltrates to depth eventually reaching the groundwater table as recharge. Infiltration to the groundwater table is conceptualized as a slow process due to the low hydraulic conductivity of the relatively fine-grained till and/or low hydraulic conductivity bedrock that underlies a majority of the area. As a result of low infiltration rates through the till, recharge and hence baseflows are not expected to fluctuate significantly either on a seasonal or annual basis. As the spring melt passes, a majority of subsequent rainfall does not contribute to either surface runoff or recharge due to high temperatures, high potential evapotranspiration rates and relatively low rainfall (relative to potential evapotranspiration).

Return Period Calculations

For the purpose of gaining an understanding of long-term flow patterns in Peterson Creek, a long-term synthetic flow series was generated for the JACINF gauge (Appendix 6.4-A). This site was selected in preference to the other gauge sites because flows are not regulated and can therefore be correlated to regional flow records. Flows at the downstream gauge sites are subject to influence by beaver dam activity and attenuation as a result of reservoir and lake filling and releases.

To generate the synthetic dataset, the JACINF daily streamflow data was correlated with concurrent data from the regional WSC hydrometric stations summarized in Table 6.4-2. That analysis indicated that data from station 08LF027 (Deadman River at Criss Creek) provided the strongest and most consistent relation. Ranked regression analysis (also known as frequency paired analysis) was then used to generate a synthetic long-term streamflow record for JACINF using monthly derived relations between the long-term streamflow data from 08LF027 (1962 to 2001) and the short-term streamflow data at JACINF (2008 to 2011). The resultant synthetic dataset covers the period 1962 to 2011. Mean annual flow for this period is 0.025 m^3/s, which represents an annual runoff of 26 mm based on a drainage area of 31 km^2. The monthly distribution of runoff is illustrated in Figure 6.4-6.

Figure 6.4-4
Regional WSC Hydrometric Stations



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Figure 6.4-5
Regional Unit Runoff Hydrograph

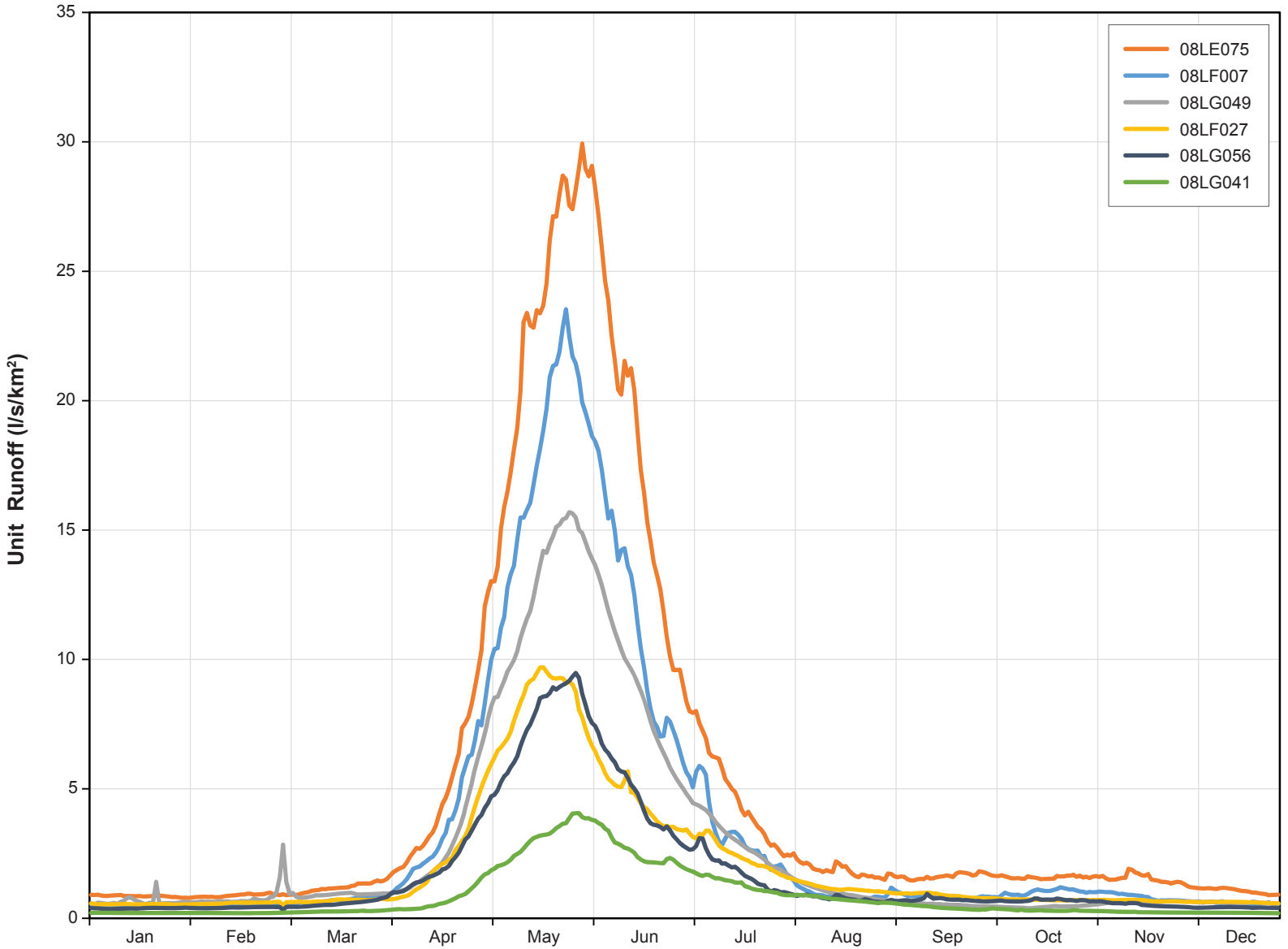


Figure 6.4-6
Average Monthly Runoff for Peterson Creek (Upper) at JACINF (1963-2011)

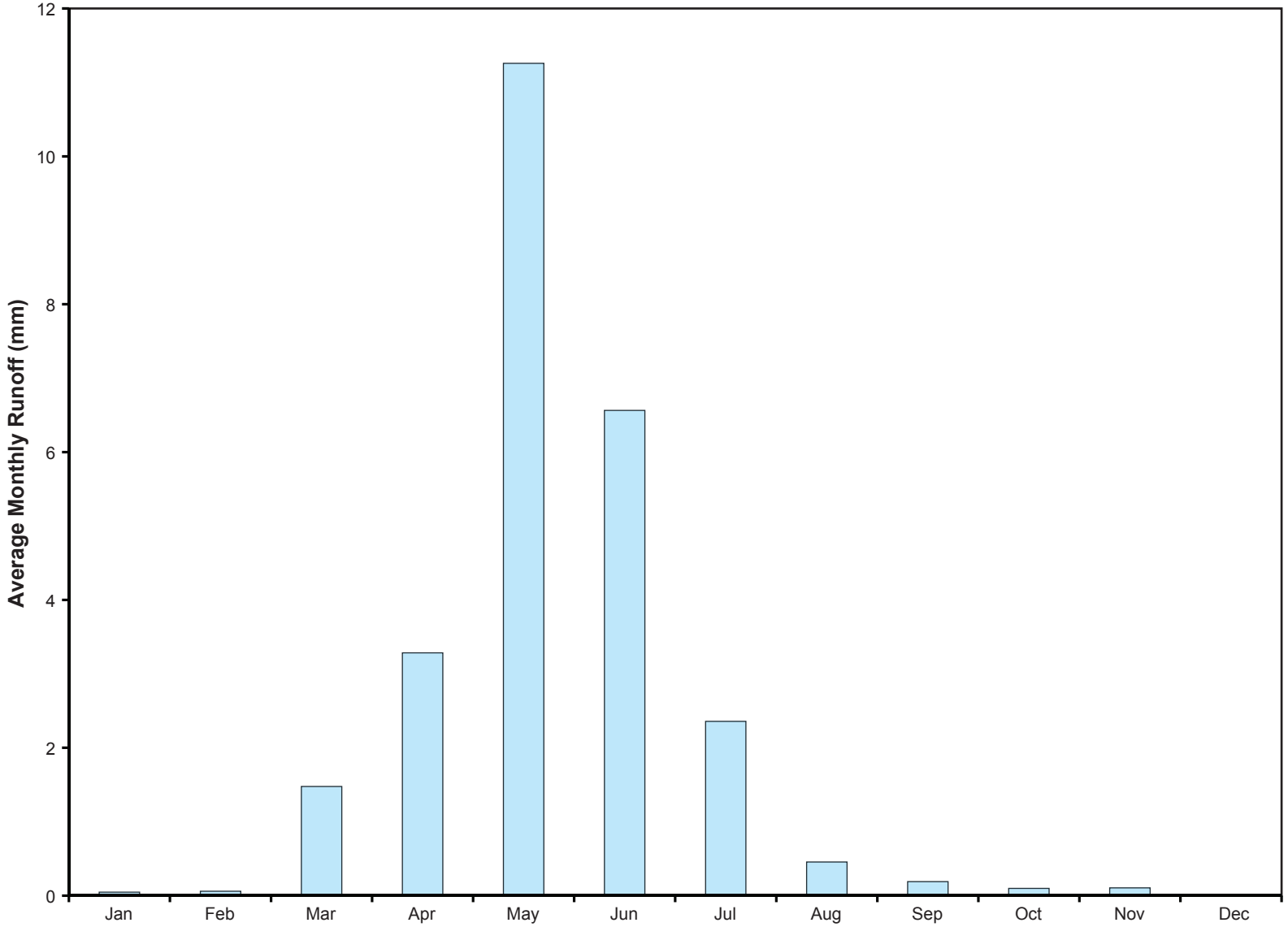


Table 6.4-2. Regional Hydrometric Stations

ID	Station Name	Period of Record	Latitude	Longitude	Distance from Site (km)	Drainage Area (km²)	Median Elevation (m)	Mean Annual Runoff (mm)
08LE075	Salmon River Above Salmon Lake	1965 - 2002	50.288	-119.956	57	143	1,350	165
08LF007	Criss Creek near Savona	1912 - present	50.883	-120.965	41	479	1,190	110
08LF027	Deadman River at Criss Creek	1913 – present	50.901	-120.974	42	878	1,190	41
08LG041	Guichon Creek at Outlet of Merrit Lake	1933 – present	50.362	-120.809	38	871	1,369	26
08LG049	Nicola River above Nicola Lake	1915 – present	50.197	-120.408	52	1,500	1,230	87
08LG056	Guichon Creek Above Tunkwa Lake Diversion	1967 - present	50.608	-120.911	27	78	1,340	56

Source: Knight Piésold (2013)

Calculation of return period monthly flows at the JACINF hydrometric station was accomplished using the 1963 to 2011 synthetic dataset. Results are presented in Table 6.4-3.

Table 6.4-3. Wet and Dry Average Monthly Flows at JACINF Hydrometric Station

	Dry (m^3/s)				Wet (m^3/s)		
Month	20-year	10-year	5-year	Mean	5-year	10-year	20-year
Jan	0.000	0.000	0.000	0.001	0.001	0.001	0.002
Feb	0.000	0.000	0.000	0.001	0.001	0.002	0.002
Mar	0.010	0.011	0.011	0.017	0.020	0.026	0.032
Apr	0.012	0.014	0.016	0.038	0.050	0.079	0.123
May	0.021	0.047	0.076	0.129	0.174	0.202	0.229
June	0.026	0.031	0.040	0.080	0.114	0.144	0.172
July	0.000	0.001	0.002	0.027	0.033	0.068	0.119
Aug	0.000	0.000	0.001	0.005	0.008	0.011	0.014
Sept	0.000	0.000	0.000	0.002	0.004	0.005	0.007
Oct	0.000	0.000	0.000	0.001	0.002	0.003	0.003
Nov	0.000	0.000	0.000	0.001	0.002	0.003	0.004
Dec	0.000	0.000	0.000	0.001	0.002	0.003	0.003

Peak instantaneous flows have also been estimated for Peterson Creek (Upper) at JACINF. Two methods were employed. The first method employed a flood frequency assessment (FFA) that used the maximum annual flows generated from the synthetic dataset. The second method employed a regional analysis using the index flood approach of Obedkoff (2003) and a scaling exponent of 0.7. Details are provided in Appendix 6.4-A. Peak flows generated using both methods are summarized in Table 6.4-4. Due to flow regulation at Jacko Lake, peak flow estimates have not been generated for locations on Peterson Creek below Jacko Lake.

Table 6.4-4. Peak Instantaneous Flow Estimates at JACINF Hydrometric Station

	Peak Instantaneous Flows (m^3/s)					
Description	Mean	2-year	10-year	50-year	100-year	200-year
Statistical	0.24	0.29	0.62	1.08	1.35	1.68
Regional	0.72	0.72	1.14	1.82	2.19	2.61

6.4.3 Assessment Boundaries

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

6.4.3.1 Spatial Boundaries

Spatial boundaries reflect the location of the Project components and consider watersheds over a range of spatial scales from local (i.e., immediately surrounding the mine footprint) to regional (i.e., the Peterson Creek watershed). The spatial boundaries for the assessment of surface water quantity have been divided into a Local Study Area (LSA) and a Regional Study Area (RSA). These areas are discussed below and presented in Figure 6.4-7. The reader should note that spatial boundaries depend on the VC being assessed and as such are not the same for all VCs.

Local Study Area

The LSA was selected to focus on the mine site and a larger, localized area of direct Project influence (Figure 6.4-7). The LSA incorporates reaches of Peterson Creek (Upper and Lower), as well as sub-watersheds on the south and north bank of Peterson Creek that may be potentially affected by the Open Pit, Tailings Storage Facility (TSF), the Mine Rock Storage Facilities (MRSFs) and various water management ponds. Sub-watersheds of note include Keynes Creek and Humphrey Creek. The LSA also includes Jacko Lake and Kamloops Lake. Although the latter is not specifically delineated on Figure 6.4-7, make-up water for the Process Plant will be sourced from Kamloops Lake. The effects of these withdrawals on Thompson River streamflows are considered here-in. The LSA extends downstream on Peterson Creek to water quality baseline site PC02, which is located downstream of all Project discharges (Figure 6.4-7).

Regional Study Area

The RSA is defined by the Peterson Creek watershed boundary and encompasses an area beyond which surface water quantity effects of the Project are not expected (Figure 6.4-7). As noted previously, the Peterson Creek watershed covers an area of approximately 130 km^2, before discharging into the South Thompson River.

Alkali Creek and Cherry Creek

Neither the LSA nor the RSA for surface water quantity include the Alkali Creek watershed or the larger Cherry Creek watershed, which it discharges into (Figure 6.4-3 and Figure 6.4-7). When streamflows are discharging through the Jacko Lake spillway and lake levels are high enough, very minor amounts of water can spill out the west arm of the lake (Figure 6.4-8). This water flows to the northwest toward Inks Lake, although there is no obvious channel upstream of the Lac le Jeune Road or a culvert through the road embankment. Some of this surface flow might report as subsurface flow to Inks Lake, but this lake is an endorheic (i.e., closed) basin with no surface outlet. Therefore, there is no surface water connection between Jacko Lake and the Alkali/Cherry Creek watersheds. Also groundwater within the Peterson Creek watershed is predicted to be contained within the watershed. Forward particle tracking results indicate that groundwater will remain within the Peterson Creek Watershed discharging to Jacko Lake, Peterson Creek, and Humphry Creek (see Appendix 6.6-D).

6.4.3.2 Temporal Boundaries

Surface water quantity will potentially be affected throughout the life of the mine, encompassing Construction, Operation, Decommissioning and Closure, and Post-Closure. The temporal boundaries of the Project include the following:

- **Construction**: 2 years;
- **Operation**: 23 years;
- **Decommissioning and Closure**: 5 years (includes project decommissioning, abandonment and reclamation activities, as well as temporary closure, and care and maintenance); and
- **Post-Closure**: 5+ years (includes ongoing reclamation activities and Post-Closure monitoring).

6.4.3.3 Administrative Boundaries

No administrative boundaries were applied to the surface water effects assessment.

6.4.3.4 Technical Boundaries

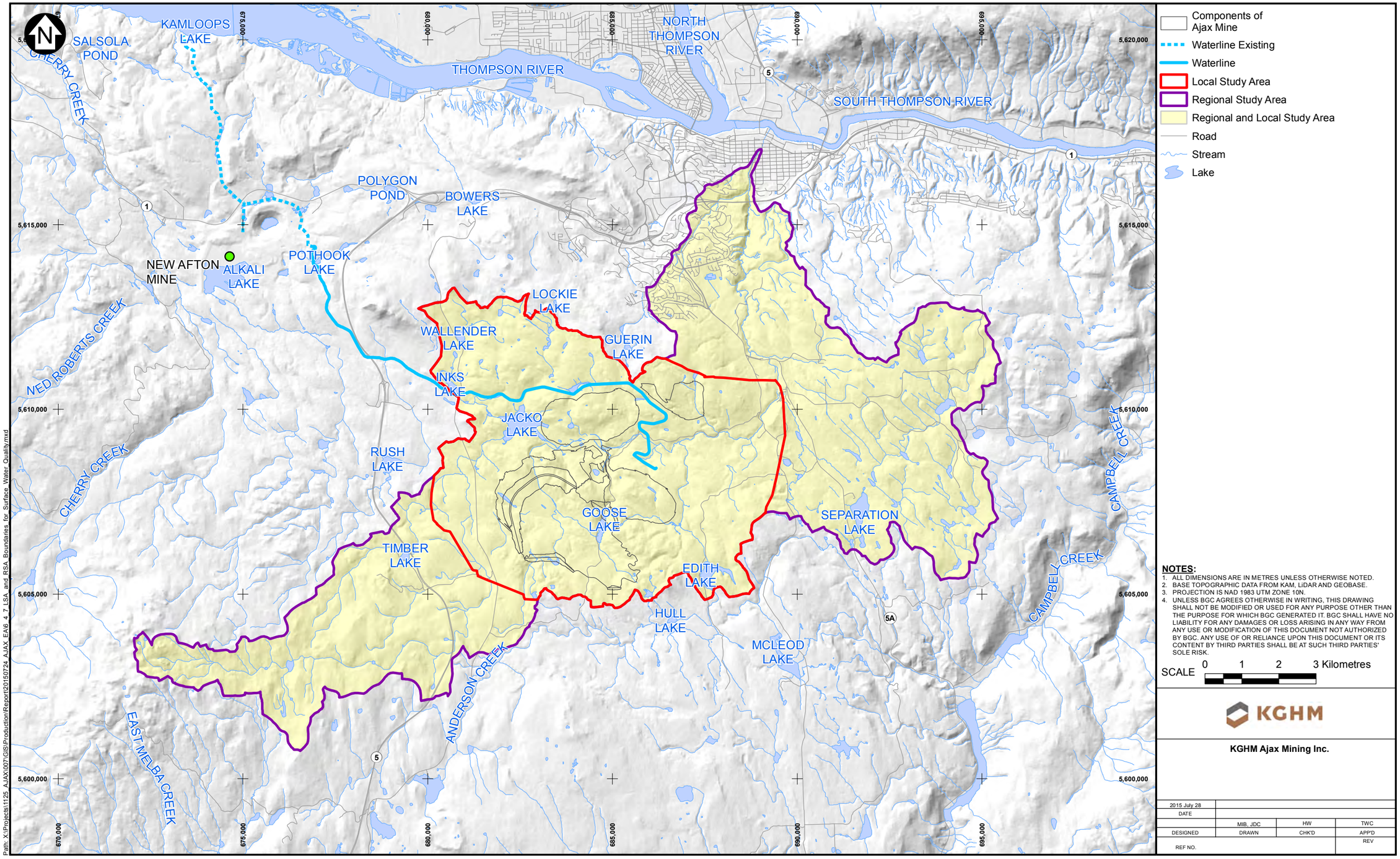
No technical boundaries were applied to the surface water effects assessment.

6.4.4 Potential Effects of the Project and Proposed Mitigation for Surface Water Quantity

Effects to surface water quantity could potentially occur during all phases of the Project. The construction and operation of mine infrastructure including the TSF, the Open Pit, the various MRSFs, and water management ponds, could have effects on surface water patterns and flow volumes in Peterson Creek. Four potential effects of the Project on the surface water quantity VC are identified. These are impacts on:

- *Annual Flow Volumes*. The annual flow volume is a measure of the total volume of water flowing past a point in a stream channel each year. Assessment of the effects of the Project on the annual flow volume will indicate the large-scale effects of the Project on the water available for aquatic and terrestrial life.
- *Monthly Flow Distribution*. Generally, Peterson Creek and its tributaries exhibit minimal flows during the late summer through winter (August to March) and high flows during the spring melt (April to June). The assessment considers the effects of the Project on the natural monthly flow distribution.
- *Peak Flows*. Peak flows typically have beneficial impacts to the natural environment through the transport of sediment (which leads to the alteration and renewal of fish habitat) and providing a source of water to sustain wetland and floodplain ecosystems along river systems.
- *Low Flows*. A minimum streamflow is required to maintain the health of aquatic ecosystems. A decrease in low flow conditions or a greater duration of low flows can impact aquatic life and water quality.

Figure 6.4-7
Local Study Area and Regional Study Area Boundaries for Surface Water Quantity



Components of Ajax Mine
Waterline Existing
Waterline
Local Study Area
Regional Study Area
Regional and Local Study Area
Road
Stream
Lake

NOTES:
1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE NOTED.
2. BASE TOPOGRAPHIC DATA FROM KAM, LiDAR AND GEOBASE.
3. PROJECTION IS NAD 1983 UTM ZONE 10N.
4. UNLESS BGC AGREES OTHERWISE IN WRITING, THIS DRAWING SHALL NOT BE MODIFIED OR USED FOR ANY PURPOSE OTHER THAN THE PURPOSE FOR WHICH BGC GENERATED IT. BGC SHALL HAVE NO LIABILITY FOR ANY DAMAGES OR LOSS ARISING IN ANY WAY FROM ANY USE OR MODIFICATION OF THIS DOCUMENT NOT AUTHORIZED BY BGC. ANY USE OF OR RELIANCE UPON THIS DOCUMENT OR ITS CONTENT BY THIRD PARTIES SHALL BE AT SUCH THIRD PARTIES' SOLE RISK.

SCALE 0 1 2 3 Kilometres

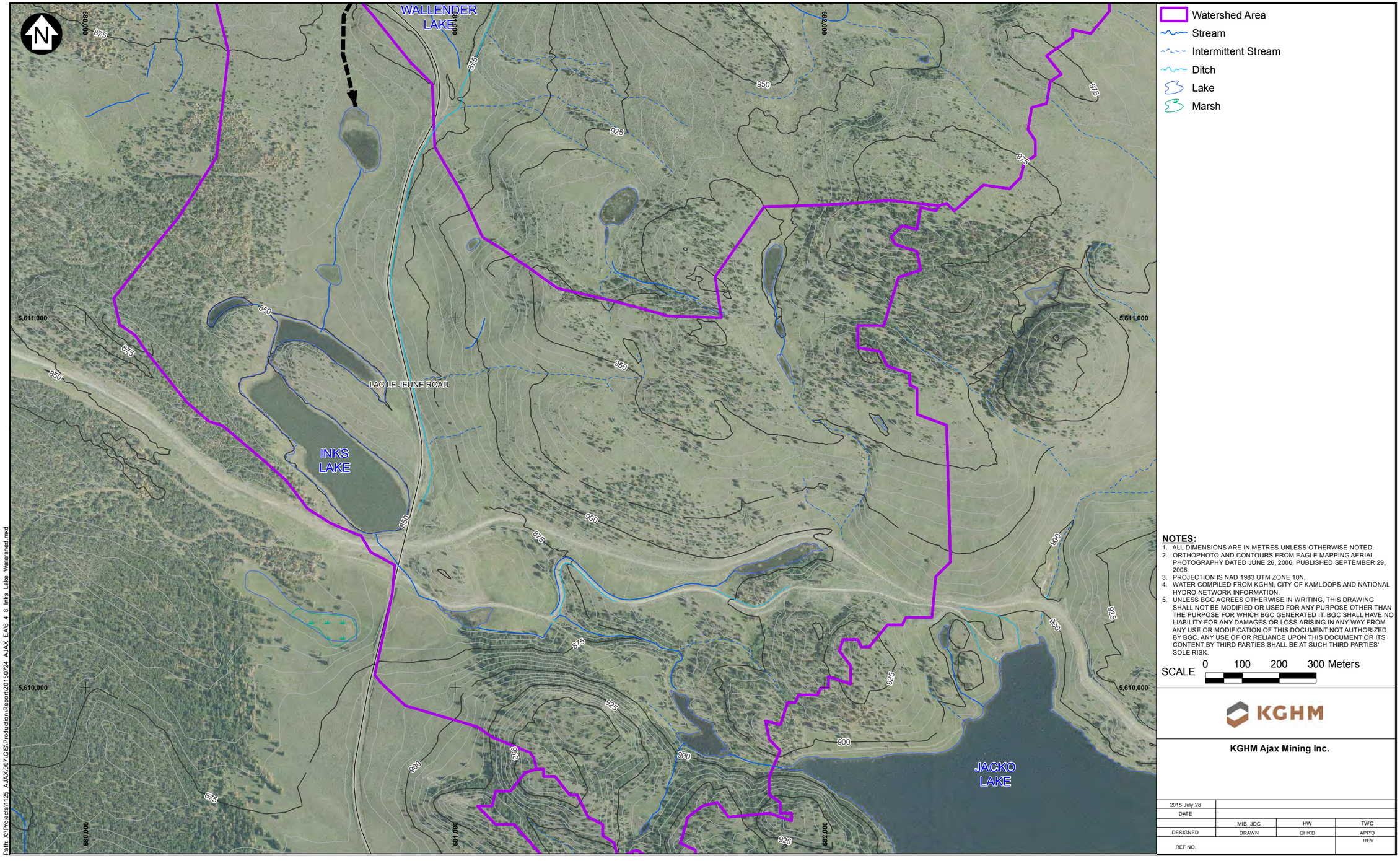
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KGHM Ajax Mining Inc.

2015 July 28			
DATE			
	MIB, JDC	HW	TWC
DESIGNED	DRAWN	CHK'D	APP'D
REF NO.			REV

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Figure 6.4-8
Inks Lake Watershed



NOTES:

1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE NOTED.
2. ORTHOPHOTO AND CONTOURS FROM EAGLE MAPPING AERIAL PHOTOGRAPHY DATED JUNE 26, 2006, PUBLISHED SEPTEMBER 29, 2006.
3. PROJECTION IS NAD 1983 UTM ZONE 10N.
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Assessment of these four effects provides a comprehensive understanding of the impacts on both magnitude and timing of surface water quantity. The use of Kamloops Lake as a source of make-up water for the Project will also impact surface water quantity in the Thompson River. Kamloops lake water will be needed during Construction, Operation, and the Decommissioning and Closure phases. Thompson River water is not expected to be required in Post-Closure. However, during all phases of mine life, there will be a decrease in streamflow in Peterson Creek, which will have a minor effect on South Thompson River flows.

It should also be recognized that surface water and groundwater quantity are linked. In cases where surface water recharges groundwater, a reduction of surface water flow may result in less groundwater recharge.

Components and activities for each temporal phase are discussed below to describe the pathways that can lead to effects on surface water quantity. The objective of this section is to identify key effects that warrant further consideration and assessment.

6.4.4.1 Identifying Potential Effects on Surface Water Quantity

Effects to surface water quantity could potentially occur during all phases of the Project. In general, the Project has the potential to change surface water quantity by:

- development of water management and mining infrastructure which will collect and enable the Project to beneficially use surface water that currently flows to Peterson Creek;
- collection and beneficial use of groundwater entering the open pit that would have otherwise discharged as baseflow to surface water;
- abstraction of water from Kamloops Lake for use as make-up water; and
- presence of a permanent open pit water body following mine closure.

Potential effects to surface water quantity from activities in each Project phase are identified below.

<u>Construction</u>

During Construction (two years), activities with the potential to affect surface water quantity will include:

- general earthworks (compaction, and dust suppression, etc.);
- the use of Kamloops Lake water to establish a pond in the TSF prior to the start of Operation (an approximate pond volume of 2.1 Mm^3 is required for mill start-up);
- the construction and filling (~60,000 m^3) of the Peterson Creek Downstream Pond;
- initial development of the TSF, Ore Stockpile, and MRSFs;
- development of the overburden/topsoil stockpile;
- contact water management – construction of the Central Pond and the establishment of water collection ponds downstream of the various MRSFs, Ore Stockpile, and TSF embankments;

- construction of the four Jacko Lake dams;
- non-contact water management - construction and operation of the Peterson Creek Diversion and Peterson Creek Downstream Pond; and
- development of the Open Pit.

Operation

During Operation (23 years), activities with the potential to affect surface water quantity will include:

- ongoing development of mine infrastructure and construction projects, as may be required;
- ongoing development of the Open Pit, which will progressively reduce the drainage area reporting to Peterson Creek (Lower) and induce a progressive lowering of the groundwater table, thereby progressively reducing baseflows reporting to Peterson Creek (Lower);
- deposition of mine rock and tailings and the associated management of contact water (operation of water collection ponds downstream of the various MRSFs, Ore Stockpile, and TSF embankments);
- contact water management from the temporary Ore Stockpile;
- ongoing stripping, loading, hauling, deposition and contouring of topsoil and overburden;
- contact water management in the TSF including the use of reclaim water in the Process Plant;
- the use of Kamloops Lake water as a source of make-up water for the Process Plant, potable water and dust control; and
- non-contact water management – management of Jacko Lake water levels, the Peterson Creek Diversion, and the Peterson Creek Downstream Pond.

Decommissioning and Closure

During Decommissioning and Closure (5 years), activities with the potential to affect surface water quantity will include:

- the natural refilling of the Open Pit, into which surface water and groundwater will be directed thus reducing flow to Peterson Creek (Lower);
- water management during decommissioning and reclamation of the TSF and various MRSFs;
- use of water for closure and reclamation activities such as compaction of soils and irrigation of vegetation;
- ongoing operation and management of contact water in the various collection ponds; and
- non-contact water management of Jacko Lake water levels and the Peterson Creek Diversion while a new channel is established between the Open Pit and the WMRSF.

Post-Closure

Post-Closure (5+ years) will last until long-term environmental objectives are achieved. Surface water and groundwater monitoring will take place during this phase. Activities with the potential to affect surface water in Post-Closure will include:

- natural filling of the Open Pit, which will slowly accumulate runoff from precipitation within the pit footprint, groundwater inflows and up gradient surface runoff thus reducing flow to Peterson Creek;
- discharge of surface runoff from the reclaimed TSF into the Humphrey Creek watershed; and
- the water management ponds located downstream of the reclaimed MRSFs and TSF embankments.

Potential effects on surface water quantity are ranked in Table 6.4-5 to focus the assessment on key effects. These key effects are considered further in the next section. The ranking system used is:

- O – no interaction expected;
- L – negligible to minor interaction expected;
- M – potential moderate interaction requiring active management/monitoring; and
- H – key interaction.

An evaluation of location, timing, frequency and magnitude were all considered in the ranking evaluation. Project components with the potential for negligible or minor expected adverse effects are not considered further in the effects assessment. Implementation of best management practices and standard mitigation measures will be used to address these concerns (e.g., access road construction).

Table 6.4-5. Project Components and Potential Effects on Surface Water Quantity

Project Activities		Surface Water Quantity
Construction	Clearing and Grubbing	L
	Earthworks	M
	Overburden/Topsoil Stockpile	M
	Laydown Areas and Storage Yards	L
	Project Lighting	O
	Site Security and Fencing	O
	Fuel Storage and Filling Area	L
	Hazardous Wastes Transport, Storage, and Disposal	L
	Construction Wastes Transport, Storage, and Disposal	L
	Sewage Infrastructure and Disposal	L
	Public Road Realignment, Use, and Maintenance	L

(continued)

Table 6.4-5. Project Components and Potential Effects on Surface Water Quantity (continued)

Project Activities		Surface Water Quantity
Construction *(cont'd)*	Site Road Construction, Use and Maintenance	L
	Peterson Creek Bridge Construction, Use, and Maintenance	L
	Site Buildings and Process Plant	L
	Explosives Magazine and Storage Facilities	L
	Open Pit Development	H
	Drilling and Blasting	L
	Crushing Waste Rock	O
	Loading, Hauling, and Deposition of Waste Rock	M
	Temporary Ore Stockpile	M
	Tailing Storage Facility Development	H
	Power Transmission, Distribution	O
	Natural Gas Line	L
	Pipeline Utility Corridor (Potable Water, Sewage, and Site Water)	L
	Water Intake from Kamloops Lake	M
	Fire Suppression Infrastructure	L
	Contact Water	M
	Non-contact Water	M
	Peterson Creek Diversion	H
	Water Management Dams	M
	Mine Staffing (Direct Employment)	O
	Contracted Employment	O
	Taxation	O
Operation	Open Pit Development	H
	Drilling and Blasting	L
	Hauling Waste Rock and Ore from Pit	O
	Crushing and Conveying Ore	O
	Temporary Ore Stockpile	M
	Development of Waste Rock Management Facilities	H
	Stripping, Loading, Hauling, Deposition, and Contouring of Topsoil and Overburden	M
	Revegetation through Progressive Reclamation	L
	Process Plant Operation	M
	Deposition to Tailing Storage Facility	H
	Site Road Use and Maintenance (Materials, Personnel, Supplies)	L
	Concentrate Transport and Storage	O
	Explosives Magazine and Storage Facilities	O
	Fire Suppression Infrastructure	O
	Fuel Storage and Filling Area	O

(continued)

Table 6.4-5. Project Components and Potential Effects on Surface Water Quantity (continued)

Project Activities		Surface Water Quantity
Operation *(cont'd)*	Hazardous Wastes Transport, Storage, and Disposal	O
	General Wastes Transport, Storage, and Disposal	O
	Sewage Infrastructure and Disposal	L
	Laydown Areas and Storage Yards	L
	Power Transmission, Distribution	O
	Project Lighting	O
	Site Access, Security and Fencing	O
	Water Intake from Kamloops Lake	M
	Contact Water	M
	Non-contact Water	M
	Potable Water Treatment and Use	L
	Peterson Creek Diversion	H
	Mine Staffing (Direct Employment)	O
	Contracted Employment	O
	Taxation	O
Decommissioning and Closure	Dismantling of Ancillary Buildings	L
	Pit Lake Planning/Filling	H
	Site Road/Bridge Decommissioning	L
	Tailing Storage Facility Decommissioning and Reclamation	H
	Waste Rock Management Facilities Reclamation	H
	Fuel Storage and Filling Area	L
	Hazardous Wastes Transport, Storage, and Disposal	L
	General Wastes Transport, Storage, and Disposal	L
	Sewage Infrastructure and Disposal	L
	Laydown Areas and Storage Yards	L
	Power Transmission, Distribution	O
	Project Lighting	O
	Site Access, Security and Fencing	O
	Contact Water	M
	Non-contact Water	M
	Potable Water Treatment and Use	L
	Peterson Creek Diversion	H
	Road use to the Project (Materials, Personnel, Supplies)	O
	Mine Staffing (Direct Employment)	O
	Contracted Employment	O
	Taxation	O

(continued)

Table 6.4-5. Project Components and Potential Effects on Surface Water Quantity (completed)

Project Activities		Surface Water Quantity
Post-Closure	General Site Inspections and Maintenance	L
	Contact Water	M
	Non-contact Water	M
	Road use to the Project (Materials, Personnel, Supplies)	O
	Mine Staffing (Direct Employment)	O
	Contracted Employment	O

Notes:

O	*No interaction anticipated.*
L	*Negligible to minor interaction expected; implementation of best practices, standard mitigation and management measures; no monitoring required, no further consideration warranted.*
M	*Potential moderate interaction requiring unique active management/monitoring/mitigation; warrants further consideration.*
H	*Key interaction; warrants further consideration.*

6.4.4.2 Key Effects on Surface Water Quantity

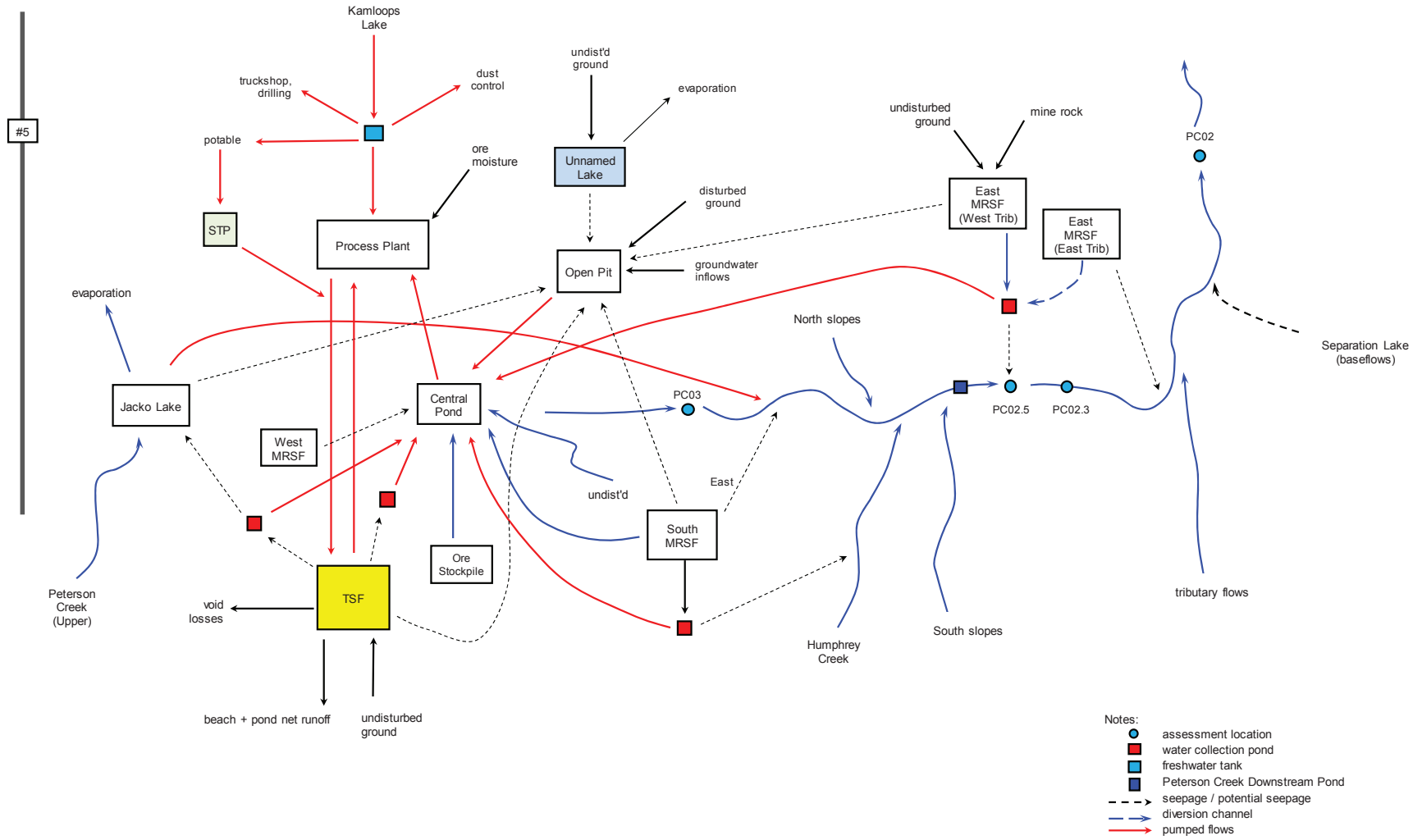
The Project components and activities have the potential to affect streamflows in Peterson Creek (Lower) and Kamloops Lake. Therefore, assessment locations were selected at various locations on Peterson Creek (Lower) and at the water intake on Kamloops Lake. A water balance model (WBM) was developed to estimate effects of the Project on annual and monthly streamflows. Details of the model, including input data, modelling assumptions, calibration, and results are available in Appendix 6.4-C. The WBM is set-up in MS Excel™ and employs a monthly time-step. The model is used as a predictive tool to estimate monthly runoff quantities at various locations both within the mine site and down gradient.

Key elements of the WBM are the Open Pit, the TSF, the various MRSFs (East, West and South), and the various water management ponds (e.g., Central Pond, EMRSF Pond, SMRSF Pond, etc.). Runoff volumes and patterns for each of these areas are unique and must be calculated separately. A water balance schematic for the WBM during Operation is provided in Figure 6.4-9. Assessment locations, which coincide with water quality stations, are shown on this schematic

The main inflows into the WBM during Operation include:

- groundwater and surface inflows into the Open Pit;
- precipitation on the pond and active and inactive beaches of the TSF;
- undisturbed runoff into Jacko Lake;
- water pumped from Kamloops Lake as a source of make-up water for the Process Plant, potable water, and water for dust control;
- precipitation on the Ore Stockpile and MRSFs; and
- runoff from natural ground downstream of Jacko Lake not impacted by Project facilities, including the Humphrey Creek drainage.

Figure 6.4-9
Ajax Water Balance Schematic during Operation



Outflows or losses include:

- void filling during tailings deposition;
- void filling of the mine rock, while it wets up to a residual moisture content;
- evaporation from open water in the ponds;
- evaporation and sublimation from the active and inactive TSF beaches; and
- onsite water uses (potable water, dust control).

The base case scenario being evaluated is average precipitation conditions, but a number of sensitivity simulations have also been evaluated, as part of the water quality modelling. Table 6.4-6 provides a list of the sensitivity scenarios considered for the surface water quantity effects assessment.

Table 6.4-6. Sensitivity Scenarios to Assess Effects on Surface Water Quantity

Group No.	Sensitivity Scenario	Precipitation[1]	MRSF Infiltration[2]	Hydraulic Conductivity[3]	TSF Conductance[4]	Pond Seepage Bypass[5]
0	Base case	Average	Base	Base	Base	Base
1	**Climate Inputs**					
	1	Variable climate	Base	Base	Base	Base
2	**MRSFs**					
	1	Average	2x higher	Base	Base	Base
3	**Groundwater Assumptions**					
	1	Average	Base	5x higher	Base	Base
	2	Average	Base	5x lower	Base	Base
	3	Average	Base	Base	10x higher	Base
	4	Average	Base	Base	Base	2x higher

[1] Average annual precipitation for the mine site is 336 mm. Variable climate conditions include stepping the WBM through the historic climate record (1897-2011) in 5 year increments.
[2] Based on unsaturated flow modelling (see Appendix 6.4-C).
[3] Increasing and decreasing the hydraulic conductivity by a factor of 5 based on groundwater modelling results. These two scenarios result in an increase/decrease in groundwater flows.
[4] Increasing the TSF conductance by a factor of 10 increases the TSF seepage estimates.
[5] This scenario refers to the amount of water that infiltrates the MRSFs and reports to the base of the facility. Some of this water will report to the groundwater table and bypass the downstream water management pond. Additional details are provided in Appendix 6.4-C.

These model inputs generate seven different combinations (the base case and six scenarios). The WBM estimated monthly flows at baseline conditions, as well as flows during Construction, Operation, Decommissioning and Closure, and Post-Closure of the Project under these seven scenarios. These results were used to estimate the effects of the Project on annual streamflows, the monthly distribution of flows, low flows and peak flows.

Streamflows in the Project area are typically at a minimum from late summer through March. Above Jacko Lake, the groundwater table in Peterson Creek (Upper) is located below the ground surface. As a result, there is typically no surface flow in Peterson Creek (Upper) from late summer through March. However, further downstream in the vicinity of assessment locations PC02 and PC02.5 (the Peterson

Creek Downstream Pond), modelling indicates that these locations are coincident with groundwater discharge zones (Appendix 6.6-D) and year round surface flow occurs. In this assessment, monthly flows in February/March were used to represent the annual low-flow indicator of streamflows.

Potential changes in annual peak flows were used as a proxy for potential changes in stream morphology. Because the WBM uses a monthly time-step, it cannot estimate the effects of the Project on peak flows. The magnitude, duration and timing of peak flows in Peterson Creek (Lower) will be impacted due to:

- a reduced watershed area;
- contact water from disturbed areas will be collected in the various water management ponds and re-used in the Process Plant;
- Jacko Lake water levels will be managed by pumping inflows around a majority of the Project infrastructure with discharge to the Peterson Creek Downstream Pond.

These changes were considered in estimating the effects of the Project on peak flows.

6.4.4.3 Mitigation Measures for Surface Water Quantity

Multiple changes to the Project design have occurred to minimize the effect to surface water quantity, primarily by relocating Project facilities to a single watershed .The Project has been designed to minimize adverse effects to surface water quantity and quality through the development and implementation of a Water Management and Hydrometric Monitoring Plan (WMP) (Chapter 11.7). The WMP describes a range of mitigation measures to reduce or eliminate the potential effects of the Project on surface water quantity. The primary goals of water management activities are to divert non-contact water, minimize the amount of contact water generated, and to collect and reuse contact water in the Process Plant. The WMP for the Project addresses the following targeted goals:

- to protect water-related ecologically sensitive sites and resources, and avoid harmful physical, chemical or biological impacts on fish and wildlife habitat;
- to supply water for mine operations while ensuring the availability and quality of water for the existing water licenses;
- to identify, locate and size the water management infrastructure that will meet the above goals; and
- to manage water during all phases of mine operations and closure to ensure that any discharges are in compliance with the applicable water quality standards, criteria, and guidelines and that any adverse impacts greater than those predicted are mitigated.

Water management and erosion prevention and sediment control measures (as outlined in the Water Management and Hydrometric Monitoring Plan and the Erosion and Sedimentation Control Plan, Sections 11.7 and 11.2 respectively) will be implemented soon after Project approvals are received and before construction/pre-production mining commences. Perimeter water diversion and sediment collection structures will be established as a first step to work activities. In addition to perimeter

diversion ditches, small-scale runoff collection measures may be used locally (e.g., temporary sediment fences around the perimeter of stockpiles). Erosion prevention and sediment control Best Management Practices (BMPs) will be implemented. These include isolation of work areas from surface waters and proper use of structural practices such as sediment traps, geotextile cloth, sediment fences, gravel berms, and straw bales to mitigate and control erosion and sediment.

During construction, a number of water management ponds will be established:

- TSF Embankment Pond 1;
- TSF Embankment Pond 2;
- Central Pond;
- Plant Site Pond;
- SMRSF Pond; and
- EMRSF Pond.

These ponds will capture and temporarily store contact runoff from a number of facilities, including a component of TSF seepage and water that infiltrates the MRSFs and reports as surface runoff. All contact water captured by the ponds listed above, and the Open Pit runoff, will be pumped to the Central Pond or Plant Site Pond where it will be reclaimed for reuse in the Process Plant, thereby reducing the make-up water demand from Kamloops Lake. Inflows to Jacko Lake are considered non-contact water and these flows will be conveyed to the Peterson Creek Diversion, whereby the lake water is pumped around the majority of the mine infrastructure and discharged back to Peterson Creek (Lower) downstream of the Central Pond. This diversion scheme results in a dry reach that extends from the outlet of Jacko Lake to downstream of the Central Pond, a distance of approximately 3.6 km.

During Decommissioning and Closure, the section of Peterson Creek between the outlet of Jacko Lake and the Central Pond will be re-established. The Peterson Creek Diversion would be decommissioned at this time, as well as the Central Pond. The other water management ponds located down gradient of the TSF and MRSFs would be retained through the Decommissioning and Closure and Post-Closure phases, although modified such that their embankments are no longer defined as dams.

Changes to surface water quantity are considered only partially mitigated with the implementation of the mitigation measures above. Residual effects are assessed in Section 6.4.5 below.

6.4.5 Residual Effects and Their Significance

6.4.5.1 Quantification of Residual Effects

Residual Effects on Peterson Creek (Lower) – Annual and Monthly Streamflows

The WBM simulation results (Appendix 6.4-C) were used to estimate the effects of the Project on mean annual and monthly flows. It should be noted that the 100% change at PO03 during Operations is due to the implementation of the Peterson Creek Diversion. The effects on mean annual flows during each phase of the Project under the base case scenario (i.e., average annual precipitation; Table 6.4-7) are:

Table 6.4-7. Average Monthly Streamflow in Peterson Creek under Average Precipitation Conditions at Various Project Phases

Month	Jacko Lake (m³/h)							PC02 (m³/h)						
	Existing	Construction	% Change	Operation	% change	Post-Closure	% Change	Existing	Construction	% Change	Operation	% Change	Post-Closure	% Change
January	0	0	0%	0	0%	0	0%	23	17	-26%	16	-30%	16	-30%
February	0	0	0%	0	0%	0	0%	25	18	-28%	17	-32%	17	-32%
March	0	0	0%	0	0%	0	0%	100	69	-31%	62	-38%	92	-8%
April	0	0	0%	0	0%	0	0%	268	191	-29%	170	-37%	275	3%
May	530	509	-4%	443	-16%	453	-15%	845	725	-14%	634	-25%	767	-9%
June	586	582	-1%	576	-2%	571	-3%	714	667	-7%	651	-9%	694	-3%
July	289	289	0%	289	0%	289	0%	335	315	-6%	312	-7%	322	-4%
August	289	289	0%	289	0%	289	0%	321	305	-5%	304	-5%	306	-5%
September	0	0	0%	0	0%	0	0	32	20	-38%	19	-41%	21	-34%
October	0	0	0%	0	0%	0	0	37	26	-30%	24	-35%	28	-24%
November	0	0	0%	0	0%	0	0	23	17	-26%	16	-30%	16	-30%
December	0	0	0%	0	0%	0	0	23	17	-26%	16	-30%	16	-30%
Annual	**142**	**140**	**-1%**	**134**	**-6%**	**135**	**-5%**	**230**	**200**	**-13%**	**188**	**-18%**	**215**	**-7%**

Month	PC03 (m³/h)						
	Existing	Construction	% Change	Operation	% change	Post-Closure	% Change
January	6	0	-100%	0	-100%	0	-100%
February	6	0	-100%	0	-100%	0	-100%
March	22	0	-100%	0	-100%	9	-59%
April	58	0	-100%	0	-100%	28	-52%
May	598	0	-100%	0	-100%	487	-19%
June	615	0	-100%	0	-100%	590	-4%
July	300	0	-100%	0	-100%	294	-2%
August	297	0	-100%	0	-100%	290	-2%
September	8	0	-100%	0	-100%	1	-88%
October	9	0	-100%	0	-100%	2	-78%
November	6	0	-100%	0	-100%	0	-100%
December	6	0	-100%	0	-100%	0	-100%
Annual	**162**	**0**	**-100%**	**0**	**-100%**	**143**	**-12%**

- Construction: the mean annual flows are decreased by 12% in Peterson Creek (Lower) at PC02. Construction of the Central Pond and the Peterson Creek Diversion System effectively result in no surface runoff at PC03, as soon as the diversion system becomes operational during the initial Construction period.
- Operation: the mean annual flows are decreased by 17% in Peterson Creek (Lower) at PC02 by the end of Operation (Year 23). This effects is progressive, as the open pit footprint increases over the life-of-mine.
- Decommissioning and Closure: results are similar to Operation, as the maximum mine footprint has been reached but active water management continues while the mine site is decommissioned and reclaimed.
- Post-Closure (100 years after operations cease): the mean annual flows are decreased by 11% and 6% in Peterson Creek (Lower) at PC03 and PC02, respectively. Streamflows are higher compared to the end of Operation, due to reclamation of the MRSFs and the TSF.

The effects on monthly flows during each phase of the Project under the base case scenario (i.e., average annual precipitation) are also summarized in Table 6.4-7 and Figure 6.4-10. There is considerable variability in the percent reduction in monthly flows with monthly flow reductions on the order of 4 to 7% at PC02 between May and August. This period coincides with the freshet and summer flow releases from Jacko Lake to satisfy downstream irrigation water licenses. Monthly flow reductions at PC02 approach 30% for the remaining months of the year when baseflows are the source of surface runoff to Peterson Creek (Lower). This occurs during a period of little to no flow within Peterson Creek, and therefore the change results in a larger percentage of the flow contributions. Baseflows are reduced due to the Open Pit footprint, which will act as a groundwater sink into the long-term such that groundwater flows will be permanently and irreversibly directed to the Open Pit. A portion of the water infiltrating the MRSF reclamation cover (i.e., recharge) is also trapped as moisture content, as it is estimated that several hundred years will be required for the mine rock to wet up to a residual water content.

Results are not shown for a majority of the sensitivity scenarios, as they have negligible impact on surface water quantity. However, they can potentially impact surface water quality, as discussed in Section 6.3. The exception is the variable climate condition run, which involves stepping through the historic climate record (1897-2011) in 5-year increments. This run allows a full range of climate conditions to be evaluated at all stages of mine life, including extreme wet and dry years and a series of years with above average or below average precipitation. To illustrate the range of runoff conditions that this sensitivity run assesses, the following extreme conditions were modelled for Operation:

- a 100-year dry year (197 mm) with the preceding year having average runoff; and
- a 100-year wet year (475 mm) with the preceding year having average runoff.

Results of these two conditions are shown in Table 6.4-8 and Figure 6.4-11 for PC02. Methodology and results of modelling sensitivities can be found in Appendix 6.4-C *Ajax Project Water Balance Model Report*.

Figure 6.4-10

Average Monthly Flows at PC02 under Existing Conditions, Construction, Operation (Year 23), and Post-Closure (100 years after the end of operations) for the Average Precipitation Scenario

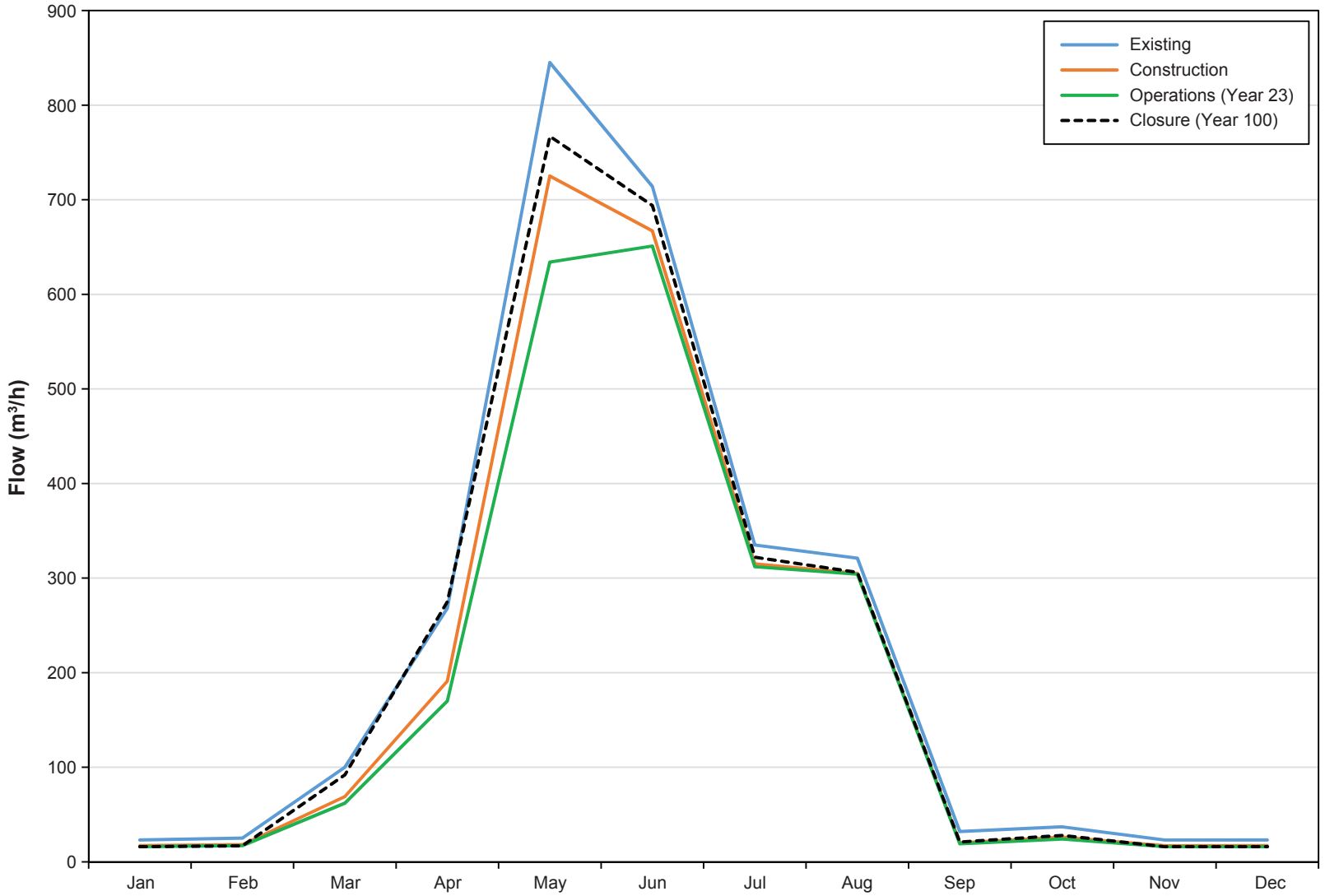


Figure 6.4-11

Average Monthly Flows at PC02 under Existing Conditions for the Three Precipitation Scnearios

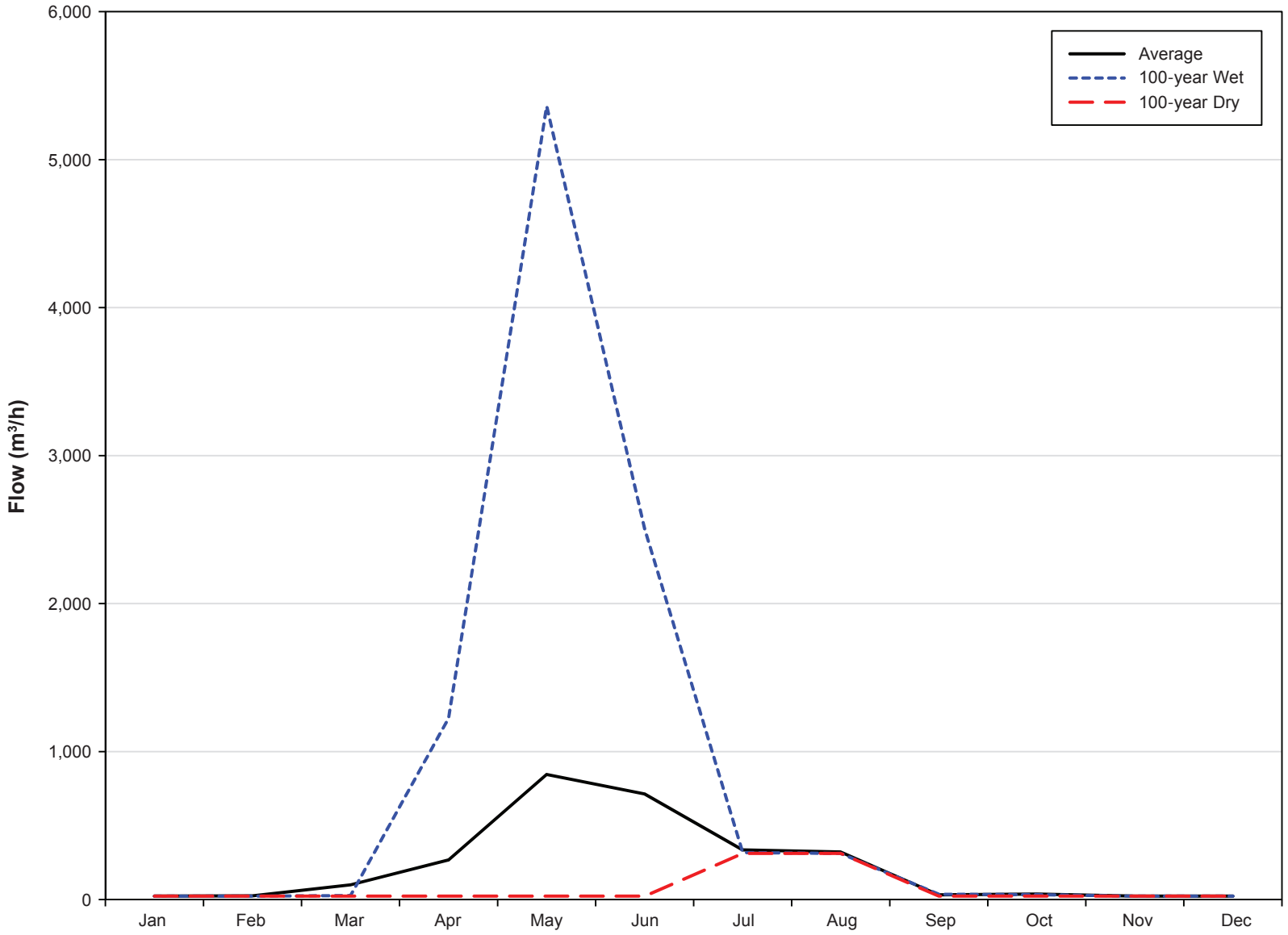


Table 6.4-8. Average Monthly Streamflow in Peterson Creek (Lower) at PC02 under 100-year Wet and Dry Precipitation Conditions during Operation

	100-year Dry (m^3/h)			100-year Wet (m^3/h)		
Month	Existing	Operation	% Change	Existing	Operation	% Change
January	23	16	-30%	23	16	-30%
February	23	16	-30%	23	16	-30%
March	23	18	-22%	28	20	-29%
April	153	94	-39%	1226	753	-39%
May	28	14	-50%	5361	4,315	-20%
June	23	13	-43%	2504	2,410	-4%
July	312	291	-7%	318	299	-6%
August	312	297	-5%	312	300	-4%
September	23	13	-43%	36	21	-42%
October	23	13	-43%	34	22	-35%
November	23	15	-35%	23	16	-30%
December	23	16	-30%	23	16	-30%
Annual	**83**	**69**	**-30%**	**831**	**688**	**-17%**

Residual Effects on Kamloops Lake - Annual and Monthly Streamflows

Potential impacts to Kamloops Lake can be evaluated by comparing the maximum abstraction rate (and predicted reduction in Peterson Creek flows) to average monthly inflows to the lake. The WSC monitors water levels on the Thompson River at Kamloops (#08LF023). The watershed area at this station is 37,800 km^2, but only water level is measured at this gauge, not flow. Historical flow data are available at the downstream hydrometric station Thompson River near Savona (#08LF033), which is located at the lake outlet. A watershed area of 39,100 km^2 reports to this discontinued station. Table 6.4-9 summarizes monthly average flow at both these stations and compares these flows to the maximum allotment of 1,505 m^3/h at the water intake. Table 6.4-10 compares average monthly flows on the Thompson River to the maximum pumping rate of 1,505 m^3/h, plus the potential reduction in Peterson Creek flows as a result of mining operations (i.e., Table 6.4-7).

Table 6.4-9 shows that the 1,505 m^3/h allotment from Kamloops Lake and reduced flows in Peterson Creek (Lower) constitute a minor component of the average monthly flow through the lake (< 0.25%). Flow reductions of this magnitude could potentially occur during Construction and Operation only. During Decommissioning and Closure, potential flow reductions would be significantly less as water requirements from Kamloops Lake (dust control and compaction) are expected to be on the order of 100 m^3/h. At Post-Closure, the impacts to Kamloops Lake would be a result of minor streamflow reductions in Peterson Creek only, as make-up water for the Project would no longer be required.

Table 6.4-9. Residual Effects, Thompson River Average Monthly Flow

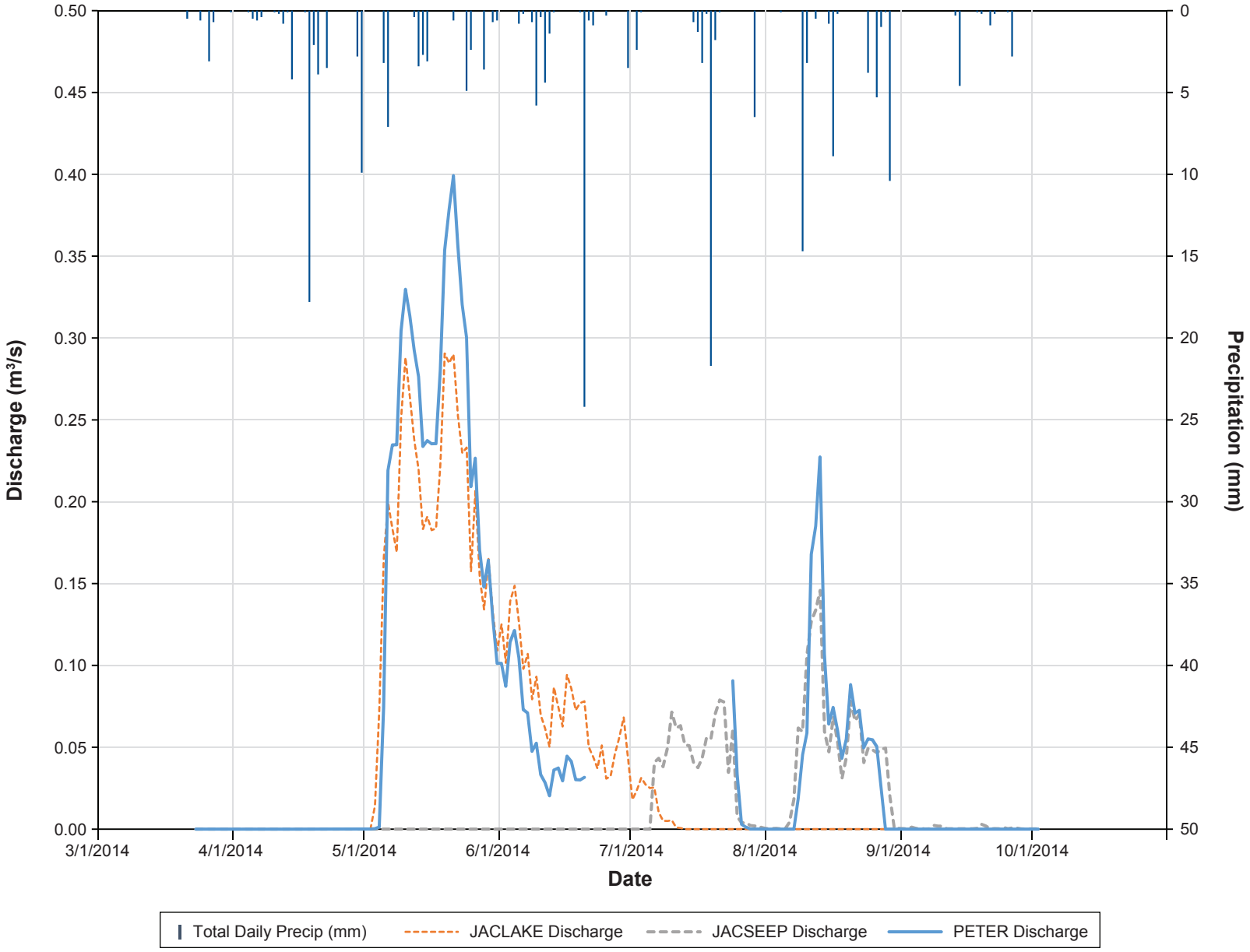
	Thompson River near Savona		
Month	(m^3/s)	(m^3/h)	1,505 m^3/h as %
January	206	742,000	0.20%
February	188	678,000	0.22%
March	182	655,000	0.24%
April	307	1,104,000	0.15%
May	1,096	3,947,000	0.04%
June	2,168	7,806,000	0.02%
July	1,573	5,662,000	0.03%
August	926	3,334,000	0.05%
September	597	2,150,000	0.07%
October	500	1,799,000	0.08%
November	392	1,412,000	0.11%
December	267	962,000	0.16%

Residual Effects on Peak Flows

The residual effect of the Project on peak flows is difficult to quantify with any certainty. The reason is that peak flows are currently regulated due to the active management of water levels in Jacko Lake. Currently, the lake is drawn down in July and August to meet downstream water license requirements. Lake levels also drop during this period due to evaporative losses from the water surface in combination with negligible to no surface runoff from Peterson Creek (Upper). Depending on the degree of lake drawdown and the magnitude of the following freshet, there is considerable variability in the potential attenuation of lake inflows. The impact of the flow regulation on Jacko Lake is illustrated by 2014 flow hydrographs for the lake spillway (JACLAKE), the low level outlet (JACSEEP), and PETER (downstream station on Peterson Creek (Lower); Figure 6.4-12). From the beginning of May to early July, water levels were high enough such that the spillway discharged lake water. This was followed by a pair of two to three week periods where flows were released via the low level outlet to accommodate the storage-supported licenses downstream of Jacko Lake.

From Construction through Decommissioning and Closure, the Project will have an impact on peak flows, as lake inflows will be pumped around a majority of the mine infrastructure via the Peterson Creek Diversion. This diversion has been designed to handle a peak flow of 0.08 m^3/s. In comparison, the 2-year and 100-year return period peak instantaneous flows into the lake (at JACINF) have been conservatively estimated at 0.72 and 2.19 m^3/s, respectively (Table 6.4-4, Appendix 6.4-A). Because of the flow regulation, the estimated peak inflows cannot be directly correlated to lake outflows. However, it is apparent that that Project will reduce peak flows on Peterson Creek (Lower) during Construction, Operation, and Decommissioning and Closure due to the active management of lake inflows. This effect is also positive, as it would reduce potential flooding issues in lower reaches of Peterson Creek within Kamloops.

Figure 6.4-12
2014 Hydrographs for JACLAKE, JACSEEP, and PETER



By Post-Closure, the Peterson Creek Diversion will no longer be operable and lake outflows will return to existing conditions. While there is a reduction in contributing watershed area downstream of Jacko Lake due to the footprint of the Open Pit, it is unlikely that this reduced watershed area will have a significant impact on peak flows, as snow-free conditions will likely exist at these lower elevations at the time of the snowmelt-driven peak flow. Thus, the lower elevations likely contribute negligible runoff to peak flows.

Residual Effects on Low Flows – Peterson Creek (Lower)

A regional 7-day (7Q) low flow analysis was conducted for Peterson Creek (Lower). Results for various return periods are presented in Table 6.4-10 for existing conditions at assessment location PC02.

Table 6.4-10. Peterson Creek (Lower) Low Flow Results Existing Conditions

	Low Flow (L/s)			
Node	7Q2	7Q5	7Q10	7Q20
PC02	6.2	4.2	4.0	3.1

Based on the monthly flow reductions observed in Table 6.4-7, there could potentially be a 40% reduction in low flows during Operation and 30% reduction during Post-Closure.

Residual Effects on Low Flows – Kamloops Lake

As well as assessing the impact of the proposed maximum abstraction rate of 1,505 m^3/h from Kamloops Lake and reduced flows in Peterson Creek on average monthly flows, the potential impacts to 10-year monthly low flows were also assessed. Results are summarized in Table 6.4-11 below.

Table 6.4-11. Residual Effects, Thompson River 10-year Low Monthly Flow

	Thompson River near Savona		
Month	(m^3/s)	(m^3/h)	1,505 m^3/h as %
January	128	460,800	0.33%
February	133	478,800	0.32%
March	130	468,000	0.33%
April	240	864,000	0.19%
May	277	997,200	0.17%
June	1,275	4,590,000	0.03%
July	955	3,438,000	0.04%
August	579	2,084,400	0.07%
September	336	1,209,600	0.13%
October	252	907,200	0.17%
November	200	720,000	0.21%
December	152	547,200	0.28%

Table 6.4-11 shows that the 1,505 m^3/h allotment from Kamloops Lake constitutes a minor component of the 10-year monthly low flow through the lake (< 0.35%). Flow reductions of this magnitude could potentially occur during Construction and Operation only. During Decommissioning and Closure, potential flow reductions would be significantly less as water requirements from Kamloops Lake (dust control and compaction) are expected to be on the order of 100 m^3/h. At Post-Closure, the impacts to Kamloops Lake would be a result of minor streamflow reductions in Peterson Creek only, as make-up water for the Project would no longer be required.

Open Pit at Post-Closure

The Open Pit will gradually fill during the closure period. Inputs to the pit include:

- the supernatant TSF pond volume at the end of Operation;
- incident precipitation within the ultimate pit footprint;
- runoff from a small undisturbed area located up gradient of the pit; and
- minor seepage inflows from Jacko Lake, the TSF, and the South and West MRSFs.

After about 300 years and assuming average runoff conditions, the pit lake reaches a relatively static elevation of about 760 m, approximately 124 m below the natural spillway elevation of 884 m on the pit perimeter. If this ultimate elevation creates a depression in the groundwater table, the Open Pit may behave as a long-term sink for groundwater in the LSA, causing bedrock groundwater to flow towards the pit from areas outside of the pit crest. The sink will be a terminal groundwater "sink" in perpetuity – strongest near the end of the operational period, when pit dewatering causes bedrock groundwater in the mine area to flow towards the Open Pit.

6.4.5.2 Summary of Residual Effects

The key changes to surface water quantity that are predicted to remain after the implementation of mitigation measures are summarized qualitatively in Table 6.4-12.

6.4.5.3 Criteria for Characterization of Residual Effects

Residual effects of the Project on surface water quantity are characterized using standard criteria (i.e., the magnitude, geographic extent, duration, frequency, reversibility, resiliency, and ecological context). Standard ratings (i.e., major, moderate, minor/low, medium, and high) for these characterization criteria are provided in Chapter 5; however, Table 6.4-13 provides a summary of definitions for each characterization criterion, specific to the surface water quantity VC.

6.4.5.4 Characterization of Residual Effects

Characterization of residual effects, likelihood, significance, and confidence for surface water quantity VCs are presented in Table 6.4-14 for Jacko Lake, Table 6.4-15 for Peterson Creek (Lower), and Table 6.4-16 for Kamloops Lake. The characterization of residual effects on Peterson Creek (Lower) considers streamflows during the Post-Closure period, while the characterization on Kamloops Lake is focused on Construction and Operation. A significantly reduced volume of make-up water from Kamloops Lake will be required for closure activities. No make-up water is required Post-Closure, when the effects on Kamloops Lake are a result of reduced streamflow in Peterson Creek only.

Table 6.4-12. Summary of Residual Effects on Surface Water Quantity

Potential Effect	Project Phase (timing of effect)	Project Component / Physical Activity	Description of Cause-Effect[1]	Description of Mitigation Measure(s)	Description of Residual Effect
Peterson Creek (Upper) and Jacko Lake					
Reduced streamflows	All phases	Construction of WMRSF and associated Pond 1	A portion of the WMRSF and Pond 1 will be constructed in the Peterson Creek (Upper) watershed reducing surface runoff and baseflows	Re-establish natural runoff patterns as much as possible through reclamation of the WMRSF	Runoff from the reclaimed MSRF will report to Pond 1, which is designed to act as an evaporative pond during Post-Closure
Peterson Creek (Lower) at PC03					
Reduced streamflow	Construction, Operation, Decom. and Closure	Operation of the Peterson Creek Diversion System	Inflows to Jacko Lake will be pumped around the mine site and re-introduced to Peterson Creek downstream of most mine infrastructure	None	No streamflow in Peterson Creek (Lower) between the lake outlet and downstream of the Central Pond, a distance of ~3.6 km
Peterson Creek (Lower) at PC02					
Reduced streamflows	Construction, Operation	Construction and operation of various surface water management ponds, MRSFs, TSF, excavation of Open Pit	Surface runoff and net infiltration will be reduced in areas covered by the MRSFs, contact surface runoff will be captured in the various water management ponds, groundwater flows will be captured by the Open Pit	None	Reduced streamflows in Peterson Creek (Lower)
Reduced peak flows	Construction, Operation	Peterson Creek Diversion	Inflows to Jacko Lake will be managed by pumping around the Open Pit and Central Pond; however, these pumped flows will be unable to simulate existing lake spillway flows given constraints on pumping capacity	Water Management Plan for Jacko Lake inflows	Reduced peak flows and duration (also has a positive effect for reducing potential flooding in Kamloops)

(continued)

Table 6.4-12. Summary of Residual Effects on Surface Water Quantity (completed)

Potential Effect	Project Phase (timing of effect)	Project Component / Physical Activity	Description of Cause-Effect[1]	Description of Mitigation Measure(s)	Description of Residual Effect
Peterson Creek (Lower) at PC02 *(cont'd)*					
Reduced streamflows	Decom. and Closure, Post-Closure	Excavation	Water table within pit excavation will be lowered as a result of dewatering throughout mining, increased pit footprint will reduce watershed area of Peterson Creek (Lower)	Actively fill Open Pit with water from TSF as well as passive seasonal surficial runoff, cease dewatering activities; reclamation of the TSF and MRSFs	The Open Pit will act as a groundwater sink into the long-term such that groundwater flows will be permanently and irreversibly directed to the Open Pit, thereby resulting in decreased groundwater discharge to (or increased recharge from) Peterson Creek and Jacko Lake; reduced watershed area will persist due to pit footprint
Reduced streamflows	Decom. and Closure, Post-Closure	MRSF water management ponds	Runoff from reclaimed MRSFs will be captured in evaporation ponds	Look for potential for passive, biological remediation; reclamation of the TSF and MRSFs	Increased evaporative losses from ponds resulting in reduced runoff to Peterson Creek (Lower)
Kamloops Lake					
Reduced streamflow	Construction, Operation	Use of Kamloops Lake as a source of make-up water, including the filling of the TSF pond for start-up; reduced Peterson Creek flows	Maximum water abstractions of 1,505 m^3/h	None	Reduced streamflows in Kamloops Lake
Reduced streamflow	Decom. and Closure, Post-Closure	Use of Kamloops Lake as a source of water for closure activities; reduced Peterson Creek flows	Maximum water abstractions of 100 m^3/h for closure activities	None	Reduced streamflows in Kamloops Lake

[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 VC.*

Table 6.4-13. Definitions of Characterization Criteria for Residual Effects on Surface Water Quantity

Magnitude	Duration	Frequency	Geographic Extent (Physical/Biophysical)	Reversibility	Resiliency	Ecological Context	Likelihood of Effects	
							Probability	Confidence Level
How severe will the effect be?	*How long will the effect last?*	*How often will the effect occur?*	*How far will the effect reach?*	*To what degree is the effect reversible?*	*How resilient is the receiving environment or population?*	*What is the current condition of the ecosystem and how commonly is it represented in the LSA?*	*How likely is the effect to occur?*	*How certain is this analysis?*
Negligible: No or very little detectable change from baseline conditions (< 5%).	**Short-term:** Effect lasts 1 to 5 years.	**Once:** Effect is confined to one discrete period in time during the life of the Project.	**Local:** Effect extends less than 500 m from infrastructure or activity.	**Reversible Short-term:** Effect can be reversed relatively quickly.	**Low:** The receiving environment or population has a low resilience to imposed stresses, and will not easily adapt to the effect.	**Low:** The receptor is considered to have little to no unique attributes or provision of functions is severely degraded.	**High:** It is highly likely that this effect will occur.	**High:** < 80% confidence. There is a good understanding of the cause-effect relationship and all necessary data are available for the Project area. There is a low degree of uncertainty and variation from the predicted effect is expected to be low.
Minor: Differs from the average value for baseline conditions between 5 and 25%.	**Medium-term:** Effect lasts 6 to 25 years.	**Sporadic:** Effect an effect that occurs at sporadic or intermittent intervals during any phase of the Project.	**Landscape:** Effect is limited to the LSA or one watershed (i.e., Sub-area).	**Reversible Long-term:** Effect can be reversed within 20 years of Post-Closure.	**Neutral:** The receiving environment or population has a neutral resilience to imposed stresses and may be able to respond and adapt to the effect.	**Neutral:** The receiving environment considered to have some unique attributes and provides most functions that an undisturbed environment would provide.	**Medium:** This effect is likely, but may not occur.	**Medium:** 50 to 80% confidence. The cause-effect relationships are not fully understood, there are a number of unknown external variables, or data for the Project area are incomplete. There is a moderate degree of uncertainty; while results may vary, predictions are relatively confident.
Medium: Differs substantially (25-75%) from the average value for baseline conditions and approaches the limits of natural variation.	**Long-term:** Effect lasts between 26 and 50 years.	**Regular:** Effect occurs on a regular basis during the life span of the Project.	**Regional:** Effect extends across the broader region (e.g., RSA, multiple watersheds, etc.).	**Irreversible:** Effect cannot be reversed (i.e., is permanent).	**High:** The receiving environment or population has a high natural resilience to imposed stresses, and can respond and adapt to the effect.	**High:** The receiving environment or population is uncommon and occurs in a natural state and provides functions at a maximum capacity.	**Low:** This effect is unlikely but could occur.	**Low:** < 50% confidence. The cause-effect relationships are poorly understood, there are a number of unknown external variables, and data for the Project area are incomplete. High degree of uncertainty and final results may vary considerably.
Major: Differs substantially (> 75%) from baseline conditions, resulting in a detectable change beyond the range of natural variation.	**Far Future:** Effect lasts more than 50 years.	**Continuous:** Effect occurs constantly during the life of the Project.	**Beyond Regional:** Effect extends beyond the regional scale, and may extend across or beyond the province.					

Table 6.4-14. Characterization of Residual Effects, Significance, Likelihood and Confidence on Surface Water Quantity at Jacko Lake

Residual Effect	Residual Effects Characterization Criteria							Significance of Adverse Residual Effects	Likelihood and Confidence	
	Magnitude	Duration	Frequency	Geographic Extent	Reversibility	Resiliency	Ecological Context		Probability	Confidence
Potential decrease in annual flow volumes	Negligible	Far Future	Continuous	Landscape	Irreversible	Neutral	Neutral	Not Significant (minor)	High	High
Potential flattening of monthly flow distribution	Negligible	Far Future	Continuous	Landscape	Irreversible	Neutral	Neutral	Not Significant (minor)	Medium	Medium
Potential decrease in peak flow	Negligible	Far Future	Continuous	Landscape	Irreversible	Neutral	Neutral	Not Significant (minor)	Medium	Medium
Potential decrease in low flow	Negligible	Far Future	Continuous	Landscape	Irreversible	Neutral	Neutral	Not Significant (minor)	High	High

Table 6.4-15. Characterization of Residual Effects, Significance, Likelihood and Confidence on Surface Water Quantity at PC02 on Peterson Creek (Lower)

Residual Effect	Residual Effects Characterization Criteria							Significance of Adverse Residual Effects	Likelihood and Confidence	
	Magnitude	Duration	Frequency	Geographic Extent	Reversibility	Resiliency	Ecological Context		Probability	Confidence
Potential decrease in annual flow volumes	Medium	Far Future	Continuous	Landscape	Irreversible	Neutral	Neutral	Not Significant (moderate)	High	High
Potential flattening of monthly flow distribution	Medium	Far Future	Continuous	Landscape	Irreversible	Neutral	Neutral	Not Significant (moderate)	Medium	Medium
Potential decrease in peak flow	Medium	Far Future	Continuous	Landscape	Irreversible	Neutral	Neutral	Not Significant (moderate)	Medium	Medium
Potential decrease in low flow	Medium	Far Future	Continuous	Landscape	Irreversible	Neutral	Neutral	Not Significant (moderate)	High	High

Table 6.4-16. Characterization of Residual Effects, Significance, Likelihood and Confidence on Surface Water Quantity at Kamloops Lake

Residual Effect	Residual Effects Characterization Criteria							Significance of Adverse Residual Effects	Likelihood and Confidence	
	Magnitude	Duration	Frequency	Geographic Extent	Reversibility	Resiliency	Ecological Context		Probability	Confidence
Potential decrease in annual flow volumes	Negligible	Medium Term	Continuous	Landscape	Reversible short-term	Neutral	Neutral	Not Significant (minor)	High	High
Potential flattening of monthly flow distribution	Negligible	Medium Term	Continuous	Landscape	Reversible short-term	Neutral	Neutral	Not Significant (minor)	High	High
Potential decrease in peak flow	Negligible	Medium Term	Continuous	Landscape	Reversible short-term	Neutral	Neutral	Not Significant (minor)	High	High
Potential decrease in low flow	Negligible	Medium Term	Continuous	Landscape	Reversible short-term	Neutral	Neutral	Not Significant (minor)	High	High

6.4.5.5 Characterization of Residual Effects

Characterization of residual effects, likelihood, significance, and confidence for surface water quantity VCs are presented in Table 6.4-14 for Jacko Lake, Table 6.4-15 for Peterson Creek (Lower) and Table 6.4-16 for Kamloops Lake. The characterization of residual effects on Peterson Creek (Lower) considers streamflows during the Post-Closure period, while the characterization on Kamloops Lake is focused on Construction and Operation. A significantly reduced volume of make-up water from Kamloops Lake will be required for closure activities. No make-up water is required Post-Closure, when the effects on Kamloops Lake are a result of reduced streamflow in Peterson Creek only.

The assessment considered results of baseline studies, predictive modelling, scientific literature, and professional experience and judgement, as discussed in Appendix 6.4-C.

Jacko Lake

- **Magnitude**: Based on estimated effects of the Project on surface water quantity, the magnitude of changes in all water quantity indices is considered **negligible**.
- **Duration**: Residual effects on streamflows will be detectable during all proposed Project phases; therefore, the residual effects are considered **far future** in duration.
- **Frequency**: The assessed indicators (i.e., annual, monthly, peak, and low flows) are **continuous** hydrologic indices that would be affected on an on-going basis, though not all indices would be affected to the same degree.
- **Geographic Extent**: Effects of the Project on Peterson Creek (Lower) streamflows are minor within the LSA. Changes in Peterson Creek flows downstream of the LSA to the confluence with the South Thompson River (i.e., within the RSA) will be even less and are also considered minor. Effects of the Project on the surface water quantity VCs are therefore at the **landscape** scale.
- **Reversibility**: Effects on streamflows are **irreversible** at the end of the project when mine operations cease.
- **Resiliency:** For surface water quantity, there is not a direct measure of resilience, and therefore a **neutral** resiliency level was selected. Indirect measures, i.e., resilience of downstream fisheries and aquatic resources to surface water quantity changes, are discussed in Chapter 6.7.
- **Ecological Context**: For surface water quantity, there is not a direct measure of ecological context, and therefore, a **neutral** level was selected. Indirect measures, i.e., unique attributes of downstream fisheries and aquatic resources, are discussed in Chapter 6.7.

Peterson Creek (Lower), PC02

- **Magnitude**: Based on estimated effects of the Project on surface water quantity, the magnitude of changes in annual stream flow volume and low flows is considered **medium** at PC02 during Construction, Operation, and Decommissioning and Closure. During Post-Closure, the magnitude for annual stream flow volume is considered **minor**.

- Potential decreases in peak flow and a flattening of the monthly flow distribution is considered **negligible** at Post-Closure, but **medium** during the remaining phases when the Peterson Creek Diversion System is operational.
- **Duration**: Residual effects on streamflows will be detectable during all proposed Project phases; therefore, the residual effects are considered **far future** in duration.
- **Frequency**: The assessed indicators (i.e., annual, monthly, peak, and low flows) are **continuous** hydrologic indices that would be affected on an on-going basis, though not all indices would be affected to the same degree.
- **Geographic Extent**: Effects of the Project on Peterson Creek (Lower) streamflows are minor within the LSA. Changes in Peterson Creek flows downstream of the LSA to the confluence with the South Thompson River (i.e., within the RSA) will be even less and are also considered minor. Effects of the Project on the surface water quantity VCs are therefore at the **landscape** scale.
- **Reversibility**: Effects on streamflows are **irreversible** at the end of the project when mine operations cease.
- **Resiliency:** For surface water quantity, there is not a direct measure of resilience, and therefore a **neutral** resiliency level was selected. Indirect measures, i.e., resilience of downstream fisheries and aquatic resources to surface water quantity changes, are discussed in Chapter 6.7.
- **Ecological Context**: For surface water quantity, there is not a direct measure of ecological context, and therefore, a **neutral** level was selected. Indirect measures, i.e., unique attributes of downstream fisheries and aquatic resources, are discussed in Chapter 6.7.

Kamloops Lake

- **Magnitude:** Based on estimated effects of the Project on surface water quantity, the magnitude of changes on all the assessed indicators is considered **negligible** at Kamloops Lake.
- **Duration**: Residual effects on streamflows will be primarily detectable only during Construction and Operation; therefore, the residual effects are considered **medium-term** in duration. During Post-Closure reduced streamflows in Peterson Creek will effect Kamloops Lake, but the magnitude of this difference could not be detected by flow measurements.
- **Frequency**: The assessed indicators (i.e., annual, monthly, peak, and low flows) are **continuous** hydrologic indices that would be affected on an on-going basis, though not to the same degree.
- **Geographic Extent**: Effects of the Project on Kamloops Lake streamflows are negligible. Changes in streamflows further downstream will be even less and are also considered negligible. Effects of the Project on the surface water quantity VCs are therefore at the **landscape** scale.
- **Reversibility**: Effects on streamflows due to flow abstractions are considered **reversible short-term**, as water abstractions from Kamloops Lake to support mining operations do not extend beyond Decommissioning and Closure. During Post-Closure reduced streamflows in

Peterson Creek will effect Kamloops Lake, but the magnitude of this difference could not be detected by flow measurements.

- **Resiliency:** For surface water quantity, there is not a direct measure of resilience, and therefore a **neutral** resiliency level was selected.
- **Ecological Context**: For surface water quantity, there is not a direct measure of ecological context, and therefore, a **neutral** level was selected.

6.4.5.6 Significance of Residual Effects

The significance of the residual effects for the various surface water quantity VCs are rated using the following criteria:

- Not Significant (Minor): Residual effects have negligible or minor magnitude, local geographic extent, short- or medium-term duration, and occur sporadically if at all. The effects on the VC are indistinguishable from background conditions (i.e., occur within the range of natural variation as influenced by hydrological processes). Land and resource management plan objectives will be met.
- Not Significant (Moderate): Residual effects have minor to medium magnitude; have local, landscape, or regional geographic extent; are short-term to irreversible; and occur at all frequencies. Residual effects on the VC may be distinguishable at the population, community, and/or ecosystem level. The ability to meet land and resource management plan objectives may be impaired.
- Significant (Major): Residual effects have high magnitude; have regional or beyond regional geographic extent; are chronic (i.e., persist into the far future); and occur at all frequencies. Residual effects on the VC are consequential (i.e., structural and functional changes in ecosystems are predicted). The ability to meet land and resource management plan objectives is impaired.

At Jacko Lake, residual effects on surface water quantity due to Project activities are predicted to be **not significant (minor)** for all water quantity metrics. At PC02 on Peterson Creek (Lower), the residual effects on surface water quantity due to Project activities are predicted to be **not significant (moderate)** for all water quantity metrics. At Kamloops Lake, residual effects on surface water quantity due to Project activities are predicted to be **not significant (minor)** for all water quantity metrics.

6.4.5.7 Characterization of Likelihood and Confidence

The probability (likelihood) of a change in surface water quantity occurring and the confidence in the significance prediction are rated as follows.

<u>Jacko Lake and Peterson Creek (Lower) at PC02</u>

- **Probability**: Project activities include construction of a TSF, various MRSFs, and water management ponds, and water withdrawal from Kamloops Lake. Therefore, the probability of changes in annual streamflow volumes and low flows is considered **high**. A **medium** probability has been assigned to changes in the monthly flow distribution and potential

decreases in peak flows. It is not clear that the lower elevations in which the Project are located actually contribute to peak flow generation, as peak flows are snowmelt driven and lower elevations are typically clear of snow before significant melt occurs at higher elevations.

- **Confidence Level**: The confidence in the significance prediction and mitigation measures being followed was rated as **high** for the residual effect of the Project on streamflow volumes and low flows. While uncertainty exists in every prediction of future change, the approach used to assess the effects on water management activities on streamflows (Appendix 6.4-C) incorporated quantitative data from baseline reports, and are considered reliable inputs to the WBM. A **medium** confidence rating has been assigned to the monthly flow distribution and peak flow indicators.

Kamloops Lake

- **Probability**: The viability of the Project relies on water withdrawal from Kamloops Lake. Therefore, the probability of changes in surface water quantity is considered **high**.
- **Confidence Level**: The confidence in the significance prediction and mitigation measures being followed is rated as **high**.

6.4.5.8 Summary of Residual Effects Assessment and Significance

Table 6.4-17 provides a summary of the residual effects, mitigation, and significance on surface water quantity. Identified residual effects are carried forward to the Cumulative Effects Assessment in Section 6.4.6.

Table 6.4-17. Summary of Residual Effects, Mitigation, and Significance on Surface Water Quantity

Residual Effects	Project Phase	Mitigation Measures	Significance
Change in surface water quantity (all metrics) in Jacko Lake	Construction, Operation, Decommissioning and Closure, Post-Closure	Water Management Plan	Not Significant (Minor)
Change in surface water quantity (all metrics) in Peterson Creek (Lower) at PC02	Construction, Operation, Decommissioning and Closure	Water Management Plan	Not Significant (Moderate)
Change in surface water quantity (low flow) in Peterson Creek (Lower) at PC02	Post-Closure	Water Management Plan	Not Significant (Moderate)
Change in surface water quantity (annual flow volume, monthly flow distribution, peak flow) in Peterson Creek (Lower) at PC02	Post-Closure	Water Management Plan	Not Significant (Minor)
Change in surface water quantity (all metrics) in Kamloops Lake	Construction, Operation, Decommissioning and Closure, Post-Closure	Water Management Plan	Not Significant (Minor)

6.4.6 Cumulative Effects Assessment

6.4.6.1 Introduction

Project-specific residual effects are predicted to occur during all phases of the Project. All four surface water quantity indices may experience residual effects. Proposed and existing activities near the baseline study area have the potential to induce additive or synergistic interactions with Project-specific water quantity effects. The long-term persistence of water quantity effects may result in interactions over a temporal scale. As a result, the potential for water quantity cumulative effects where water affected by historical and proposed activities overlaps spatially and temporally with water affected by the Project.

6.4.6.2 Identification of Other Actions that May Affect Surface Water Quantity

The Project mine site falls within the Peterson Creek watershed, which discharges into the South Thompson River, while make-up water for the Project will be abstracted from Kamloops Lake. Therefore, cumulative effects assessment boundaries include both the Peterson Creek and Thompson River watersheds.

Historical and proposed activities within watersheds of the LSA and RSA have the potential to have cumulative effects with Project-specific water quantity effects. Water quantity effects have the potential to result in interactions over a long temporal scale. The potential for water quantity cumulative effects were considered where water quantity was or could be affected by historical and/or proposed activities that overlap spatially and temporally with the Project.

Past projects and activities within these watersheds that were considered to have a spatial linkage with potential effects of the Project are summarized in Table 6.4-18 below.

Of the activities listed in the table above, only the New Afton Mine is considered for inclusion in the CEA. Currently the mine is licenced to draw an annual volume of 1.218 Mm^3 (139 m^3/h) from Kamloops Lake for water supply to the processing plant. An application to withdraw an additional 1.324 Mm^3 (151 m^3/h) is currently in review. The Project would share the Ranching and agricultural activities which impact surface water quantity in Peterson Creek through existing water licenses, but these water uses are accounted for in the baseline conditions water balance model.

6.4.6.3 Interactions between Residual Project Effects and Other Project or Activity Effects

The Ajax Project has a maximum abstraction rate of 1,505 m^3/h from Kamloops Lake plus reduced flows in Peterson Creek as a result of mining operations. This abstraction rate would have a cumulative impact on the existing and proposed New Afton water licenses that total 290 m^3/h. The potential impacts on Kamloops Lake streamflow volumes was less than 0.35% for both average monthly flows and 10-year monthly low flows (see Section 6.4.5.1). Consideration of the New Afton water licenses has only a minor effect impact on these values, as illustrated in Table 6.4-19 for the average case.

Table 6.4-18. Ranking Potential for Residual Effects to Interact Cumulatively with Effects of Other Human Actions on Surface Water Quantity

	Industrial Projects/Activities													Natural Resources and Land Use			Tourism and Commercial Recreation Activities					Community Infrastructure			Transportation					
Residual Effect	Vidette Lake Mine	Afton Mine (Historical)	Iron Mask Mine	Bonaparte Mine	New Afton Mine (New Gold)	Highland Valley Copper Mine (Teck)	Domtar Kamloops Pulp Mill	Tolko-Hefley Creek Plywood and Veneer	LaFarge Cement Plant	Trans Mountain Pipeline System (Kinder Morgan)	Trans Mountain Pipeline System - Expansion (Kinder Morgan)	Harper Creek	Highland Valley Copper - Bethlehem Expansion	Kamloops Forest District	Agriculture	Ranching	Tranquille on the Lake	Lac Le Jeune Resort	Tobiano Golf Course	Recreational Hunting, Fishing, Foraging	Recreational Trails	City of Kamloops Wastewater Management	Water Treatment Centre	City Expansion and Growth	Lac le Jeune Road	Highway 1	Highway 5A	Highway 5 (Coquihalla Highway)	Kamloops Airport	Rail Yards and Lines (CP and CN)
Surface Water Quantity	O	O	O	O	M	O	O	O	O	O	O	O	O	O	M	M	O	O	O	O	O	O	O	O	O	O	O	O	O	O

Notes:

(-) *No spatial or temporal overlap.*

O *Spatial or temporal overlap, but no interaction anticipated OR No change from current condition anticipated, and already captured as part of baseline characterization. No further consideration warranted.*

L *Negligible to minor interaction expected; implementation of best practices, standard mitigation and management measures; no monitoring required, no further consideration warranted.*

M *Potential moderate interaction requiring unique active management/monitoring/mitigation; warrants further consideration.*

H *Key interaction; warrants further consideration.*

Table 6.4-19. Cumulative Effects, Thompson River Average Monthly Flow

Month	Thompson River near Savona		
	(m^3/s)	(m^3/h)	1,805 m^3/h as %
January	206	742,000	0.24%
February	188	678,000	0.27%
March	182	655,000	0.28%
April	307	1,104,000	0.16%
May	1,096	3,947,000	0.05%
June	2,168	7,806,000	0.02%
July	1,573	5,662,000	0.03%
August	926	3,334,000	0.05%
September	597	2,150,000	0.08%
October	500	1,799,000	0.10%
November	392	1,412,000	0.13%
December	267	962,000	0.19%

6.4.6.4 Proposed Mitigation Measures

The Project has been designed to reduce adverse effects to surface water quantity and quality through the development of a Water Management and Hydrometric Monitoring Plan (WMP; Section 11.7). The WMP describes a range of mitigation measures to reduce or eliminate the potential effects of the Project on surface water quantity. One of these measures includes the reuse of contact water in the Process Plant, thereby limiting the amount of make-up water required for process.

6.4.6.5 Evaluation of Significance of Residual Cumulative Effects

Regardless of the mitigation measures applied, make-up water for the Project will need to be sourced from Kamloops Lake, resulting in a residual cumulative effect on surface water quantity in Kamloops Lake (Table 6.4-20).

Table 6.4-20. Summary of Cumulative Effects Mitigation Measures and Residual Effects on Surface Water Quantity at Kamloops Lake

Ajax Project Activity	Other Human Action Activity	Description of Potential Cumulative Effect	Description of Mitigation Measure(s)	Description of Residual Cumulative Effect
Use of Kamloops Lake as a source of make-up water	New Afton Mine water abstraction	Change in surface water quantity in Kamloops Lake	Water Management Plan	Reduction in surface water quantity in Kamloops Lake

Characterization of the cumulative residual effects is summarized in Table 6.4-21 below. At Kamloops Lake, the cumulative residual effects on surface water quantity due to Project activities are predicted to be **not significant (minor)** for all water quantity metrics.

Table 6.4-21. Characterization of Cumulative Residual Effects, Significance, Likelihood and Confidence on Surface Water Quantity at Kamloops Lake

Residual Effect	Residual Effects Characterization Criteria							Significance of Adverse Residual Effects	Likelihood and Confidence	
	Magnitude	Duration	Frequency	Geographic Extent	Reversibility	Resiliency	Ecological Context		Probability	Confidence
Potential decrease in annual flow volumes	Negligible	Medium-term	Continuous	Landscape	Reversible Short-term	Neutral	Neutral	Not Significant (minor)	High	High
Potential flattening of monthly flow distribution	Negligible	Medium-term	Continuous	Landscape	Reversible Short-term	Neutral	Neutral	Not Significant (minor)	High	High
Potential decrease in peak flow	Negligible	Medium-term	Continuous	Landscape	Reversible Short-term	Neutral	Neutral	Not Significant (minor)	High	High
Potential decrease in low flow	Negligible	Medium-term	Continuous	Landscape	Reversible Short-term	Neutral	Neutral	Not Significant (minor)	High	High

6.4.7 Conclusion

A combination of modelling techniques, which included a water balance model with a monthly time step and regional frequency analyses, were employed to assess the potential effects of the Project on surface water quantity. A number of surface water quantity indices (annual streamflow volume, monthly flow distribution, low flow, and peak flow) were selected for evaluation, with a primary focus on Peterson Creek (Lower) and Kamloops Lake streamflows. Annual streamflow volumes in Peterson Creek (Lower) will be reduced on the order of 17% during Operation and 6% during Post-Closure under average precipitation conditions. Residual effects on surface water quantity due to Project activities are predicted to be **not significant (moderate)** for all surface water quantity indices during Construction, Operation, and Decommissioning and Closure. This rating changes to **not significant (minor)** for annual streamflow volume, peak flows, and monthly flow distribution during Post-Closure.

Make-up for the Project will be sourced from Kamloops Lake at a maximum rate of 1,505 m^3/h. This abstraction, plus reduced streamflows in Peterson Creek as a result of mining operations, constitutes a minor component of the average monthly flow through the lake (< 0.35%). These flow reductions would be greater during Construction and Operation, as make-up water for the Project is not required in Post-Closure and significantly reduced volumes are required for Decommissioning and Closure. Residual and cumulative effects on surface water quantity at Kamloops Lake due to Project activities are predicted to be **not significant (minor)** for all water quantity metrics, as summarized in Table 6.4-22.

Table 6.4-22. Summary of Project and Cumulative Residual Effects, Mitigation, and Significance for Surface Water Quantity

Residual Effects	Project Phase	Mitigation Measures	Residual Effect Significance	Residual Cumulative Effect Significance
Change in surface water quantity (all metrics) in Jacko Lake	Construction, Operation, Decom. and Closure, Post-Closure	See Water Management Plan Operation of Peterson Creek Diversion System; Re-establish Peterson Creek as natural draining Post-Closure	Not Significant (Minor)	Not Significant (Minor)
Change in surface water quantity (all metrics) in Peterson Creek (Lower) at PC02	Construction, Operation, Decom. and Closure	See Water Management Plan Operation of Peterson Creek Diversion System	Not Significant (Moderate)	Not Significant (Moderate)
Change in surface water quantity (low flow) in Peterson Creek (Lower) at PC02	Post-Closure	See Water Management Plan Re-establish Peterson Creek as natural draining	Not Significant (Moderate)	Not Significant (Moderate)
Change in surface water quantity (annual flow volume, monthly flow distribution, peak flow) in Peterson Creek (Lower) at PC02	Post-Closure	See Water Management Plan Re-establish Peterson Creek as natural draining	Not Significant (Minor)	Not Significant (Minor)
Change in surface water quantity (all metrics) in Kamloops Lake	Construction, Operation, Decom. and Closure, Post-Closure	See Water Management Plan Maximize capture and re-use of contact water.	Not Significant (Minor)	Not Significant (Minor)

6.5 GROUNDWATER QUALITY

6.5.1 Rationale

The purpose of the scoping process is to allow the Environmental Assessment (EA) to focus on the components that are valued and have the greatest potential to cause significant adverse effects (Beanlands and Duinker 1983). Valued Components (VCs) are defined as components of the natural and human environment that are considered to be of scientific, ecological, economic, social, cultural, or heritage importance (Environmental Assessment Office and Canadian Environmental Assessment Agency 2013). In addition, the project must be likely to affect the VC for it to be included in an EA.

Groundwater Quality was selected as a VC for inclusion in the EA for the Ajax Project (the Project) by KGHM Ajax Mining Inc. (KAM), based on their scoping process. Groundwater quality is the characterization of the physical and chemical properties of groundwater and is influenced by the interactions with the lithological units that it flows through and is further influenced by the length of time it interacts with various units along a flow pathway. Groundwater is present in the subsurface in the Local Study Area (LSA) and the Regional Study Area (RSA) and is used for domestic purposes, for irrigation and livestock watering. Creeks in the area are supported by local groundwater discharge and thus groundwater is important for aquatic resources and understanding groundwater-surface water interactions was an objective identified in the Kamloops Land and Resource Management Plan (Kamloops Interagency Management Committee 1995).

Groundwater Quality was identified by government agencies, stakeholders, and Aboriginal communities, during consultations on the Project as a potential VC because of its importance to human health, livestock, and use as irrigation water. Concerns that were raised are recorded in the issues tracking tables in Appendix 15-B of the Application/EIS. Comments were raised by government agencies, members of the public and stakeholder groups, and by aboriginal groups during the public consultation periods about potential effects to groundwater quality. Similar concerns were raised by all of the above mentioned groups and these comments have been compiled and are summarized below:

- Effects of ML/ARD on groundwater quality;
- Effects of liquids and chemical leaching from the Tailings Storage Facility (TSF) into local groundwater;
- Effects of seepage from mine facilities on groundwater quality affecting use for domestic and irrigation purposes;
- Water quality effects on fish, wildlife, livestock and human health;
- Impact of contaminated groundwater on Kamloops Lake water quality.

Specific concerns raised by Aboriginal groups concerning the Groundwater Quality VC include seepage from facilities to groundwater, potential effects to domestic drinking water, and potential effects on Jacko Lake as well as other water bodies due to changes in groundwater quality. Additional concerns are discussed in more detail in Appendix 15-B.The Supporting Topic - Jacko Lake, section 8.7, serves to aggregate summaries for all VCs that have potential pathways of effect from the Project on Jacko Lake.

The intent of the section's summaries is to provide a snapshot of residual effects, mitigations and the determination of significance for each of the relevant VCs."

The relevant provincial and federal statutory framework, guidance documents, and policies related to potential Project-related groundwater quality effects were reviewed for the Project as part of the scoping phase:

- *Water Sustainability Act,* to come into effect in 2016 (2014);
- BC *Water Act* (1996a) and Groundwater Protection Regulation (BC Reg 299/2004);
- Canada *Water Act* (1985a);
- *Water Protection Act* (1996b);
- *Environmental Management Act* (2003);
- *Fish Projection Act* (1997)
- *Fisheries Act* (1985b);
- *Mines Act* (1996c);
- *Environmental Management Act* (2003);
- BC Water Quality Guidelines (BCWQG; Approved and Working; BC MOE 2015a, 2015b);
- CCME Water Quality Guidelines (CCME 2014);
- Guidelines for Canadian Drinking Water Quality (Health Canada 2012);
- Policy for Metal Leaching and Acid Rock Drainage at Minesites in British Columbia (BC MEM and BC MOE 1998);
- Guidelines for Metal Leaching and Acid Rock Drainage in British Columbia (Price and Errington 1998);
- Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials (Price 2009);
- Water and Air Baseline Monitoring Guidance Document for Mine Proponents and Operators (BC MOE 2012);
- Guidelines for Designing and Implementing a Water Quality Monitoring Program in British Columbia (Cavanagh et al., 1998);
- BC Field Sampling Manual (MWLAP, 2003);
- Guidelines for Interpreting Water Quality Data (MELP, 1998);
- Approved Water Quality Guidelines Summary Report (MOE, 2015); and
- Guidance for the Derivation and Application of Water Quality Objectives in British Columbia (BC MOE, 2013).

Groundwater Quality was included as a VC for the EA because Project components and activities have the potential to change groundwater quality from baseline conditions during the Construction, Operation, Decommissioning and Closure and Post Closure phases. The potential Project interactions with the Groundwater Quality VC are identified in Section 6.5.4. The relationship between groundwater and surface water in the project area is discussed in greater detail in the

Groundwater Quantity VC (Section 6.6), as well as within the baseline groundwater hydrology assessment (Appendix 6.6-A). These interactions were incorporated into the Water Balance Model (Appendix 6.4-C) and the Ajax Numerical Groundwater Flow Model (Appendix 6.6-D).

The assessment focuses on potential interactions between the Project and Groundwater Quality that are likely during normal operating conditions; occurrences such as spills and accidents that are unlikely to occur are considered to be outside of normal operating conditions and are therefore addressed in Accidents and Malfunctions as well as in the Spill Contingency Plan in Section 11 of the Application/EIS.

Predicted changes in Groundwater Quality from baseline (or pre-Project) conditions will be presented and characterized through comparisons to guidelines, where provincial or federal guidelines exist.

Groundwater and surface water interactions can be complex and changes to groundwater quantity and quality typically result in changes to surface water quantity and quality. Surface water and groundwater flows and mine contact water source volumes (runoff and seepage) have been modelled in the site wide water balance model (described in Section 6.4) and loading associated with all of the flow pathways, plus loading associated with dust deposition were integrated into the model to predicted changes in surface water quality (described in Section 6.3). Groundwater quality modelling conducted to support the Groundwater Quality VC effects assessment relied upon outputs from the surface water quality model for source chemistry for seepage from specific facilities into the groundwater system. Potential effects to surface water quality and aquatic resources and human health as a result of predicted changes in Groundwater Quality will be assessed and presented in the relevant sections of the Application/EIS, as follows:

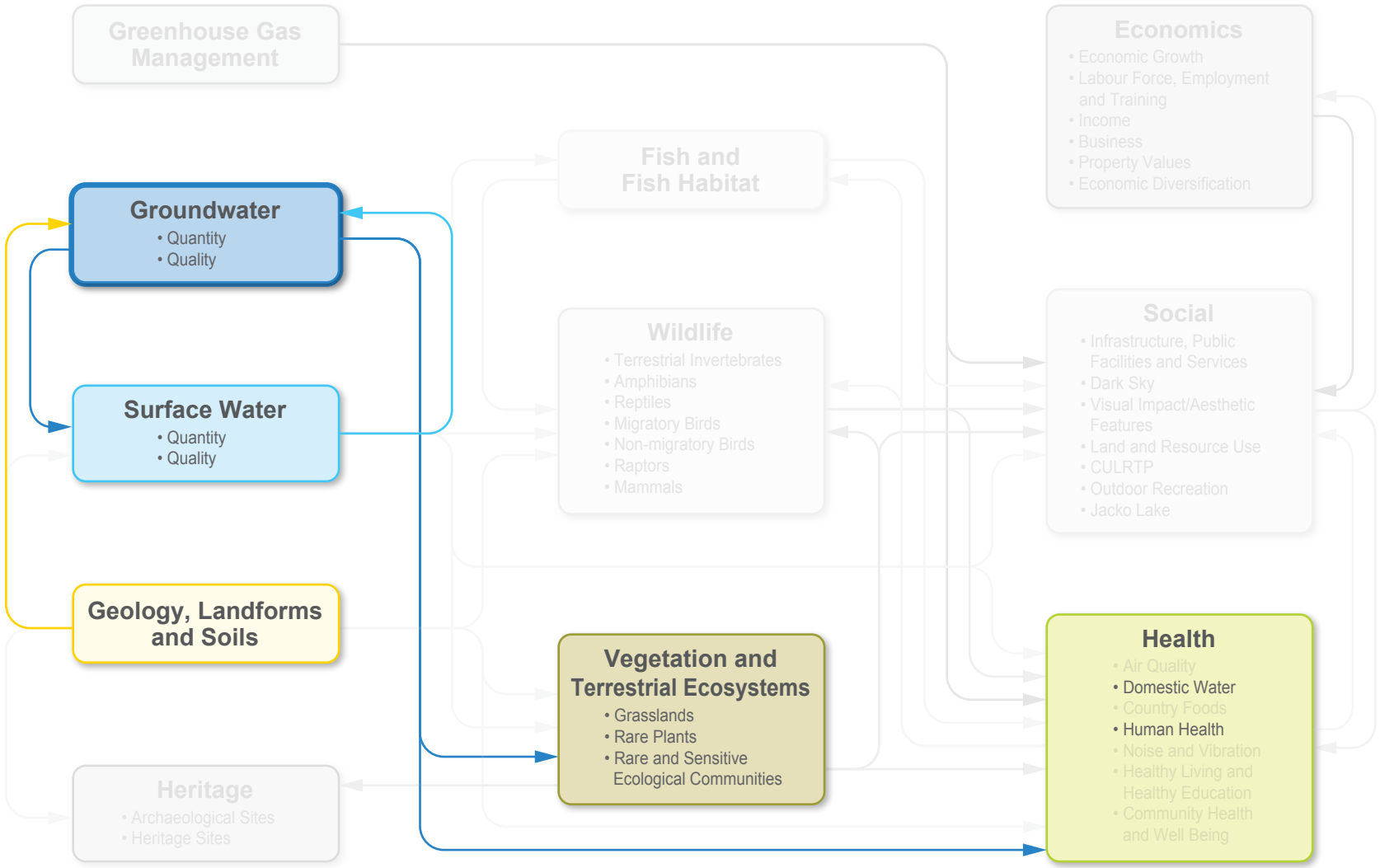
- Surface Water Quality (Section 6.3); and
- Assessment of Potential Health Effects (Section 10):
  - Domestic Water Quality (Section 10.2); and
  - Country Foods (Section 10.3).

Through the scoping process, Groundwater Quality was selected for inclusion in the EA as a VC, primarily to inform the effects assessment of other VCs (e.g., surface water quality and aquatic resources, human health, etc.; Figure 6.5-1). The groundwater quality baseline data collected for the Project is presented in Appendix 6.3-A and summarized in Section 6.5.2.3 and the groundwater quality plume migration model is presented in Appendix 6.5-A and summarized in Section 6.5.4.2. This model was used to evaluate which seepage sources from mine infrastructure may reach a nearby residential well. To evaluate which seepage sources may reach this well, forward and reverse particle tracking simulations were performed using MODPATH, a commonly-used particle tracking program developed for MODFLOW (Version 3; Pollock 1994).

The Groundwater Quality section follows the effects assessment methodology described in Section 5 of the Application/EIS and conforms to the requirements outlined in Section 6.5 of the AIR/EIS Guidelines (BC EAO 2015); however, the determination of significance of residual effects is addressed in the Human Health VC (Section 10) where the cumulative effects of changes to groundwater quality from various receptor pathways are addressed.

Figure 6.5-1

Groundwater Quality Pathway of Effects



6.5.2 Background

6.5.2.1 Regional Overview

The hydrogeological setting and conceptual model is based upon the Ajax Project *Baseline Groundwater Hydrology Assessment* report (BGC Engineering Inc. (BGC) 2015a) which is provided in Appendix 6.6-A and summarized in Section 6.6. The study area boundaries (RSA and LSA) and groundwater sampling locations described in Section 6.5.2.3 and Section 6.5.3.1. A total of 13 aquifers have been mapped within the region, five of which are located within the LSA. Three of the project area aquifers, the Sugarloaf Hill (No. 0276), Knutsford (No. 0275), and Brigade Lake (No. 0278) are bedrock aquifers, and the Davidson Creek (No. 0277) and Peterson Creek (No. 0278) are sand and gravel aquifers. Glacial and post-glacial deposits comprise the surficial materials in the RSA, which consist primarily of discontinuous glacial till and occasional sand and gravel hummocks. The layering and heterogeneity due to complex depositional history has resulted in variable states of aquifer confinement and limited connectivity of hydraulically conductive gravels. Within the LSA, hydraulic conductivity (K) generally decreases with depth, which suggests that shallow and deep groundwater flow systems may be separated. Several alteration zones and geologic faults have been identified to act as barriers to groundwater flow (i.e., the Hugh Allen and Versatile faults) or to potentially enhance K (i.e., the serpentinized picrite within the Edith Lake Fault Zone) in the bedrock aquifer system.

Groundwater flow in the RSA is separated between shallow overburden and deep bedrock, with the shallow regional system recharging the deeper regional system. The deeper system moves slowly north towards Kamloops Lake/Thompson River (down-gradient), while the shallow system is controlled by topography, with recharge in upland areas and discharge at lower elevations. Slope stability (Section 6.2) in the Aberdeen area, a residential area of Kamloops, is maintained by the abstraction of water, creating a regional scale sink for groundwater flows. Within the RSA, groundwater flows converge toward two main discharge areas: the existing Ajax West Pits and the topographic saddle near the confluence of Peterson Creek with Jacko Lake. From the latter convergence zone, groundwater flows either northwest, beyond the RSA, or east, following Peterson Creek.

6.5.2.2 Historical Activities

The proposed Project is partially located on a historical mine site and mining activities in the immediate project area began in 1989. Mining operations ceased under Teck Cominco in the Afton, Ajax East and Ajax West open pits in 1997. Previously mined areas on site include two mine rock piles, the partially backfilled Ajax East open pit, and the Ajax West open pit, within which lakes are developing. The water elevation in these historical open pits remains well below the natural ground level and the surrounding measured groundwater levels; therefore there are no suspected discharges from these lakes. The lake in east lobe of the Ajax West Pit is approximately 30 m at its deepest point and has an estimated surface area of 1.7 ha and the high walls along the west, north, and eastern boundaries of the pit are still visible. The lake in west lobe of the Ajax West Pit has been measured up to approximately 13 m deep. Historical-mined rock was backfilled into Ajax East open pit and the surface was reclaimed and the two other mine rock piles were also covered with a vegetated layer as part of the reclamation. The Trans Mountain Pipeline (Kinder Morgan) cuts across the LSA, extending from north to south, immediately east of Jacko Lake and west of the extent of the Ajax West open pits. This pipeline has been in operation since 1953 and is used to transport crude oil and refined petroleum products from Alberta to southern British Columbia and the United States.

Peterson Creek has been used as a source of domestic water, irrigation, and as a drainage channel since the late 1800s. Jacko Lake has been altered due to human activities dating back to the late 1940s when the outlet channel (Peterson Creek) was modified for irrigation purposes. In order to accommodate irrigation requirements the lake was raised in the 1970s leading to the expansion into the northeast and southeast arms and an expansion of the two westerly arms. In 1990 the lake was again altered with the addition of 1 m to the outlet structure at Peterson Creek and the dredging of silt to effectively double the live storage capacity of the lake. At the same time, a 1,000 m portion of the Peterson Creek channel immediately downstream of Jacko Lake was lined with till to help mitigate water losses from the channel due to seepage. Water licences for extraction from Jacko Lake and Peterson Creek date back to the late 1800s and on wetter years the current requirements can be met through effective management, however, these requirements are not met on drier years (Price 1991).

The Water Resource BC database indicates that there are 495 registered wells in the RSA, the majority of which are private domestic sources (267 wells), with the remainder registered as commercial and industrial (6 wells), irrigation (6 wells), water supply systems (3 wells), and observation wells (1 well), and a further 209 wells did not have usage documented (BGC 2015a).

6.5.2.3 Baseline Studies

The groundwater sampling program was initiated in 2007, and with the exception of one year (2009), has continued to the present day. The specific objectives include the following:

- define the existing characteristics of water quality;
- characterize seasonal and spatial trends in water quality; and
- identify exceedances of the relevant guidelines.

Data Sources

The groundwater quality baseline characterization is mainly based on information summarized in the Ajax Project - Baseline Water Quality Report (KP 2015), which is provided in Appendix 6.3-A and includes an analysis of all groundwater quality samples and *in situ* data, collected from 2007, when the program commenced, to October 31, 2014. In addition to the baseline water quality report, information from the following reports has been used to support the characterization of baseline conditions, as they pertain to groundwater quality:

- Baseline Groundwater Hydrology Assessment (BGC 2015a); and
- *Testing in support of development of a science based environmental benchmark for sulphate for the Ajax Mine* (Nautilus 2015; Appendix 6.3-B).

Methods

The water quality program and sampling protocols were implemented following the general requirements of the following documents:

- Guidelines for Designing and Implementing a Water Quality Monitoring Program in British Columbia. BC Ministry of Environment, Lands and Parks, Wildlife Branch. Resource Inventory Committee. 1998.

- British Columbia Field Sampling Manual for Continuous Monitoring and the Collection of Air, Air-emission, Water, Wastewater, Soil, Sediment and Biological Samples. 2003 Edition. BC Ministry of Water, Land and Air Protection.
- Protocols Manual for Water Quality Sampling in Canada. Canadian Council of Minister of the Environment. 2011.
- Water and Air Baseline Monitoring Guidance Document for Mine Proponents and Operators. Prepared by the Ministry of Environment. October 9, 2012 (BC MOE 2012).

Monitoring wells were typically installed in the vicinity of proposed Project facilities to provide information on groundwater gradients (vertical gradients assessed through installation of wells at multiple depths at the same location), flow, and chemistry up-gradient, down-gradient and within facility footprints. The Project has evolved since the monitoring program was initiated in 2007 and the monitoring well network has expanded over time as the project design changed. A total of 73 monitoring wells have been installed in the LSA, 51 of which have been sampled. Forty-six (46) of these monitoring wells continue to be sampled in the ongoing groundwater monitoring program. A summary of the monitoring well locations is provided in Table 6.5-1 and the site locations are shown on Figure 6.5-2.

The groundwater sampling methodology for the Project has evolved since its inception in 2007 as updated practices to improve sample integrity have been established. Initially, the monitoring wells were purged and sampled using Waterra inertial pumps (tubing with foot valves) and/or bailers (for slow recovery wells), and all wells were purged of three well volumes, or dry, prior to collecting a sample. Sample turbidity exceeded ideal ranges for some monitoring wells using these methods, so the methodology was changed and electronic submersible pumps were used. The three well volume approach to purging was phased out in 2011 to current methods which are specific to low-flow (minimum draw-down) purging and sampling. During each sampling event, *in situ* parameters were recorded using a multiparameter probe and water samples were collected when the draw-down depth and *in situ* parameters stabilized and a specified minimum volume of water has been purged. Samples were submitted to ALS Environmental in Burnaby for the analysis of physical tests, dissolved anions, nutrients, total and dissolved metals, cyanide, and organics.

A quality assurance/quality control (QA/QC) program was implemented from the on-set of the environmental baseline program to assess the data collection methods and the data collected in comparison to the pre-set data quality objectives (DQOs). The QA/QC program, described in detail in Appendix 6.3-A, encompasses all elements of the data collection program, including staffing the project with experienced/trained individuals, documenting site visits, adhering to standard protocols for sample collection, calibration and maintenance of equipment, and collecting and analyzing duplicate and blank samples. In accordance with the QA/QC program, suspect data were flagged and further examined; data that were determined not to meet the DQOs were rejected.

Table 6.5-1. Groundwater Sampling Locations

Nearest Proposed Facility[4]	Site ID	Coordinates[1]			Completion Zone[2]		Screened/Monitored Stratigraphy	Rationale Based on Proximity to Propose Facility[3,4]
		Easting	Northing	Elevation (masl)	From (mbgs)	To (mbgs)		
Project Site West	MW11-01S	679,734	5,612,460	928	19.4	22.4	Glacial Till	Vicinity of old TSF option
Project Site West	MW11-09S	679,860	5,609,079	910	11.5	14.5	Nicola Volcanics	Vicinity of old TSF option
Project Site West	MW11-09D	679,861	5,609,076	910	28.4	29.9	Nicola Volcanics	Vicinity of old TSF option
Project Site West	MW11-02	680,492	5,610,459	855	38.7	41.7	Nicola Volcanics	Vicinity of old TSF option
Jacko Lake North	MW11-07S	681,750	5,612,894	941	5.8	7.3	Iron Mask Hybrid	Vicinity of old MRSF option
Jacko Lake North	MW11-07D	681,751	5,612,893	941	47.9	50.9	Iron Mask Hybrid	Vicinity of old MRSF option
Jacko Lake North	MW11-04S	682,619	5,610,367	899	17.6	20.6	Iron Mask Hybrid	Proximity to Open Pit and Jacko Lake; vicinity to old MRSF option
Jacko Lake North	MW11-06S	683,404	5,612,239	943	8.3	9.8	Fluvial/ Glaciofluvial	Vicinity of old MRSF option
Jacko Lake North	MW11-06D	683,405	5,612,236	943	42.3	45.3	Iron Mask Hybrid	Vicinity of old MRSF option
Jacko Lake South	MW11-08D	681,391	5,609,123	897	31.3	32.8	Nicola Volcanics	Up-gradient of proposed project - reference location.
TSF	BGC14-003D	683,544	5,608,858	897	28.4	31.4	Nicola Volcanics	Down-gradient of TSF and WMRSF; seepage and runoff
TSF	BGC14-003I	683,544	5,608,858	897	16.8	19.8	Fluvial/ Glaciofluvial	Down-gradient of TSF and WMRSF; seepage and runoff
TSF	BGC14-003S	683,544	5,608,858	897	9.8	11.3	Glacial Till	Down-gradient of TSF and WMRSF; seepage and runoff
TSF	BGC14-012D	681,950	5,608,373	924	20.4	26.2	Nicola Volcanics	Down-gradient of TSF and WMRSF; seepage and runoff
TSF	BGC14-012S	681,950	5,608,373	924	2.7	3.4	Colluvium	Down-gradient of TSF and WMRSF; seepage and runoff
TSF	BGC14-002D	682,756	5,608,900	925	16.8	22.9	Nicola Volcanics	Down-gradient of TSF and WMRSF; ELFZ foot wall

(continued)

Table 6.5-1. Groundwater Sampling Locations (continued)

Nearest Proposed Facility[4]	Site ID	Coordinates[1]			Completion Zone[2]		Screened/Monitored Stratigraphy	Rationale Based on Proximity to Propose Facility[3,4]
		Easting	Northing	Elevation (masl)	From (mbgs)	To (mbgs)		
TSF	BGC14-002S	682,756	5,608,900	925	9.1	15.2	Glacial Till	Down-gradient of TSF and WMRSF; ELFZ foot wall
TSF	BGC14-001D	682,286	5,608,796	936	18.0	24.1	Nicola Volcanics	Down-gradient of TSF and WMRSF; ELFZ foot wall
TSF	BGC14-010	681,730	5,607,514	979	46.0	58.2	Nicola Volcanics	Down-gradient of TSF and WMRSF; seepage and runoff
TSF	BGC14-011D	682,796	5,605,945	1029	23.5	29.6	Nicola Volcanics	Up-gradient of TSF; Potential groundwater divide location.
TSF	BGC14-011S	682,796	5,605,945	1029	15.2	18.3	Nicola Volcanics	Up-gradient of TSF; Potential groundwater divide location.
TSF	BGC14-016	685,348	5,607,041	1039	23.5	29.6	Nicola Volcanics	Down-gradient of TSF and SMRSF
TSF	BGC14-017D	685,515	5,605,954	1040	23.5	29.6	Nicola Volcanics	Down-gradient of TSF and SMRSF
TSF	BGC14-017S	685,515	5,605,954	1040	3.0	4.6	Glacial Till	Down-gradient of TSF and SMRSF
Open Pit	AJGW01-D	683,382	5,609,474	903	11.3	14.3	Glacial Till	Open Pit inflow chemistry
Open Pit	AJGW02-D	683,582	5,609,338	900	16.2	19.8	Nicola Volcanics	Open Pit inflow chemistry
Open Pit	AJGW02-S	683,581	5,609,337	900	1.8	8.2	Glacial Till	Open Pit inflow chemistry
Open Pit	AJGW03-D	684,046	5,609,278	897	22.3	25.9	Fluvial/Glaciofluvial	Open Pit inflow chemistry
Open Pit	AJGW04-D	684,191	5,609,265	890	22.9	29.0	Glacial Till	Open Pit inflow chemistry
Open Pit	AJGW05-S	684,584	5,609,348	886	9.1	15.2	Fluvial/Glaciofluvial	Open Pit inflow chemistry
Open Pit	AJGW06-D	685,013	5,609,448	903	22.9	32.0	Iron Mask Hybrid	Open Pit inflow chemistry
Open Pit	AJGW07-D	683,278	5,609,634	909	22.9	29.0	Nicola Volcanics	Open Pit inflow chemistry
Open Pit	AJGW07-S	683,280	5,609,634	909	9.8	17.5	Fluvial/Glaciofluvial	Open Pit inflow chemistry
Open Pit	KAX-14-107S	683,223	5,609,202	896	29.9	38.0	Lacustrine	Jacko Lake-Open Pit Hydrogelogical Connectivity

(continued)

Table 6.5-1. Groundwater Sampling Locations (continued)

Nearest Proposed Facility[4]	Site ID	Coordinates[1]			Completion Zone[2]		Screened/Monitored Stratigraphy	Rationale Based on Proximity to Propose Facility[3,4]
		Easting	Northing	Elevation (masl)	From (mbgs)	To (mbgs)		
Open Pit	KAX-14-108S	683,140	5,609,428	901	32.3	35.4	Glacial Till	Jacko Lake-Open Pit Hydrogelogical Connectivity
Open Pit	KAX-14-114S	683,210	5,609,277	896	22.0	31.1	Glacial Till or Fluvial/ Glaciolacustrine	Jacko Lake-Open Pit Hydrogelogical Connectivity
Open Pit	KAX-14-128D	683,315	5,609,490	904	71.7	90.0	Nicola Volcanics	Jacko Lake-Open Pit Hydrogelogical Connectivity
Open Pit	MW12-01	684,638	5,609,892		36.0	38.5	Mine Rock backfill	Geochemistry of groundwater in historic Mine Rock
Open Pit	MW12-02	684,637	5,609,894		15.1	16.8	Mine Rock backfill	Geochemistry of groundwater in historic Mine Rock
Open Pit	PW-01	683,365	5,609,531	905	33.5	199.9	Nicola Volcanics/ Picrite/Sugarloaf Diorite	ELFZ; Open Pit inflows
SMRSF	BGC14-009	686,799	5,608,647	919	47.9	54.0	Iron Mask Hybrid	Down-gradient of SMRSF; seepage and runoff
SMRSF	BGC14-013	686,466	5,606,777	987	27.4	30.5	Nicola Volcanics	Down-gradient of SMRSF; seepage and runoff
SMRSF	BGC14-014D	686,672	5,607,810	986	23.5	29.6	Nicola Volcanics	Down-gradient of SMRSF; seepage and runoff
SMRSF	BGC14-015D	686,773	5,606,920	977	23.5	29.6	Nicola Volcanics	Down-gradient of SMRSF; seepage and runoff
SMRSF	BGC14-015S	686,773	5,606,920	977	8.2	11.3	Glacial Till	Down-gradient of SMRSF; seepage and runoff
SMRSF	MW12-04	684,327	5,609,146		32.0	35.5	Glacial Till	Geochemistry of groundwater in historic Mine Rock

(continued)

Table 6.5-1. Groundwater Sampling Locations (completed)

Nearest Proposed Facility[4]	Site ID	Coordinates[1]			Completion Zone[2]		Screened/Monitored Stratigraphy	Rationale Based on Proximity to Propose Facility[3,4]
		Easting	Northing	Elevation (masl)	From (mbgs)	To (mbgs)		
EMRSF	BGC14-005	687,161	5,609,519	878	47.2	50.5	Iron Mask Hybrid	Vertical hydraulic gradients between Peterson Creek Aquifer and underlying Sugarload Hill Bedrock Aquifer
EMRSF	BGC14-006D	687,288	5,610,779	940	20.4	26.5	Iron Mask Hybrid	EMRSF seepage and runoff and interactions with Aberdeen
EMRSF	MW11-05D	686,723	5,610,692	961	25.6	28.6	Iron Mask Hybrid	Vertical hydraulic gradients and seepage from EMRSF
EMRSF	MW11-05S	686,723	5,610,689	961	12.7	14.2	Iron Mask Hybrid	Vertical hydraulic gradients and seepage from EMRSF
EMRSF	MW11-10D	687,494	5,609,466	887	76.2	79.2	Fluvial/Glaciofluvial	Vertical hydraulic gradients and seepage from EMRSF
Domestic Water Sources in Project Area								
Domestic	RES-1	689,070	5,610,372					Domestic water supply
Domestic	RES-2	688,782	5,609,430					Domestic water supply
Domestic	RES-3	687,063	5,608,767					Domestic water supply
Domestic	RES-4	689,458	5,610,436					Domestic water supply
Domestic	RES-5	686,056	5,609,419					Domestic water supply
Domestic	RES-6	688,782	560,943					Domestic water supply

Notes:

[1] GPS coordinates are in UTM WGS84 Zone 10 U. Ground and surface elevations are estimated from LIDAR. Coordinates for domestic water sources may not be accurate for the well, but are specific to the property area.

[2] Completion zone is top and bottom of well screens.

[3] Rationale based on proximity to proposed facility: Up-gradient monitoring locations to assess the interactions with project facilities; down-gradient monitoring location to assess potential seepage pathways; within facilities to assess basin characteristics.

[4] Abbreviations: Tailings Storage Facility - TSF, West Mine Rock Storage Facility - WMRSF, South Mine Rock Storage Facility - SMRSF, East Mine Rock Storage Facility – EMRSF; Edith Lake Fault Zone- ELFZ.

Baseline water quality analytical and *in situ* data were examined and compared to relevant guidelines with respect to all categories of potential water use as outlined in the Application Information Requirements (AIR) for the Project. The guidelines relevant to the water quality data for the Project are as follows:

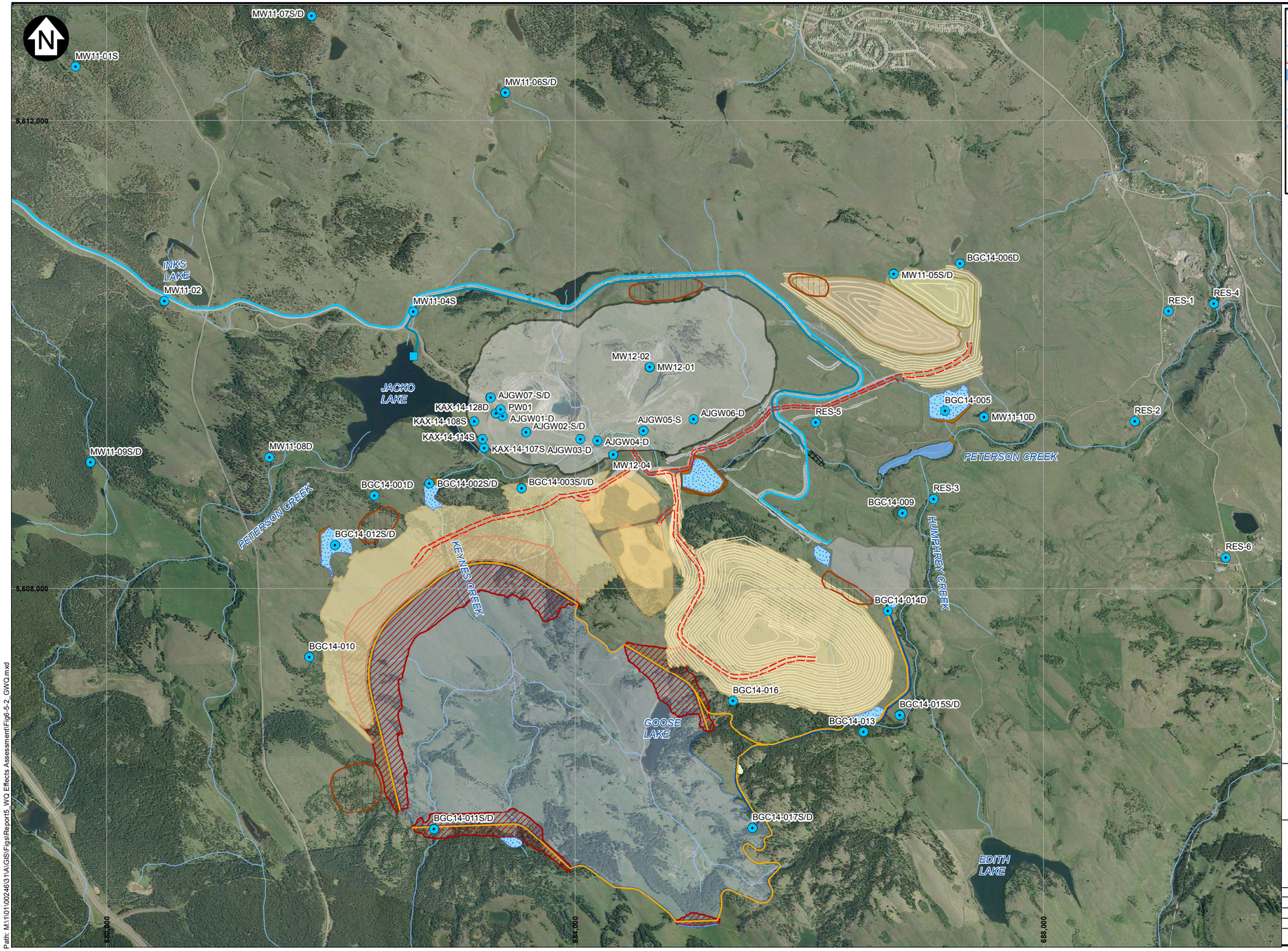
- British Columbia Ministry of Environment Approved and Working Water Quality Guidelines (BCWQG) (BC MOE 2015a and BC MOE 2015b):
  - Drinking Water Supply (BCWQG-DW);
  - Fresh Water Aquatic Life (BCWQG-Aq):
    - Maximum (BCWQG-Max);
    - 30 Day Average (BCWQG-30 D);
  - Livestock Water Supply (BCWQG-Livestock);
  - Irrigation (BCWQG-Irrigation); and
  - Recreation (BCWQG-Rec);
- Canadian Council of Ministers of the Environment (CCME), Canadian Environmental Quality Guidelines (CEQG) (CCME 2015):
  - Water Quality Guidelines for the Protection of Aquatic Life (Freshwater) (CEQG-PAL);
  - Water Quality Guidelines for the Protection of Agriculture (Livestock) (CEQG-Livestock);
  - Water Quality Guidelines for the Protection of Agriculture (Irrigation) (CEQG-Irrigation);
  - Water Quality Guidelines for the Protection of Wildlife (CEQG-Wildlife); and
- Health Canada (2012):
  - Guidelines for Canadian Drinking Water Quality (HC-DW), and
  - Guidelines for Canadian Recreational Water Quality (HC-Rec).

The varied terrain of the LSA and its proximity to densely populated areas contribute to the multidisciplinary water use and the relevance of many different guidelines. While aquatic life guidelines are not directly applicable to groundwater sources, they are used as a basis for comparison as groundwater discharge is an important contributor to flow in aquatic habitat. Most exceedances of guidelines are within the subset of those of aquatic life guidelines, which are generally the most stringent.

Physical parameters and nutrients are important for water quality characterization; however guidelines are often not directly applicable. For the following parameters, ranges of parameter concentrations are used to qualitatively describe water types: hardness, pH, total dissolved solids (TDS), total suspended solids (TSS), alkalinity, and phosphate. Many of the aquatic life guidelines are specified as hardness- or pH-dependant equations, which can affect the toxicity of metal parameters. Phosphate is a common limiting nutrient in natural waters and is used to define the trophic status of each water body.

Figure 6.5-2
Ground Water Quality Monitoring Well Locations

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The BCWQG-30 D (aquatic life) for sulphate is dependent on hardness concentrations, with guideline values that are higher for waters of higher hardness. Waters of very high hardness (i.e., greater than 250 mg/L), such as those of the LSA, require site specific toxicity testing to be conducted. The toxicity testing, documented in *Testing in support of development of a science based environmental benchmark for sulphate for the Ajax Mine* (Nautilus 2015), resulted in a recommended science based environmental benchmark (SBEB) for a maximum sulphate concentration of 429 mg/L, which is the same as the current BCWQG-30 D, but with the maximum hardness adjusted up to 800 mg/L $CaCO_3$ which is protective of early life stages for trout (present from May through June). An alternative SBEB of 730 mg/L for a hardness of up to 1,377 mg/L $CaCO_3$ was recommended for surface waters where early life stages for trout are never present, or for periods of the year when these life stages are not expected to be present in a given reach of Peterson Creek (July through April).

Regional Groundwater Quality

Regional groundwater quality in the Thompson River watershed, in the Thompson Plateau (Interior Plateau and Highlands groundwater region of British Columbia) is described as having high levels of TDS (>500 mg/L) and in some areas the sulphate concentrations are above the 500 mg/L Health Canada Drinking Water Standards (Zubel 2001). Water quality in the area is characterized as very hard and highly mineralized and of the carbonate to sulphate water type; however, these interpretations are based upon limited data (Zubel 2001).

Groundwater quality in the LSA was reported by Golder Associates (2008) in a *Hydrogeological Investigation (1998 – 2000), Aberdeen Area, Kamloops, BC* report. The groundwater quality characterization covered a broad area, extending from Chuwels Mountain to the Aberdeen subdivision and included samples from monitoring wells, springs, seeps, and lakes. Groundwater was reported to generally increase in TDS and sodium with depth. Major anions ranged from sulphate to bicarbonate (alkalinity-dominated) and major cations were typically either sodium or magnesium. Chloride concentrations were reported to increase with decreasing elevation and were related to high evaporation of meteoric (rain) water. Nitrate concentrations were elevated (>0.1 mg/L) in the samples from springs and seeps in the Aberdeen area, though concentrations were not reported to increase with depth of sample location.

The Ministry of Environment, Lands and Parks (MoELP), Groundwater Section, carried out a Water Quality Check Program through the late 1970s and 1990s as a part of their greater Ambient Groundwater Quality Monitoring and Assessment Program. The program objective was to assess ambient groundwater quality conditions in the province as a baseline for comparison with future trends as a result of potential impacts from human activities (BC MoELP 2000). Arsenic (BC MOE 2007a) and nitrate (BC MOE 2007b) were two parameters that were identified by the Water Quality Check Program to be elevated with respect to drinking water quality guidelines in groundwater samples from the Kamloops area.

Characterization of Groundwater Quality Baseline Condition

The hydrochemical signature (facies) of water is influenced by the interactions with the lithological units that it flows through and is further influenced by the length of time it interacts with various units along a flow pathway. Groundwater quality data for the LSA was assessed with respect to the lithology of the monitoring well completion zone and was further interpreted with respect to proximity to local

groundwater recharge (upland areas) and discharge zones (historical open pits, Jacko Lake, Peterson Creek, and local sloughs) and proximity to the deposit area and historic mine rock. Groundwater monitoring wells were installed north and west of the proposed project area based on proximity to facilities relevant to outdated project layouts. The shallow monitoring wells were typically completed in overburden [colluvium, fluviual/glaciofluvial, glacial till, lacustrine, and anthropogenic materials (mine rock)] and the deeper wells were completed in bedrock lithological units (Iron Mask Hybrid and Nicola Volcanics). Hydrochemical signatures and trace metal and metalloid concentrations in groundwater were not well correlated with the major lithological units and the distribution appears to be more strongly influenced by local geological enrichment in specific minerals (deposit area) and by proximity to local scale groundwater discharge areas which are typically at lower elevation in the Project area (historical open pit, Peterson Creek, Peterson Creek aquifer).

Groundwater hydraulic gradients were assessed by BGC (2015) wherever monitoring wells and piezometers were installed at multiple depths at the same location. Groundwater quality samples representing hydraulic gradients were compared wherever monitoring wells were installed at multiple depths at the same location in order to understand what, if any, correlation the direction of these hydraulic gradients have with concentrations of specific parameters. Groundwater pH was generally higher in shallower wells and hardness and alkalinity concentrations were observed to decrease with depth. Fluoride, arsenic, boron, iron, and manganese concentrations tended to increase with depth. Exceptions were noted for manganese and fluoride at the BGC14 003D/I/S monitoring location and iron at the BGC14 002D/S monitoring location; concentrations for these parameters at these monitoring sites decreased with depth. TDS and sulphate concentrations were typically similar in the samples from deep and shallow wells at the same monitoring locations. No trends were noted for selenium or molybdenum.

Physical Parameters

Groundwater quality in the project area is generally characterized as alkaline, hard to very hard, and high in dissolved solids. TDS and pH commonly exceeded groundwater drinking water limits. Groundwater TDS concentrations were typically lower in samples collected from monitoring wells at higher elevations or in the upper reaches of local catchments (local groundwater recharge areas) and higher in samples from wells at lower elevations in the project area (local groundwater discharge areas such as sloughs and creeks). Highest TDS concentrations were observed for samples from monitoring wells in the existing open pit area and the backfilled Ajax East Pit, and in samples collected from monitoring wells along Peterson Creek, in the vicinity of the Peterson Creek aquifer.

Major Ions

The major water types identified in the project area were sodium-sulphate, magnesium-sulphate, or sulphate type with only weakly dominant cations. Sodium was typically the dominant cation in samples from deeper monitoring wells located in the Open Pit area, and wells to the west and north of Jacko Lake; whereas magnesium was the dominant cation in samples from shallower monitoring wells located in the Open Pit area and most wells to the east and southeast of the Open Pit. Calcium was weakly dominant in samples from a few wells which were all located between Jacko Lake and the Ajax West open pits. Bicarbonate was only dominant in samples collected from monitoring wells in the upland areas of the Humphrey Creek and Keynes Creek watersheds and a few monitoring

wells south of Jacko Lake, likely indicative of closer proximity to local groundwater recharge areas compared to other monitoring sites in the project area.

Sulphate concentrations were elevated in groundwater samples collected from throughout the baseline study area and the highest sulphate concentrations were noted for those wells that are in the vicinity of local groundwater discharge areas, such as the Ajax West open pits, sloughs, Inks Lake, and Peterson Creek. As previously note, sulphate concentrations are elevated in groundwater in the RSA. Groundwater samples from monitoring wells in the LSA frequently exceeded the livestock guidelines (BCWQG-Livestock and CEQG-Livestock; both 1000 mg/L) and most of the samples exceeded the more stringent drinking water guidelines (BCWQG-DW and HC DW of 500 mg/L). The lowest sulphate concentrations were in samples from monitoring wells in the Keynes Creek and Humphrey Creek watersheds and guideline exceedances were less frequent. This SBEB (aquatic life) was exceeded regularly in groundwater samples collected from the baseline study area, particularly in the open pit area, Peterson Creek aquifer, and the north Peterson Creek watershed.

Fluoride concentrations were elevated in groundwater samples collected from monitoring wells throughout the project area and were highest in samples collected from monitoring wells in the vicinity of the proposed Open Pit. Fluoride concentrations were often greater than the livestock and irrigation water use guideline limits, with the greatest proportion of exceedances in the samples from the Open Pit area.

Nutrients

Nutrients that exceeded guidelines include nitrate and ammonia, which exceeded the raw drinking water guidelines occasionally.

Metals and Metalloids

Trace metal and metalloid concentrations in groundwater were not always well correlated with the major ions and the distribution appears to be more strongly influenced by local geological enrichment in specific minerals and thus by proximity to the open pit area. The majority of the wells in the open pit area are completed in overburden and those that are installed in bedrock tend to be in the Nicola Volcanics. Arsenic, boron, iron, manganese, molybdenum, and selenium were metals and metalloids that were elevated in the groundwater quality baseline study area with respect to water quality guidelines, though the spatial extent varied somewhat by parameter. Arsenic, boron, manganese, and selenium concentrations tend to be higher in samples collected from monitoring wells in the Open Pit area. Arsenic, molybdenum, and selenium were elevated in samples collected from the monitoring wells installed in the mine rock backfill in the historical Ajax East Pit. Manganese and iron concentrations were elevated in samples from monitoring wells installed in the vicinity of the proposed EMRSF and in the lower reaches of the Humphrey Creek watershed.

Summary of Common Guideline Exceedances

Aquatic life guideline exceedances for groundwater quality were most common through the majority of the baseline groundwater quality LSA for fluoride, sulphate, and arsenic, less common for boron, copper, iron, manganese, molybdenum, and selenium, and rare for aluminum, antimony, cadmium, chromium, cobalt, mercury, uranium, and zinc.

The groundwater in the LSA is generally not suitable as a raw drinking water source as groundwater samples from the LSA commonly exceeded drinking water quality guidelines for pH, TDS, sulphate, fluoride, manganese and sodium, and exceedances of these guidelines were noted, but were less common for nitrate, ammonia, arsenic, selenium, and uranium.

Livestock water use guideline exceedances were common throughout the Project area for specific conductance, TDS, and molybdenum, and less common for sulphate, fluoride, and arsenic. Irrigation water use guideline exceedances are common for specific conductance, TDS, manganese and molybdenum, and less common for chloride, selenium, and uranium.

Livestock water use guideline exceedances were common throughout the Project area for specific conductance, TDS, and molybdenum, and less common for sulphate, fluoride, and arsenic. Irrigation water use guideline exceedances were common for specific conductance, TDS, manganese and molybdenum, and less common for chloride, selenium, and uranium. Molybdenum also exceeded guidelines for livestock water use.

6.5.3 Assessment Boundaries

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

6.5.3.1 Spatial Boundaries

Local Study Area

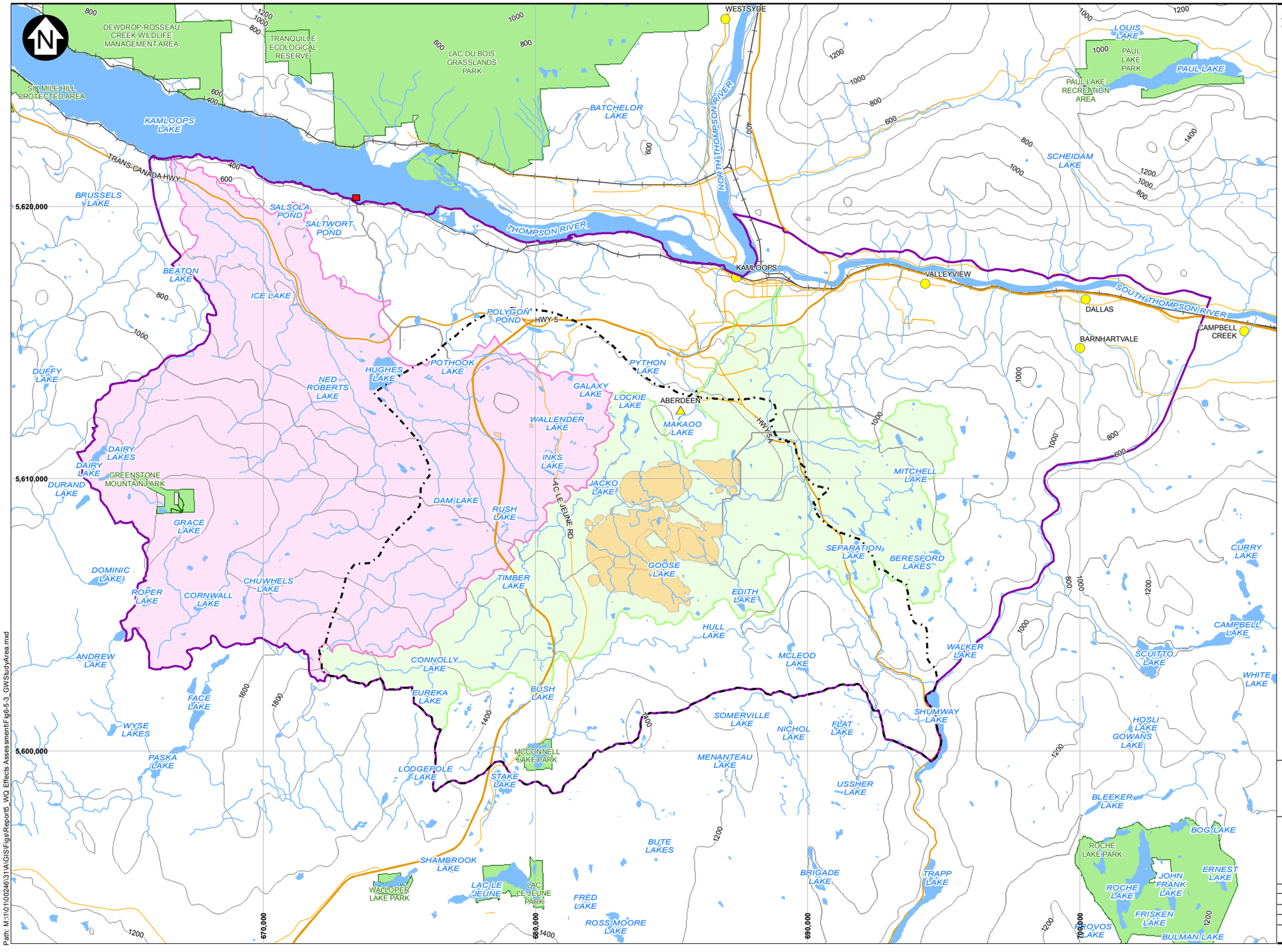
The Local Study Area (LSA) for the Groundwater Quality VC is the same as that indicated for the Groundwater Quantity VC and has been set as a surface boundary that represents the underlying groundwater system, based on the area that has been assumed to be directly affected by the development of the Project. The LSA is shown on Figure 6.5-3. The LSA includes the mapped extent of two sand and gravel aquifers (Peterson Creek, No. 0278 and Davidson Creek, No. 0277) and the majority of the underlying Sugarloaf Hill (No. 0276) mapped aquifer.

Regional Study Area

The Regional Study Area (RSA) for the Groundwater Quality VC is the same as that indicated for the Groundwater Quantity VC and has been set as the limits of the Cherry Creek (west), Peterson Creek (east), and Anderson Creek (south) watersheds and bound by Kamloops Lake and the Thompson River to the north, and includes the Aberdeen area to the north of the mine site. The RSA is shown on Figure 6.5-3.

Figure 6.5-3
Groundwater Quality Local and Regional Study Areas

Knight Piésold CONSULTING



LEGEND:

GENERAL
- CITY/TOWN
- SUBDIVISION
- MAJOR/PAVED ROAD
- CONTOUR (200 m)
- RAILWAY
- RIVER/CREEK
- LAKE
- PROVINCIAL PARK
- CHERRY CREEK WATERSHED
- PETERSON CREEK WATERSHED

PROPOSED FACILITIES
- INTAKE
- MINE INFRASTRUCTURE
- MINE SITE
- LOCAL STUDY AREA (LSA)
- REGIONAL STUDY AREA (RSA)

NOTES:
1. BASE MAP: BC TRIM AND CANADA NTS MAPPING.
2. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 10N.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:150,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
4. STUDY AREAS SOURCED FROM BGC ENGINEERING INC.

SCALE 0 1 2 3 4 Kilometres

KGHM

KGHM Ajax Mining Inc.

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6.5.3.2 Temporal Boundaries

The temporal boundaries of the assessment are the time periods (Project phases) during which proposed Project activities and components are expected to interact with the Groundwater Quality VC. The temporal phases of the Project are:

- **Construction**: 2 years;
- **Operation**: 23 years;
- **Decommissioning and Closure**: 5 years (includes project decommissioning, reclamation activities and closure); and
- **Post Closure**: 5+ years.

The focus of the Groundwater Quality VC assessment is on Operation through Post Closure phases as the project components have the potential to interact with groundwater quality on a continuous basis through all mine phases.

6.5.3.3 Administrative Boundaries

Administrative boundaries did not influence the assessment of the Groundwater Quality VC.

6.5.3.4 Technical Boundaries

Technical boundaries for the Groundwater Quality VC were considered with respect to the extent to which the baseline groundwater quality could be adequately characterized and thus the effects be quantified. Groundwater monitoring wells have been installed throughout the proposed mine site area, specifically in the vicinity of proposed facilities. Groundwater quality is typically well understood in close proximity to the Project facilities and in the LSA where monitoring wells were installed to support the baseline characterization for the current project and historical alternate project layouts. Groundwater quality data outside of the main LSA are limited and the characterization of groundwater quality is reliant on available local and regional data and the technical competence of others who were responsible for collection and interpretation of the groundwater sample results. Groundwater quality data for the Davison Creek Aquifer, to the west of the project area is limited to a few samples from residential wells in that area, with samples collected by KAM environmental staff with the permission of the residents.

6.5.4 Potential Effects of the Project and Proposed Mitigation for Groundwater Quality

6.5.4.1 Identifying Potential Effects on Groundwater Quality

The purpose of this section is to identify the potential effects of the Project on Groundwater Quality that can result from interactions between proposed Project components or activities for each Project phase within the LSA and RSA. Of the potential effects identified, key Project-Groundwater Quality VC interactions that are more likely to require assessment as a residual effect are identified and carried forward for assessment in Section 6.5.4.2.

Preliminary Screening for Potential Effects to Groundwater Quality

Project components and activities that have a reasonable potential to affect Groundwater Quality during Construction, Operation, Decommissioning and Closure, and Post Closure are listed in Table 6.5-2. These interactions are similar to those for the Surface Water Quality VC as changes to surface water quality have potential implications on groundwater quality through seepage losses from water management ponds.

The interactions matrix ranks Project components and activities by phase on a four-point scale for the potential to interact with the Groundwater Quality VC and cause a potential effect, as follows:

- Zero (0): No interaction anticipated
- Low (L): Negligible to minor interaction expected; implementation of best practices, standard mitigation and management measures; no monitoring required, no further consideration warranted.
- Moderate (M): Potential moderate interaction requiring unique active management/ monitoring/mitigation; warrants further consideration.
- High (H): Key interaction; warrants further consideration.

Table 6.5-2. Identifying Potential Project Interactions and Effects on Groundwater Quality

	Project Component/ Project Activities	Potential Effects on Groundwater Quality
Construction	Clearing and Grubbing	O
	Earthworks	O
	Overburden/Topsoil Stockpile	L
	Laydown Areas and Storage Yards	O
	Project Lighting	O
	Site Security and Fencing	O
	Fuel Storage and Filling Area	O
	Hazardous Wastes Transport, Storage, and Disposal	O
	Construction Wastes Transport, Storage, and Disposal	O
	Sewage Infrastructure and Disposal	O
	Public Road Realignment, Use, and Maintenance	O
	Site Road Construction, Use and Maintenance	O
	Peterson Creek Bridge Construction, Use, and Maintenance	O
	Site Buildings and Process Plant	O
	Explosives Magazine and Storage Facilities	O
	Open Pit Development	M
	Drilling and Blasting	M
	Crushing Mine Rock	L
	Loading, Hauling, and Deposition of Mine Rock	H
	Temporary Ore Stockpile	H

Project Component/ Project Activities		Potential Effects on Groundwater Quality
	Tailing Storage Facility Development	H
	Power Transmission, Distribution	O
	Natural Gas Line	O
	Pipeline Utility Corridor (Potable Water, Sewage, and Site Water)	O
	Water Intake from Kamloops Lake	O
	Fire Suppression Infrastructure	O
	Contact Water	H
	Non-contact Water	O
	Peterson Creek Diversion	O
	Water Management Dams	O
	Mine Staffing (Direct Employment)	O
	Contracted Employment	O
	Taxation	O
Operation	Open Pit Development	M
	Drilling and Blasting	M
	Hauling Mine Rock and Ore from Pit	L
	Crushing and Conveying Ore	L
	Temporary Ore Stockpile	H
	Development of Mine Rock Management Facilities	H
	Stripping, Loading, Hauling, Deposition, and Contouring of Topsoil and Overburden	L
	Revegetation through Progressive Reclamation	L
	Process Plant Operation	O
	Deposition to Tailing Storage Facility	H
	Site Road Use and Maintenance (Materials, Personnel, Supplies)	L
	Concentrate Transport and Storage	O
	Explosives Magazine and Storage Facilities	O
	Fire Suppression Infrastructure	O
	Fuel Storage and Filling Area	O
	Hazardous Wastes Transport, Storage, and Disposal	O
	General Wastes Transport, Storage, and Disposal	O
	Sewage Infrastructure and Disposal	O
	Laydown Areas and Storage Yards	O
	Power Transmission, Distribution	O
	Project Lighting	O
	Site Access, Security and Fencing	O
	Water Intake from Kamloops Lake	O
	Contact Water	H
	Non-contact Water	O
	Potable Water Treatment and Use	O
	Peterson Creek Diversion	L

	Project Component/ Project Activities	Potential Effects on Groundwater Quality
	Mine Staffing (Direct Employment)	O
	Contracted Employment	O
	Taxation	O
Decommissioning and Closure	Dismantling of Ancillary Buildings	O
	Pit Lake Filling	M
	Site Road/Bridge Decommissioning	L
	Tailing Storage Facility Decommissioning and Reclamation	H
	Mine Rock Management Facilities Reclamation	L
	Fuel Storage and Filling Area	O
	Hazardous Wastes Transport, Storage, and Disposal	O
	General Wastes Transport, Storage, and Disposal	O
	Sewage Infrastructure and Disposal	O
	Laydown Areas and Storage Yards	O
	Power Transmission, Distribution	O
	Project Lighting	O
	Site Access, Security and Fencing	O
	Contact Water	H
	Non-contact Water	O
	Potable Water Treatment and Use	O
	Peterson Creek Diversion	L
	Road use to the Project (Materials, Personnel, Supplies)	O
	Mine Staffing (Direct Employment)	O
	Contracted Employment	O
	Taxation	O
Post Closure	General Site Inspections and Maintenance	O
	Contact Water	H
	Non-contact Water	O
	Road use to the Project (Materials, Personnel, Supplies)	O
	Mine Staffing (Direct Employment)	O
	Contracted Employment	O

Notes:

O	*No interaction anticipated.*
L	*Negligible to minor interaction expected; implementation of best practices, standard mitigation and management measures; no monitoring required, no further consideration warranted.*
M	*Potential moderate interaction requiring unique active management/monitoring/mitigation; warrants further consideration.*
H	*Key interaction; warrants further consideration.*

Project components and activities for which zero interaction (0) is anticipated, or for which there is a potential negligible to minor interaction (L) are not carried forward in the assessment. Project components and activities with the potential to have a moderate (M) or key interaction (H) with the Groundwater Quality VC are carried forward for further analysis in the effects assessment.

Based on the preliminary screening exercise for potential effects on Groundwater Quality, the Project has the potential to change to groundwater quality throughout the life of the Project from Construction to Post Closure.

Construction Phase Potential Effects

The Construction phase will occur over the first two years (Yr -2 and Yr -1) of the Project life. The proposed Project components and associated activities that will take place during the Construction phase are described in detail in Section 3.0 Project Description of the Application/EIS.

Based on the preliminary screening exercise and interactions matrix (Table 6.5-2), the potential interactions that are anticipated to contribute to a change in Groundwater Quality can occur through the following key pathways of interactions:

- the operation of construction equipment, vehicles and development of the open pit by drilling, blasting, transporting and crushing mine rock will contribute dust to the atmosphere, resulting in dustfall, which has an indirect effect on groundwater quality due to the effects on surface water quality and the resultant seepage from surface water into the surrounding groundwater; and
- Contact Water - has the potential to change the concentrations of key parameters through interactions as follows:
  - metal leaching and seepage from the mine rock materials used to construct the TSF; and
  - metal leaching and seepage from MRSFs and temporary stockpiles.

Operation Phase Potential Effects

The Operation phase will occur over a 23 year period of the Project life. The proposed Project components and associated activities that will take place during the Operation phase are described in detail in Section 3.0 Project Description of the Application/EIS.

Based on the preliminary screening exercise and interactions matrix (Table 6.5-2), the potential interactions that are anticipated to contribute to a change in Groundwater Quality can occur through the following key pathways of interactions:

- the operation of construction equipment, vehicles and development of the open pit by drilling, blasting, transporting and crushing mine rock will contribute dust to the atmosphere, resulting in dustfall, which has an indirect effect on groundwater quality due to the effects on surface water quality and the resultant seepage from surface water into the surrounding groundwater; and
- Contact Water - has the potential to change the concentrations of key parameters through interactions as follows:
  - metal leaching and seepage from the TSF and the embankment mine rock materials; and
  - metal leaching from MRSFs and ore stockpiles.

Decommissioning and Closure Phase Potential Effects

The Decommissioning and Closure phase will occur over a five year period, immediately following the Operation phase. The proposed Project components and associated activities that will take place during the Decommissioning and Closure phase are described in detail in Section 3.0 Project Description of the Application/EIS.

Based on the preliminary screening exercise and interactions matrix (Table 6.5-2), the potential interactions that are anticipated to contribute to a change in Groundwater Quality can occur through the following key pathways of interactions:

- the operation of equipment and vehicles for reclamation activities will contribute dust to the atmosphere, resulting in dustfall, which has an indirect effect on groundwater quality due to the effects on surface water quality and the resultant seepage from surface water into the surrounding groundwater; and
- Contact Water - has the potential to change the concentrations of key parameters through interactions as follows:
  - metal leaching and seepage from the TSF and the embankment mine rock materials; and
  - metal leaching from MRSFs.

Post Closure Phase Potential Effects

The Post Closure phase will occur from the end of the Decommissioning and Closure phase and for the purposes of the Surface Water Quality VC effects assessment this phase is limited to 97 years, but is acknowledged to extend continuously into the future. The proposed Project components and associated activities that will take place during the Post Closure phase are described in detail in Section 3.0 Project Description of the Application/EIS.

Based on the preliminary screening exercise and interactions matrix (Table 6.5-2), the potential interactions that are anticipated to contribute to a change in Groundwater Quality can occur through the following key pathways of interactions:

- Contact Water - has the potential to change the concentrations of key parameters through interactions as follows:
  - metal leaching and seepage from the TSF and the embankment mine rock materials; and
  - metal leaching from MRSFs.

6.5.4.2 Effects on Groundwater Quality

<u>Changes in Groundwater Quality</u>

Analytical Plume Migration Models

Analytical plume migration models were developed by BGC, using forward and reverse particle tracking simulations to assess potential changes to groundwater quality in the Peterson Creek aquifer area immediately east of the Project. The model inputs, assumptions, methods and results are summarized here and expanded documentation of these models is provided in Appendix 6.5-A.

Objectives

The objectives of the models were to assess the potential change in groundwater quality in the vicinity of the residential wells due east of the Project in the Peterson Creek aquifer. Residential well RES-2 is interpreted to be installed within this aquifer and is downstream of the PCDP and down-gradient of the EMRSF and EMRSF Pond and is the nearest residential well down-gradient from the proposed mining infrastructure. Particle tracking was conducted in MODPATH for the groundwater flow modelling (Section 6.4 – Groundwater Quantity) to assess potential flow pathways for seepage losses from mine facilities and RES-2 was noted along the flow pathways predominantly from the PCDP and close to the pathways from the EMRSF and EMRSF Pond.

Particle tracking was conducted in the groundwater flow model to assess the potential for seepage losses from the PCDP, EMRSF Pond and the EMRSF to be intercepted in the RES-2 well. The results of the particle tracking model showed that seepage from the PDCP was expected to reach the area around the groundwater well at RES-2 through advective transport but that seepage losses from the EMRSF and EMSF Pond would not. Advective transport refers to the process by which mass is carried directly along groundwater flow pathways. The particle tracking model provides information on advective transport flow pathways but does not consider the potential for dispersion, which is expected and could result in some effects to groundwater quality at RES-2 from the EMRSF and EMRSF Pond. Dispersion is the groundwater term used to describe the mechanical mixing process that can take place in the groundwater system that could result in mass transport outside of the direct (advective) groundwater flow pathways. The groundwater quality models were developed to account for potential loading from advection and dispersion from the three sources (PCDP, EMRSF Pond, and EMRSF) to RES-2. The location of RES-2 is shown on Figure 6.5-2 and the coordinates are provided in Table 6.5–1.

Model Chemistry Inputs

The following source chemistry inputs were used for the groundwater quality predictions:

- EMRSF seepage chemistry – based on the geochemical source terms provided by Lorax Environmental Services Ltd. (Lorax) (provided in Appendix 6.3-C Water Quality Model Report);
- EMRSF Pond seepage chemistry – based on results provided for the Base Case water quality model (surface water) (Knight Piésold Ltd. 2015b);
- PCDP seepage chemistry - based on results provided for the Base Case water quality model (surface water) (Knight Piésold Ltd. 2015b); and
- RES-2 baseline chemistry – data provided in the Ajax Project - Baseline Water Quality Report (Knight Piésold Ltd. 2015a; Appendix 6.3-A); one sample collected in October 2014.

Analytical Models

Two analytical models were developed to assess groundwater quality at RES-2: (1) a continuous source model, and (2) a pulse model. The continuous source model (Domenico and Robbins 1985) was used to assess the change in RES-2 parameter concentrations as a result of constant seepage from the three mine sources (EMRSF, EMRSF Pond, and the PCDP) based on the maximum concentrations predicted for each of these sources. A pulse model (Baetsle 1969) was used to assess the change in RES-2 parameter concentrations as a result of a sudden release from the EMRSF Pond,

which would occur if the pond liner was torn and then repaired shortly thereafter. The possibility of this type of release is associated with the use of any liner system, but does not necessarily occur.

Sensitivity analyses were conducted to address the various model inputs: hydraulic conductivity, effective porosity, and dispersion to address how these model input parameters would affect the travel times and the plume concentrations at RES-2. Maximum concentrations were predicted based on the incorporation of the sensitivity analysis findings into the plume model inputs.

Model Results

Model results are summarized in guideline comparison tables in Appendix 6.5-B. The discussion of the results below is based on the comparison of the results to the water quality guidelines for drinking water, livestock, and irrigation, as these are the most likely receptor pathways for groundwater sources. The comparison of the results to the aquatic life guidelines has also been discussed as these guidelines tend to be the most restrictive; though it is acknowledged that aquatic life guidelines are specific to surface water environment. The effects to aquatic life are not discussed in this section as they are addressed in Surface Water Quality effects assessment (Section 6.3). The results have also been compared against the water quality guidelines for wildlife, and recreation and aesthetics.

Drinking Water Guidelines - Predicted maximum parameter concentrations at RES-2 were below all of the health based guidelines for drinking water quality (BCWQG-DW and HC-DW). Aesthetic objectives were exceeded both in baseline and in the predicted chemistry. Aesthetic objectives are not health-based and are specific to water taste or smell and also address potential for staining of laundry and plumbing. The following aesthetic objectives were exceeded:

- sulphate under baseline and predicted conditions;
- iron – under baseline and predicted conditions; and
- manganese – under predicted conditions (maximum case; baseline values were below the objective).

Irrigation Water Use Guidelines – Predicted maximum concentrations at RES-2 were below all values provided in the BCWQG-Irrigation and CEQG-Irrigation.

Livestock Drinking Water Guideline - Predicted maximum concentrations at RES-2 were below all values provided in the BCWQG-Livestock and CEQG-Livestock except for sulphate which was above these guidelines (1000 mg/L) under baseline and predicted conditions.

Aquatic Life Water Quality Guidelines – Predicted maximum concentrations at RES-2 exceeded one or all of the BCWQG-Max, BCWQG-30 D and CEQG-PAL:

- fluoride (CEQG only) – baseline and predicted conditions;
- sulphate under baseline and predicted conditions;
- copper (BCWQG-Max and CEQG-PAL) – baseline and predicted conditions;

- iron (BCWQG-Max and CEQG-PAL) – baseline and predicted conditions; and
- zinc (CEQG-PAL only) – baseline and predicted conditions.

Parameters were categorized into two groups based on the comparison to relevant water quality guidelines: Category 1 parameters include parameters that exceed at least one of the relevant guidelines, and Category 2 parameters include all parameters that either do not have guidelines or that do not exceed any guidelines. Potential residual effects of the Project are carried through for each of the Category 1 parameters, but significance ratings are not assigned, as the significance is determined in the Human Health VC (Section 10.4), with the changes to all metals parameter concentrations assessed as inputs to the Domestic Water and Country Foods VC. Significance is also determined indirectly through the Surface Water Quality VC (Section 6.3) as seepage and groundwater discharge to surface water are accounted for in the predictions for that VC.

- ***Category 1 Parameters***

Category 1 parameters include the major ions fluoride and sulphate, and the dissolved metals copper, iron, manganese, and zinc. The Category 1 parameters discussed in this section are considered to have a high potential for adverse effects due to the Project and are carried forward in the assessment of residual effects.

Fluoride – Major Ion – Baseline and predicted fluoride groundwater concentrations exceed the 0.12 mg/L CEQG-PAL (aquatic life), but is not predicted to exceed the 1.57 mg/L BCWQG-Max (aquatic life), the HC-DW and BCWQG-DW (1.5 mg/L), the BCWQG-Irrigation and CEQG-Irrigation (1 mg/L), or the BCWQG-Livestock and CEQG-Livestock (1 mg/L). The maximum predicted fluoride concentration (0.35 mg/L) is 1.1 times greater than the baseline concentration (0.32 mg/L) and the minimum (0.33 mg/L) is 1.04 times greater.

Sulphate – Major Ion – Baseline and predicted sulphate groundwater concentrations exceed the BCWQG-DW and HC-DW 500 mg/L aesthetic objective, the 1000 mg/L BCWQG-Livestock and CEQG-Livestock, and the 429 mg/L BCWQG-30 D (aquatic life), and the 730 mg/L (for hardness of up to 1377 mg/L $CaCO_3$) SBEB that was developed for the baseline surface water quality characterization due to baseline exceedances of the maximum hardness threshold (i.e. greater than 250 mg/L $CaCO_3$) for the BCWQG-30 D for sulphate. Sulphate is naturally elevated in both the surface and ground water in the project area and exceedances of these guidelines and the SBEB are common. The maximum predicted sulphate concentration (1050 mg/L) is 1.04 times higher than baseline (1010 mg/L) and the minimum (1027 mg/L) is 1.02 times higher than baseline.

Copper – Dissolved Metal – Baseline and predicted groundwater copper concentrations exceed the aquatic life guidelines (BCWQG-Max, BCWQG-30 D, and CEQG-PAL, based on assumed maximum hardness values for hardness based calculations), but neither the baseline nor predicted concentrations exceed the drinking water (aesthetic objectives; BCWQG-DW – 0.5 mg/L and HC-DW – 1.0 mg/L), livestock (BCWQG-Livestock – 0.3 mg/L and CEQG-Livestock – 1.0 mg/L), or irrigation (BCWQG-Irrigation – 0.2 mg/L and CEQG-Irrigation – 1.0 mg/L) water quality guidelines. The maximum predicted copper concentration (0.0919 mg/L) is 1.01 times higher than baseline (0.0913 mg/L) and the minimum predicted concentration (0.0915 mg/L) is 1.003 times

higher; the difference in the predicted to baseline ranges in the realm of analytical uncertainty (i.e., the change could not reliably be detected in samples).

Iron – Dissolved Metal – Baseline and predicted iron groundwater concentrations exceed the aquatic life guidelines (BCWQG-Max – 0.35 mg/L and CEQG-PAL – 0.3 mg/L) and the HC-DW aesthetic objective (0.3 mg/L), but are below the CEQG-Irrigation (5 mg/L). The maximum predicted iron concentration (0.323 mg/L) is 1.03 times higher than baseline (0.314 mg/L) and the minimum predicted concentration (0.318 mg/L) is 1.01 times higher than baseline; similar to copper, these changes are within the range of analytical uncertainty for this parameter.

Manganese – Dissolved Metal – The maximum predicted groundwater manganese concentration at RES-2 exceeds the 0.05 mg/L HC-DW aesthetic objective (no BCWQG-DW established for manganese), but remains below the irrigation guidelines (0.2 mg/L BCWQG and CEQG) and the aquatic life guidelines (BCWQG-30 D – 1.91 mg/L, based on maximum hardness for hardness-based calculation). The maximum predicted manganese concentration (0.051 mg/L) is 1.39 times higher than the baseline concentration (0.037 mg/L) and the minimum predicted concentration (0.043 mg/L) is 1.16 times higher than the baseline concentrations. The minimum predicted manganese groundwater concentration is below the HC-DW aesthetic objective. The baseline manganese concentration at RES-2 was 0.037 mg/L and the maximum predicted concentration was 0.051 mg/L; a maximum increase of 0.014 mg/L was predicted. Although the change in concentration for manganese is higher compared to most other category 1 parameters, it is important to note that the only exceedance is for the HC-DW aesthetic objective (which is not health related), and the predicted concentration is only 0.001 mg/L above the 0.05 mg/L objective.

Molybdenum – Dissolved Metal – The maximum predicted groundwater molybdenum concentration at RES-2 exceeds the 0.02 mg/L BCWQG-Irrigation and the 0.01 mg/L CEQG-Irrigation and the baseline and minimum predicted concentrations exceed only the CEQG-Irrigation. Neither the maximum nor minimum concentrations exceed any other relevant guidelines (drinking water (BCWQG-DW 025 mg/L), livestock (BCWQG-Livestock 0.05 mg/L and CEQG-Livestock 0.5 mg/L), and aquatic life (CEQG-PAL 0.073 mg/L and BCWQG-30D 1 mg/L)). The maximum predicted molybdenum concentration (0.023 mg/L) is 1.47 times higher than the baseline concentration (0.016 mg/L) and the minimum predicted concentration (0.019 mg/L) is 1.2 times higher than the baseline concentration.; a maximum increase of 0.007 mg/L was predicted. Although the change in concentration for molybdenum is higher compared to most other category 1 parameters, it is important to note that the only guidelines exceeded are the BCWQG and CEQG for irrigation. The maximum predicted concentration is only 0.003 mg/L above the 0.02 mg/L BCWQG-Irrigation and the minimum predicted change is below the BCWQG-Irrigation.

Zinc – Dissolved Metal – Baseline and predicted groundwater zinc concentrations at RES-2 exceed the 0.3 mg/L CEQG-PAL, but remain below the hardness-based BC aquatic life guidelines (BCWQG-30 D and BCWQG-Max). Zinc concentrations remain below all other water quality guidelines. The maximum predicted zinc concentration (0.0491 mg/L) is 1.02 times higher than the baseline concentration (0.0484 mg/L) and the minimum predicted concentration (0.0487 mg/L) is 1.006 times higher than the baseline concentration. Similar to copper, this magnitude of change would likely not be detectable.

- **Category 2 Parameters**

Category 2 parameters include conventional parameters and major ion parameters (hardness, bromide, chloride, calcium, magnesium, potassium, and sodium), nutrients (ammonia, nitrate, nitrite, and phosphorus), and dissolved metals (aluminum, antimony, arsenic, barium, boron, cadmium, chromium, cobalt, lead, lithium, manganese, molybdenum, nickel, selenium, silicon, silver, strontium, thallium, uranium, and vanadium). The baseline and predicted concentrations of these parameters are provided in Appendix 6.5-B, but are excluded from further discussions and are not carried through as a residual effect, based on the detail that they are predicted to remain below all of the protective relevant water quality guidelines.

6.5.4.3 Mitigation Measures for Groundwater Quality

Mitigation measures are proposed by KAM for the Project to avoid, minimize, compensate, restore-on-site, off-set or otherwise mitigate for adverse effects to Groundwater Quality as a result of Project components and activities. Mitigation measures for the protection of groundwater quality have been applied in the engineering associated with the Project design and water management plan. Note that the development of the surface water quality model, which was a primary chemistry input source for the groundwater plume model, was an iterative approach and included mitigation measures that were developed through changes in mine design and water management strategies to avoid or minimize adverse effects to Surface Water Quality and Groundwater Quality. Multiple changes have been made to project design to minimize the effect on water quality. The assumptions regarding the effectiveness of these mitigation measures has been provided in other sections of the Application/EIS. The details are summarized below:

- Dry cover closure for the TSF - At closure, a dry cover will be placed on the TSF. Retention of a pond at closure, while potentially maximizing evaporation losses, would likely result in locally increased TSF seepage rates (i.e., beneath the pond footprint) relative to the dry cover design due to an increased hydraulic head created by the pond. While a majority of the TSF seepage is predicted to report to the Open Pit (Drawing 18, Appendix 6.6-D), there remains the possibility of unforeseen seepage paths toward Peterson Creek (Upper) and Jacko Lake. Thus, this design is considered a prudent mitigative measure in that it would reduce TSF seepage rates;
- Design enhancements to the reclamation covers for the MRSFs to encourage runoff and reduce infiltration - Unsaturated flow modelling (HYDRUS) indicates that infiltration is minimized by placing a cover on the mine rock and tailings (see Appendix A of Appendix 6.4-C). For bare mine rock, the unsaturated modelling indicates that average annual infiltration is on the order of 44 mm, which is about 2 times greater than runoff from undisturbed ground. HYDRUS modelling indicates that annual infiltration into the mine rock is reduced by a small amount when a nominal reclamation cover is placed over the mine rock. This infiltration value is reduced to 8 mm assuming a 0.3 m thick, compacted low permeability till cover is placed between the mine rock and the includes a 0.5 m to 0.6 m thick layer of till (silty clay) followed by approximately 0.35 m of topsoil. The topsoil will be loosely placed to prevent compaction and allow for better seed and moisture retention. The MRSFs will be seeded with a dry land mix of agronomic and native species. Grading of the

engineered cover to minimize the potential development of topographic lows (where surface runoff can accumulate and pond) will also be a key component in reducing infiltration.

- Construction of the EMRSF of entirely Not Potentially Acid Generating (NPAG) material - this will minimize potential impacts to water quality. The EMRSF Pond is well situated in that it is located downgradient of the mine rock at the base of a natural watercourse. However, groundwater modelling indicates that seepage from the EMRSF could bypass the pond and discharge into Peterson Creek (Lower) (Drawing 08 and 09, Appendix 6.6-D). Given that the EMRSF is to be built with NPAG material, the effects of this potential seepage on water quality in Peterson Creek (Lower) would be minimized.
- Optimization of the locations of water management ponds to promote the capture of seepage and surface contact water - Each of the water management ponds (Central Pond, North Embankment Pond 1, North Embankment Pond 2, SMRSF Pond and EMRSF Pond) is well located from the perspective of surface runoff in that the embankments are located in existing drainages. The ponds are also coincident with groundwater discharge zones as demonstrated on Drawing 08 (EMRSF Pond), Drawing 16 (SMRSF Pond) and Drawings 17 and 18 (North Embankment Ponds 1 and 2) of Appendix 6.6-D. The Open Pit also serves as a discharge zone for seepage from the TSF, as illustrated by Drawing 18 of Appendix 6.6-D.

The final results of the models are considered to represent the residual effects of the Project on the Surface Water Quality VC and the Groundwater Quality VC, after the application of mitigation measures so the discussion of mitigation measures presents a summary of:

- proposed mitigation measures for other VCs;
- Environmental Management Plans; and
- Environmental Monitoring Plans.

Note that potential effects to aquatic resources, human health, wildlife, and other VCs as a result of predicted changes in Groundwater Water Quality have been assessed and presented in the relevant sections of the Application/EIS along with their associated proposed mitigation measures:

- Surface Water Quality, Section 6.3;
- Domestic Water Quality, Section 10.2;
- Country Foods, Section 10.3; and
- Human Health, Section 10.4.

Mitigation and management plans outline a range of measures to reduce Project effects on VCs. Many of the mitigation and management measures work along the interaction pathway between the Project and the VC. In addition to the Groundwater Quality Management and Monitoring Plan (Section 11.24), the following management and monitoring plans will also contain measures that will protect groundwater and surface water quality during the normal course of mine operations, from Construction through Post Closure:

- Soil Salvage and Handling Plan, Section 11.3;
- Construction Waste Management Plan, Section 11.4;
- Metal Leaching and Acid Rock Drainage Management and Monitoring Plan,, Section 11.5.
- Water Management and Hydrometric Monitoring Plan, Section 11.7;
- Solid Waste Management Plan, Section 11.9;
- Hazardous Waste Management Plan, Section 11.10;
- Risk Management Plan (Accidents and Malfunctions), Section 11.12;
- Surface Water Quality Management and Monitoring Plan, Section 11.23; and
- Landscape Design and Restoration Plan, Section 11.26.

Changes in Groundwater Quality

The mitigation and management measures presented in this section are specific to those that are proposed to reduce the effects of the Project on groundwater parameter concentrations and include site water management, dust management, and source loading management specific to metal leaching and acid rock drainage (ML/ARD).

Mine Water Management Plan

The objectives of mine water management include the minimization of effects to water quality by maximizing diversion of non-contact water sources around mine infrastructure, maximizing reclaim use of contact waters within the mine footprint, and minimizing seepage losses and runoff from mine facilities and infrastructure. There must be sufficient water to meet the mine water demand (process requirements (reclaimed and freshwater sources), potable water, explosives mixing, fire protection, truck shop, dust control, etc.) and sufficient clean water sources to sustain surface water flows and quality in the lakes and creeks downstream of the project facilities. The freshwater source is via a pipeline from Kamloops Lake and the reclaim (recycled) water sources are the process water from the mill, reclaim from the TSF pond, water from open pit dewatering, water collected at the WMRSF Ponds, EMRSF Pond, and SMRSF Pond, and contact water from the Plant Site. Recycled water sources are the primary source for most mine operations and any deficit will be made up with the freshwater supply.

Peterson Creek Diversion and the Peterson Creek Downstream Pond (PCDP)

Key aspects of the water management design include the Peterson Creek Diversion and the Peterson Creek Downstream Pond (PCDP). The Peterson Creek Diversion is required to manage the conveyance of excess water from Jacko Lake to the PCDP around major mining activities and infrastructure. This will be achieved via the construction of the Peterson Creek Diversion System (PCDS), which will allow for excess water from Jacko Lake to be pumped around the mine site and re-introduced upstream of the PCDP. This system will be decommissioned in the Decommissioning and Closure phase and a new channel will be established from the outlet of Jacko Lake, along the southern extent of the Open Pit and into the existing Peterson Creek channel, upstream of the PCDP. The PCDP will be constructed during the Construction phase and is intended to provide ease of access for a province-appointed water bailiff to manage outflows to meet the requirements of the

downstream water licences and aquatic habitat that have been managed at the outlet of Jacko Lake to date, but also results in reduced effects to water quality by conveying water around the majority of the on-site facilities thus reducing potential loading from runoff, seepage interception, and dustfall.

MRSF Water Management Overview

Contact water (runoff and seepage) from the MRSFs will be managed in down-gradient water management ponds. Runoff and seepage from the TSF, WMRSF, and TSF North Embankment will be managed in the North Embankment Pond 1 and North Embankment Pond 2. Runoff and seepage from the southern portion of the SMRSF will be managed in the SMRSF Pond and to the north in the Central Pond and Open Pit. Runoff and seepage from the EMRSF will be managed in the EMRSF Pond, to the south and the Open Pit (seepage) to the west.

Water intercepted in the North Embankment Pond 1 and 2 and the EMRSF will be pumped to the Central Pond and then directed to the mill for process during Operations and water intercepted at the SMRSF Pond will be routed to the Plant Site Pond. The EMRSF Pond, SMRSF Pond, and North Embankment Ponds 1 and 2 will all be retained during Decommissioning and Closure and Post-Closure with the intention of functioning as either evaporation ponds (North Embankment Ponds 1 and 2) or as semi-evaporative ponds with some surface discharge to Humphrey Creek (SMRSF Pond) and Peterson Creek (EMRSF Pond) during periods of the year when runoff is greatest (i.e. spring freshet). The MRSFs will be reclaimed progressively during Operations and fully reclaimed during Decommissioning and Closure. The objective of the closure cover design is to minimize infiltration (thus minimizing contact water load generation) by maximizing evapotranspiration and runoff. The proposed cover includes a 0.6 m layer of till, followed by approximately 0.35 m of topsoil.

Tailings Storage Facility Water Management Overview

TSF water management features include water management ponds, diversion ditched, and French drains. Prior to construction of the TSF embankments, an underdrain system will be installed to manage seepage. The underdrain system includes installation of a 200 mm diameter perforated drainage pipe, geofabric lining for the drain and drainage rock. Seepage through the embankments is expected to be managed through the application of a seepage reduction liner system on the upstream face of the embankment along with a low-permeability glacial till basin liner (Norwest 2015a). Stage expansion of the TSF embankments will be on-going through Operations at a schedule required to maintain freeboard and meet storage requirements. The following are key aspects of TSF water management during Operations:

- Runoff from undisturbed areas in the TSF will be collected within the TSF Pond;
- Tailings supernatant will be reclaimed to the mill through the water reclaim pipeline and freshwater requirements made up through the pipeline from Kamloops Lake; and
- Embankment seepage and runoff along the South and Southeast Embankments will be collected in the South and Southeast Embankments Ponds.

The TSF embankments, which are constructed of non-potentially acid generating (NPAG) mine rock, will be progressively reclaimed during Operations and will be fully reclaimed during Decommissioning and Closure. The TSF supernatant pond that remains at the end of Operations

will be pumped to the Open Pit and mine rock will be deposited onto the surface of the tailings in order to facilitate reclamation. The TSF surface will be reclaimed with a cover system designed to store and release water, minimizing infiltration and thus decreasing seepage flows into the underlying tailings solids. There will be no pond in the TSF in Post-Closure and the surface will be re-contoured to shed excess water from the surface into Humphrey Creek via a constructed spillway channel. Details specific to the closure and reclamation of the TSF are provided in the Water Management and Hydrometric Monitoring Plan (Section 11.7).

6.5.5 Residual Effects and Their Significance

6.5.5.1 Summary of Residual Effects

Plume migration models were used to predict the change in groundwater parameter concentrations at the RES-2 residential well in the Peterson Creek aquifer east of the PCDP and southeast of the EMRSF. Parameters were categorized into two groups based on the comparison to relevant water quality guidelines: Category 1 parameters include parameters that exceed at least one of the relevant guidelines, and Category 2 parameters include all parameters that either do not have guidelines or that are not predicted to exceed any guidelines. Potential residual effects of the Project have been carried through for each of the Category 1 parameters, but significance ratings have not assigned, as the significance is determined in the Human Health VC (Section 10.4), with the changes to all metals parameter concentrations assessed as inputs to the Domestic Water and Country Foods VC. Significance is also determined indirectly through the Surface Water Quality VC (Section 6.3.5) as seepage and groundwater discharge to surface water are accounted for in the predictions for that VC.

Manganese and Molybdenum are predicted to have the greatest change in concentration at the RES-2 residential well. Although the change in concentration for manganese is higher compared to most other category 1 parameters, it is important to note that the only exceedance is for the HC-DW aesthetic objective (which is not health related), and the predicted concentration is only 0.001 mg/L above the 0.05 mg/L objective. The change in concentration for molybdenum is also higher compared to most other category 1 parameters, and the only guidelines exceeded are the BCWQG and CEQG for irrigation with the maximum predicted concentration only 0.003 mg/L above the 0.02 mg/L BCWQG-Irrigation and the minimum predicted change is below the BCWQG-Irrigation.

Residual Effects

Increases in Groundwater Fluoride, Sulphate, Copper, Iron, Manganese, Molybdenum, and Zinc Concentrations in RES-2 Well

The residual effects for the Groundwater Quality VC are summarized in Table 6.5-3 along with summary details on key mitigation and management measures. Residential well RES-2 is interpreted to be installed within the Peterson Creek aquifer and is downstream of the PCDP and down-gradient of the EMRSF and EMRSF Pond. Mine site loading that could potentially affect water quality in the vicinity of the residential well includes all sources upstream of the PCDP (TSF and WMRSF runoff and seepage, and seepage from the TSF and WMRSF water management ponds, SMRSF and SMRSF Pond runoff and seepage, and dustfall), and a portion of the runoff and seepage from the EMRSF and

EMRSF Pond (understood to reach the vicinity of the well through dispersion not advection). Natural catchment contributions are also important load contributors to water quality.

Parameters that have been identified as having potential residual effects at the RES-2 well are limited to fluoride, sulphate, copper, iron, manganese, molybdenum, and zinc; those that are predicted to exceed one of the relevant guidelines. The relevant guidelines that have been presented here are based on the most likely receptors which include human health through drinking water, and livestock and irrigation water uses, and have been expanded to include the aquatic life guidelines as these guidelines tend to be the most restrictive and provide a common comparison with the Surface Water Quality VC.

6.5.5.2 Criteria for Characterization of Residual Effects

The criteria that are used to characterize the residual effects of the Project to Groundwater Quality are described in this section. The standard criteria (i.e., the magnitude, geographic extent, duration, frequency, reversibility, and ecological or social context) are described in detail in Section 5 Assessment Methodology of the Application/EIS.

The general definitions of the characterization criteria that are used are provided below and the ratings for Groundwater Quality are outlined in Table 6.5-4:

- **Magnitude**. This refers to the expected magnitude or severity of the residual effect.
- **Geographic Extent**. This refers to the spatial scale over which the residual effect is expected to occur. The geographic extent can be local, landscape/watershed, regional or beyond regional.
- **Duration**. This refers to the length of time the effect lasts; the duration of an effect can be short-term to long-term. Short-term effects may have a lower impact than long-term effects.
- **Frequency**. This refers to how often the effect occurs; the frequency of an effect can be frequent to infrequent. Infrequent effects may have a lower impact than frequent effects.
- **Reversibility**. This refers to the degree to which the effect is reversible. Effects can be fully reversible, partially reversible, or permanent.
- **Resilience and Ecological Context**. Specific to the resilience of the potentially affected population and is therefore not assessed here, but is addressed through the Human Health VC and indirectly through the Surface Water Quality VC (Section 6.3) where seepage and groundwater discharge to surface water have been accounted.

Table 6.5-3. Summary of Residual Effects on Groundwater Quality

Potential Effect	Project Phase (timing of effect)	Project Component/ Physical Activity	Description of Cause-Effect[1]	Description of Mitigation Measure(s)	Description of Residual Effect
Change in Groundwater Quality	O, CD, PC	Contact Water from all mine facilities	Seepage from PCDP (inclusive of contact water from TMF, WMRSF, SMRSF, and dustfall), EMRSF, and EMRSF Pond.	Mine Site Water Management Plan • TSF Design which includes an underdrain system in the embankment foundation, seepage reduction liner system on the upstream face of the embankment overlying a low permeability glacial till basin liner. • Operations – North Embankment WMP 1 – interception of seepage from TSF and seepage and runoff from North Embankment and WMRSF, reclaimed for Operations water demand • Operations – interception of seepage from the SMRSF, WMRSF, EMRSF and low grade ore with associated WMPs, reclaimed to mill for Operations water demand • North Embankment WMP 1 is converted to an evaporation pond in Closure and Post Closure • Reclamation of MRSFs in Decommissioning and Closure with a low permeability till layer overlain with topsoil to reduce infiltration and maximize evapotranspiration and runoff • Dry cover on TSF to reduce infiltration into the underlying tailings solids and increase non-contact runoff. Air Quality Management Plan	Change in Groundwater Quality in RES-2 Well

[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 VC.*
[2] *(C) Construction Phase, (O) Operation Phase, (CD) Decommissioning and Closure Phase and (PC) Post Closure Phase*

The characterization of residual effects for the Groundwater Quality VC is limited to magnitude, duration, frequency, and geographic extent and is based on the comparison to the generic water quality guidelines for the most likely receptors of a groundwater source, as discussed above. As stated above, resilience and ecological context cannot be assessed independent of the receptors, and similar to the determination of significance, these sections of the characterization of residual effects are deferred to the Human Health VC and the Surface Water Quality VC. Baseline conditions, which are the basis for understanding the potential change in the groundwater quality concentrations, have been accounted for in the predictions and in the characterization of the magnitude, duration, and frequency specific to each parameter.

6.5.5.3 Characterization of Residual Effects

The residual effects of the Project have characterized based on the criteria established in Table 6.5-4. The outcome of this assessment is discussed below and summarized in Table 6.5-5.

Increases in Groundwater Fluoride, Sulphate, Copper, Iron, Manganese, Molybdenum, and Zinc Concentrations in RES-2 Well

- Magnitude
  - Fluoride: Baseline and predicted fluoride groundwater concentrations exceed the baseline concentration and are predicted to exceed the 0.12 mg/L CEQG-PAL (aquatic life) but not the 1.57 mg/L BCWQG-Max (aquatic life) or the 1 mg/L BCWQG-Irrigation and CEQG-Irrigation. The predicted maximum concentration is less than 10% above the baseline fluoride concentration. The magnitude is **medium**.
  - Sulphate: The predicted maximum and minimum sulphate concentrations are greater than baseline; maximum by 4%. Baseline and predicted sulphate concentrations exceed all relevant guidelines. The magnitude is **medium**.
  - Copper: The predicted maximum copper concentration is less than 1% greater than the baseline copper concentration. Baseline and predicted groundwater copper concentrations exceed the aquatic life guidelines (BCWQG-Max, BCWQG-30 D, and CEQG-PAL), but don't exceed the drinking water (aesthetic objectives; BCWQG-DW – 0.5 mg/L and HC-DW – 1.0 mg/L), livestock (BCWQG-Livestock – 0.3 mg/L and CEQG-Livestock – 1.0 mg/L), or irrigation (BCWQG-Irrigation – 0.2 mg/L and CEQG-Irrigation – 1.0 mg/L) water quality guidelines. The magnitude is **low**.
  - Iron: The predicted maximum and minimum iron concentrations are greater than the baseline concentration; maximum by 3%. Baseline and predicted iron exceed the 0.3 mg/L HC-DW aesthetic guideline and the 0.3 mg/L CEQG-PAL, but do not exceed the 0.35 mg/L BCWQG-Max or the 5mg/L BCWQG-Irrigation. The magnitude is **medium**.
  - Manganese: The predicted maximum manganese concentration is 39% greater than the baseline concentration and is predicted to just exceed the 0.05 mg/L HC-DW guideline (no BCWQG-DW for this parameter) but is below the irrigation guidelines (0.2 mg/L BCWQG and CEQG) and the aquatic life guidelines (BCWQG-30 D – 1.91 mg/L). The minimum predicted concentration is below the aesthetic guideline as is baseline. The magnitude is **medium**.
  - Molybdenum: The predicted maximum molybdenum concentration is 47% greater than the baseline concentration maximum predicted groundwater molybdenum concentration at RES-2 exceeds the 0.02 mg/L BCWQG-Irrigation and the 0.01 mg/L CEQG-Irrigation and the baseline and minimum predicted concentrations exceed only the CEQG-Irrigation. Neither the maximum or minimum concentrations exceed any other relevant guidelines (drinking water (BCWQG-DW 025 mg/L), livestock (BCWQG-Livestock 0.05 mg/L and CEQG-Livestock 0.5 mg/L), and aquatic life (CEQG-PAL 0.073 mg/L and BCWQG-30D 1 mg/L)). The magnitude is **medium**.
  - Zinc: Baseline and predicted zinc concentrations exceed the 0.3 mg/L CEQG-PAL but remain below all other guidelines (drinking water (5 mg/L aesthetic objective; HC-DW and BCWQG-DW), irrigation (1 mg/L; BCWQG and CEQG), livestock (2 mg/L

BCWQG-Livestock and 50 mg/L CEQG-Livestock), and aquatic life (0.162 mg/L BCWQG-30 D and 0.187mg/L BCWQG-Max). The maximum predicted concentration is 1.5% higher than the baseline concentrations. The magnitude is **medium**.

- Geographic Extent
  - Fluoride, Sulphate, Copper, Iron, Manganese, Molybdenum, and Zinc: The RES-2 well location is within the same watershed as the Project infrastructure and activities and is in the LSA; the geographic extent is **landscape**.
- Duration
  - Fluoride, Sulphate, Copper, Iron, Manganese, Molybdenum, and Zinc: The predicted changes in concentration are based in single values that represent the maximum and minimum predicted change in concentration at RES-2, based on maximum source seepage concentrations. Given that these results are seepage related and are likely to remain into Post Closure the duration is **far future**.
- Frequency
  - Fluoride, Sulphate, Copper, Iron, Manganese, Molybdenum, and Zinc: The predicted maximum and minimum concentrations exceed baseline for all parameters, although by negligible amounts (less than 1%) for some parameters, the frequency is conservatively assumed to be **continuous**.
- Reversibility
  - Fluoride, Sulphate, Copper, Iron, Manganese, Molybdenum, and Zinc: Groundwater quality effects due to seepage losses from the mine facilities upstream of RES-2 and reclamation activities will reduce seepage losses from all mine sources. The effects are therefore **partially reversible**.

6.5.5.4 Significance of Residual Effects

The significance of the residual effects on groundwater quality are assessed in terms of the cumulative effect on the Human Health VC (Section 10) with the groundwater quality model results used as inputs to the contributing Domestic Water and Country Foods VCs which are under the umbrella of the Human Health VC. Significance is also determined indirectly through the Surface Water Quality VC (Section 6.3) as seepage and groundwater discharge to surface water are accounted for in the predictions for that VC.

6.5.5.5 Characterization of Likelihood and Confidence

The probability (likelihood) of the residual effect occurring and the confidence in the significance predictions and use of mitigation measures are made. The Likelihood and Confidence of each of the adverse residual effects based on these criteria is summarized in Table 6.5-5.

6.5.5.6 Summary of Residual Effects Assessment and Significance

The residual effects for the Groundwater Quality VC are summarized in Table 6.5-6 along with summary details on key mitigation and management measures. The significance rating is deferred to

the Human Health VC (Section 10), where it is addressed cumulatively through the Domestic Water and Country Foods VCs.

6.5.6 Cumulative Effects Assessment

The project is predicted to have residual effects on groundwater quality within the LSA; however, cumulative effects to groundwater quality have not been assessed specifically for this VC but have been addressed in the Surface Water Quality VC (Section 6.3) and the Human Health VC (Section 10).

Groundwater quality effects are directly attributed to seepage from mine facilities and all loading associated with these seepage pathways is understood to be intercepted in the surface water environment within the surface water quality model domain and have been accounted for in the surface water quality effects assessment. The spatial distribution of the seepage pathways are limited to the LSA, with all seepage pathways surfacing in close proximity to the mine facilities and thus cumulative groundwater quality effects are not expected.

The New Afton Project and the historical Afton TSF are within the Cherry Creek watershed and cumulative groundwater quality effects are not anticipated as seepage flow pathways from the Project facilities are not expected to migrate in that direction. Ranching activities and the effects on groundwater quality are already accounted for in the baseline characterization for the Project and have thus been included in the effects assessment through the use of baseline conditions as inputs to the water quality predictive models

6.5.7 Conclusion

Groundwater Quality was selected as a VC for consideration in the environmental effects assessment for the Project based on consultation with government agencies, members of the public and stakeholder groups, and Aboriginal groups. The Project has the potential to affect groundwater quality in in close proximity to the Project as a result of uncaptured seepage (contact water) migrating into local groundwater. Mitigation measures to reduce seepage loading to groundwater have been implemented into the development, operation, and reclamation of key mine components which include:

- TSF seepage management features (underdrain system in the embankment foundation, underlay seepage reduction liner system on the upstream face of the embankment overlying a low permeability glacial till basin liner);
- MRSF water management during all mine phase (maximize seepage and runoff interception at down-gradient water management ponds);
- Reclamation of MRSF in Decommissioning and Closure with a low permeability till layer overlain with topsoil to reduce infiltration and maximize evapotranspiration and runoff; and
- Reclamation of the TSF in Decommissioning and Closure for a dry closure concept which results in limiting infiltration into the underlying tailing solids and thus reducing seepage loading, and the resultant conveyance of non-contact surface runoff off of the facility into the Humphrey Creek watershed.

Table 6.5-4. Definitions of Characterization Criteria for Residual Effects on Groundwater Quality

Magnitude	Duration	Frequency	Geographic Extent (Physical/Biophysical)	Reversibility	Resiliency	Ecological Context	Likelihood of Effects	
							Probability	Confidence Level
How severe will the effect be?	*How long will the effect last?*	*How often will the effect occur?*	*How far will the effect reach?*	*To what degree is the effect reversible?*	*How resilient is the receiving environment or population?*	*What is the current condition of the ecosystem and how commonly is it represented in the LSA?*	*How likely is the effect to occur?*	*How certain is this analysis?*
Negligible: Predicted concentration change is very low (likely undetectable), similar to baseline ranges, and is below applicable water quality guidelines.	**Short-term:** Effect lasts 1 to 5 years, regardless of when the effect begins.	**Once:** Effect is confined to one discrete period in time during the life of the Project.	**Local:** Effect extends less than 500 m from infrastructure or activity.	**Reversible:** Effect can be reverse.	Resilience will be addressed for the Human Health VC and Surface Water Quality VC.	Ecological Context will be addressed for the Human Health VC and Surface Water Quality VC.	**High:** It is highly likely that this effect will occur.	**High:** < 80% confidence. There is a good understanding of the cause-effect relationship and all necessary data are available for the Project area. There is a low degree of uncertainty and variation from the predicted effect is expected to be low.
Low: Predicted concentration exceeds baseline concentration ranges by less than 1%; may exceed a guideline but does under baseline conditions.	**Medium-term:** Effect lasts 6 to 31 years, regardless of when the effect begins.	**Sporadic:** Effect that occurs at sporadic or intermittent intervals during any phase of the Project.	**Landscape:** Effect is limited to the LSA or one watershed (i.e., Sub-area).	**Partially Reversible:** Effect can be partially reversed.			**Medium:** This effect is likely, but may not occur.	**Medium:** 50 to 80% confidence. The cause-effect relationships are not fully understood, there are a number of unknown external variables, or data for the Project area are incomplete. There is a moderate degree of uncertainty; while results may vary, predictions are relatively confident.
Medium: Predicted concentrations exceed baseline range and exceed the lowest applicable water quality guidelines (typically for aquatic life), or an aesthetic guideline, and are less than 10% above the baseline maximum (within accepted range of analytical error).	**Long-term:** Effect lasts between 32 and 50 years, regardless of when the effect begins.	**Regular:** Effect occurs on a regular / seasonal basis during any or all of the phases on the Project.	**Regional:** Effect extends across the broader region (e.g., RSA, multiple watersheds, etc.).	**Irreversible:** Effect cannot be reversed (i.e., is permanent).			**Low:** This effect is unlikely but could occur.	**Low:** < 50% confidence. The cause-effect relationships are poorly understood, there are a number of unknown external variables, and data for the Project area are incomplete. High degree of uncertainty and final results may vary considerably.
High: Predicted concentrations exceed baseline range, and all applicable water quality guidelines and are greater than 10% above baseline maximum.	**Far Future:** Effect lasts more than 50 years, regardless of when the effect begins.	**Continuous:** Effect occurs constantly during the life of the Project.	**Beyond Regional:** Effect extends beyond the regional scale, and may extend across or beyond the province.					

Table 6.5-5. Characterization of Residual Effects, Significance, Likelihood and Confidence on Groundwater Quality

Residual Effect	Residual Effects Characterization Criteria						Significance of Adverse Residual Effects	Likelihood and Confidence	
	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Resiliency		Probability	Confidence
Increases in Groundwater Fluoride, Sulphate, Copper, Iron, Manganese, Molybdenum and Zinc Concentrations in RES-2 Well									
Fluoride	Medium	Local	Far Future	Continuous	Partially Reversible	Human Health VC (Section 10) and Surface Water Quality VC (Section 6.3)	Human Health VC (Section 10) and Surface Water Quality VC (Section 6.3)	Medium	Medium
Sulphate	Medium	Local	Far Future	Continuous	Partially Reversible	Human Health VC (Section 10) and Surface Water Quality VC (Section 6.3)	Human Health VC (Section 10) and Surface Water Quality VC (Section 6.3)	Medium	Medium
Copper	Low	Local	Far Future	Continuous	Fully Reversible	Human Health VC (Section 10) and Surface Water Quality VC (Section 6.3)	Human Health VC (Section 10) and Surface Water Quality VC (Section 6.3)	Medium	Medium
Iron	Medium	Local	Far Future	Continuous	Partially Reversible	Human Health VC (Section 10) and Surface Water Quality VC (Section 6.3)	Human Health VC (Section 10) and Surface Water Quality VC (Section 6.3)	Medium	Medium
Manganese	Medium	Local	Far Future	Continuous	Partially Reversible	Human Health VC (Section 10) and Surface Water Quality VC (Section 6.3)	Human Health VC (Section 10) and Surface Water Quality VC (Section 6.3)	Medium	Medium
Molybdenum	Medium	Local	Far Future	Continuous	Partially Reversible	Human Health VC (Section 10) and Surface Water Quality VC (Section 6.3)	Human Health VC (Section 10) and Surface Water Quality VC (Section 6.3)	Medium	Medium
Zinc	Medium	Local	Far Future	Continuous	Partially Reversible	Human Health VC (Section 10) and Surface Water Quality VC (Section 6.3)	Human Health VC (Section 10) and Surface Water Quality VC (Section 6.3)	Medium	Medium

Table 6.5-6. Summary of Residual Effects, Mitigation, and Significance on Groundwater Quality

Residual Effects	Project Phase	Project Component/ Physical Activity	Description of Cause-Effect[1]	Mitigation Measures	Significance
Increases in Groundwater Fluoride, Sulphate, Copper, Iron, Manganese, Molybdenum, and Zinc Concentrations in RES-2 Well	O, CD, PC	Contact Water (EMRSF) and the PCDP with accounts for the cumulative loading from all other upstream sources	Seepage from the SMRSF and runoff from the reclaimed SMRSF and reclaimed TSF, and seepage and runoff from the EMRSF and EMRSF Pond	Mine Site Water Management Plan • TSF Design which includes an underdrain system in the embankment foundation, a seepage reduction liner system on the upstream face of the embankment overlying a low permeability glacial till basin liner. • SMRSF Pond – manage seepage and runoff from the southern extent of the SMRSF • Reclamation of MRSFs in Decommissioning and Closure with a low permeability till layer overlain with topsoil to reduce infiltration and maximize evapotranspiration and runoff • Dry cover on TSF to reduce infiltration into the underlying tailings solids and increase non-contact runoff. Air Quality Management Plan	Refer to Human Health VC (Section 10) and Surface Water Quality VC (Section 6.3)

Notes:
[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 VC.
[2] (C) Construction Phase, (O) Operation Phase, (CD) Decommissioning and Closure Phase and (PC) Post Closure Phase

Changes in groundwater quality were assessed by modelling the change in parameter concentrations to the nearest down-gradient residential water supply well in the LSA (RES-2). Increases in groundwater fluoride, sulphate, copper, iron, manganese, molybdenum, and zinc concentrations were predicted in the vicinity of the RES-2 well. The magnitude for most parameters was **medium**, the geographic extent **local**, with a **far future** duration and a **continuous** frequency and most were **partially reversible** as a result of reclamation and none were considered irreversible.

The significance of the residual effects on groundwater quality are assessed in terms of the cumulative effect on the Human Health VC (Section 10) with the groundwater quality model results used as inputs to the contributing Domestic Water and Country Foods VCs which are under the

umbrella of the Human Health VC. Significance is also determined indirectly through the Surface Water Quality VC (Section 6.3) as seepage and groundwater discharge to surface water are accounted for in the predictions for that VC. A summary of the residual effects and mitigation measures is provided in Table 6.5-7.

A groundwater quality monitoring plan has been developed as part of the Groundwater Quality Management and Monitoring Plan (Section 11.24) to address the anticipated follow-up monitoring requirements.

Table 6.5-7. Summary of Project and Cumulative Residual Effects, Mitigation, and Significance for Groundwater Quality

Residual Effects	Project Phase	Mitigation Measures	Residual Effect Significance	Residual Cumulative Effect Significance
Increases in Groundwater Fluoride, Sulphate, Copper, Iron, Manganese, Molybdenum, and Zinc Concentrations in RES-2 Well	O, CD, PC	Mine Site Water Management Plan • TSF Design which includes an underdrain system in the embankment foundation, a seepage reduction liner system on the upstream face of the embankment overlying a low permeability glacial till basin liner. • SMRSF Pond – manage seepage and runoff from the southern extent of the SMRSF • Reclamation of MRSFs in Decommissioning and Closure with a low permeability till layer overlain with topsoil to reduce infiltration and maximize evapotranspiration and runoff • Dry cover on TSF to reduce infiltration into the underlying tailings solids and increase non-contact runoff. Air Quality Management Plan	Refer to Human Health VC (Section 10) and Surface Water Quality VC (Section 6.3)	Refer to Human Health VC (Section 10) and Surface Water Quality VC (Section 6.3)

Notes:
[1] (C) Construction Phase, (O) Operation Phase, (CD) Decommissioning and Closure Phase and (PC) Post Closure Phase

6.6 GROUNDWATER QUANTITY

6.6.1 Rationale

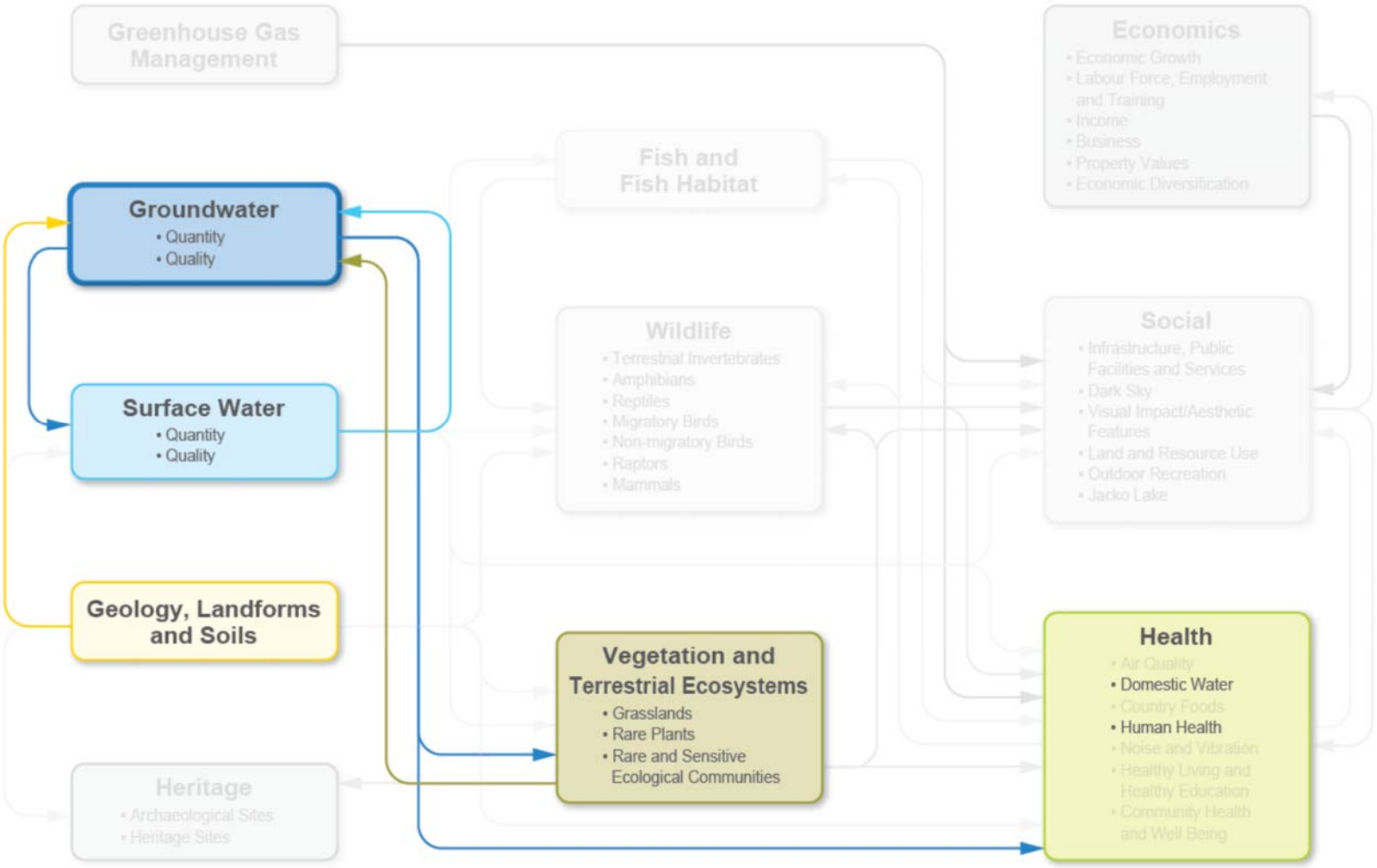
This section includes a description of the scoping process used to identify Groundwater Quantity Effects for inclusion in the assessment of potential environmental effects (effects assessment) of the Ajax Project (the Project). Scoping is fundamental to focusing the Application for an Environmental Assessment Certificate/Environmental Impact Statement (Application/EIS) on those issues where there is the greatest potential for the Project to cause significant adverse effects. Valued components (VCs) are components of the natural and human environment that are considered to be of scientific, ecological, economic, social, cultural, or heritage importance (CEAA 2006; EAO 2013). To be included in the effects assessment, there must be a perceived likelihood that the VC will be affected by the proposed Project. VCs are scoped into the environmental assessment (EA) based on issues raised during consultation with Aboriginal communities, government agencies, the public and other stakeholders.

Groundwater is legislated in British Columbia under the *Water Act* and the forthcoming *Water Sustainability Act*. Agencies with an interest in Project groundwater resources are the Effects Assessment Office (EAO), the Canadian Effects Assessment (CEA) Agency, and the Groundwater Working Group (comprising the BC Ministry of Forests, Lands and Natural Resources Operations (FLNRO), City of Kamloops (the City), Environment Canada. The groundwater quantity assessment considered stakeholder input from the public, the Kamloops Area Preservation Association, Kamloops Stockman's Association, and Aberdeen Highlands Development Corporation, Stk'emlupsemc te Secwépemc Nation (SSN), Lower Nicola Indian Band (LNIB), and the Ashcroft Indian Band (AIB).

Groundwater Quantity was selected as a VC for its importance to humans for drinking water, and livestock and irrigation water and for the indirect effects of changes in Groundwater Quantity on other VCs (Figure 6.6-1). Aboriginal groups have expressed specific concern around seepage to groundwater from Project facilities and seepage from Jacko Lake to the Open Pit. Additional concerns included potential effects to Peterson Creek and domestic water supply due to a change in groundwater quantity. Groundwater Quantity refers to the amount of groundwater in the subsurface, groundwater flow, groundwater elevations, groundwater recharge, and groundwater discharge. Groundwater Quantity is both influenced by and influences other VCs (Figure 6.6-1).

The Supporting Topic - Jacko Lake (Section 8.7) serves to aggregate summaries for all VCs that have potential pathways of effect from the Project on Jacko Lake. The intent of the section's summaries is to provide a snapshot of residual effects, mitigations and the determination of significance for each of the relevant VCs.

Geology, Landforms and Soils influence Groundwater Quantity (Figure 6.6-1). Geological and soil properties influence the rates of groundwater movement through the subsurface. Landforms influence patterns and rates of groundwater recharge and groundwater discharge as well as patterns and rates of groundwater movement through the subsurface. Geology, Landforms and Soils are assessed in Section 6.2.


Greenhouse Gas Management
Economics
• Economic Growth
• Labour Force, Employment and Training
• Income
• Business
• Property Values
• Economic Diversification
Fish and Fish Habitat
Groundwater
• Quantity
• Quality
Wildlife
• Terrestrial Invertebrates
• Amphibians
• Reptiles
• Migratory Birds
• Non-migratory Birds
• Raptors
• Mammals
Social
• Infrastructure, Public Facilities and Services
• Dark Sky
• Visual Impact/Aesthetic Features
• Land and Resource Use
• Outdoor Recreation
• Jacko Lake
Surface Water
• Quantity
• Quality
Geology, Landforms and Soils
Vegetation and Terrestrial Ecosystems
• Grasslands
• Rare Plants
• Rare and Sensitive Ecological Communities
Health
• Air Quality
• Domestic Water
• Country Foods
• Human Health
• Noise and Vibration
• Healthy Living and Healthy Education
• Community Health and Well Being
Heritage
• Archaeological Sites
• Heritage Sites

Surface Water Quantity and Groundwater Quantity are closely related (Figure 6.6-1). The overall water balance reflects both surface water and groundwater components. The climate exerts strong influence over the water balance through the rates, timing, distribution and variability of snow and rain, evaporation from open water and moist soil, and transpiration through vegetation. Groundwater recharge occurs through soils and by leakage from ponds and losing reaches of streams. Groundwater discharge provides baseflow to gaining reaches of streams, rivers, and lakes. Groundwater Quantity elements of the overall water balance are provided as inputs to the Surface Water Quantity assessment and the Surface Water Quantity effects are assessed in Section 6.4.

Groundwater Quality is intimately linked to Groundwater Quantity (Figure 6.6-1). Groundwater transports dissolved substances by bulk groundwater movement in a process called advection. Dissolved substances spread out along groundwater flow paths as the results of different groundwater velocities along different groundwater flow paths in a process called dispersion. Dissolved substances also spread slowly in groundwater by molecular diffusion. Groundwater Quality effects are presented in Section 6.5.

Vegetation and Terrestrial Ecosystems interact with the groundwater flow system (Figure 6.6-1). Plants draw water through their roots from the moist soil zone above the water table and transport the water above ground where it is used to build plant tissue or is lost to transpiration. Groundwater is one of the sources of water in the soil zone used by plants. Plants also intercept infiltrating water that would supply groundwater recharge. Consumption of water by growing plants can lower the water table elevation. Thus, plants modify rates and patterns of groundwater recharge and discharge, as well as groundwater elevations and local patterns of groundwater flow. Vegetation and Terrestrial Ecosystem effects assessments are provided in sections 6.8, 6.9, and 6.10.

Groundwater is a vital resource for many residents of Kamloops and surrounding communities as a source of water supply for private water systems as well as for agricultural and non-residential uses. The baseline hydrogeology assessment that was completed for the Project identified 13 mapped aquifers and 495 registered water wells in the region (Appendix 6.6-A). Mapped aquifers and registered water wells are shown on Drawing 6.6-E-3 of Appendix E. Golder (2008a) reported that the Aberdeen neighbourhood of Kamloops (Aberdeen), approximately 3 km north of the Project, has slope stability conditions that are affected by existing and historical residential and municipal irrigation practices. The Project is expected to modify the amount, timing and distribution of groundwater recharge and discharge resulting in changes in groundwater elevations and patterns of groundwater flow (including the interaction between groundwater and surface water) within, and some distance downstream from, the Mine Site (Figure 6.6-2).

Two documents, the baseline groundwater hydrology assessment (Appendix 6.6-A) and the numerical groundwater flow model report (Appendix 6.6-D), comprise the primary references for the Groundwater Quantity effects assessment. Discussion on the potential for aquifer compaction beneath the Tailings Storage Facility (TSF) and Mine Rock Storage Facilities (MRSFs) is provided in Appendix 6.6-F. The Groundwater Quantity effects assessment considered the Application Information Requirements / EIS Guidelines (AIR/EIS Guidelines) for the Ajax Project as outlined in EAO (2015). The Groundwater Quantity effects assessment also considers guidance from the following additional sources:

- Section 4.1 of the document *Framework for a Hydrogeologic Study in support of an application for an Environmental Assessment Certificate under the Environmental Assessment Act and Regulations for groundwater extraction projects* published by the British Columbia Ministry of Environment (BC MOE; BC MOE 2013);
- *Guidelines for Groundwater Modelling to Assess Impacts of Proposed Natural Resource Development Activities* (BC MOE 2012a); and
- *Water and Air Baseline Monitoring Guidance Document for Mine Proponents and Operators* (BC MOE 2012b).

6.6.2 Background

Preliminary regional study area (RSA) and local study area (LSA) boundaries for groundwater have been delineated to coincide with mapped watersheds (iMapBC 2013), and the limits of the underlying regionally mapped aquifers documented within the Water Resources of British Columbia (WRBC) atlas (BC MOE 2014). The limits of the RSA and LSA are included on the Drawings in Appendix 6.6-E and shown on Drawing 6.6-E-3. Further rationale for boundary delineation is provided in Section 6.6.3.

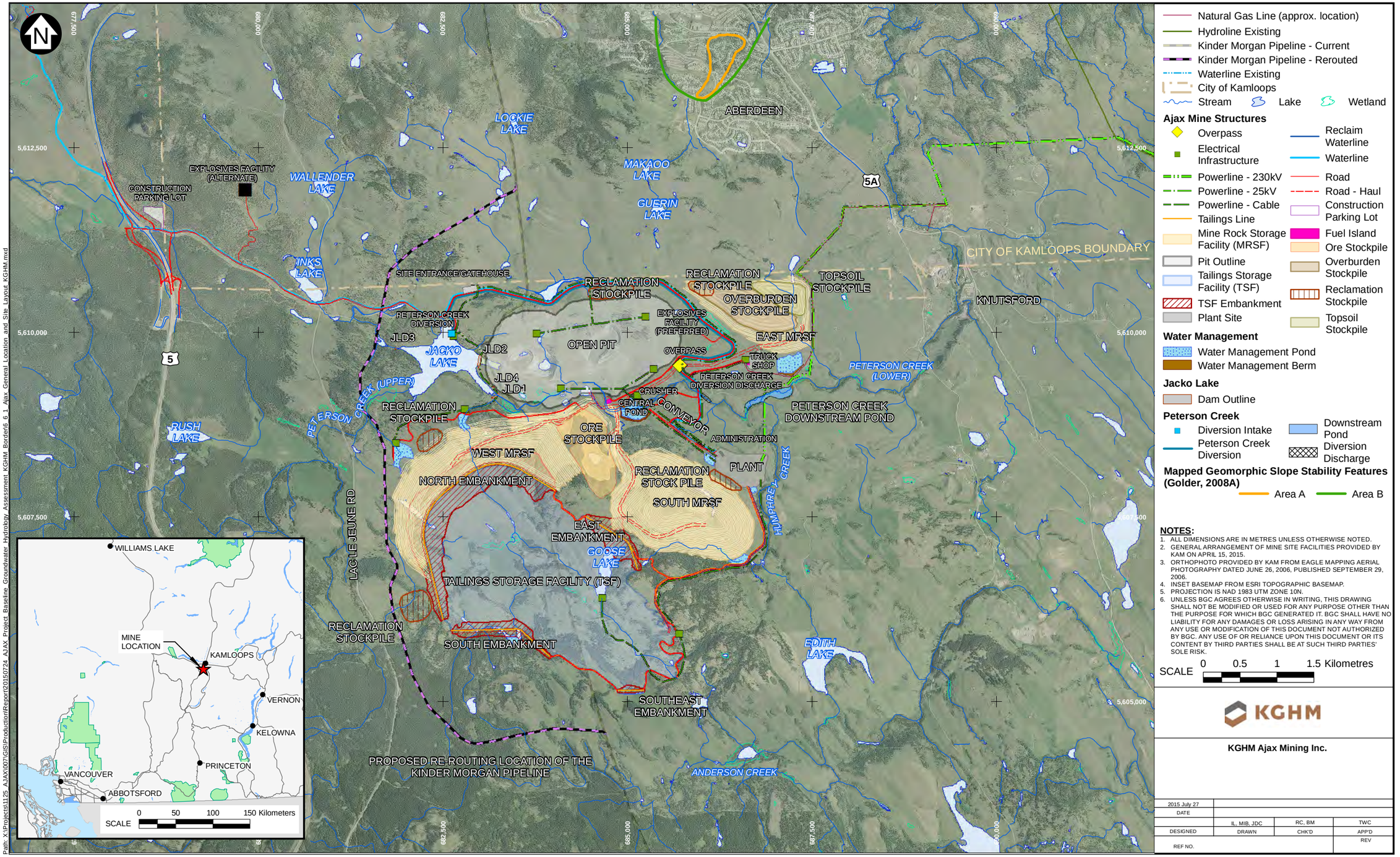
Appendix 6.6-A describes the baseline groundwater hydrology assessment. Appendices 6.6-B, 6.6-C, and 6.2-B describe the results of additional investigations completed in parallel with the baseline hydrology assessment. Appendix 6.6-D describes the numerical groundwater flow model development and simulation results used to support the Groundwater Quantity effects assessment. Appendix 6.5-A provides a plume migration analysis used to support the assessment of potential effects to Human Health (Section 10.4). Sections 6.6.2.1 through 6.6.2.3 provide a brief summary of background information directly applicable to the Groundwater Quantity effects assessment. Please refer to the appendices for additional information.

6.6.2.1 Regional Overview

The topographic relief in the region is approximately 1,600 m. Elevation ranges from approximately 1,900 masl at Chuwhels Mountain, approximately 20 km southwest of the planned open pit, to about 340 masl in the Thompson River valley, approximately 7 km north of the planned open pit (Appendix 6.6-A). Quaternary glacial and post-glacial deposits of variable thickness (i.e., from less than 5 m to greater than 120 m thick) blanket most of the region (Drawing 6.6-E1 in Appendix 6.6-E).

The underlying bedrock consists of the Upper Triassic Nicola Group (volcanics, volcaniclastics, and picrite), the Late Triassic to Early Jurassic Iron Mask Batholith (dioritic intrusive rocks), and the Eocene Kamloops Group (volcanics and sedimentary rocks). Numerous fault systems have been mapped in the bedrock, including the major basement faults of the Nicola Group and younger faults within the Iron Mask Batholith. The Edith Lake Fault Zone (ELFZ) is a regionally mapped northwest-southeast trending structure whose outcrop is poorly defined, and is shown to pass through the Mine Site on Appendix 6.6-E, Drawing 6.6-E-2 (Appendix 6.6-A).

Figure 6.6-2
Ajax General Location and Site Layout



Natural Gas Line (approx. location)
Hydroline Existing
Kinder Morgan Pipeline - Current
Kinder Morgan Pipeline - Rerouted
Waterline Existing
City of Kamloops
Stream
Lake
Wetland

Ajax Mine Structures

- Overpass
- Electrical Infrastructure
- Powerline - 230kV
- Powerline - 25kV
- Powerline - Cable
- Tailings Line
- Mine Rock Storage Facility (MRSF)
- Pit Outline
- Tailings Storage Facility (TSF)
- TSF Embankment
- Plant Site
- Reclaim Waterline
- Waterline
- Road
- Road - Haul
- Construction Parking Lot
- Fuel Island
- Ore Stockpile
- Overburden Stockpile
- Reclamation Stockpile
- Topsoil Stockpile

Water Management

- Water Management Pond
- Water Management Berm

Jacko Lake

- Dam Outline

Peterson Creek

- Diversion Intake
- Peterson Creek Diversion
- Downstream Pond
- Diversion Discharge

Mapped Geomorphic Slope Stability Features (Golder, 2008A)

- Area A
- Area B

NOTES:

1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE NOTED.
2. GENERAL ARRANGEMENT OF MINE SITE FACILITIES PROVIDED BY KAM ON APRIL 15, 2015.
3. ORTHOPHOTO PROVIDED BY KAM FROM EAGLE MAPPING AERIAL PHOTOGRAPHY DATED JUNE 26, 2006, PUBLISHED SEPTEMBER 29, 2006.
4. INSET BASEMAP FROM ESRI TOPOGRAPHIC BASEMAP.
5. PROJECTION IS NAD 1983 UTM ZONE 10N.
6. UNLESS BGC AGREES OTHERWISE IN WRITING, THIS DRAWING SHALL NOT BE MODIFIED OR USED FOR ANY PURPOSE OTHER THAN THE PURPOSE FOR WHICH BGC GENERATED IT. BGC SHALL HAVE NO LIABILITY FOR ANY DAMAGES OR LOSS ARISING IN ANY WAY FROM ANY USE OR MODIFICATION OF THIS DOCUMENT NOT AUTHORIZED BY BGC. ANY USE OF OR RELIANCE UPON THIS DOCUMENT OR ITS CONTENT BY THIRD PARTIES SHALL BE AT SUCH THIRD PARTIES' SOLE RISK.

SCALE 0 0.5 1 1.5 Kilometres

KGHM

KGHM Ajax Mining Inc.

2015 July 27			
DATE			
	IL, MIB, JDC	RC, BM	TWC
DESIGNED	DRAWN	CHK'D	APP'D
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Several surficial aquifers and bedrock aquifers have been mapped in the region by MOE (Drawing 6.6-E-3 in Appendix 6.6-E and BC MOE 2014). Five mapped aquifers fall within LSA. These include the Sugarloaf Hill (No. 0276) and Knutsford (No. 0275) bedrock aquifers, part of the Brigade Lake (No. 0274) bedrock aquifer and the Davidson Creek (No. 0277) and Peterson Creek (No. 0278) sand and gravel aquifers. The Peterson Creek and Davidson Creek Aquifers are mapped along Lower Peterson Creek and Davidson Brook, to the southeast and east of the proposed Ajax pit.

The potentiometric surface/water table is interpreted as a subdued replica of topography, with depths to groundwater typically being greater in the uplands than in local valleys or the Thompson River valley. Groundwater flow is generally directed from south to north from Chuwels Mountain to Kamloops Lake/Thompson River, but with local variations due to topography and geological conditions (Figure 6.6-3). Project-scale groundwater flow is predicted to be dominated by local-scale flow systems primarily within glacial sediments and shallow fractured bedrock (Appendix 6.6-A).

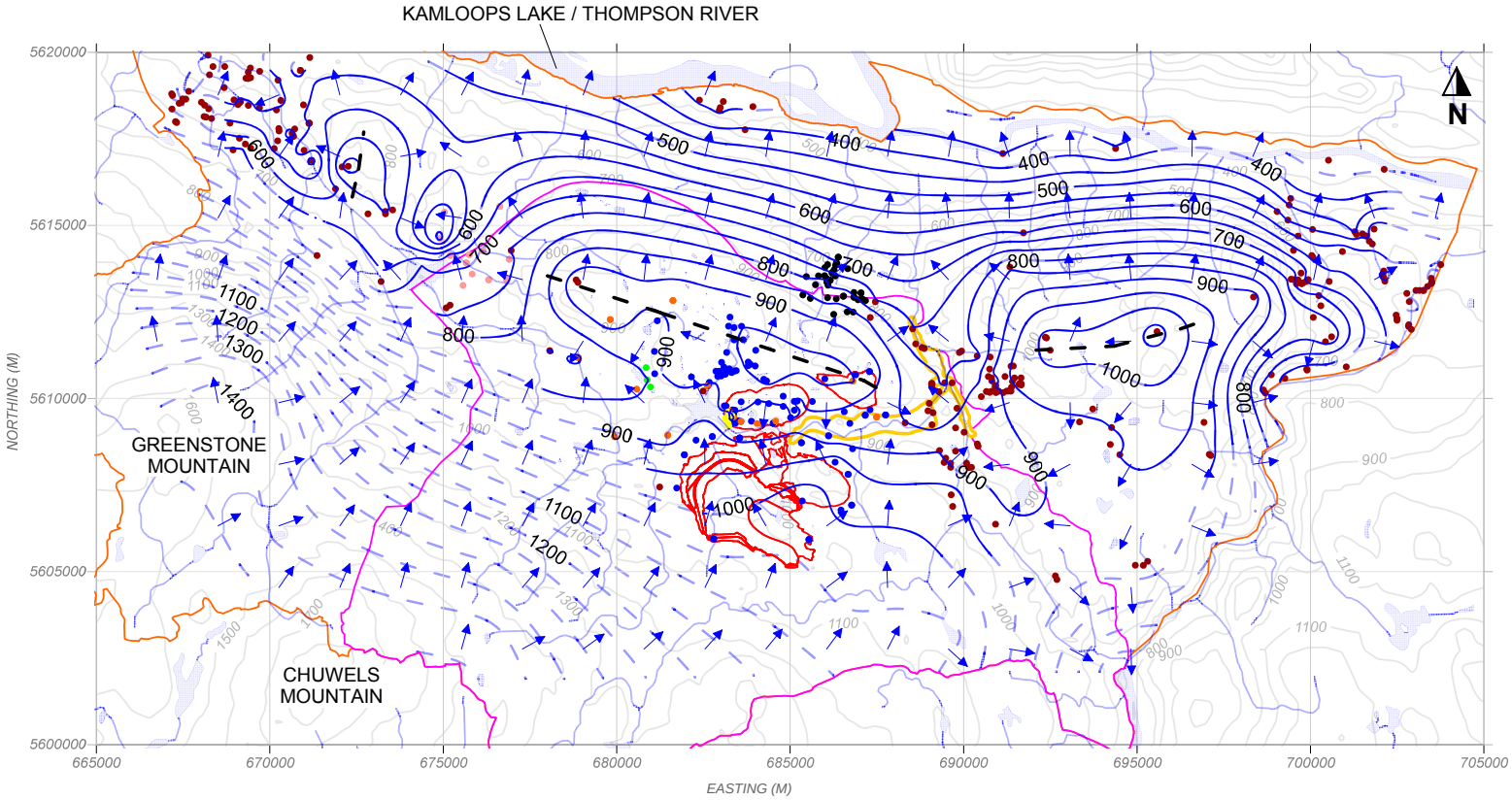
The region has a semi-arid steppe climate. Precipitation is limited, especially at lower elevations, and evaporation rates are high (Knight Piésold [KP] 2014d). Therefore, groundwater recharge rates are low. Groundwater recharge rates are interpreted to be less than 10 mm/year as a regional average (Golder 2008a). Groundwater recharge is from the infiltration of snowmelt and rainfall principally in uplands, irrigation in developed areas, with lesser components supplied by surface water infiltration from streams, creeks, lakes, and ponds. Groundwater discharge zones are generally restricted to streams, rivers, and low topographical areas where the groundwater elevation is close to ground surface resulting in evapotranspiration losses from the shallow groundwater. Groundwater discharge is also interpreted to occur along valley bottoms, in depressions, ponds, and lakes. Flowing artesian conditions exist in some wells completed at the toes of slopes and down gradient of upland areas (Appendix 6.6-A).

6.6.2.2 Historical Activities

The Kamloops area grew after the First World War until development slowed during the Depression and the Second World War. After this period, the City began to grow again, and much of the land that had formerly been used for farming in the valley was used for residential development. Ranching (including cattle grazing) also developed, and is currently ongoing immediately within and adjacent to the Project. Groundwater supply for farming, residential use and ranching have modified groundwater conditions in the RSA. Irrigation and changes in land use have likely modified patterns and rates of groundwater recharge and discharge over time.

In the Project area, groundwater has been affected by mining activity that can be traced back over 100 years, with exploration in the Project area beginning in the 1880s and continuing intermittently to present. Copper, gold, and iron mineralization was discovered at the Iron Mask Mine near Kamloops in 1896.

The Afton Mine went into operation in 1977. Mining operations were initiated on the Ajax East and Ajax West open pits in 1989 and subsequently suspended in 1991 due to depressed metal prices. A second period of production began in 1994 and was again suspended in 1997. The raw ore from the Ajax open pits was trucked approximately 10 km west to the processing plant adjacent to the Afton open pit. During these periods of production, it is estimated that 17 Mt of ore was mined and 13 Mt of ore was milled.


KAMLOOPS LAKE / THOMPSON RIVER
GREENSTONE MOUNTAIN
CHUWELS MOUNTAIN
N
NORTHING (M)
EASTING (M)
5620000
5615000
5610000
5605000
5600000
665000
670000
675000
680000
685000
690000
695000
700000
705000
LEGEND
WATER LEVEL DATA SOURCE
BGC
KNIGHT PIESOLD
KCBL
GOLDER
PITEAU
CITY OF KAMLOOPS (ABERDEEN)
WRBC DATABASE
POTENTIOMETRIC CONTOUR INTERPRETED FROM WATER LEVEL DATA (M ASL)
POTENTIOMETRIC CONTOUR INTERPRETED FROM REGIONAL TOPOGRAPHY (M ASL)
INTERPRETED GROUNDWATER FLOW DIRECTION
INTERPRETED GROUNDWATER FLOW DIVIDE
COMPONENTS OF AJAX MINE
MAPPED SAND AND GRAVEL AQUIFERS
REGIONAL STUDY AREA (RSA)
LOCAL STUDY AREA (LSA)
TOPGRAPHIC CONTOUR (M ASL)

In the late 1990s, the Afton tailings facility and project components were decommissioned and reclaimed by the Afton Mine in accordance with their closure plan. At the Ajax site, this includes reclaimed waste rock dumps adjacent to Peterson Creek in the location of the proposed Ore Stockpiles. Waste rock has also been placed north of and within the existing pits.

The New Afton Mine occupies the site of the historic Afton Mine infrastructure. New Afton began underground mining immediately beneath the historic Afton Mine open pit in June 2012. This mine is able to produce up to 11,000 tonnes per day of raw ore though the processing plant. Currently the mine is licenced to draw up to approximately 6,960 m^3/d (290 m^3/h) from Kamloops Lake for water supply to the processing plant. An application to withdraw an additional approximately 5,000 m^3/d is currently in review. Taking water from Kamloops Lake has no impact on groundwater quantity in the RSA. Releasing Kamloops Lake water on the Mine Site, whether for the purposes of dust control, or sequestered in tailings, may affect the groundwater quantity near the Project.

6.6.2.3 Baseline Studies

The baseline groundwater hydrology assessment (Appendix 6.6-A) presents the conceptual understanding of the baseline groundwater hydrology near the Project and surrounding region. The baseline groundwater hydrology assessment was performed to provide a baseline against which any predicted effects to groundwater quantity could be compared. The baseline groundwater hydrology assessment was based on a review and compilation of existing site investigation (SI) data and results from geological, hydrogeological, geotechnical and groundwater quality field programs conducted by BGC and others on behalf of KGHM Ajax Mining Inc. (KAM) and Abacus Mining and Exploration Corporation (AME) as part of various engineering and permitting phases for the Ajax Project. Publicly available hydrogeologic data for the region and from hydrogeological assessments to support historical mining operations were also compiled and considered in the study. The baseline groundwater hydrology assessment provides the conceptual basis for the development of the numerical groundwater flow model developed to support the Groundwater Quantity effects assessment (Appendix 6.6-D).

Data Sources

KAM provided site-specific information to BGC to support the groundwater hydrology assessment, the 3D numerical groundwater flow model development, and the Groundwater Quantity effects assessment. In addition, BGC obtained published regional information to supplement the information provided by KAM. BGC compiled and reviewed data from these sources for the purpose of preparing the baseline groundwater hydrology assessment (Appendix 6.6-A) and the 3D numerical groundwater flow model (Appendix 6.6-D). Specific data sources are described below.

Key site-specific information considered in the groundwater baseline report (Appendix 6.6-A) includes data from the following sources:

- The 3-dimensional geologic model in the area of the planned open pit created based on drilling completed since 1980 (Wardrop 2009).
- A hydrogeology study completed by Klohn Leonoff Consulting Engineers in 1988 for the historical Ajax Mine (Klohn Leonoff 1988).

- A hydrogeological assessment carried out in 2005 by Piteau Associates (2006) for the nearby New Afton site for New Gold Inc.
- Hydrogeological, geotechnical, hydrometeorological and water quality investigations completed by KP since 2007 in support of various levels of environmental assessment and permit applications for the Project (KP 2007, 2008, 2008a, 2008b, 2009, 2011a, 2012a, 2012b, 2013a, 2013b, 2014a, 2014b, 2014c, 2014d).
- GIS datasets of surficial geologic materials mapped near the Mine Site (Keystone 2008; KP 2014d).
- Various hydrogeological and geotechnical investigations, groundwater monitoring, water management and modelling studies completed by BGC since 2009 in support of the Ajax pit slope design, pit depressurization, mine rock pile and plant infrastructure design and baseline surface water and groundwater assessments to support permitting (BGC 2011a, 2011b, 2011c, 2011d, 2012a, 2012b, 2013a, 2013b, 2013c, 2014a, 2014b, 2015b, 2015e).
- Data from SI and design studies carried out by Golder Associates Ltd. (Golder) in 2010 and 2011 near the Mine Site (Golder 2011a, 2011b).
- A compilation of regional structural geological information and preliminary results of mapping of the Edith Lake Fault Zone (ELFZ; i.e., an area of potential faulting to the south of the Mine Site) completed in 2011 and 2014 under the direction of BGC (BGC 2014b; Campbell 2011, 2014). Results from drilling investigations and hydraulic testing of the ELFZ in 2015 are also considered (BGC 2015a).
- Stratigraphic information from boreholes advanced into mine rock from previous mining activities in the LSA under the supervision of Lorax in 2012.
- A preliminary SI and hydrogeology conceptualization completed around the Jacko Lake area by Klohn Crippen Berger Ltd. (KCB) in 2013 and 2014 (Klohn Crippen Berger 2013, 2014).
- Preliminary drill hole results from the 2014 condemnation drilling program around the tailings storage facility (TSF) area provided by KGHM.
- Hydraulic testing of the Peterson Creek Aquifer to the south east of the planned open pit under the supervision of BGC (BGC 2015f).
- Geotechnical investigations (including test pitting, drilling and packer testing) in the area of the TSF under the supervision of KP (KP 2015b).

In addition to the above noted site specific information, publicly available information from a hydrogeological and geotechnical data compilation CD for the Aberdeen area were also consulted (City of Kamloops 2012). Pertinent material for regional assessment includes data compiled from the WRBC atlas (BC MOE 2014), as well as information from other publicly available maps, air photos and reports referenced herein.

Campbell (2011) reviewed the structural geology within the LSA and provided a summary of regional geology based on the 1987 study of the Iron Mask Batholith by Kwong (1987), the 2005 digital compilation by the BC Geological Survey Branch (Massey et al. 2005), and the study of porphyry Cu-Au deposits of the Iron Mask Batholith by Logan and Mihalynuk (2005).

The bedrock geology within the Aberdeen area, just north of the LSA, has been mapped by Read (1998) on behalf of the City of Kamloops (the City) to support groundwater and slope stability studies in Aberdeen. Read (1998) provided geological and structural interpretations based on data archived by the City, which are summarized in Golder (2008a). Geological contacts and faults described in the work of Golder (2008a) were considered in baseline groundwater hydrology assessment.

BGC's understanding of regional surficial geology is based on publicly available maps, stereographic aerial photographs and reports (Armstrong and Fulton 1965; Brennand and Lian 2009; Fulton 1967, 1969, 1975; Fulton and Smith 1978; GSC 1995; Johnsen 2004; Johnsen and Brennand 2004; National Air Photo Library (Ottawa) 1964). The thickness of surficial deposits at the regional scale has been interpreted based on compiled drill data from the WRBC database (BC MOE 2014), digital files and reports provided by the City of Kamloops (2012) and borehole data reported by Piteau Associates (2006).

Data for thickness delineation of surficial deposits and hydrostratigraphic characterization on the Ajax property are available from mapping and drilling investigations completed by BGC, KP, KCB, KAM, Golder, and Keystone Wildlife Research Ltd. (Keystone; Appendix 6.6-A).

In addition to the data sources noted above, the 3D geologic and structural model created by AME and updated by KAM was available to BGC for subsurface material delineation in the LSA. The version of the geological model that was available to BGC to support this work was received on September 22, 2014; the structural model supporting this work was received on February 2, 2011. Campbell (2014) completed an investigation into the evidence for and against the presence of the Edith Lake Thrust Fault (ELTF) mapped by Logan and Mihalynuk (2006) south of the Ajax West and East open pits.

A total of 118 instruments monitor groundwater elevation near the Mine Site, consisting of 24 vibrating wire piezometers (VWPs) and 94 standpipe piezometers.

The groundwater monitoring network (Appendix 6.6-E, Drawing 6.6-E-4) consists of:

- Twenty-nine standpipe piezometers installed into boreholes drilled in 2014 by BGC for KAM as part of the groundwater monitoring program designed around the current GA to the support the Groundwater Quantity effects assessment (Appendix 6.6-B). Eleven of these piezometers were installed into surficial deposits and 18 were installed into bedrock.
- Twenty-three standpipe piezometers installed into geotechnical drill holes between 2010 and 2011 by BGC as part of the Project feasibility study (FS) design work completed for AME (BGC 2011a, 2011d).
- Six VWPs installed in holes drilled for a pumping test conducted by BGC for AME in the winter of 2010-2011 in support of the Project FS (BGC 2011b). Two of these were installed into surficial deposits and four were installed into bedrock.
- Eleven VWPs installed into bedrock in the open pit area by BGC between 2009 and 2013 as part of Prefeasibility Study (PFS) and FS-level mining geotechnical assessment work for AME

(BGC 2011c) and geotechnical investigations to support the 2013 *Mines and Environmental Management Act* (MEMA) permit application for KAM around the Pre-2014 GA (BGC 2012a).

- Twenty-eight standpipe piezometers installed into boreholes by KP during hydrogeological investigations carried out in 2007 and 2011 on behalf of AME and KAM in support of various levels of permitting and environmental assessment (KP 2007, 2008c, 2011a). Twelve of these piezometers were installed into surficial deposits and sixteen were installed into bedrock.
- Nine standpipe piezometers installed into geotechnical boreholes by KCB in 2014 for KAM as part of hydrogeological assessments in support of the Project effects assessment (Klohn Crippen Berger 2014). Four of these piezometers were installed into surficial deposits and five were installed into bedrock.
- Four VWPs installed into bedrock within geotechnical boreholes by KCB in 2014 for KAM as part of hydrogeological assessments in support of the Project effects assessment (Klohn Crippen Berger 2014).
- Five standpipe piezometers installed by Golder as a part of geotechnical investigations around the Pre-2014 GA (Golder Associates 2011ab). Two of these piezometers were installed into surficial deposits and three were installed into bedrock.

The groundwater monitoring network is maintained by KAM field staff and is visited on an approximate quarterly basis in order to complete data downloads from locations with dataloggers and to collect manual measurements.

Additional groundwater elevation data for baseline characterization are available from additional locations on site and within the RSA. The database used for groundwater elevation assessment includes:

- historical measurements from 242 locations reported by the BC MOE in the WRBC database both in the RSA and LSA (BC MOE 2014);
- historical measurements at monitoring wells/VWPs from 20 locations reported by Piteau Associates (2006), and located near the New Afton Mine to the west of the Project site;
- historical measurements from 42 monitoring locations compiled from digital data provided by the City (2012), and located in the Aberdeen area;
- manual measurements collected intermittently between 2010 and 2014 from more than 141 standpipe piezometers, VWPs, and a 200 m deep prototype depressurization well installed by BGC and others on the Project site; and
- automatic measurements collected with electronic dataloggers since 2011 from select standpipe piezometers and VWPs installed by BGC and others on the Project site.

The WRBC data collected during drilling likely do not represent the stable groundwater elevations, and many of these measurements reflect the conditions at the time of drilling, rather than present day conditions. In addition, the province of BC disclaims responsibility for the accuracy of the information provided in the WRBC well database. For these reasons, the WRBC data are considered to be less reliable than data collected by BGC and those documented in other, more recent consultant reports.

Hydraulic conductivity data within the RSA were compiled to support the baseline groundwater hydrology assessment for the Project. The compiled dataset includes estimates from tests conducted by BGC, KP, KCB, and Golder for the Project and nearby New Afton Mine. Hydraulic conductivity values estimated from WRBC drill records for this assessment, as well as data compiled by Golder (2008a) for the City (2012) in the Aberdeen area are also noted and discussed. Based on the reports, data available from Piteau's investigations in the New Afton area (Piteau Associates 2006) and from Golder's SIs and compiled data (Golder 2008a) in the Aberdeen area are of acceptable quality for the purposes of this study. Data from historical well records and the WRBC were collected by third parties for other purposes and are therefore of lower confidence than data collected to assess groundwater conditions for the Project.

Drawing 6.6-E-4 in Appendix 6.6-E provides an indication of the spatial distribution of borehole and groundwater monitoring data near the Mine Site. Available installation and well construction details are provided in Appendix 6.6-A.

Methods

The baseline groundwater hydrology assessment was conducted by compiling and reviewing the available geological, hydrogeological, geotechnical and groundwater quality data obtained for AME and KAM from previous and ongoing investigations on the property. Appendix 6.6-A describes methods used to complete the baseline groundwater hydrology assessment. Those methods are summarized below:

- The distribution of surficial geology was characterized by compiling information from published maps and studies, in addition to surficial geology studies completed for the Project.
- The thickness of surficial deposits was interpreted from reported depth to bedrock published in the data sources described in the previous section. The interpreted thickness of surficial deposits was also constrained by mapped bedrock outcrop locations (i.e., thickness of surficial deposits equal to 0 m). Professional judgment was applied as required to interpret the thickness of surficial materials in areas with limited spatial data. Statistical correlation using variograms was used to interpolate the thickness of surficial deposits between data points and spot-estimates defined using professional judgment.
- Bedrock topography was defined by subtracting the interpreted surficial deposit thickness from the land surface topography.
- The understanding of the distribution of bedrock geology near the Mine Site was based on compiled information from published maps and studies. The KAM 3D geologic model was used to define the pit-area distribution of geology. Beyond the boundaries of the geologic model, geologic boundaries were assumed to extend vertically downward from the outcrops shown on Drawing 6.6-E-2 in Appendix 6.6-E.
- Regional and local-scale groundwater elevations were mapped using available water level data. Each data point was evaluated based on groundwater elevation over time (where available) and against known or suspected causes of non-representative groundwater elevation changes (e.g., slug tests, pumping tests, drilling, slow recovery after installation, defective instruments, flowing artesian wells, etc.). Data points considered to be non-

representative were removed from the data set. The groundwater elevation data were interpolated between data points and placed on a regular grid so that groundwater contours could be drawn. In areas without groundwater elevation data, topography, combined with the BGC's understanding of the regional groundwater flow system, were used to interpret the potentiometric surface/water table elevation contours and groundwater flow directions.

- Seasonal variations in groundwater elevation were evaluated by creating hydrographs for wells on the site with active monitoring, plotted together with precipitation and snowfall data.
- Vertical hydraulic gradient components were evaluated for 32 well pairs with active monitoring. The magnitude, direction (upward or downward) and variability through time were evaluated.
- Hydraulic conductivity was characterized for each identified geologic formation based on published information, site investigation results, and estimates of hydraulic conductivity derived from well yields. A variety of testing methods have been employed by BGC and others to obtain estimates of hydraulic conductivity within surficial deposits and bedrock materials in the LSA and RSA. These methods include rising and falling head (slug), packer, pumping and pump-in tests. Approximate hydraulic conductivity values for geologic materials were estimated using data from wells reported in the WRBC database (i.e., well radii, approximate well yields and static water levels) using a Theim-Dupuit method (i.e., steady state unconfined flow to a well).
- Geologic formations were divided into hydrostratigraphic units based on geologic provenance interpreted from available mapping and published depositional models for the area, as well as textural descriptions and hydraulic test data collected during hydrogeological and geotechnical site investigations for the Project.
- For hydrostratigraphic units with sufficient hydraulic conductivity data, the range in hydraulic conductivity, geometric mean, 25th percentile, and 75th percentile were identified.
- Potential groundwater recharge was estimated based on a compilation of available data from regional hydrogeological studies and from surface water licences for irrigation throughout the RSA. Meteoric recharge near the Mine Site was estimated based on unsaturated flow modelling and a chloride mass balance (CMB) method using geological and water quality data collected from the Ajax property.
- Potential groundwater discharge was estimated based on the review of available data from hydrogeological, hydrological, and hydrometeorological studies conducted on the Ajax property and in the surrounding area. Potential groundwater abstraction from domestic pumping was also estimated based on the number of registered wells within the RSA and LSA and average household water use per the City and Statistics Canada.
- A conceptual hydrogeologic model was developed by compiling and interpreting the available geologic and hydrogeologic data.
- A regional 3D numerical groundwater flow model was developed and calibrated to baseline hydrogeologic and hydrologic data (i.e., groundwater elevations, groundwater recharge and discharge, and groundwater flow). The numerical groundwater flow model was also used to assess the groundwater budget for existing conditions. Development of the groundwater

flow model was based directly on the conceptual hydrogeological model. Appendix 6.6-D provides additional information on the 3D numerical groundwater flow model development, calibration, and predictive simulation results.

Results

Surface topography has a pervasive influence on groundwater flow throughout the RSA. Groundwater elevations are a subdued replica of topography in surficial deposits (Figure 6.6-4) and shallow bedrock (Figure 6.6-5). Near the Mine Site, groundwater converges locally towards the existing Ajax West Pits. Groundwater also converges towards the topographic saddle that occurs near the confluence of Peterson Creek with Jacko Lake, and then flows either northwestward from Jacko Lake beyond the Mine Site, or eastward following the Peterson Creek drainage. The ridge system trending northwest-southeast and located north of the Mine Site coincides with an interpreted groundwater divide between northward (i.e., towards Aberdeen and the Thompson River) and southward (i.e., towards the Mine Site) groundwater flow systems. This divide will likely become more pronounced as dewatering and open pit excavation proceeds during the mine life. Hydraulic conductivity varies within and between the interpreted hydrostratigraphic units and with depth (Figures 6.6-6, 6.6-7, and 6.6-8). Hydraulic conductivity in the surficial deposits and upper 100 m to 200 m of bedrock varies across a larger range (i.e., 4 to 5 orders of magnitude) and generally slightly higher than hydraulic conductivity (range of 3 to 4 orders of magnitude) in deeper bedrock, however this interpretation may be influenced by the greater number of tests conducted over the shallower depth range. Surficial hydrostratigraphic units are comprised primarily of low permeability glacial till in upland areas, with moderate to high hydraulic conductivity glaciofluvial/glaciolacustrine sand and gravel complexes within topographic depressions. The glaciofluvial/glaciolacustrine sand and gravel complexes comprise the major sand and gravel aquifers within the region, including the Peterson Creek and Davidson Creek Aquifers near the Ajax Project. The underlying bedrock hydrostratigraphy, from most to least hydraulically conductive consists of the Kamloops Group, Iron Mask Hybrid, Picrite, Sugarloaf Diorite and Nicola Group units. The Sugarloaf Hill bedrock aquifer is included with the Iron Mask Hybrid and the Knutsford bedrock aquifer is included in the Kamloops Group hydrostratigraphic units, respectively. The sub-horizontal deposition of Kamloops Group rocks may impart a layered characteristic giving it a macroscale anisotropy, potentially magnified by the presence of "swelling clays" mapped in Aberdeen (Golder 2008a).

A number of faults have been mapped in the vicinity of the Mine Site. At the open pit scale, faults have not been defined as distinct hydrogeologic structures because the available hydraulic conductivity test data did not indicate that these zones are significantly more or less conductive than the surrounding rock mass. However, some geologic fault zones within the RSA have been identified as hydraulically significant. The Hugh Allen/Versatile faults to the north of the Ajax Project have been interpreted by Golder (2008a) to act as barriers to northward groundwater flow from Aberdeen towards Kamloops Lake/Thompson River due to lower hydraulic conductivities than adjacent bedrock. The ELFZ could potentially act as a local groundwater flow conduit along strike in areas of locally enhanced hydraulic conductivity. However, as discussed in Appendix 6.6-A and 6.6-E, some uncertainty remains on the interpretation of the overall hydraulic properties, thickness, orientation and regional extent of the ELFZ. The numerical groundwater flow model considers the potential for the ELFZ as a more permeable zone than the surrounding bedrock as an alternative conceptual hydrogeologic model (Appendix 6.6-D).

Figure 6.6-4
Interpreted Local Scale Flow System – Surficial Deposits

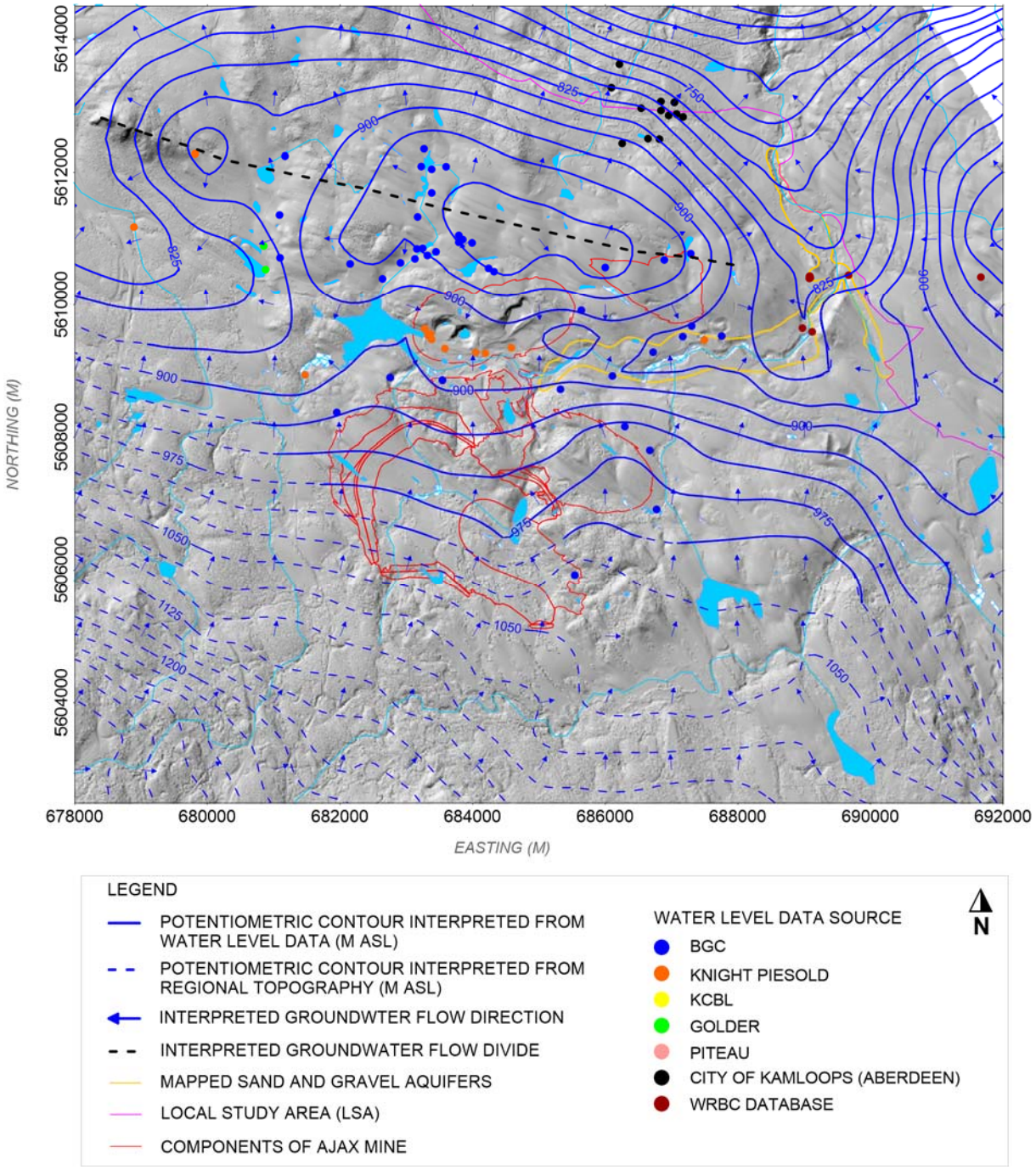
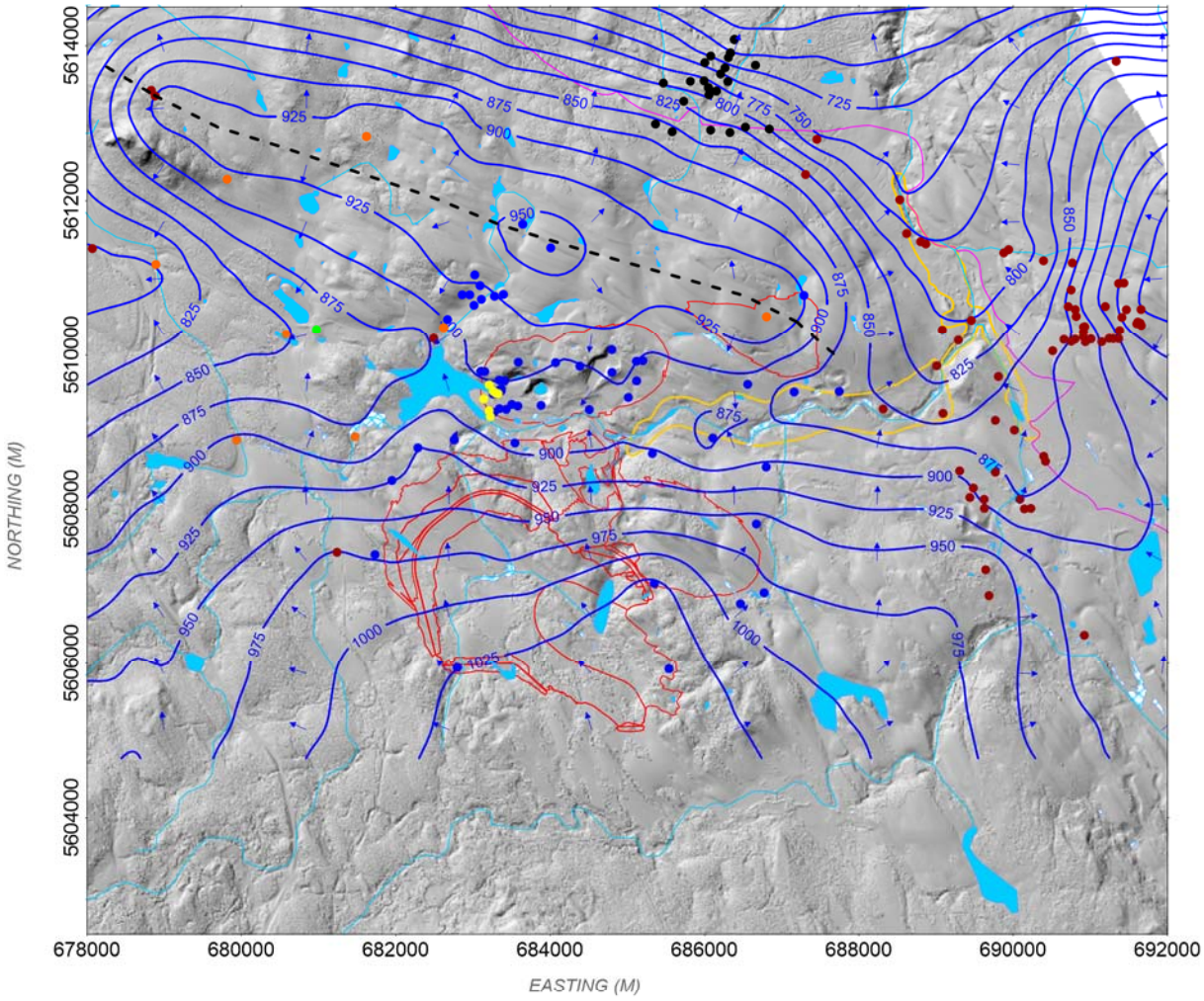
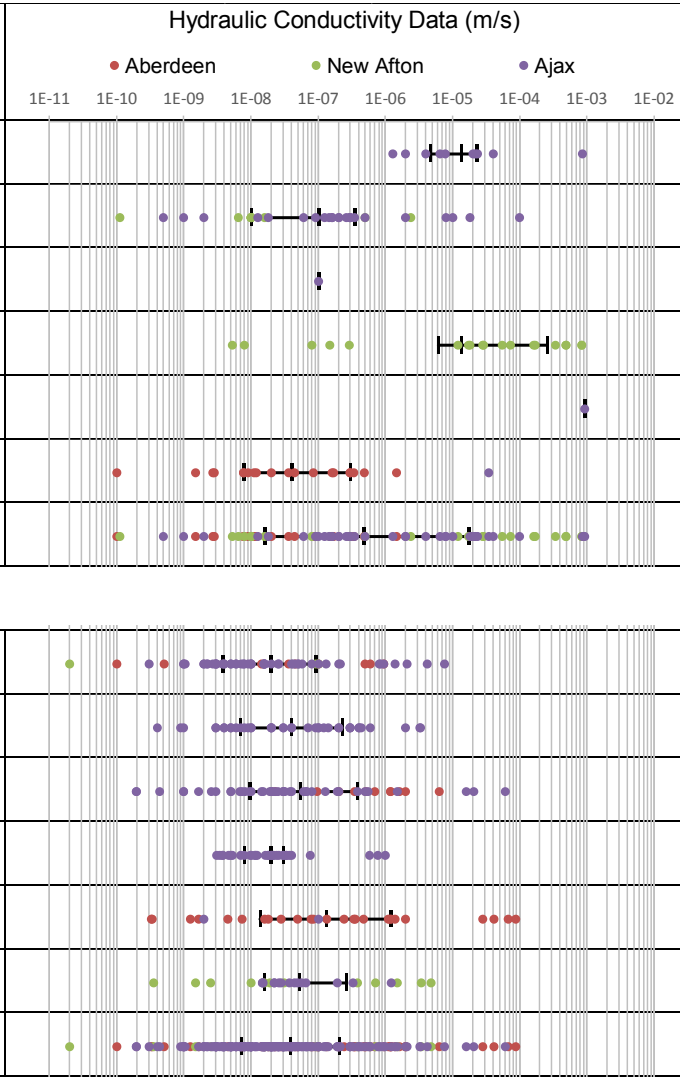


Figure 6.6-5
Interpreted Local Scale Flow System - Bedrock



	Hydrostratigraphic Unit	Hydraulic Conductivity Data (m/s)	Geometric Mean K $(m/s)^2$	Specific Storage (1/m)
SURFICIAL DEPOSITS	Fluvial and Glaciofluvial Sands and Gravels		1 E-05	1E-05 - 2E-03
	Glacial Till, Diamicton and Undivided Glacial Material		1 E-07	2E-06 - 2E-02
	Lacustrine and Glaciolacustrine Deposits and Undivided Recent Lake Sediments		1 E-07	1E-03[1]
	Mine Rock and Anthropogenic Materials		1 E-05	1E-03[1]
	Colluvium		9 E-04	1E-03[1]
	Undivided Surficial Deposits		4 E-08	1E-03[1]
	All Surficial Deposits		**5 E-07**	2E-06 - 2E-02
BEDROCK	Nicola Group Volcanics and Sediments		2 E-08	5E-07 - 4E-03
	Picrite		4 E-08	2E-07[1]
	Iron Mask Hybrid		5 E-08	4E-07 - 9E-04
	Sugarloaf Diorite		2 E-08	1E-06 -1E-07[1]
	Kamloops Group		1 E-07	1E-06[1]
	Unndivided Bedrock		5 E-08	1E-07 - 2E-03
	All Bedrock		**4 E-08**	1E-07 - 9E-04

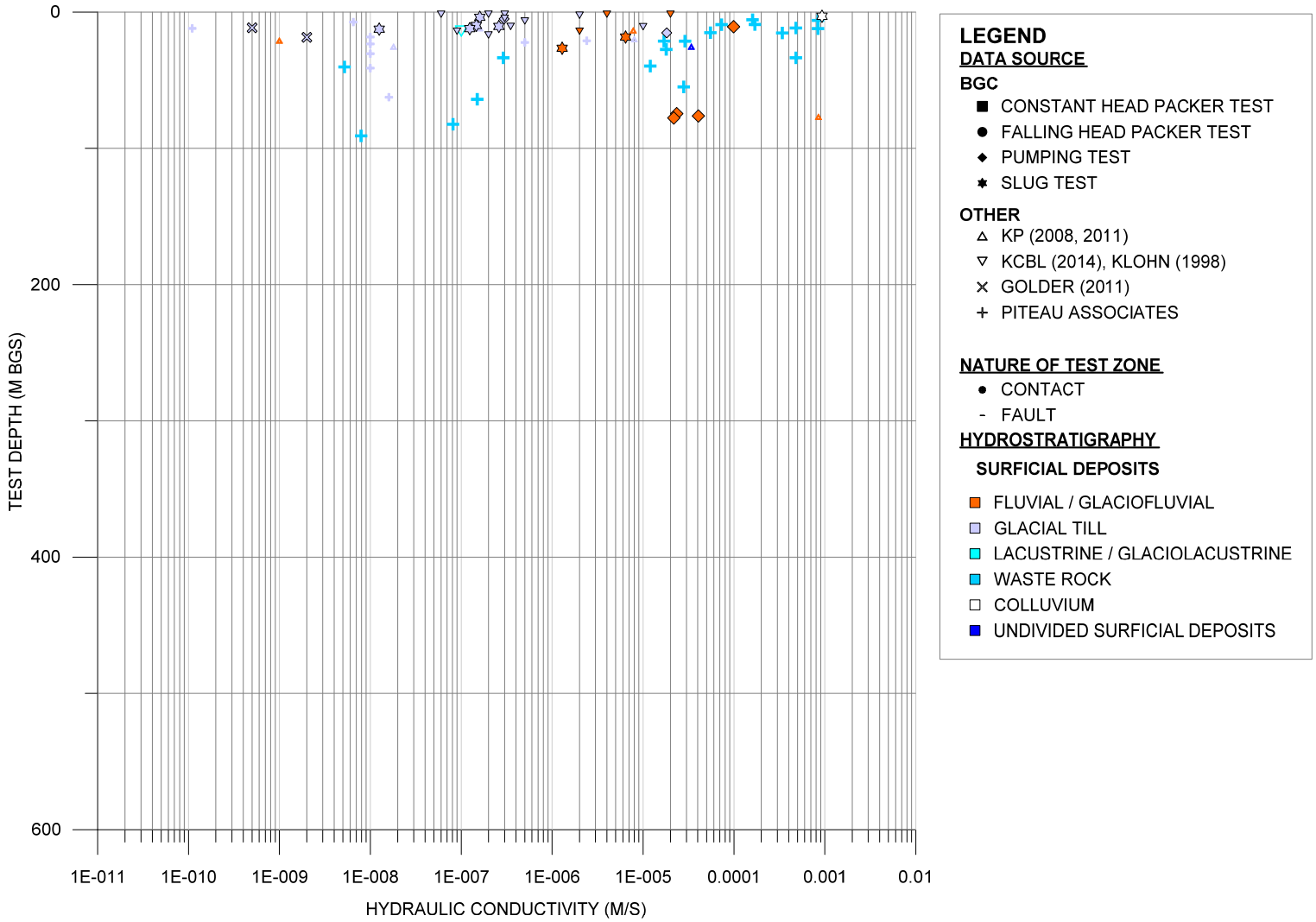


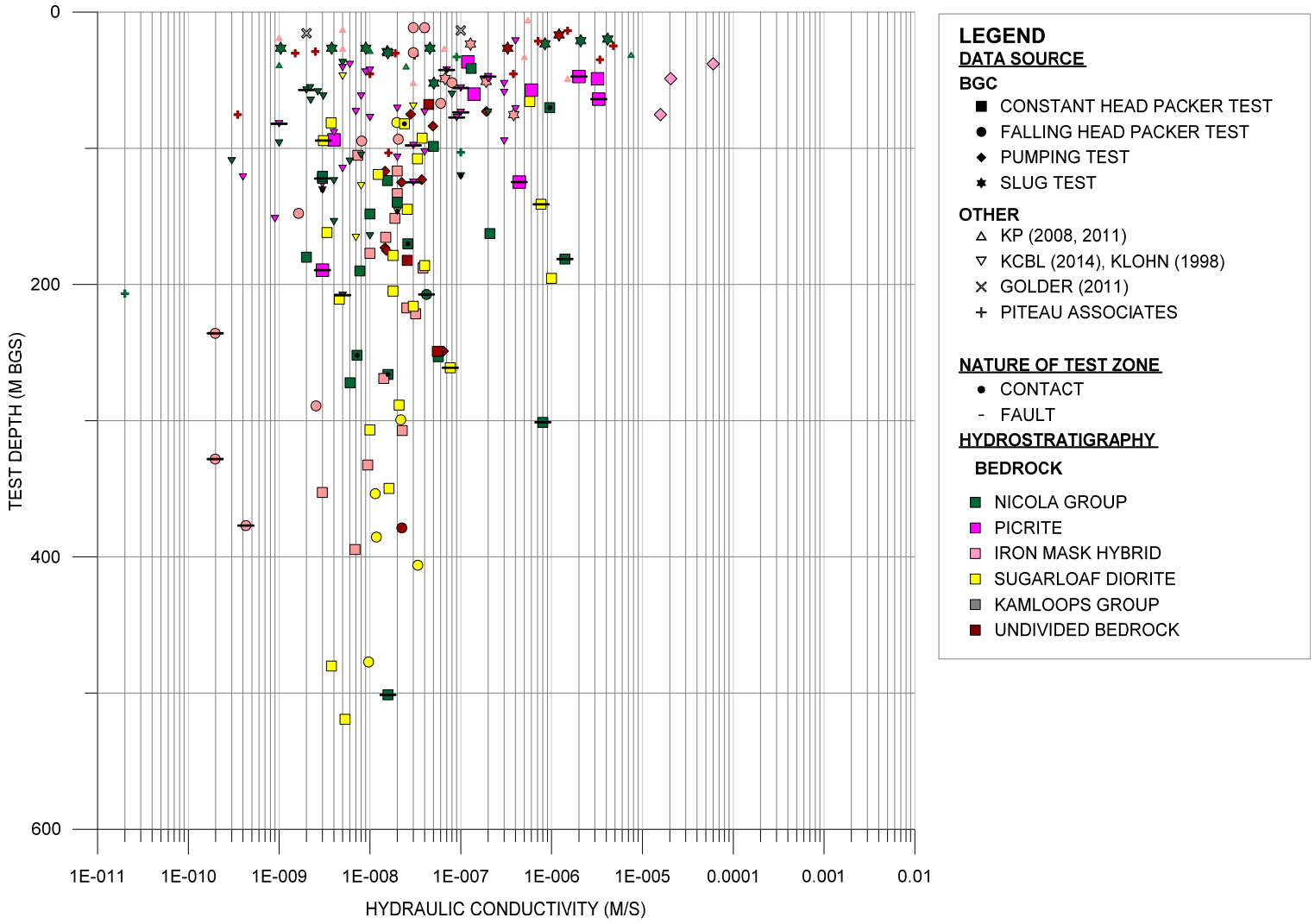
Notes:

1. Storage estimates based on calibrated parameters in numerical groundwater flow model (Appendix 6.6-E).

2. I Denotes first quartile, geometric mean and third quartile values for K estimated from SI data for the Ajax, Aberdeen and New Afton Mine areas.

Figure 6.6-7
Estimated Hydraulic Conductivity vs. Depth within Interpreted Surficial Hydrostratigraphic Units




0
200
400
600
TEST DEPTH (M BGS)
1E-011
1E-010
1E-009
1E-008
1E-007
1E-006
1E-005
0.0001
0.001
0.01
HYDRAULIC CONDUCTIVITY (M/S)
LEGEND
DATA SOURCE
BGC
CONSTANT HEAD PACKER TEST
FALLING HEAD PACKER TEST
PUMPING TEST
SLUG TEST
OTHER
KP (2008, 2011)
KCBL (2014), KLOHN (1998)
GOLDER (2011)
PITEAU ASSOCIATES
NATURE OF TEST ZONE
CONTACT
FAULT
HYDROSTRATIGRAPHY
BEDROCK
NICOLA GROUP
PICRITE
IRON MASK HYBRID
SUGARLOAF DIORITE
KAMLOOPS GROUP
UNDIVIDED BEDROCK

The vertical component of groundwater flow is variable, with nests of groundwater monitoring wells indicating upward and downward components of flow (Figure 6.6-9). Principal groundwater discharge zones near the Mine Site include reaches of Lower Peterson Creek and Jacko Lake, the existing Ajax West pit lakes, as well as other local ephemeral streams, sloughs and ponds. Local flowing artesian conditions are observed in some wells installed in the low lying region that extends from the north arm of Jacko Lake and in topographic depressions around the TSF, west mine rock storage facility (WMRSF) and south mine rock storage facility (SMRSF) footprints (Figure 6.6-9).

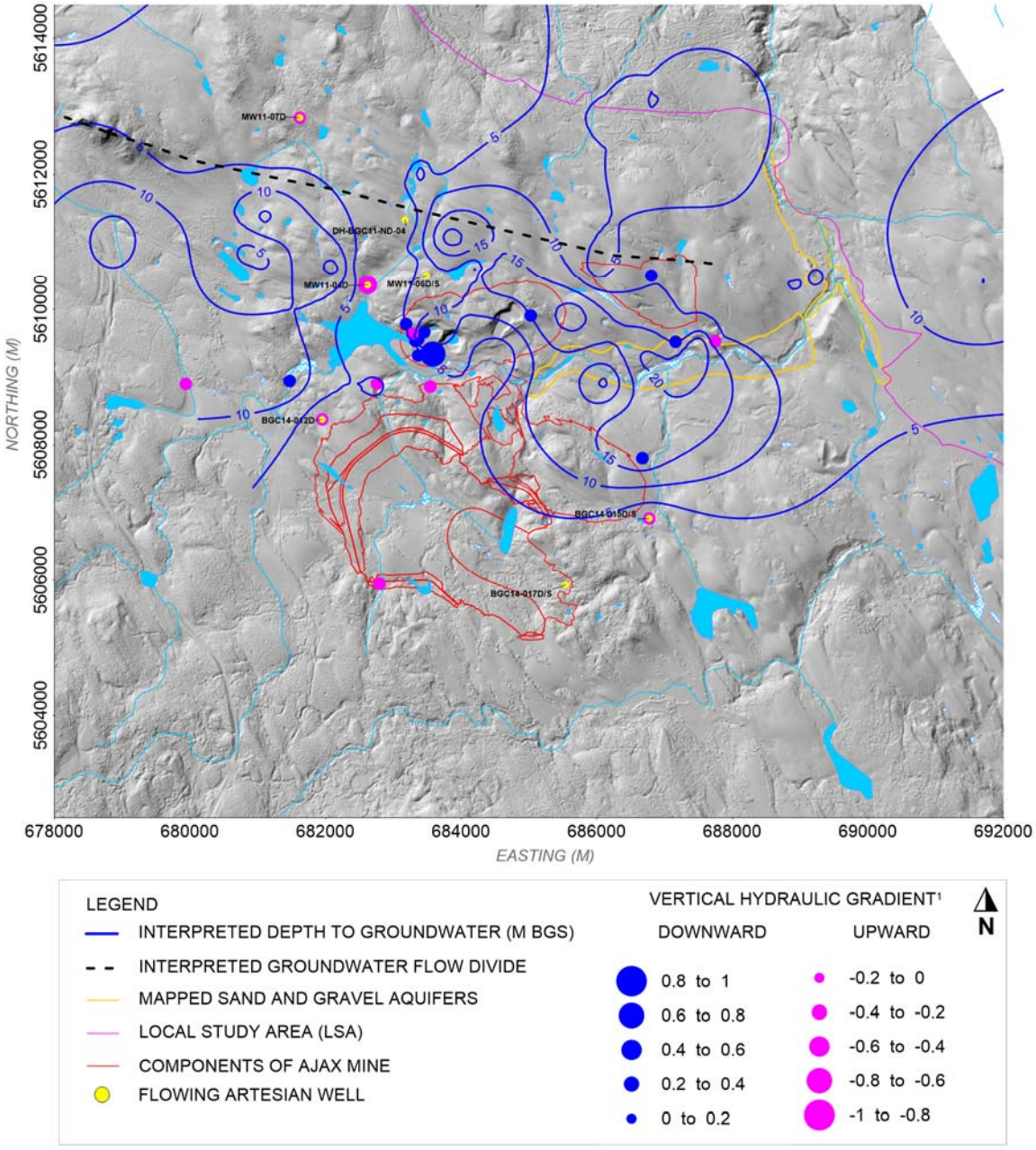
Seasonal fluctuations in groundwater elevations range from less than 0.1 m to approximately 4 m, annually (Appendix 6.6-A). Groundwater elevations monitored near the Mine Site typically decline through the winter and spring (i.e., late September to March), and are highest during the summer and fall (i.e., June to September). The seasonal variation in groundwater elevations is consistent with climate trends. Some groundwater monitoring locations show rapid water level recoveries following precipitation events. These locations are interpreted to receive localized recharge due higher permeability near surface sediments or fractured bedrock. Monitoring locations where groundwater levels reach seasonal maxima in September or October may receive recharge from more distal sources in addition to delayed surface infiltration caused by near surface lower permeability sediments.

Groundwater recharge in the RSA is from infiltration of precipitation and snowmelt primarily in uplands, with lesser amounts from surface water infiltration at ponds, lakes, creeks, and gullies. Estimates of meteoric recharge compiled from hydrogeological studies in the RSA range from 0.1 mm/yr in the Kamloops area (approximate elevation 350 to 700 masl) to 99 mm/yr at Chuwels Mountain (approximate elevation of 1,830 masl). Near the Mine Site, meteoric recharge is estimated to range between 0.3 and 8 mm/yr based on unsaturated flow modelling and a CMB method using site data (Appendix 6.6-A). The annual rise in groundwater levels (i.e., from June to September) observed in wells installed on the Mine Site suggests that meteoric recharge is associated with the spring freshet (i.e., snowmelt).

Groundwater recharge is also supplied to developed areas through irrigation by the municipality (e.g., parks, playing fields, medians, leaking pipes, and other landscaped areas), homeowners (e.g., lawn watering, car washing, and gardening) and businesses (e.g., golf courses) that are serviced by the City's water supply system. Golder (2008a) reported estimates of potential recharge due to irrigation in Aberdeen between 153 and 924 mm/yr based on metered water use data from City and measured irrigation use from 10 residents of the subdivision. Golder [2008a] also found that anthropogenic recharge rates of 135 mm/yr for residential and 336 mm/yr for golf course areas were able to simulate the hydraulic heads measured in Aberdeen as part of their studies. Groundwater recharge from domestic and municipal irrigation is known to cause increases in piezometric pressures that drive slope instabilities in Aberdeen (Golder 2008a).

Ranch irrigation may also contribute to groundwater recharge. A review of existing surface water use licenses in the RSA indicate that a total of approximately 3.2 Mm^3 of water is allocated to ranch irrigation on an annual basis within the Cherry Creek and Peterson Creek watersheds. However, since no data exist as to which licenses within the Peterson Creek watershed are exercised on an annual basis and to what extent, the amount of diverted surface water that potentially could infiltrate to the water table from irrigation cannot be quantified.

Figure 6.6-9
Interpreted Depth to Groundwater and Vertical Components of Hydraulic Gradients in the LSA



Notes:

1. Negative sign indicates potential upward component of groundwater flow.
2. Depth to groundwater contours interpreted from water level data at groundwater monitoring locations within overburden.
3. Vertical components of hydraulic gradients calculated for piezometers installed at MW11-01D/S, 03D/S, 10D/S, BGC14-006D/S, 007D/S, 008D/S and 017D/S are not shown as water levels at these locations are recovering.

Groundwater primarily discharges as evapotranspiration, particularly where the water table is near the ground surface. Monthly potential evapotranspiration (PET) at the Mine Site was estimated by KP using the Thornthwaite (1955) equation and temperature records at the AJAXMET climate station, as well as long-term synthetic temperature data (KP 2014a). Average estimates of monthly PET based on KP's study range from 0 mm in December and January to 130 mm in July, with a total annual PET of 579mm/yr for the Mine Site.

Groundwater also discharges to streams and rivers as baseflow, with minor amounts to seeps (e.g., to the existing Ajax West pits) and breaks in slope. Baseflows were approximated by average flows measured at gauging stations installed throughout the RSA during the annual low flow period (i.e., July through November). Annual low flows range between 0 and 178 mm/yr near the Mine Site (i.e., within the Peterson Creek watershed) and 0 and 177 mm/yr in the RSA. It is noted that seasonal low flows at some gauging stations have been impacted by surface water management, land use and groundwater use due to ranching and residential development. Seasonal low flow rates therefore may not represent natural groundwater discharge as baseflows. The extent to which groundwater discharge has been modified was not assessed due to limited documentation on water use practices. However, the characterization of baseflows on this basis is considered to be representative of the flow regime for existing conditions, and the interaction of the shallow groundwater and surface water flow systems within the Mine Site area.

Other potential sources of groundwater abstraction within the RSA include, but may not be limited to:

- dewatering in Aberdeen through the Aberdeen Dewatering and Monitoring System (DWMS);
- lawn watering and residential use from groundwater wells; and
- irrigation and livestock watering from groundwater wells.

The DWMS is operated by the City in order to maintain low piezometric pressures in critical areas for slope stability. The DWMS consists of "more than 30" groundwater dewatering wells in the Aberdeen area (City of Kamloops 2008). The City has also required the installation of sub-drains with the construction of new lots to limit infiltration of irrigation to the groundwater system (Golder 2008b). The modelling studies of Golder (2008a) indicate that DWMS removes groundwater at a rate on the order of 70 m^3/day. The amount of infiltrating water intercepted by sub-drain systems was not known at the time of this study, but presumably is accounted for in net infiltration/recharge numbers used by Golder in their modelling.

There are an estimated 267 registered water wells used for domestic purposes within the RSA. Per capita household water use in Canada is estimated to be about 343 L/day (Environment Canada 2013); estimates available for British Columbians indicate usage of about 490 L/day (BC MOE 2013b) and the City of Kamloops estimates per capita water use at about 800 L/day (City of Kamloops 2013a). Average persons per household in British Columbia is 2.5 (Statistics Canada 2011). Usage of 343 L/day per person times 2.5 persons per household results in an estimated usage of 860 L/day (0.86 m^3/day) per household for Canadians. Similarly, 800 L/day per person for Kamloops times 2.5 persons per household results in an estimated usage of 2,000 L/day (2.0 m^3/day) per household for Kamloops residents. If each registered domestic water well supplies one household, domestic water use in the RSA is estimated to range from 229 to 534 m^3/day (Appendix 6.6-A). Many of the

registered domestic wells are located within the limits of the City's municipal water supply. The above ranges in estimates therefore are considered to represent upper limits for domestic groundwater extraction, as many residents could also make use of the City's water supply. The distribution of recharge and discharge areas for existing conditions in the RSA, based on the calibrated groundwater flow model, is shown on Figure 6.6-10.

The overall regional groundwater balance, calculated using the 3D groundwater flow model, is dominated by meteoric groundwater recharge and groundwater discharge by evapotranspiration (Figure 6.6-11). Recharge sources to the groundwater flow system include Project area streams (i.e., within the Peterson Creek watershed) and natural lakes. Discharge from the groundwater flow system is to Project area streams (i.e., within the Peterson Creek watershed) and other streams in the region. Discharge to Kamloops Lake and the Thompson River represents 3% of the groundwater balance calculated for the RSA.

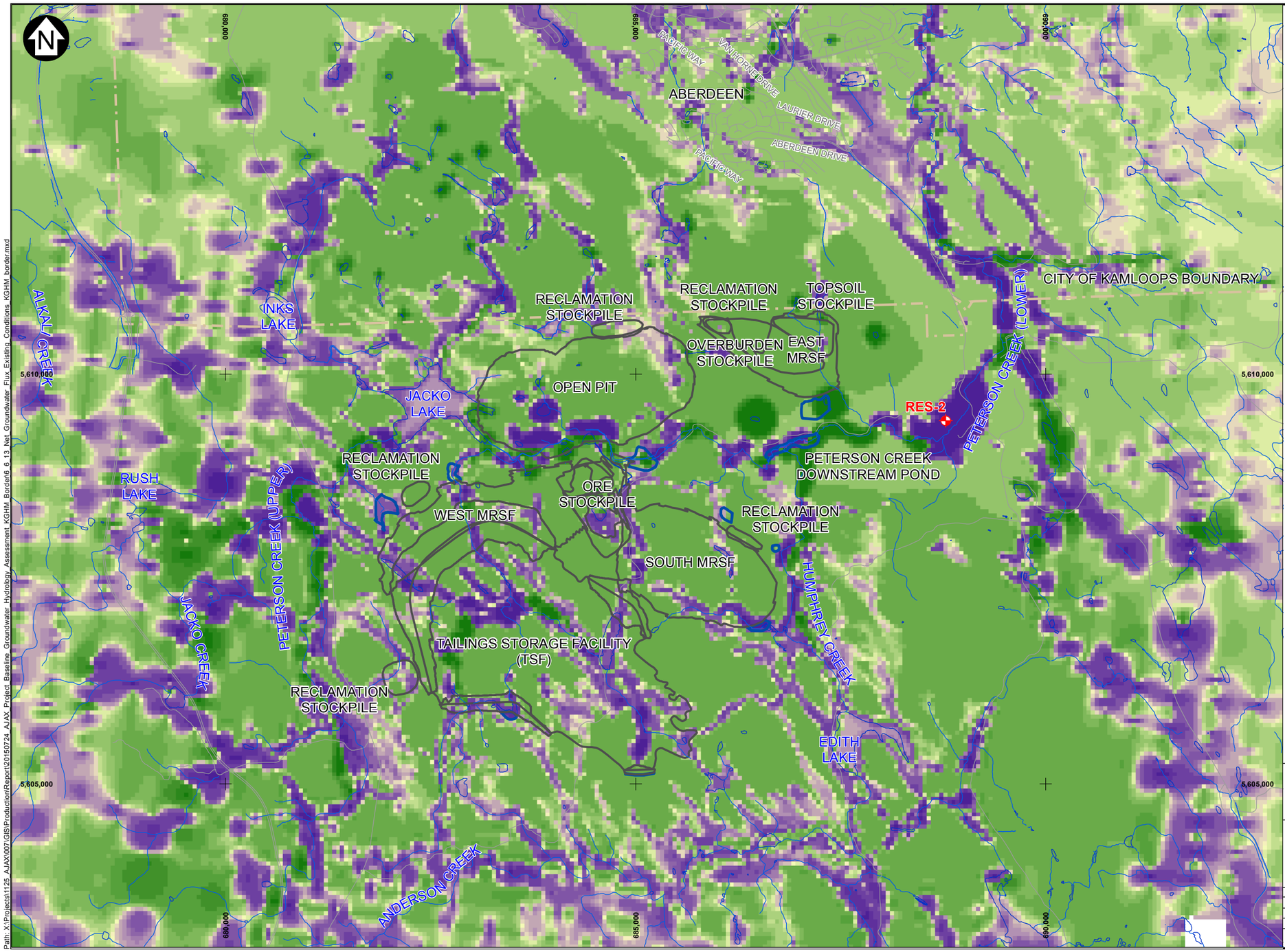
Figure 6.6-12 illustrates the conceptual understanding of groundwater movement in the region. Three types of groundwater flow systems are interpreted within both the RSA and the LSA based on the hydrogeological conditions. These include:

- shallow (localized) groundwater flow systems;
- an intermediate groundwater flow system; and
- a regional groundwater flow system.

Shallow groundwater flow systems are interpreted to be controlled by local topography and near surface geological conditions. These systems are thought to exist primarily within surficial deposits and shallow bedrock at depths less than 30 m on average, but up to 80 m in areas with thick surficial deposits, such as the Peterson Creek Aquifer. Groundwater flow paths in shallow systems may be on the order of a few tens to several hundreds of metres. Shallow systems are conceptualized to be recharged primarily by infiltration of precipitation and snowmelt, and to discharge to streams, creeks and seeps, and as evapotranspiration. Shallow systems may also be recharged by, and discharge to the underlying intermediate scale groundwater flow system.

The intermediate groundwater flow system is interpreted to exist within the upper 200 m of bedrock within more permeable fractured and faulted zones. The intermediate system is conceptualized to be recharged by the shallow system and to discharge to the deeper regional flow system. The intermediate system may also discharge to the shallow system in localized areas where upward hydraulic gradients develop, such as areas near the Peterson Creek Aquifer, Jacko Lake, Humphrey Creek, and potentially the ELFZ in areas of this fault zone where hydraulic conductivity may be greater than the host rock. Flow paths within the intermediate system may be on the order of hundreds of metres to several kilometres.

Figure 6.6-10
Simulated Net Groundwater Flux - Existing Conditions



NOTES:

1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE NOTED.
2. GENERAL ARRANGEMENT OF MINE SITE FACILITIES PROVIDED BY KAM ON APRIL 15, 2015.
3. PROJECTION IS NAD 1983 UTM ZONE 10N.
4. THESE RESULTS ARE BASED ON CLOSURE MODEL WITH PIT LAKE ELEVATION OF 500 MASL (SEE APPENDIX 6.6-E).
5. POSITIVE NUMBERS INDICATE NET GAIN TO THE GROUNDWATER SYSTEM (RECHARGE) AND NEGATIVE NUMBERS INDICATE NET LOSS FROM THE GROUNDWATER SYSTEM (DISCHARGE).
6. UNLESS BGC AGREES OTHERWISE IN WRITING, THIS DRAWING SHALL NOT BE MODIFIED OR USED FOR ANY PURPOSE OTHER THAN THE PURPOSE FOR WHICH BGC GENERATED IT. BGC SHALL HAVE NO LIABILITY FOR ANY DAMAGES OR LOSS ARISING IN ANY WAY FROM ANY USE OR MODIFICATION OF THIS DOCUMENT NOT AUTHORIZED BY BGC. ANY USE OF OR RELIANCE UPON THIS DOCUMENT OR ITS CONTENT BY THIRD PARTIES SHALL BE AT SUCH THIRD PARTIES' SOLE RISK.

SCALE 0 0.5 1 1.5 Kilometres

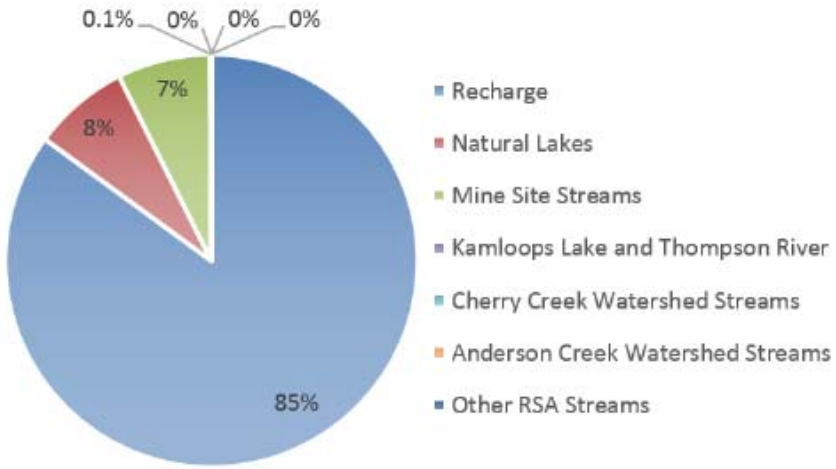
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KGHM Ajax Mining Inc.

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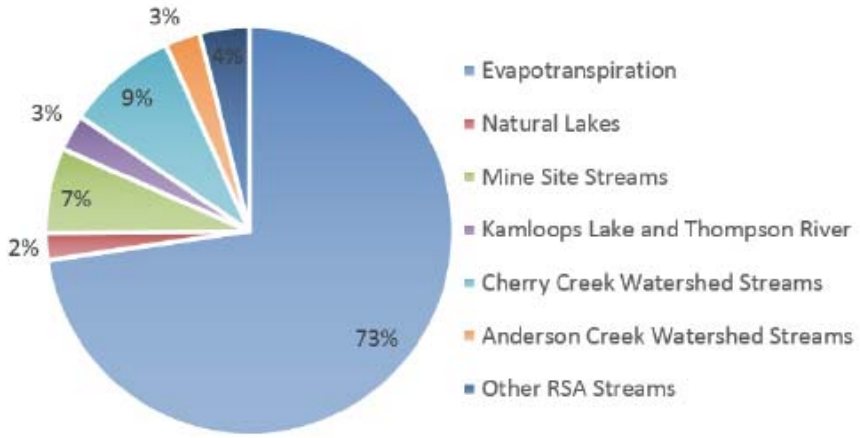
Path: X:\Projects\1125 AJAX\007\GIS\Production\Report\20150724 AJAX Project Baseline Groundwater Hydrology Assessment KGHM Border\6 6 13 Net Groundwater Flux Existing Conditions KGHM border.mxd

Groundwater Inputs



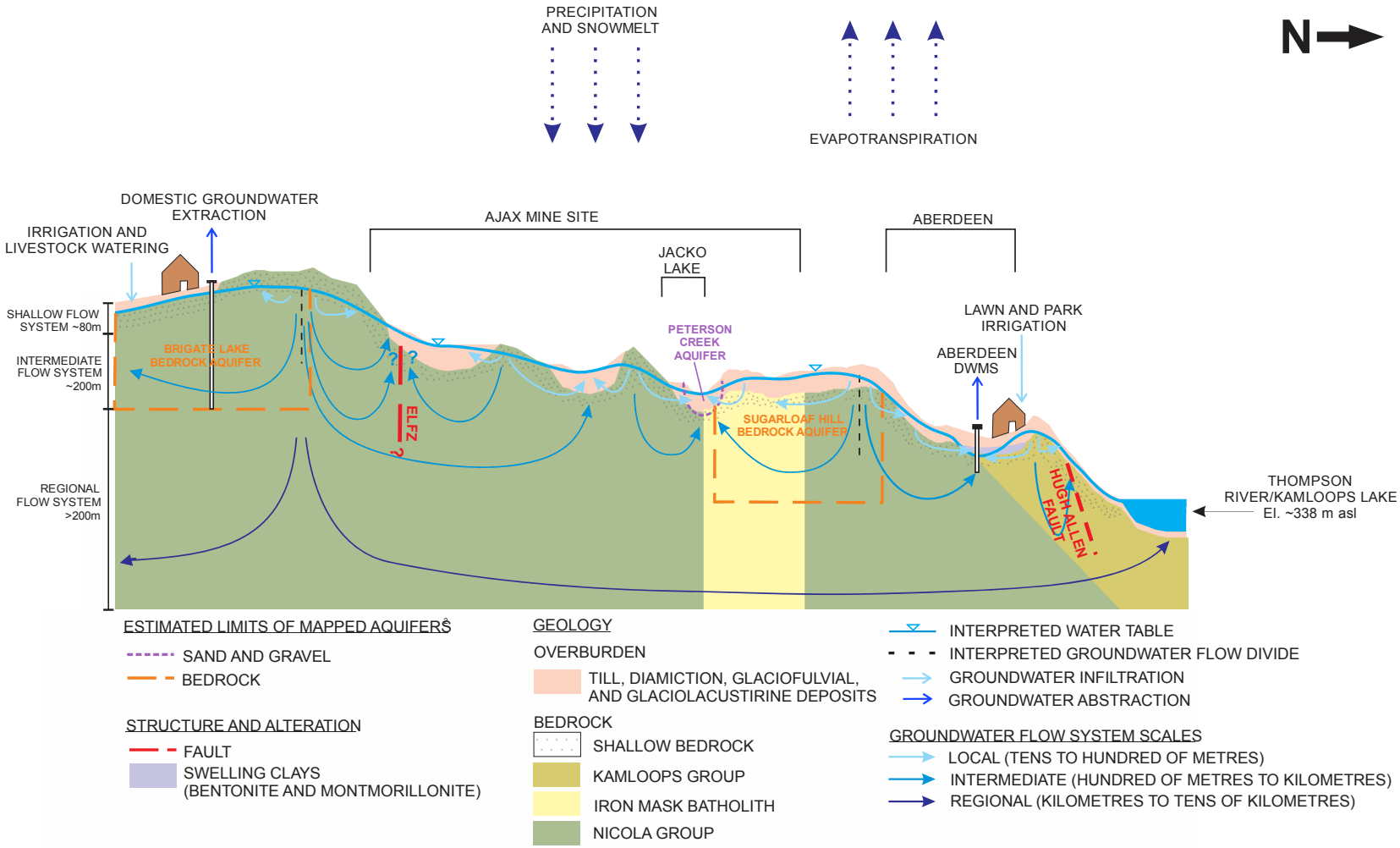
Groundwater Inputs	m^3/d	Percent Total
Recharge	10669	85%
Natural Lakes	949	8%
Mine Site Streams	913	7%
Kamloops Lake and Thompson River	15	0.1%
Cherry Creek Watershed Streams	0	0%
Anderson Creek Watershed Streams	0	0%
Other RSA Streams	0	0%
Total In	**12546**	**100%**

Groundwater Outputs



Groundwater Outputs	m^3/d	Percent Total
Evapotranspiration	9123	73%
Natural Lakes	266	2%
Mine Site Streams	846	7%
Kamloops Lake and Thompson River	361	3%
Cherry Creek Watershed Streams	1107	9%
Anderson Creek Watershed Streams	350	3%
Other RSA Streams	493	4%
Total Out	**12545**	**100%**

NOTE: MINE SITE STREAMS INCLUDE PETERSON AND HUMPHREY CREEK



Notes:

1. Drawing is schematic and not to scale. Limits of bedrock aquifers estimated based on WRBC mapped limits and maximum practical depth of groundwater abstraction in registered water wells (approximately 200m)
2. Aberdeen DWMS = Dewatering and Monitoring System.
3. The Hugh Allen fault is interpreted as a groundwater flow barrier by Golder (2008a).

The regional groundwater flow system is interpreted to exist at depths greater than 200 m within bedrock of low hydraulic conductivity. Flow paths of the regional system may be on the order of kilometres to tens of kilometres. The regional system is thought to be recharged by vertical leakage at the highest elevations in the RSA and from the intermediate system and to discharge primarily to the Thompson River/Kamloops Lake. The regional system could also discharge to the intermediate system in localized areas where intercepted by deep-seated fractures or fault zones, such as the ELFZ, if hydraulic conductivity within these zones is higher than surrounding bedrock. However, data from the majority of faults tested within the LSA as part of site investigation for the Project do not exhibit significantly higher or lower hydraulic conductivity than the surrounding rock mass.

6.6.3 Assessment Boundaries

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

6.6.3.1 Spatial Boundaries

The spatial boundaries for the Groundwater Quantity effects assessment are the same as the spatial boundaries for the baseline groundwater hydrology assessment (Appendix 6.6-A). In general, assessment boundaries depend on the VC under consideration. Therefore, the spatial boundaries described below apply to the Groundwater Quantity VC and may not apply to other VCs. Drawing 6.6-E-3 in Appendix 6.6-E illustrates the extents of the RSA and LSA. The rationale for study area selection is provided below.

Regional Study Area

The southwestern and western limits of the RSA for groundwater have been delineated to coincide with limits of the Cherry Creek, Peterson Creek and Anderson Creek watersheds (iMapBC 2013), and the limits of the underlying mapped aquifers 0727 and 0728 documented within the WRBC atlas (BC MOE 2014). In the north, the RSA is bounded by the Thompson River and Kamloops Lake, and the limits of mapped aquifers 0283, 0284 and 0286. The RSA is bounded by Campbell Creek in the east, and the southeast limit of the RSA was set to coincide with mapped aquifer 0275. A portion of the City of Kamloops to the south of the Thompson River and Kamloops Lake (which includes Aberdeen) falls within the RSA. The limits of the RSA are shown on Drawing 6.6-E-3 in Appendix 6.6-E.

Local Study Area

The LSA boundaries were set to coincide with the expected area of potential Project effects to the underlying groundwater flow system. The limits of the LSA are shown on Drawing 6.6-E-3 in Appendix 6.6-E and include the extents of two mapped sand and gravel aquifers (Peterson Creek Aquifer, No. 0278 and Davidson Creek Aquifer, No. 0277) and the majority of an underlying

mapped bedrock aquifer (Sugarloaf Hill Aquifer, No. 0276). The majority of the northern and eastern extents of the LSA are defined by the limits of the aforementioned aquifers. The boundary south of the Davidson Creek Aquifer, (i.e., the eastern and southern limit of the LSA) was set to coincide with the limits of the Anderson Creek and Peterson Creek watersheds (iMapBC 2013). West of the Sugarloaf Hill Aquifer the northern limit of the LSA was set to coincide with Hughes Lake. The western limit of the LSA was delineated based on an inferred groundwater flow path between Chuwels Mountain and Hughes Lake.

6.6.3.2 Temporal Boundaries

The Project has the following four phases:

- **Construction**: 2 years;
- **Operation**: 23 years;
- **Decommissioning and Closure**: 5 years (includes project decommissioning, abandonment and reclamation activities, as well as temporary closure, and care and maintenance); and
- **Post Closure**: 5+ years (includes ongoing reclamation activities and Post Closure monitoring).

The Post Closure period for Groundwater Quantity incudes accounting for the slow recovery of groundwater elevations in bedrock following the end of dewatering, as groundwater and surface water flow into the open pit and create a pit lake. The site-wide water balance model (WBM) developed for the Ajax Project (Appendix 6.4-C) predicts a stabilized pit lake elevation of 760 masl, approximately 134 m below the pit rim and Jacko Lake. The predicted stable pit lake elevation is the elevation at which precipitation, groundwater and surface water inflows are balanced by evaporation losses from the lake surface. The WBM predicts that the Post Closure pit lake will be a permanent sink for water and will not discharge to groundwater under the conditions assessed.

6.6.3.3 Administrative Boundaries

The LSA includes a portion of the City of Kamloops. The City of Kamloops provided hydrogeological data for the Aberdeen area to support the Groundwater Quantity assessment. The data were used in the baseline groundwater hydrology assessment as described in Appendix 6.6-A. Use of Aberdeen data for the Groundwater Quantity effects assessment was limited to using borehole log data to define depth to bedrock and using steady-state groundwater elevation data to calibrate the 3D numerical groundwater flow model.

British Columbia manages groundwater well registration in the province as part pf the WRBC atlas. As noted previously, information from the WRBC atlas (BC MOE 2014) was used to estimate groundwater elevations, hydraulic conductivity, and depth to bedrock in the RSA. The WRBC data are less reliable than data collected for the Project (i.e., water levels likely do not represent static or present-day contains and the province of BC cannot guarantee accuracy of the information provided within the WRBC database). However, the large data set expanded spatial coverage across the region to define and calibrate the regional 3D numerical groundwater flow model.

6.6.3.4 Technical Boundaries

Flow in Peterson Creek is regulated by hydraulic structures. Groundwater withdrawals for domestic use and irrigation are common within the LSA. Licensed surface water withdrawal volumes are reported. However, data on actual water usage quantities and timing of irrigation diversions from Peterson Creek, domestic wells, and irrigation wells were not available. Irrigation rates and timing, crops planted, and water demands are also poorly known. Therefore, some water balance components were necessarily estimated indirectly.

Hydraulic conductivity measurements in the RSA and LSA range over approximately 8 orders of magnitude (i.e., a factor of 100,000,000) for the variety of sediments, rock types, and depths measured within the RSA. Hydraulic conductivity ranges by approximately 2 to 3 orders of magnitude (i.e., a factor of 100 to 1,000) for a given sediment or rock type within a defined depth range. Therefore bulk average hydraulic properties (hydraulic conductivity and storage properties) for individual hydrostratigaphic units defined in the conceptual and numerical groundwater flow model were estimated by groundwater model calibration. Local variability of hydraulic conductivity contributes uncertainty to the Groundwater Quantity effects assessment; the degree to which this uncertainty may, or may not affect the results of the groundwater modeling completed to evaluate these effects was considered using sensitivity analyses (discussed in Appendix 6.6-D).

Storage coefficients, called "specific yield" and "specific storage coefficient" control the quantity of groundwater stored or released for a given change in groundwater elevation over time. These coefficients were determined from pumping tests completed in bedrock and surficial deposits on the Ajax property, by measuring water elevations at observation wells within the zone of influence for each pumping test. The storage coefficient values were extrapolated to other areas where required. Transient changes to Groundwater Quantity and the timing of those changes are sensitive to the storage coefficient values. Therefore, transient Project effects on Groundwater Quantity during Construction, Operation, and Decommissioning and Closure are also subject to some uncertainty. The Post Closure Project effects are represented as independent of time (i.e., steady state) and therefore the model simulation results for the scenarios considered are not sensitive to storage coefficient values.

It was not possible to directly investigate the materials that form the Jacko Lake lakebed, or materials beneath the lakebed as part of the EA. As such, estimates of the material types, thickness, hydraulic conductivity, storage properties and porosity of these materials were developed based on previous information in the area (Klohn 1988), recent detailed geotechnical and hydrogeological site investigations in areas immediately adjacent to the lake (KCB 2014), similar locations in the LSA, on published literature values and professional judgement.

The Groundwater Quantity effects assessment addressed the technical boundaries through sensitivity and uncertainty analysis (Appendix 6.6-D). The ranges of predicted effects described in the following sections reflect base case and sensitivity analysis results.

6.6.4 Potential Effects of the Project and Proposed Mitigation for Groundwater Quantity

6.6.4.1 Identifying Potential Effects on Groundwater Quantity

The primary potential effects on Groundwater Quantity are changes in magnitude and timing of the groundwater balance (groundwater recharge, groundwater discharge, and changes in groundwater storage) and the resulting changes in groundwater elevations, groundwater flow rates and groundwater flow directions. Groundwater Quantity changes are anticipated within the Mine Site and are expected to extend some distance from the Mine Site. The following specific aspects of Groundwater Quantity were considered:

- magnitude and timing of groundwater recharge or discharge; and
- groundwater elevations, groundwater flow rates and groundwater flow directions.

Table 6.6-1 is an interaction matrix that identifies and ranks the potential magnitude of interaction between Project activities and Groundwater Quantity. The ranking system used is:

- O – no interaction expected;
- L – negligible to minor interaction expected;
- M – potential moderate interaction requiring active management/monitoring; and
- H – key interaction.

An evaluation of location, timing, frequency and magnitude were all considered in the ranking evaluation of potential Groundwater Quantity effects. Project components with the potential for negligible or minor expected adverse effects are not required to be considered further in the effects assessment. For example, the planned Project water intake system from Kamloops Lake is expected to have negligible to minor interaction with the groundwater supply potentially used by the Cherry Creek – Savona communities because the location of the intake system is located more than 2,100 m down gradient from any registered groundwater wells and mapped aquifers (i.e., the Cherry Creek bedrock aquifer (No. 0727) and sand and gravel aquifer (No. 0728), locations of which are shown on Drawing 6.6-E-3 of Appendix E). Implementation of best management practices and standard mitigation measures will be used to address any potential concerns related to "O" and "L" ranked interactions.

The effects assessment described in Section 6.6.4.2 focusses on Project interactions that manifest during Construction, Operation, Decommissioning and Closure, and that may persist into the Post Closure period with "moderate" or "key" interaction with Groundwater Quantity, identified as follows:

- open pit development, pit dewatering, and pit lake filling;
- temporary ore stockpile;
- development and reclamation of waste rock storage facilities;
- tailings storage facility development, deposition, decommissioning and reclamation;
- Peterson Creek diversion and Peterson Creek Downstream Pond (PCDP); and
- water management dams and ponds.

Table 6.6-1. Identifying Potential Project Interactions and Effects on Groundwater Quantity

Project Activities		Potential Effects on Groundwater Quantity	
		Alter Magnitude or Timing of Groundwater Recharge and Discharge	Alter Groundwater Elevations, Groundwater Flow Rates, or Groundwater Flow Directions
Construction	Clearing and Grubbing	L	L
	Earthworks	L	L
	Overburden/Topsoil Stockpile	L	L
	Laydown Areas and Storage Yards	L	L
	Project Lighting	O	O
	Site Security and Fencing	O	O
	Fuel Storage and Filling Area	L	L
	Hazardous Wastes Transport, Storage, and Disposal	O	O
	Construction Wastes Transport, Storage, and Disposal	O	O
	Sewage Infrastructure and Disposal	L	L
	Public Road Realignment, Use, and Maintenance	L	L
	Site Road Construction, Use and Maintenance	L	L
	Peterson Creek Bridge Construction, Use, and Maintenance	L	L
	Site Buildings and Process Plant	L	L
	Explosives Magazine and Storage Facilities	L	L
	Open Pit Development	M	M
	Drilling and Blasting	L	L
	Crushing Waste Rock	L	L
	Loading, Hauling, and Deposition of Waste Rock	L	L
	Temporary Ore Stockpile	M	M
	Tailing Storage Facility Development	M	M
	Power Transmission, Distribution	L	L
	Natural Gas Line	L	L
	Pipeline Utility Corridor (Potable Water, Sewage, and Site Water)	L	L
	Water Intake from Kamloops Lake	L	L
	Fire Suppression Infrastructure	L	L
	Contact Water	L	L
	Non-contact Water	L	L

(continued)

Table 6.6-1. Identifying Potential Project Interactions and Effects on Groundwater Quantity (continued)

Project Activities		Potential Effects on Groundwater Quantity	
		Alter Magnitude or Timing of Groundwater Recharge and Discharge	Alter Groundwater Elevations, Groundwater Flow Rates, or Groundwater Flow Directions
Construction (*cont'd*)	Peterson Creek Diversion	M	M
	Water Management Dams/Ponds	M	M
	Mine Staffing (Direct Employment)	O	O
	Contracted Employment	O	O
	Taxation	O	O
	Clearing and Grubbing	L	L
	Earthworks	L	L
	Overburden/Topsoil Stockpile	L	L
	Laydown Areas and Storage Yards	L	L
	Project Lighting	O	O
	Site Security and Fencing	O	O
	Fuel Storage and Filling Area	L	L
	Hazardous Wastes Transport, Storage, and Disposal	O	O
	Construction Wastes Transport, Storage, and Disposal	O	O
	Sewage Infrastructure and Disposal	L	L
	Public Road Realignment, Use, and Maintenance	L	L
	Site Road Construction, Use and Maintenance	L	L
	Peterson Creek Bridge Construction, Use, and Maintenance	L	L
	Site Buildings and Process Plant	L	L
	Explosives Magazine and Storage Facilities	L	L
	Open Pit Development	M	M
	Drilling and Blasting	L	L
	Crushing Waste Rock	L	L
	Loading, Hauling, and Deposition of Waste Rock	L	L
	Temporary Ore Stockpile	M	M
	Tailing Storage Facility Development	M	M
	Power Transmission, Distribution	L	L

(continued)

Table 6.6-1. Identifying Potential Project Interactions and Effects on Groundwater Quantity (continued)

Project Activities		Potential Effects on Groundwater Quantity	
		Alter Magnitude or Timing of Groundwater Recharge and Discharge	Alter Groundwater Elevations, Groundwater Flow Rates, or Groundwater Flow Directions
Construction (*cont'd*)	Natural Gas Line	L	L
	Pipeline Utility Corridor (Potable Water, Sewage, and Site Water)	L	L
	Water Intake from Kamloops Lake	O	O
	Fire Suppression Infrastructure	L	L
	Contact Water	L	L
	Non-contact Water	L	L
	Peterson Creek Diversion	M	M
	Water Management Dams	M	M
	Mine Staffing (Direct Employment)	O	O
	Contracted Employment	O	O
	Taxation	O	O
Decommissioning and Closure	Dismantling of Ancillary Buildings	L	L
	Pit Lake Planning / Filling	H	H
	Site Road/Bridge Decommissioning	L	L
	Tailing Storage Facility Decommissioning and Reclamation	H	H
	Waste Rock Management Facilities Reclamation	H	H
	Fuel Storage and Filling Area	L	L
	Hazardous Wastes Transport, Storage, and Disposal	L	L
	General Wastes Transport, Storage, and Disposal	L	L
	Sewage Infrastructure and Disposal	L	L
	Laydown Areas and Storage Yards	L	L
	Power Transmission, Distribution	L	L
	Project Lighting	O	O
	Site Access, Security and Fencing	O	O
	Contact Water	L	L
	Non-contact Water	L	L

(continued)

Table 6.6-1. Identifying Potential Project Interactions and Effects on Groundwater Quantity (completed)

Project Activities		Potential Effects on Groundwater Quantity	
		Alter Magnitude or Timing of Groundwater Recharge and Discharge	Alter Groundwater Elevations, Groundwater Flow Rates, or Groundwater Flow Directions
Decommissioning and Closure (*cont'd*)	Potable Water Treatment and Use	L	L
	Peterson Creek Diversion	M	M
	Road use to the Project (Materials, Personnel, Supplies)	L	L
	Mine Staffing (Direct Employment)	O	O
	Contracted Employment	O	O
	Taxation	O	O
Post Closure	General Site Inspections and Maintenance	L	L
	Contact Water	L	L
	Non-contact Water	L	L
	Road use to the Project (Materials, Personnel, Supplies)	L	L
	Mine Staffing (Direct Employment)	O	O
	Contracted Employment	O	O

Notes:

O	*No interaction anticipated.*
L	*Negligible to minor interaction expected; implementation of best practices, standard mitigation and management measures; no monitoring required, no further consideration warranted.*
M	*Potential moderate interaction requiring unique active management/monitoring/mitigation; warrants further consideration.*
H	*Key interaction; warrants further consideration.*

EAO (2015) describe the Groundwater Quantity effects assessment requirements as follows:

> *Identify and analyze potential adverse effects resulting from the Project, including potential for increases in piezometric levels in the Aberdeen Hills area that may adversely impact slope stability in that area, and potential impacts on Jacko Lake and Peterson Creek. It will include effects of construction, operation, decommissioning and closure, and post-closure activities*
>
> *Describe measures the Proponent will commit to undertaking to mitigate [potential adverse effects to Groundwater Quantity identified as part of the Groundwater Quantity effects assessment.*

Key Project effects to be evaluated below are changes to the:

- LSA groundwater balance;
- LSA groundwater elevations, flow directions, and rates;
- Groundwater elevations in the Aberdeen area;
- Jacko Lake groundwater balance; and
- Peterson Creek groundwater balance.

6.6.4.2 Effects on Groundwater Quantity

A 3D numerical groundwater flow model (the groundwater model) was developed as the primary tool to evaluate Project interactions with Groundwater Quantity. The groundwater model is based on data compiled and interpreted as part of the baseline groundwater hydrology assessment (Appendix 6.6-A).

Simulation results were analyzed to evaluate Project effects on Groundwater Quantity. The results and interpretation are provided in the following effects assessment.

The 3D numerical groundwater flow model was calibrated to existing conditions (i.e., baseline conditions). Appendix 6.6-D describes model development, calibration and simulation results. In summary, the calibrated model formed the basis to evaluate the effects of the Project on Groundwater Quantity during Construction, Operation, Decommissioning and Closure, and Post Closure. Steady-state models were constructed to represent Post Closure conditions for three pit lake elevations (500, 600, and 700 masl). The WBM (Appendix 6.4-C) indicates a pit lake filling time of more than 700 years to an estimated final elevation of 760 masl. Sensitivity simulations were completed to evaluate model uncertainty and the effects of alternative conceptual models on model results.

Changes to the Groundwater Balance Within the LSA

Table 6.6-2 provides a summary of the groundwater balance for snapshots during Construction (year -2), at the end of Operation (year 23), and Post Closure (pit lake elevation = 500 masl). The groundwater balance for other pit lake elevations (600 and 700 masl) is similar to the groundwater balance for 500 masl. Results for other pit lake elevations are presented in Appendix 6.6-D. The Post Closure Groundwater Quantity effects assessed for a pit lake elevation of 500 masl are greater than for the predicted stable pit lake elevation of 760 masl (i.e., the predicted hydraulic gradient and groundwater inflow rates to the open pit are greater for a pit lake elevation of 500 masl) and are therefore considered to be conservative.

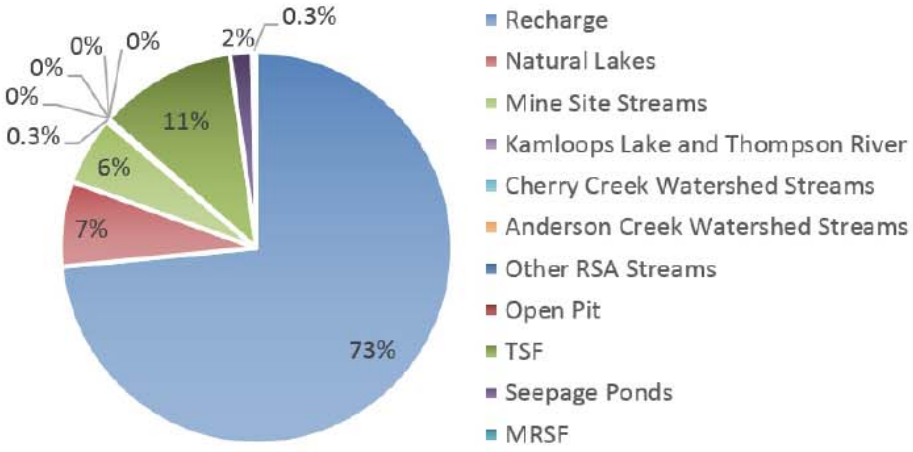
Figure 6.6-13 illustrates the regional groundwater balance for Post Closure conditions (pit lake elevation = 500 masl). Compared to existing conditions (Figure 6.6-11), the overall Post Closure groundwater recharge and discharge quantities are higher. Similar to existing conditions, groundwater recharge and evapotranspiration dominate the Post Closure scenario water balance. Seepage from the TSF to groundwater results in greater recharge to the groundwater flow system, with much of the increased recharge discharging to the open pit. Please see Appendix 6.6-D for water balances for other Project stages.

Table 6.6-2. Net Groundwater Flows Summary

Mine Facility	Net Groundwater Flows (m^3/d)								
	Construction			End of Operation			Post Closure		
	Minimum	Base Case	Maximum	Minimum	Base Case	Maximum	Minimum	Base Case	Maximum
Open Pit	-269	-57	-15	-2012	-723	-357	-7964	-1635	-157
TSF	55	63	206	1273	2545	6187	356	1603	7940
N. Emb. Pond 1	0	0	0	1	2	2	-18	1	1
N. Emb. Pond 2	0	0	0	-0.6	0.5	0.5	-10	-2	-0.3
Jacko Lake	-51	-4	0	60	127	270	60	131	272
CCP	0	0	0	10	11	12	6	11	12
S. Emb. Pond	0	0	0	-387	-36	-0.6	-433	-88	-20
SE. Emb. Pond	0	0	0	5	23	48	-42	-9	-3
EMRSF Pond	0	0	0	14	15	15	9	15	15
SMRSF Pond	0	0	0	-26	-11	-3	-47	-16	-8
Lower Peterson Cr.	-664	-268	-101	-979	-259	-70	-1077	-243	-49
Upper Peterson Cr.	-1054	151	460	-290	151	578	18	278	792
Humphrey Cr.	-33	34	51	18	34	72	-47	35	86
Peterson Cr. DS Pond	0	0	0	-70	78	1490	-286	151	1314
Unnamed Lake	-24	-5	-4	-12	-4	24	-24	5	66

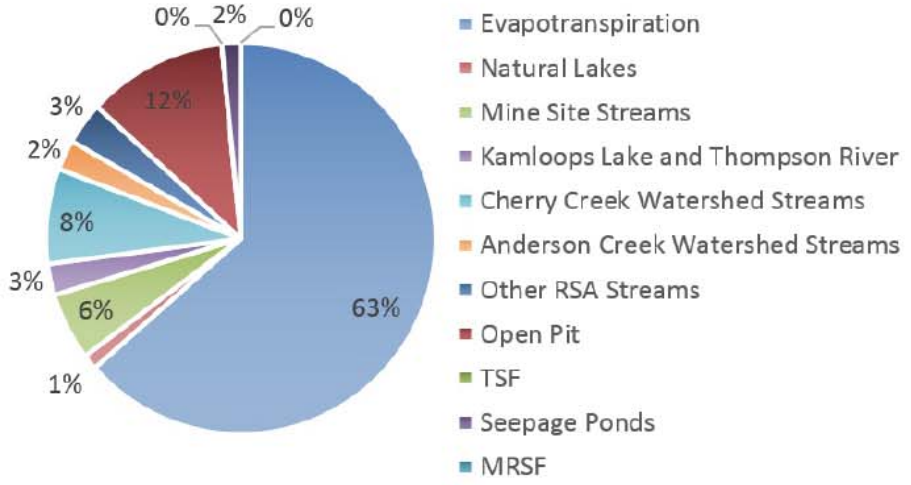
Notes:
Sign Convention: Positive for flows entering groundwater system, negative for flows leaving groundwater system.
Abbreviations: N.= North, Emb.= Embankment, CCP= Central Collection Pond, S.= South, SE.= Southeast, EMRSF= East Mine Rock Storage Facility, SMRSF= South Mine Rock Storage Facility, Cr.= Creek, DS= Downstream, TSF= Tailings Storage Facility

Groundwater Inputs



Groundwater Inputs	m^3/d	Percent Total
Recharge	10318	73%
Natural Lakes	988	7%
Mine Site Streams	791	6%
Kamloops Lake and Thompson River	39	0.3%
Cherry Creek Watershed Streams	0	0%
Anderson Creek Watershed Streams	0	0%
Other RSA Streams	0	0%
Open Pit	0	0%
TSF	1602	11%
Seepage Ponds	259	2%
MRSF	47	0.3%
Total In	**14044**	**100%**

Groundwater Outputs



Groundwater Outputs	m^3/d	Percent Total
Evapotranspiration	8916	63%
Natural Lakes	175	1%
Mine Site Streams	786	6%
Kamloops Lake and Thompson River	363	3%
Cherry Creek Watershed Streams	1107	8%
Anderson Creek Watershed Streams	350	2%
Other RSA Streams	491	3%
Open Pit	1633	12%
TSF	0	0%
Seepage Ponds	220	2%
MRSF	0	0%
Total Out	**14042**	**100%**

NOTES:
1. TSF= TAILINGS STORAGE FACILITY, MRSF= MINE ROCK STORAGE FACILITIES
2. MINE SITE STREAMS INCLUDE PETERSON AND HUMPHREY CREEK

The Construction groundwater balance is similar to existing conditions, and the end of Operation groundwater balance represents groundwater balance effects for Operation, Decommissioning and Closure. The "base case" groundwater flows reflect best estimate predictions for the calibrated 3D numerical groundwater flow model. The "minimum" and "maximum" estimates reflect lower and upper bound estimates from the sensitivity simulations considered in the assessment.

Negative values in Table 6.6-2 indicate groundwater discharge (i.e., groundwater leaving the groundwater flow system/model) and positive values indicate groundwater recharge (i.e. water entering the groundwater flow system/model). The results for Jacko Lake, Upper Peterson Creek, and Lower Peterson Creek are discussed later in this section.

Figure 6.6-14 illustrates the Post Closure distribution of groundwater recharge and groundwater discharge. The patterns of recharge and discharge are generally similar between existing conditions (Figure 6.6-13) and Post Closure. Differences occur near the TSF, the open pit, beneath Jacko Lake, and near the Peterson Creek downstream pond as discussed in the following sections.

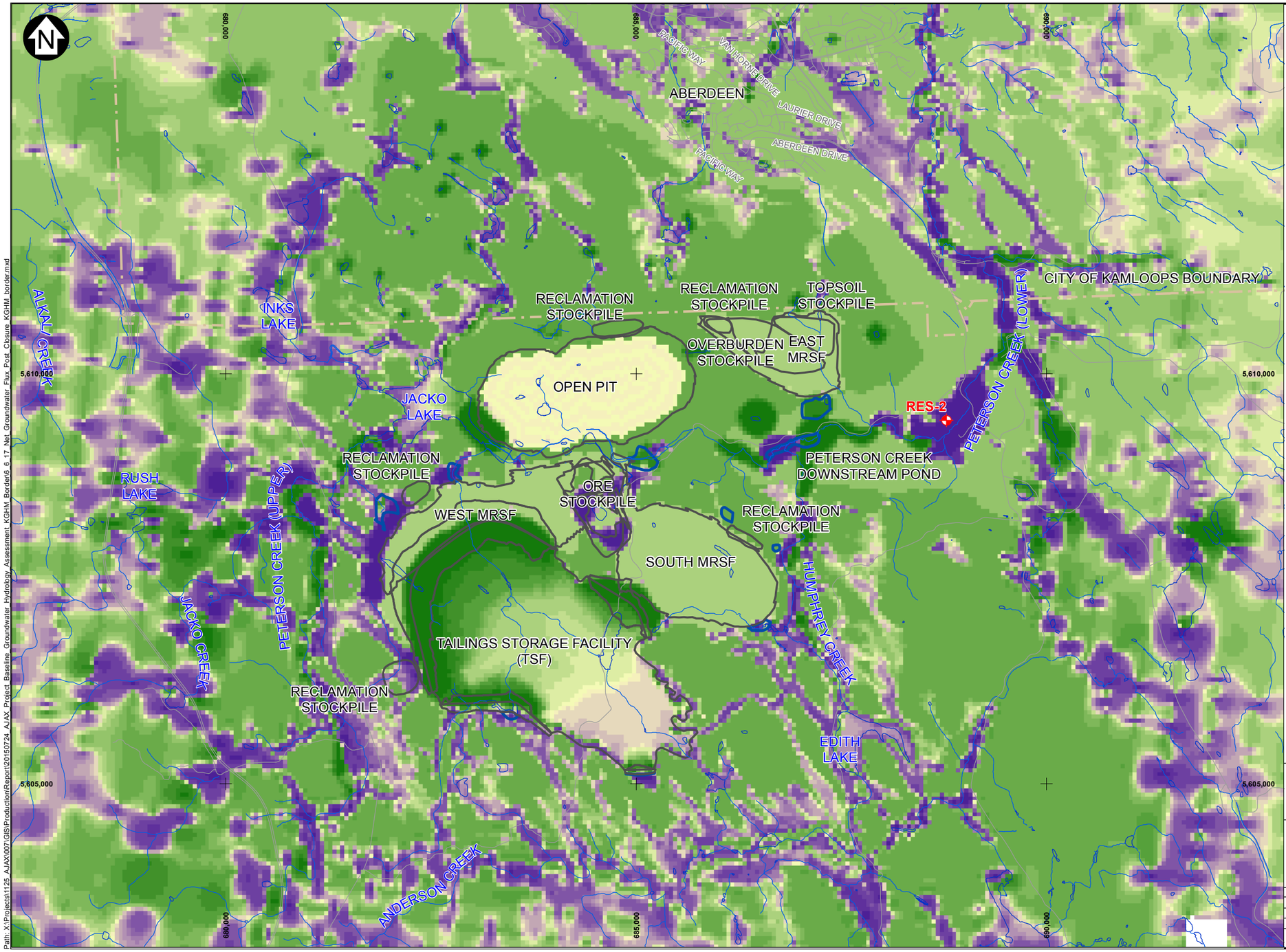
Changes to Groundwater Elevations Within the LSA

Figure 6.6-15 illustrates groundwater elevations in the LSA for Construction, Operation, Decommissioning and Closure. Groundwater elevations are predicted to decline through time by up to approximately 200 m within the open pit footprint and near the open pit in response to open pit excavation, pit slope depressurization and dewatering. Groundwater elevations are simulated to increase through time by up to approximately 100 m beneath the TSF in response to deposition of saturated tailings and, during operations, the formation of a tailings pond. Groundwater flow patterns are predicted to shift near the open pit and the TSF in response to changes in groundwater elevations. Local groundwater flow is simulated to be directed away from the TSF and towards the open pit. Groundwater management ponds locally distort groundwater flow patterns but do not materially change the overall directions of groundwater flow. Beyond the LSA, groundwater elevations and groundwater flow patterns are not predicted to change with time. The groundwater flow divide between the Project and Aberdeen is predicted to persist throughout Construction, Operations, Decommissioning and Closure, and Post Closure, and strengthen as the open pit is excavated and dewatering proceeds.

Figure 6.6-16 illustrates the difference in groundwater elevations between existing conditions and Post Closure conditions. Negative values (red, orange, and yellow) indicate that Post Closure groundwater elevations will be lower than existing conditions, whereas positive values (blue) indicate that Post Closure groundwater elevations will be higher than existing conditions.

Post Closure groundwater elevations are predicted to be lower adjacent to the pit lake, the EMRSF, and the SMRSF. The pit lake elevation of 760 masl is approximately 134 m lower than groundwater elevations under existing conditions. Ongoing flow of groundwater towards the lower elevation of the pit lake will result in lower groundwater elevations proximate to the pit lake. The MRSFs will be reclaimed with soil covers designed to minimize infiltration and groundwater recharge. Unsaturated flow simulations considering various reclamation covers predict that Post Closure infiltration through the MRSFs will be reduced by about 80% compared to uncovered mine rock (BGC, 2015). Therefore, Post Closure groundwater recharge beneath the MRSF footprints is predicted to be lower than existing conditions, leading to lower groundwater elevations.

Figure 6.6-14
Net Groundwater Flux - Post Closure



NOTES:

1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE NOTED.
2. GENERAL ARRANGEMENT OF MINE SITE FACILITIES PROVIDED BY KAM ON APRIL 15, 2015.
3. PROJECTION IS NAD 1983 UTM ZONE 10N.
4. THESE RESULTS ARE BASED ON CLOSURE MODEL WITH PIT LAKE ELEVATION OF 500 MASL (SEE APPENDIX 6.6-E).
5. POSITIVE NUMBERS INDICATE NET GAIN TO THE GROUNDWATER SYSTEM (RECHARGE) AND NEGATIVE NUMBERS INDICATE NET LOSS FROM THE GROUNDWATER SYSTEM (DISCHARGE).
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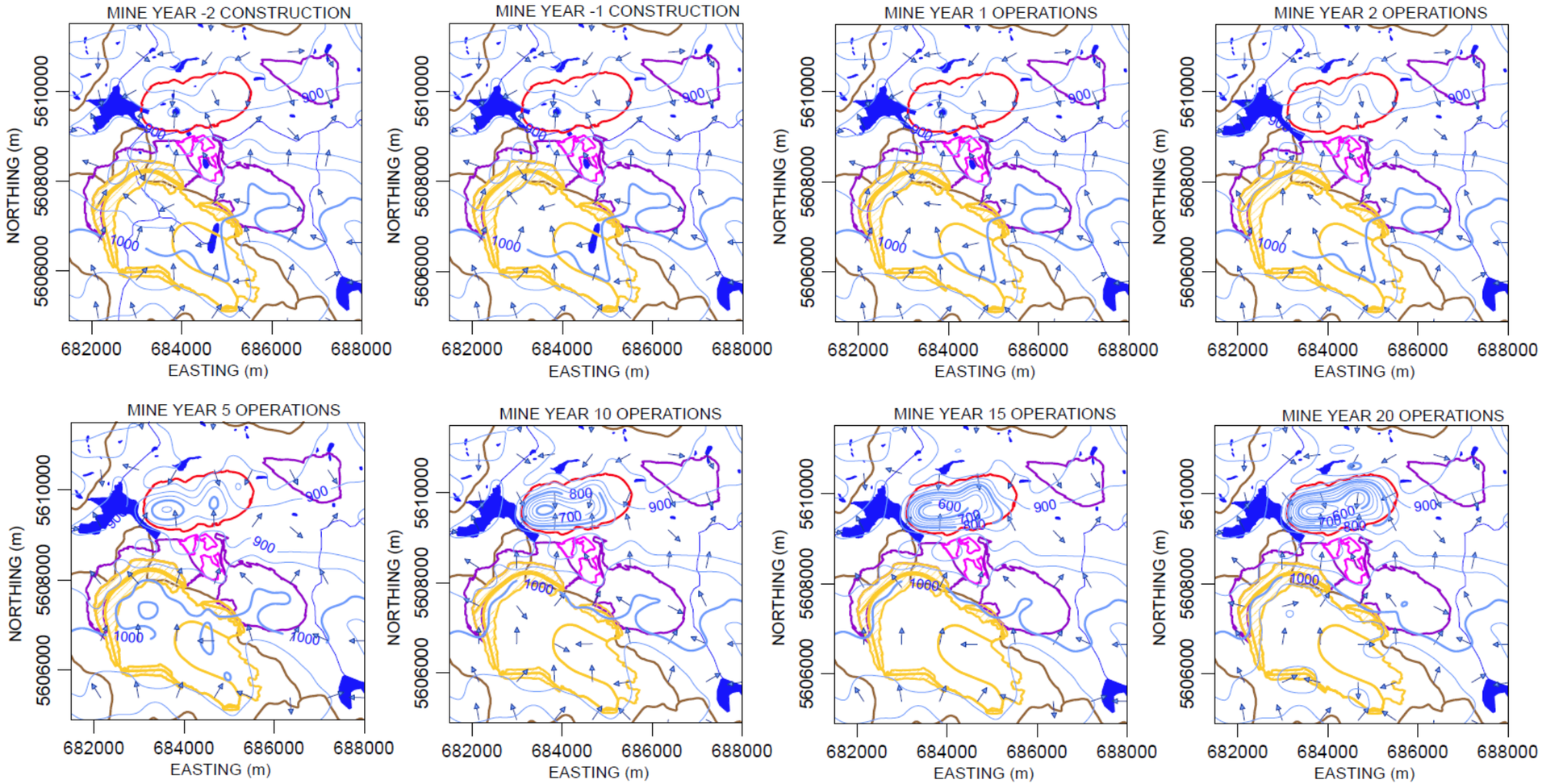
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2015 July 27			
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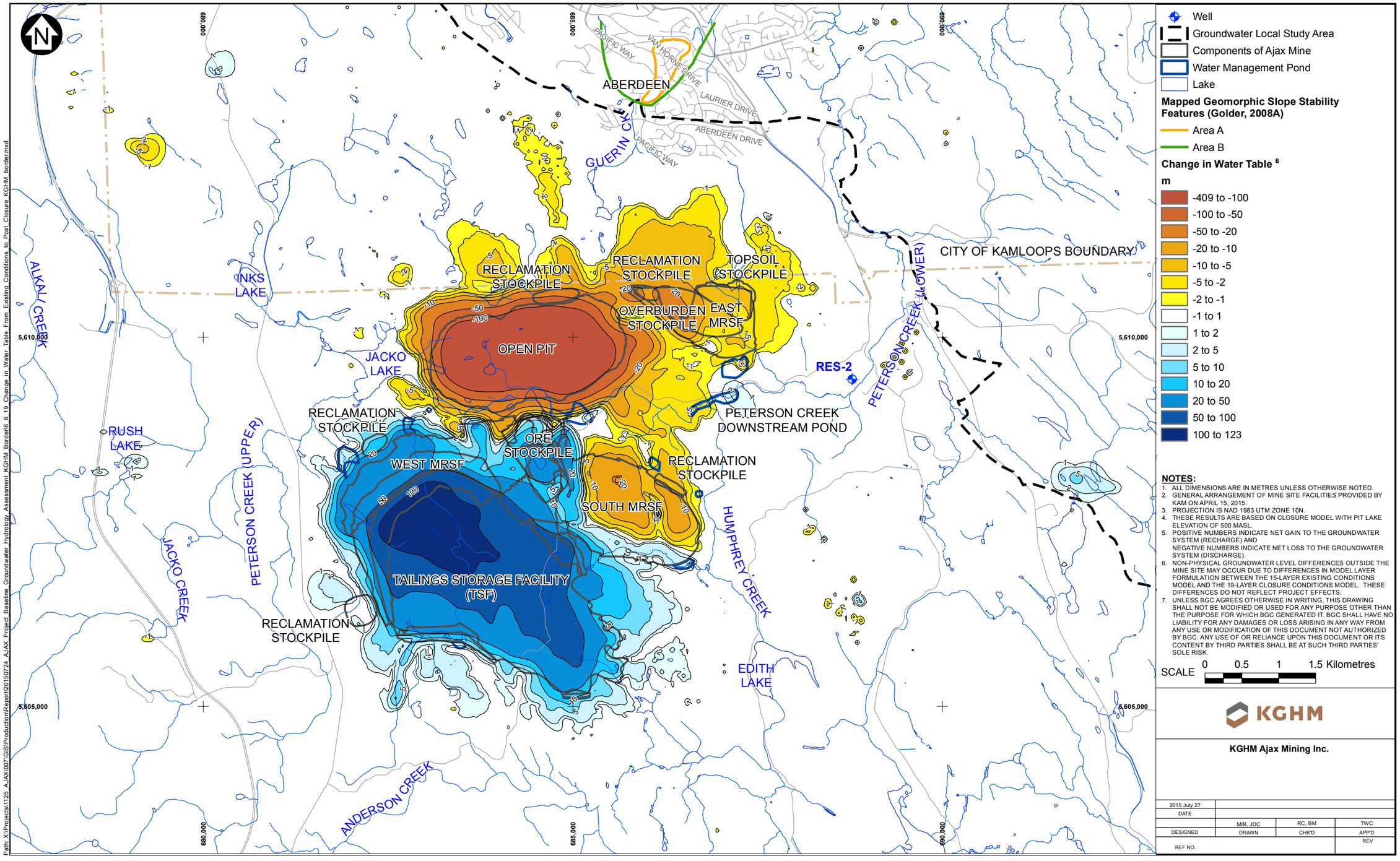
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NOTES:
1. COORDINATE SYSTEM NAD 83 DATUM UTM ZONE 10.
2. REFER TO DRAWING 01 FOR FACILITY LABELS.
3. 50m HYDRAULIC HEAD CONTOUR INTERVAL.
4. GRID IS SEVEN DEGREES OFFSET FROM NORTH TO ALIGN MODEL AXIS TO PRINCIPAL GROUNDWATER FLOW DIRECTION. 3
5. iMapBC (2013). MINISTRY OF FORESTS, LAND AND NATURAL RESOURCE OPERATIONS GIS DATA. AVAILABLE AT: http://webmaps.gov.bc.ca/imfx/imf.jsp?site=imapbc ACCESSED FEBRUARY, 2013.

Figure 6.6-16
Change in Water Table (From Existing Conditions to Post Closure)



NOTES:

1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE NOTED.
2. GENERAL ARRANGEMENT OF MINE SITE FACILITIES PROVIDED BY KAM ON APRIL 15, 2015.
3. PROJECTION IS NAD 1983 UTM ZONE 10N.
4. THESE RESULTS ARE BASED ON CLOSURE MODEL WITH PIT LAKE ELEVATION OF 500 MASL.
5. POSITIVE NUMBERS INDICATE NET GAIN TO THE GROUNDWATER SYSTEM (RECHARGE) AND NEGATIVE NUMBERS INDICATE NET LOSS TO THE GROUNDWATER SYSTEM (DISCHARGE).
6. NONPHYSICAL GROUNDWATER LEVEL DIFFERENCES OUTSIDE THE MINE SITE MAY OCCUR DUE TO DIFFERENCES IN MODEL LAYER FORMULATION BETWEEN THE 15-LAYER EXISTING CONDITIONS MODEL AND THE 19-LAYER CLOSURE CONDITIONS MODEL. THESE DIFFERENCES DO NOT REFLECT PROJECT EFFECTS.
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SCALE 0 0.5 1 1.5 Kilometres

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Post Closure groundwater elevations are predicted to be higher within the footprints of the TSF, the reclaimed footprint of the Operation ore stockpile area, and West MRSF. The TSF is represented with a general head boundary (GHB) in the 3D numerical groundwater flow model, which is consistent with ongoing consolidation and drainage of tailings porewater from the TSF. The TSF is planned to be reclaimed with a dry cover. Therefore, once the tailings consolidation is complete, infiltration is expected to be lower and the groundwater mound below the TSF is expected to subside. The reclaimed ore stockpile is within a low area that receives groundwater discharge under existing conditions. The West MRSF footprint receives seepage from the TSF. The groundwater elevation increase predicted below the West MRSF is therefore a result of seepage from the TSF.

The spatial extent of predicted changes to groundwater elevations is greatest within the Mine Site near the open pit and TSF, and extends up to approximately 2 km. The temporal extent of predicted changes to groundwater elevations begins early in Operation, and extends to Post Closure. Figure 6.6-16 shows changes greater than 1 m from existing conditions. The natural seasonal variability in groundwater elevations is up to 4 m (Appendix 6.6-A) and, therefore, groundwater elevation changes less than 1 m are considered to be negligible (i.e., return to within the range of seasonal variability).

Changes to Piezometric Elevations in the Aberdeen Area

The City of Kamloops has implemented measures to reduce piezometric elevations at Aberdeen (Golder 2008). Piezometric elevations and groundwater elevations are directly related. The potential effects on piezometric elevations at Aberdeen were assessed by comparing Post Closure groundwater elevations to existing conditions groundwater elevations as simulated by the 3D numerical groundwater flow model (Appendix 6.6-D).

Figure 6.6-16 indicates that no changes to groundwater elevations in the Aberdeen area are predicted under base case conditions. The pit lake elevation will be approximately 210 m lower than existing conditions and will create locally greater than 100 m lower Post Closure groundwater elevations. The East MRSF will be reclaimed to minimize groundwater recharge Appendix 6.4-C), resulting in lower groundwater recharge and approximately 10 to 20 m lower groundwater elevations Post Closure, compared to existing conditions. Therefore, the effects on Aberdeen piezometric elevations are predicted to be negligible.

Changes to the Jacko Lake Groundwater Balance

Table 6.6-2 provides a summary of the Jacko Lake groundwater balance during Construction, at the end of Operation, and Post Closure for the base case and maximum and minimum flow rates from sensitivity simulation results. The Jacko Lake water balance during Construction is the same as under existing conditions. The Jacko Lake groundwater balance at the end of Operation is the same as for Decommissioning and Closure.

Under existing conditions and during Construction, Jacko Lake receives groundwater inflows of approximately 4 m^3/day for base case conditions (range of 0 to 51 m^3/day). By the end of Operation, Jacko Lake contributes approximately 127 m^3/day (range of 60 to 270 m^3/day) to the groundwater flow system that discharges to the open pit. The Post Closure water balance is nearly the same as at the end of Operation (i.e., approximately 131 m^3/day, with a range of 60 to 272 m^3/day). The change

in Jacko Lake water balance is due to the development of the adjacent open pit. The combined groundwater and surface water balance for Jacko Lake at existing conditions has a net average annual flow from the lake of 160 m^3/hr for existing conditions which is predicted to decrease to 152 m^3/hr in Post Closure, which is a flow reduction of approximately 5%. Overall, Jacko Lake will remain a net gaining system. The effects of changes to the Jacko Lake water balance on Surface Water Quantity are assessed in Section 6.4.

Changes to the Upper Peterson Creek Groundwater Balance

The portion of the Peterson Creek upstream of Jacko Lake is referred to as Upper Peterson Creek (Figure 6.6-2). Table 6.6-2 provides a summary of the Upper Peterson Creek groundwater balance during Construction, at the end of Operation, and Post Closure. The Upper Peterson Creek water balance during Construction is the same as under existing conditions. The Upper Peterson Creek groundwater balance at the end of Operation is the same as for Decommissioning and Closure.

Under existing conditions and Construction, Upper Peterson Creek has both gaining and losing reaches. The 3D numerical groundwater flow model predicts that Upper Peterson Creek will be either a net gaining or net losing stream, depending on the sensitivity conditions considered. Observations of no flow in Upper Peterson Creek during portions of the year (Appendix 6.4-C) indicate that Upper Peterson Creek is a losing stream. Therefore, sensitivity cases predicting that Upper Peterson Creek is a gaining stream are considered unrealistic. Neglecting results from sensitivity simulations considered unrealistic, the range of seepage losses from Upper Peterson Creek to the groundwater flow system under existing conditions and during construction thus ranges from 0 to 460 m^3/day, with a base case estimate of 151 m^3/day. Seepage losses can increase to up to 580 m^3/day for Operation and Decommissioning and Closure (base case estimate of 151 m^3/day), and up to 790 m^3/day for Post Closure (base case estimate of 278 m^3/day).

Changes to the Lower Peterson Creek Groundwater Balance

The portion of the Peterson Creek downstream of Jacko Lake is referred to as Lower Peterson Creek (Figure 6.6-2). Table 6.6-2 provides a summary of the Lower Peterson Creek groundwater balance during Construction, at the end of Operation, and Post Closure. The Lower Peterson Creek water balance during Construction is the same as under existing conditions. The Lower Peterson Creek groundwater balance at the end of Operation is the same as for Decommissioning and Closure.

Under existing conditions and during Construction, Lower Peterson Creek is predicted to receive net groundwater discharge (i.e., baseflows) of approximately 268 m^3/day (range of 101 m^3/day and 664 m^3/day). Locally, both gaining and losing segments are predicted to occur (Figure 6.6-10). During Operation, a portion of Lower Peterson Creek downstream of Jacko Lake will be diverted to allow mine development, the Peterson Creek downstream water management pond will be developed, and other nearby mine facilities will influence local groundwater elevations. Lower Peterson Creek is predicted to remain an overall gaining stream throughout Operation, Decommissioning and Closure, and Post Closure. Groundwater discharge to Lower Peterson Creek at the end of Operation and during Decommissioning and Closure is estimated to be approximately 259 m^3/day (range of 70 to 979 m^3/day). Post Closure groundwater discharge to Lower Peterson Creek is estimated to be approximately 243 m^3/day (range of 49 to 1077 m^3/day).

The base case groundwater discharge to Lower Peterson Creek declines from 268 m^3/day under existing conditions to 243 m^3/day under Post Closure conditions for best estimate parameters conditions. However, sensitivity analysis results indicate that groundwater discharge to Lower Peterson Creek may increase or decrease due to the Project, depending on the actual distribution of groundwater recharge and discharge and actual hydraulic properties of the subsurface deposits. The base case change in baseflow is approximately a 9% reduction overall. Considering uncertainty, the baseflow contribution could increase by up to 62% or decrease by up to 51% for Post Closure, compared to existing conditions.

The range of uncertainty in the Post Closure baseflow to Lower Peterson Creek is large. The uncertainty in Project effects is the result of the hydrogeologic setting of Lower Peterson Creek above the Peterson Creek Aquifer, combined with limitations in Surface Water Quantity monitoring data. The Peterson Creek Aquifer underlies Lower Peterson Creek. The simulated water balance between Lower Peterson Creek and the Peterson Creek Aquifer is sensitive to the hydraulic conductivity of the Peterson Creek Aquifer. Small changes to hydraulic conductivity result in changes to simulated groundwater elevations of a few metres within the aquifer beneath Lower Peterson Creek. These simulated groundwater elevation changes are sufficiently large to change the simulated pattern of gaining and losing reaches in Lower Peterson Creek. The effects of Post Closure changes to the Lower Peterson Creek groundwater balance are sensitive to small changes in Post Closure simulated groundwater conditions in the Peterson Creek Aquifer.

6.6.4.3 Mitigation Measures for Groundwater Quantity

Changes to the local groundwater balance and local groundwater elevations are an inevitable consequence of the Project. The spatial extent of the changes is predicted to be limited to within approximately 2 km of mine facilities, or less. Groundwater recharge through MRSFs will be minimized Post Closure to reduce potential Groundwater Quality (Section 6.5) and Surface Water Quality (Section 6.3) effects from these facilities. Discussion in this section is limited to mitigation measures for Groundwater Quantity effects. Please refer to other sections of the EA for discussion of mitigation measures for Project effects on other VCs.

Mitigation measures to mitigate changes in baseflow for Jacko Lake, Upper Peterson Creek and Lower Peterson Creek are discussed in Section 6.4 as part of the Surface Water Quantity assessment.

The pit lake is predicted to act as a permanent groundwater discharge zone (Figure 6.6-16), with a stable lake elevation of approximately 760 masl (Appendix 6.4-C), which is approximately 134 m lower than existing groundwater elevations within the open pit footprint. Initial pit lake levels will be approximately 500 masl and are predicted to increase to 760 masl over a period of 700 to 800 years (Appendix 6.4-C). The expected reduction in groundwater elevation may impact nearby groundwater wells. The Groundwater Quantity effects could be mitigated by deepening or replacing affected groundwater supply wells within 2 km of the open pit, as required. Four registered groundwater wells are reported within approximately 2 km of the open pit (Drawing 6.6-E-3 in Appendix 6.6-E). Groundwater Quality (Section 6.5) would also need to be considered.

A long-term groundwater mound is predicted to develop beneath the TSF. Initially, the groundwater mound will develop as a result of seepage due to water release during and after

tailings deposition, due to tailings consolidation and initial tailings pore water drainage. The 3D numerical groundwater flow model represented TSF seepage using a GHB to represent tailings consolidation and initial tailings pore water drainage from the TSF.

Current predictive simulations with the groundwater model include an implementation of the TSF boundary condition based on a preliminary design proposed in 2014 to deposit tailings as a slurry. However, the advancement of Project engineering during 2015 has identified thickened tailings as the Best Available Technology for the Project. This advancement includes a reduced start-up water volume (2.5 Mm^3 for thickened tailings versus 13 Mm^3 for conventional tailings) and lower make up water requirements than were considered in the groundwater modeling. This change in design concept for the TSF is considered to have little to no impact on the simulated groundwater flow system and Groundwater Quantity effects assessment for the following reasons:

- During Construction, a smaller TSF start up pond volume will be required for the thickened tailings concept. The smaller TSF pond will translate into less total seepage from the TSF to the groundwater system during the construction and mine start-up period (i.e. the current groundwater model overestimates the amount of water that seeps into the foundation of the TSF during this period because a larger pond area is simulated with the conventional tailings concept). However, during this period the seepage losses from the TSF are interpreted to be filling up the unsaturated void space underlying the TSF. The tailings basin will eventually be filled and so the net effect would be that the saturation process is simulated to occur faster for conventional tailings than it would for thickened tailings (i.e., the magnitude of the effect is not likely to change, but the timing of the effect will be offset).
- During Operation and Closure and Decommissioning, the amount of water entering and/or exiting the groundwater flow model in the TSF basin is largely controlled by the footprint of saturated tailings. The plant milling rate does not change and so the filling schedule for the TSF would not change significantly with the thickened tailings technology. Thus, the effect on model predictions during these phases of mining are considered to be minor (i.e., the extent of the boundary condition implemented in the groundwater flow model to simulate the tailings would be essentially the same for both types of tailings deposition however the pond level may be slightly different/offset in time).
- For the Post Closure phase, the overall footprint of the TSF that will be covered with tailings will not change with the thickened tailings technology. Thus, the boundary condition used to simulate the TSF in Post Closure would be the same.

Additional discussion of the post closure TSF boundary conditions and model prediction results is provided in Appendix 6.6-D.

The TSF is planned to be reclaimed with a dry cover that limits infiltration and groundwater recharge. The current mine design includes a low hydraulic conductivity zone within the TSF embankments to limit lateral seepage through the embankments, as part of the base case evaluation.

The water management ponds will either collect groundwater discharge or infiltrate water to groundwater. Low hydraulic conductivity liners, such as compacted till or double-layer geomembranes, are planned to minimize seepage from the water management ponds. The water

management pond locations and designs will continue to be optimized as project site investigation and design activities continue in the future.

Residual, permanent groundwater elevation changes of greater than 100 m within the mine footprint are expected to occur even with mitigation. Closure design to minimize recharge through the TSF may result in lower Post Closure groundwater elevations than currently predicted. Groundwater Quantity changes, defined as at least 1 m change from existing conditions, are expected to be limited to within approximately 2 km of mine infrastructure.

Environmental management plans (EMPs) will be developed to monitor groundwater and surface water conditions. These EMPs will be designed, in part, to detect changes to groundwater elevations and baseflow contributions to streams near the Project, and will focus on the spatial extent within approximately 2 km of mining facilities. The monitoring network will be designed to allow an assessment of the zone of anticipated groundwater quantity effects. Monitoring results will be used to compare actual conditions to predictions and to provide input to adaptive management plans, if needed.

6.6.5 Residual Project Effects and Their Significance

6.6.5.1 Summary of Residual Effects

The key changes to groundwater quantity that are predicted to remain after the implementation of mitigation measures are summarized qualitatively in Table 6.6-3. Quantitative effects are discussed in the following sections.

6.6.5.2 Criteria for Characterization of Residual Effects

Residual effects of the Project on groundwater quantity are characterized using standard criteria (i.e., the magnitude, geographic extent, duration, frequency, reversibility, resiliency, and ecological context). Standard ratings (i.e., major, moderate, minor/low, medium, and high) for these characterization criteria are provided in Chapter 5; however, Table 6.6-4 provides a summary of definitions for each characterization criterion.

6.6.5.3 Characterization of Residual Effects

Residual effects for Jacko Lake, Upper Peterson Creek, and Lower Peterson Creek are characterized in Section 6.4 as part of the Surface Water Quantity assessment. The assessment in Section 6.4 includes the changes in groundwater contributions to surface water flows.

The local groundwater balance will be altered during Construction, Operation, Decommissioning and Closure, and Post Closure. The change will be continuous and will extend up to approximately 2 km from mine facilities, extending to the landscape scale. The change is irreversible. The water balance change has neutral resiliency and neutral ecological context as a result of groundwater use in the LSA.

Table 6.6-3. Summary of Residual Effects on Groundwater Quantity

Potential Effect	Project Phase (timing of effect)	Project Component/ Physical Activity	Description of Cause-Effect[1]	Description of Mitigation Measure(s)	Description of Residual Effect
Jacko Lake Groundwater Balance	Operation, Decommissioning and Closure, and Post Closure	Pit development	Excavation of the open pit lowers groundwater elevations and induces seepage from Jacko Lake	Water management plan (Section 6.4)	Seepage from Jacko Lake toward the mine pit
Upper Peterson Creek Groundwater Balance	Operation, Decommissioning and Closure, and Post Closure	Mine pit, MRSFs, TSF, ore stockpile*	Changes in groundwater elevations cause changes in baseflow contribution	Water management plan (Section 6.4)	Residual changes to baseflow
Lower Peterson Creek Groundwater Balance	Operation, Decommissioning and Closure, and Post Closure	Mine pit, MRSFs, TSF, ore stockpile*	Changes in groundwater elevations cause changes in baseflow contribution	Water management plan (Section 6.4)	Residual changes to baseflow
Groundwater Balance	Operation, Decommissioning and Closure, and Post Closure	Mine pit, MRSFs, TSF, ore stockpile*	Open pit development lowers groundwater elevations and creates a groundwater sink. MRSF, TSF, and stockpile development (and subsequent removal) and reclamation change the topography and groundwater balance within their footprints	Water management plan	Increase in groundwater discharge to the open pit footprint, reduced recharge through the MRSFs and stockpile, increased recharge through the TSF.
Groundwater Elevations	Operation, Decommissioning and Closure, and Post Closure	Mine pit, MRSFs, TSF, ore stockpile*	Changes in the location and amount of groundwater recharge and discharge create changes in groundwater elevations	Water management plan.	Permanent groundwater elevation changes within ~2 km of mine infrastructure
Aberdeen Piezometric Elevations	Operation, Decommissioning and Closure, and Post Closure	Mine pit, MRSFs, TSF, ore stockpile*	No effect	Monitor groundwater elevations	None

[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 VC.*Ore stockpile is mined out and processed and the ore stockpile footprint is reclaimed during closure. Ore stockpile is not present in post-closure.*

Table 6.6-4. Definitions of Characterization Criteria for Residual Effects on Groundwater Quantity

Magnitude	Duration	Frequency	Geographic Extent (Physical/Biophysical)	Reversibility	Resiliency	Ecological Context	Likelihood of Effects	
							Probability	Confidence Level
How severe will the effect be?	*How long will the effect last?*	*How often will the effect occur?*	*How far will the effect reach?*	*To what degree is the effect reversible?*	*How resilient is the receiving environment or population?*	*What is the current condition of the ecosystem and how commonly is it represented in the LSA?*	*How likely is the effect to occur?*	*How certain is this analysis?*
Negligible: No or very little detectable change from baseline conditions.	**Short-term:** Effect lasts 1 to 5 years.	**Once:** Effect is confined to one discrete period in time during the life of the Project.	**Local:** Effect extends less than 500 m from infrastructure or activity.	**Reversible Short-term:** Effect can be reversed relatively quickly.	**Low:** The receiving environment or population has a low resilience to imposed stresses, and will not easily adapt to the effect.	**Low:** The receptor is considered to have little to no unique attributes or provision of functions is severely degraded.	**High:** It is highly likely that this effect will occur.	**High:** < 80% confidence. There is a good understanding of the cause-effect relationship and all necessary data are available for the Project area. There is a low degree of uncertainty and variation from the predicted effect is expected to be low.
Minor: Differs from the average value for baseline conditions to a small degree.	**Medium-term:** Effect lasts 6 to 25 years.	**Sporadic:** Effect an effect that occurs at sporadic or intermittent intervals during any phase of the Project.	**Landscape:** Effect is limited to the LSA or one watershed (i.e., Sub-area).	**Reversible Long-term:** Effect can be reversed within 20 years of Post Closure.	**Neutral:** The receiving environment or population has a neutral resilience to imposed stresses and may be able to respond and adapt to the effect.	**Neutral:** The receiving environment considered to have some unique attributes and provides most functions that an undisturbed environment would provide.	**Medium:** This effect is likely, but may not occur.	**Medium:** 50 to 80% confidence. The cause-effect relationships are not fully understood, there are a number of unknown external variables, or data for the Project area are incomplete. There is a moderate degree of uncertainty; while results may vary, predictions are relatively confident.
Medium: Differs substantially from the average value for baseline conditions and approaches the limits of natural variation.	**Long-term:** Effect lasts between 26 and 50 years.	**Regular:** Effect occurs on a regular basis during the life span of the Project.	**Regional:** Effect extends across the broader region (e.g., RSA, multiple watersheds, etc.).	**Irreversible:** Effect cannot be reversed (i.e., is permanent).	**High:** The receiving environment or population has a high natural resilience to imposed stresses, and can respond and adapt to the effect.	**High:** The receiving environment or population is uncommon and occurs in a natural state and provides functions at a maximum capacity.	**Low:** This effect is unlikely but could occur.	**Low:** < 50% confidence. The cause-effect relationships are poorly understood, there are a number of unknown external variables, and data for the Project area are incomplete. High degree of uncertainty and final results may vary considerably.
Major: Differs substantially from baseline conditions, resulting in a detectable change beyond the range of natural variation.	**Far Future:** Effect lasts more than 50 years.	**Continuous:** Effect occurs constantly during the life of the Project.	**Beyond Regional:** Effect extends beyond the regional scale, and may extend across or beyond the province.					

Local groundwater elevations will change beneath mine facilities during Construction, Operation, Decommissioning and Closure, and Post Closure. The change will be continuous and will extend up to 2 km from mine facilities with a threshold of 1 m of groundwater elevation change, extending to the landscape scale. The change is irreversible. The change in groundwater elevations has neutral resiliency and neutral ecological context as a result of groundwater use in the LSA.

Please see Table 6.6-5 for a summary of the characterization of residual effects.

6.6.5.4 Significance of Residual Effects

The significance of the residual effects for the various groundwater quantity VCs are rated using the following criteria:

- Not Significant (Minor): Residual effects have negligible or minor magnitude, local geographic extent, short- or medium-term duration, and occur sporadically if at all. The effects on the VC are indistinguishable from background conditions (i.e., occur within the range of natural variation as influenced by hydrogeological processes). Land and resource management plan objectives will be met.
- Not Significant (Moderate): Residual effects have minor to medium magnitude; have local, landscape, or regional geographic extent; are short-term to irreversible; and occur at all frequencies. Residual effects on the VC may be distinguishable at the population, community, and/or ecosystem level. The ability to meet land and resource management plan objectives may be impaired.
- Significant (Major): Residual effects have high magnitude; have regional or beyond regional geographic extent; are chronic (i.e., persist into the far future); and occur at all frequencies. Residual effects on the VC are consequential (i.e., structural and functional changes in ecosystems are predicted). The ability to meet land and resource management plan objectives is impaired.

Changes to groundwater elevations and groundwater recharge and discharge are expected to occur. Large changes to groundwater elevations are anticipated. Groundwater elevations are expected to be more than 100 m lower near the pit Post Closure compared to existing conditions. Groundwater elevations are expected to be more than 100 m higher under the TSF Post Closure compared to existing conditions. The changes in groundwater elevations are associated with changes in groundwater flow rates and groundwater flow directions within approximately 2 km of Project facilities.

The Aberdeen area of the City of Kamloops is approximately 3 km north of the open pit and the East MRSF. The City of Kamloops operates measures to reduce piezometric elevations in Aberdeen due to stability concerns (Golder 2008). No changes to piezometric elevations are anticipated at Aberdeen due to the Project.

Groundwater elevation changes may result in reductions in well productivity for wells installed within 2 km of the mine pit. Four registered wells are reported to be within approximately 2 km of the mine pit. Some of these wells may need to be relocated or deepened.

Table 6.6-5. Characterization of Residual Effects, Significance, Likelihood and Confidence on Groundwater Quantity

Residual Effect	Residual Effects Characterization Criteria							Significance of Adverse Residual Effects	Likelihood and Confidence	
	Magnitude	Duration	Frequency	Geographic Extent	Reversibility	Resiliency	Context		Probability	Confidence
Changes to Magnitude or Timing of Groundwater Recharge and Discharge	Major	Far Future	Continuous	Landscape	Irreversible	Neutral	Neutral	Not Significant (moderate)	High	Medium
Changes to Groundwater Elevations, Groundwater Flow Rates, or Groundwater Flow Directions	Major	Far Future	Continuous	Landscape	Irreversible	Neutral	Neutral	Not Significant (moderate)	High	Medium

As described in Section 6.6-1, the significance of changes to groundwater elevations and groundwater recharge and discharge on other VCs, such as Surface Water Quantity (Section 6.4), Groundwater Quality (Section 6.5), Vegetation and Terrestrial Ecosystems (Sections 6.8, 6.9, 6.10) are described as part of those VC assessments. The residual effects on Groundwater Quantity are predicted to be not significant (moderate) because the effects are limited to within 2 km of the Project facilities, up to four registered groundwater wells may require mitigation, and no effect on Aberdeen piezometric elevations are predicted.

6.6.5.5 Characterization of Likelihood and Confidence

The probability (likelihood) of residual Groundwater Quantity effects summarized in Table 6.6-5 is high. The confidence in the characterization of effects to the groundwater balance and groundwater elevations is high; however, the confidence in the characterization of residual Groundwater Quantity effects is medium because of the inherent variability of hydraulic properties of materials (heterogeneity and anisotropy), the scale dependence of hydraulic conductivity, the necessary assignment of similar and different materials to a single hydrostratigraphic unit based on similar interpreted hydraulic properties and the fact that the geology of the subsurface cannot be perfectly known/mapped.

6.6.5.6 Summary of Residual Effects Assessment and Significance

Table 6.6-6 provides a summary of the residual effects, mitigation, and significance on groundwater quantity. Identified residual effects are carried forward to the Cumulative Effects Assessment in Section 6.6.6.

Table 6.6-6. Summary of Residual Effects, Mitigation, and Significance on Groundwater Quantity

Residual Effects	Project Phase	Mitigation Measures	Significance
Changes to Magnitude or Timing of Groundwater Recharge and Discharge	Operation, Decommissioning and Closure, Post Closure	Water management plan	Not significant (moderate)
Changes to Groundwater Elevations, Groundwater Flow Rates, or Groundwater Flow Directions	Operation, Decommissioning and Closure, Post Closure	Water management plan.	Not significant (moderate)

6.6.6 Cumulative Effects Assessment

6.6.6.1 Introduction

Changes to Groundwater Quantity are caused by physical changes to the groundwater domain (e.g., mining) and changes to the groundwater balance (e.g., changes to groundwater recharge and discharge due to changes in land use, groundwater abstraction, changes in evapotranspiration, etc.). Project effects are predicted to be limited to within 2 km of mine facilities. Therefore, Project activities with the potential for cumulative effects are limited to those with the potential to change Groundwater Quantity within 2 km of the Mine Site.

6.6.6.2 Identification of Other Actions that May Affect Groundwater Quantity

Historical and proposed activities within the LSA and RSA have the potential to have cumulative effects with Project-specific Groundwater Quantity effects. Groundwater Quantity effects have the potential to result in interactions over a long temporal scale. The potential for Groundwater Quantity cumulative effects were considered where Groundwater Quantity was or could be affected by historical and/or proposed activities that overlap spatially and temporally with the Project. Past projects and activities within the RSA and LSA that were considered to have a spatial linkage with potential effects of the Project are summarized in Table 6.6-7.

Of the activities considered in Table 6.6-7, three activities were identified to have the potential to contribute to cumulative Groundwater Quantity effects: agriculture, ranching, and City expansion and growth. Groundwater use can lower groundwater elevation near the well due to pumping, and increase groundwater elevation away from the well due to irrigation of the pumped water. Agricultural irrigation is common in the region. Irrigation can affect Groundwater Quantity in two ways: by contributing groundwater recharge in the case of excessive irrigation and by removing water from the groundwater flow system by pumping wells. Ranching can affect Groundwater Quantity by groundwater abstraction for human consumption and for livestock watering, or by impounding water such as at Jacko Lake, creating additional recharge and seepage. For example, seepage from Jacko Lake due to the historical footprint would have been less than seepage caused by the impounded Jacko Lake.

These three activities are ongoing in the LSA. If the intensity of groundwater supply, agriculture, and ranching remain about the same in the future as in the past, then no cumulative effects would be predicted. If the intensity of one or more of these activities were to increase or decrease, then cumulative effects could occur in combination with Project activities.

6.6.6.3 Interactions between Residual Project Effects and Other Project or Activity Effects

Domestic groundwater use, agricultural irrigation, agricultural groundwater abstraction, and groundwater abstraction for ranching may interact with changes to the water balance and groundwater elevations caused by the Project. The Groundwater Quantity effects from agricultural and ranching activities are reversible and largely seasonal. Groundwater use for agriculture and ranching is a historical and ongoing practice. Future agriculture and ranching activities could be more or less intensive than practices that currently occur. Changes in the intensity of groundwater use from these activities in the future could alter the local groundwater balance compared to existing conditions. The magnitude of the changes would be expected to be small, located near the area of influence for individual groundwater wells.

City expansion and growth may change groundwater conditions from current conditions. As the City expands, areas that currently rely on groundwater sources will likely be added to the City water supply. Lawn watering could increase groundwater elevations and change the groundwater balance. Measures to maintain slope stability (such as those ongoing at Aberdeen) could result in lower groundwater elevations. The effects from City expansion are expected to be permanent, small in magnitude, and limited to areas within or immediately adjacent to City limits

Table 6.6-7. Ranking Potential for Residual Effects to Interact Cumulatively with Effects of Other Human Actions on Groundwater Quantity

Residual Effect	Industrial Projects/Activities													Natural Resources and Land Use			Tourism and Commercial Recreation Activities					Community Infrastructure			Transportation					
	Vidette Lake Mine	Afton Mine (Historical)	Iron Mask Mine	Bonaparte Mine	New Afton Mine (New Gold)	Highland Valley Copper Mine (Teck)	Domtar Kamloops Pulp Mill	Tolko-Hefley Creek Plywood and Veneer	LaFarge Cement Plant	Trans Mountain Pipeline System (Kinder Morgan)	Trans Mountain Pipeline System - Expansion (Kinder Morgan)	Harper Creek	Highland Valley Copper – Bethlehem Expansion	Kamloops Forest District	Agriculture	Ranching	Tranquille on the Lake	Lac Le Jeune Resort	Tobiano Golf Course	Recreational Hunting, Fishing, Foraging	Recreational Trails	City of Kamloops Wastewater Management	Water Treatment Centre	City Expansion and Growth	Lac le Jeune Road	Highway 1	Highway 5A	Highway 5 (Coquihalla Highway)	Kamloops Airport	Rail Yards and Lines (CP and CN)
Changes to Magnitude or Timing of Groundwater Recharge and Discharge	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	L	L	(-)	(-)	(-)	(-)	(-)	(-)	(-)	L	(-)	(-)	(-)	(-)	(-)	(-)
Changes to Groundwater Elevations, Groundwater Flow Rates, or Groundwater Flow Directions	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	L	L	(-)	(-)	(-)	(-)	(-)	(-)	(-)	L	(-)	(-)	(-)	(-)	(-)	(-)

Notes:

(-) *No spatial or temporal overlap.*

O *Spatial or temporal overlap, but no interaction anticipated OR No change from current condition anticipated, and already captured as part of baseline characterization. No further consideration warranted.*

L *Negligible to minor interaction expected; implementation of best practices, standard mitigation and management measures; no monitoring required, no further consideration warranted.*

M *Potential moderate interaction requiring unique active management/monitoring/mitigation; warrants further consideration.*

H *Key interaction; warrants further consideration.*

6.6.6.4 Proposed Mitigation Measures

Interacting effects on Groundwater Quantity between the Project and agriculture or ranching are expected to be limited to ranching and farming activities within approximately 2 km of the Mine Site. Groundwater supply wells within approximately 2 km of the open pit may need to be deepened or relocated as the result of lower groundwater elevations. Mine infrastructure and the effects on groundwater elevations and groundwater recharge and discharge may need to be considered in water management plans for local groundwater resources.

Groundwater elevation changes due to City expansion are not anticipated to require mitigation. However, if City expansion caused local slope instability, the City could mitigate instability using similar approaches as those used at Aberdeen.

6.6.6.5 Evaluation of Significance of Residual Cumulative Effects

The Groundwater Quantity residual cumulative effects are the same as the residual effects due to the Project alone (Table 6.6-8). Other activities do not contribute additional Groundwater Quantity residual cumulative effects.

6.6.7 Conclusion

Groundwater Quantity was selected as a VC for its importance to humans for drinking water, and livestock and irrigation water and for its importance for ecological and aquatic habitats. The baseline groundwater hydrology assessment identified 13 mapped aquifers and 495 registered water wells in the region (Appendix 6.6-A). The Project is expected to alter groundwater elevations, patterns of groundwater recharge and discharge, and patterns of groundwater flow within approximately 2 km of the Mine Site. Aberdeen is 3 km north of the Mine Site and therefore the Project is predicted to have no effect on piezometric elevations at Aberdeen.

Residual Project effects on Groundwater Quantity occur during Operation, Decommissioning and Closure, and Post Closure. Two residual effects to Groundwater Quantity are predicted:

- increases and decreases to groundwater recharge and groundwater discharge within up to 2 km from the mine facilities; and
- increases and decreases to groundwater elevations within up to 2 km form the mine facilities.

Residual effects to other VCs due to changes in Groundwater Quantity are assessed in the sections that discuss those VCs. The residual effects to Groundwater Quantity are predicted to be not significant (moderate).

Cumulative effects to Groundwater Quantity from existing activities, Project activities combined with future ranching, agriculture, and domestic water use within 2 km of the Mine Site would not be significantly different form the anticipated effects from existing activities and Project activities. Therefore, the residual effects to Groundwater Quantity due to cumulative effects are predicted to be not significant (moderate; Table 6.6-9).

Table 6.6-8. Characterization of Cumulative Residual Effects, Significance, Likelihood and Confidence on Groundwater Quantity

Cumulative Residual Effect	Residual Effects Characterization Criteria							Significance of Adverse Residual Effects	Likelihood and Confidence	
	Magnitude	Duration	Frequency	Geographic Extent	Reversibility	Resiliency	Context		Probability	Confidence
Changes to Magnitude or Timing of Groundwater Recharge and Discharge	Major	Far Future	Continuous	Landscape	Irreversible	Neutral	Neutral	Not Significant (moderate)	High	Medium
Changes to Groundwater Elevations, Groundwater Flow Rates, or Groundwater Flow Directions	Major	Far Future	Continuous	Landscape	Irreversible	Neutral	Neutral	Not Significant (moderate)	High	Medium

Table 6.6-9. Summary of Project and Cumulative Residual Effects, Mitigation, and Significance for Groundwater Quantity

Residual Effects	Project Phase	Mitigation Measures	Residual Effect Significance	Residual Cumulative Effect Significance
Changes to Magnitude or Timing of Groundwater Recharge and Discharge	Operation, Decommissioning and Closure, Post Closure	Water management plan	Not significant (moderate)	Not significant (moderate)
Changes to Groundwater Elevations, Groundwater Flow Rates, or Groundwater Flow Directions	Operation, Decommissioning and Closure, Post Closure	Water management plan	Not significant (moderate)	Not significant (moderate)

6.7 FISH POPULATIONS AND FISH HABITAT

6.7.1 Rationale

This section summarizes the scoping process used to identify Fish and Fish Habitat as a valued component (VC) in the assessment, following the methodology outlined in Section 5. Fish and Fish Habitat was scoped into the environmental assessment based on concerns raised during consultation with Aboriginal communities, government agencies, the public and stakeholders, as well as legislative requirements. Fish and Fish Habitat are affected by surface water and groundwater quality and quantity and have an effect on human and ecological health and land and resource use. The interconnection between the Fish and Fish Habitat VCs and other environmental and Socio-economic VCs are illustrated on Figure 6.7-1. In addition the Supporting Topic - Jacko Lake, Section 8.7, serves to aggregate summaries for all VCs that have potential pathways of effect from the Project on Jacko Lake.

In addition to the linkage between Fish and Fish Habitat to water quality and quantity, other environmental aspects that were considered during the VC screening and selection process were:

- sediment quality; and
- benthic macroinvertebrates.

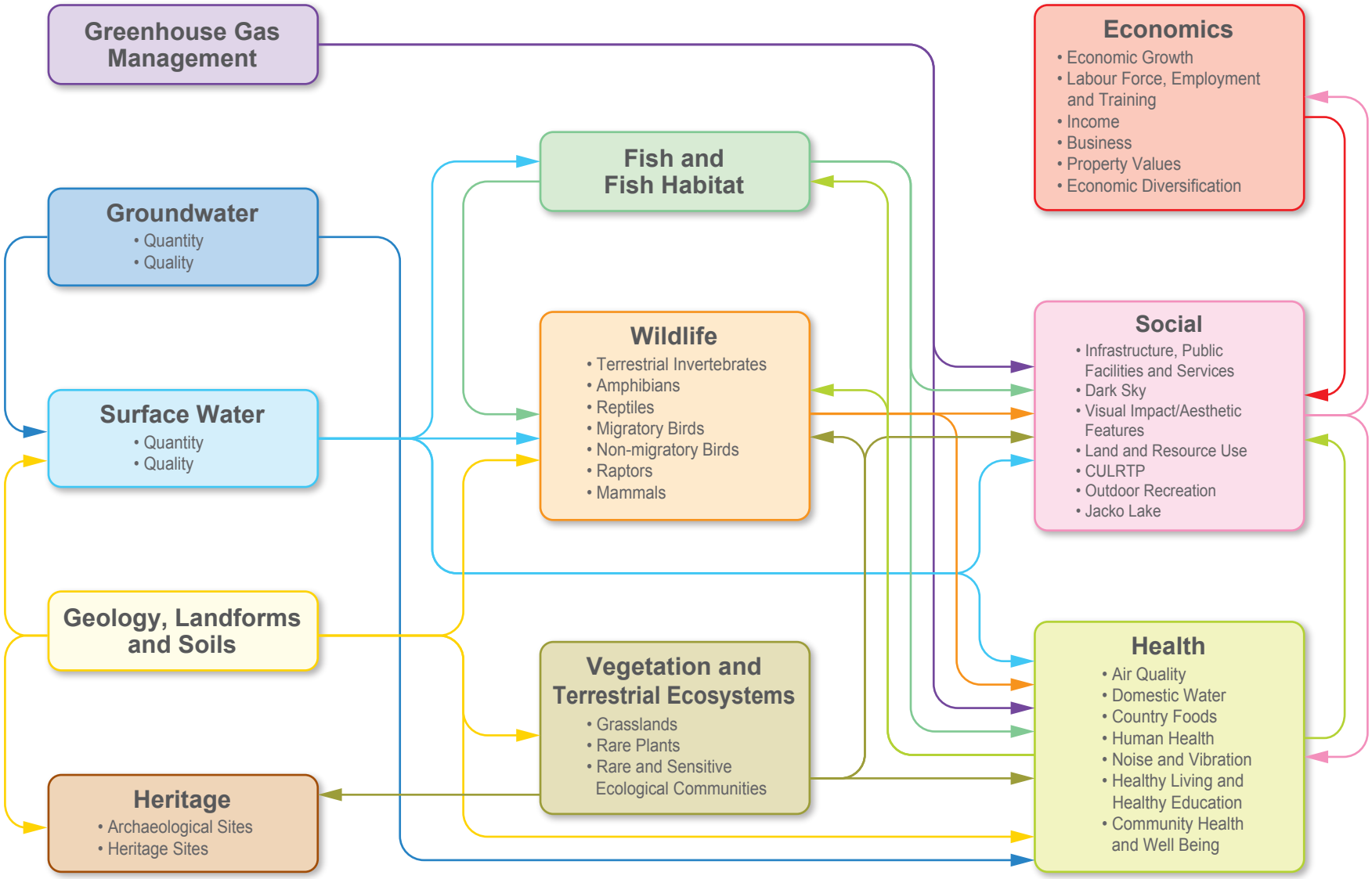
Sediment quality is an important indicator of benthic invertebrate community health. Benthic invertebrate communities are continually exposed to stream conditions in a stream and reflect overall water, sediment, and physical processes in a watershed. Benthic invertebrates have been used as indicators of water quality for over a century and are also used in biomonitoring programs in Canada and the United States. They consume smaller animals and plants, aid in decomposition of organic material, and are an important source of food for fish and other animals. Changes in benthic productivity (food supply) can have a direct effect on fish (abundance, size, accumulation of metals in tissue), which can affect birds and wildlife that consume fish. Therefore it was determined that both sediment quality and benthic macroinvertebrates would be effectively considered within the assessment of the Fish and Fish Habitat VC; therefore they were carried forward as indicators in the assessment.

The first step in determining whether an environmental aspect was a candidate VC was to assess whether there would be a spatial and temporal overlap between the Project and the environmental aspect. Key Project facilities include the Open Pit, Tailings Storage Facility (TSF); Tailings Embankments; four mine rock storage facilities (MRSFs); water management ponds; Peterson Creek diversion, and process plant. The majority of Project facilities will be located within the Peterson Creek watershed. In addition, the Project will require fresh water from Kamloops Lake, requiring construction or upgrade of a water intake on the south shore of Kamloops Lake. The Project therefore has the potential to interact with the Fish and Fish Habitat VC.

Figure 6.7-1

Ajax Project Fish and Fish Habitat Valued Component Interactions

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Concerns about potential effects to fish and fish habitat were raised by government agencies, members of the public and stakeholder groups, and by Aboriginal Groups. The issues and concerns raised by Aboriginal Groups in relation to the Project on their Fishing Asserted Rights and Interests included (Appendix 15-B AMEC Aboriginal Groups Table of issues; meeting minutes April 21):

- potential effects of blasting and vibration on fish and fish habitat in Jacko Lake;
- changes in availability of coho salmon and rainbow trout habitat in Jacko Lake and its outflow, Peterson Creek;
- loss of Aboriginal fishery in Peterson Creek above Bridal Veil Falls
- changes in access to fishing in Jacko Lake; and
- cumulative effects on ability to fish.

The issues and concerns raised by stakeholders and government agencies in relation to the Project included:

- loss of Jacko Lake littoral areas;
- potential effects of blasting in proximity to Jacko Lake on the recreational fishing experience;
- loss of Peterson Creek in the Project area affecting fish productivity in Jacko Lake;
- reduced connectivity between the stocked rainbow trout population in Jacko Lake and the resident population downstream in Peterson Creek; and
- use of Kamloops Lake water.

In addition to concerns raised by the public, stakeholders, government agencies and Aboriginal Groups, the following provincial and federal regulations are designed to protect fish and fish habitat:

- Canada *Fisheries Act* (R.S.C., 1985, c. F-14)
- Canada *Species at Risk Act* (S.C. 2002, c. 29)
- BC *Water Act* (RSBC 1996)
- BC *Water Protection Act* (RSBC 1996)
- BC *Fish Protection Act* (SBC 1997), and
- BC *Environmental Management Act* (SBC 2003).

Sections of the *Fisheries Act* relevant to the Construction, Operation, and Decommissioning and Closure phases of the Project are outlined below.

- Section 35 (1) prohibits a person from conducting any work, undertaking or activity that results in serious harm to fish that are part of a commercial, recreational or Aboriginal fishery, or that support such a fishery unless authorized by the Minister and carried on in accordance with the conditions established by the Minister.
- Section 36 (3) prohibits the deposit of a deleterious substance of any type in water frequented by fish without authorization.

The *Species at Risk Act* (SARA) is designed to prevent wildlife species in Canada from disappearing, and to provide for the recovery of extirpated, endangered, or threatened wildlife species, as well as to manage species of special concern to prevent them from becoming endangered or threatened. The wildlife species at risk are listed in Schedule 1, 2 and 3 of the *SARA*. None of the fish species documented in Kamloops Lake, Jacko Lake or Peterson Creek in the provincial Fisheries Information Summary System database (Ministry of Environment 2015) are on the Schedule 1, 2 or 3 lists.

All water in BC is owned by the Crown and authority to divert and use surface water is obtained by a licence or approval in accordance with the statutory requirements of the *Water Act* and the *Water Protection Act*. A Water Licence Application is assessed to identify potential impacts, including minimum instream flow requirements. A "large scale project" is defined under the *Water Protection Act* as one that can divert or extract a peak instantaneous flow of 10 m^3 or more per second of water. In addition, in order to make changes in and about a stream, approval is required under Section 9 of the BC *Water Act*, or in accordance with Part 7 of the Water Regulation, or under a Water Licence or Order.

Water managers have legislative authority under the BC *Fish Protection Act* to consider impacts on fish and fish habitat before approving new licences, amendments to licences or issuing approvals for work in or near streams. The Act focuses on ensuring sufficient water for fish, protecting and restoring fish habitat, improving riparian protection and enhancement, and providing stronger local government powers in environmental planning. Under Section 4(3) of the *Fish Protection Act,* a person must not construct a bank to bank dam anywhere on a protected river; the North Thompson River, South Thompson River and Thompson River are protected rivers under Section 4(1) of this Act. Under Section 6(1) of this Act the Lieutenant Governor in Council may designate a stream as a sensitive stream if the designation is considered to contribute to the protection of a population of fish whose sustainability is at risk because of inadequate flow or degradation of fish habitat. The Sensitive Streams Designation and Licensing Regulation of the *Fish Protection* Act includes 15 streams in the Schedule of Designated Streams; none of these streams are near the Mine Site.

Section 14(1) of the BC *Environmental Management Act* authorizes the introduction of waste (which includes air contaminants and effluent) into the environment subject to requirements for the protection of the environment.

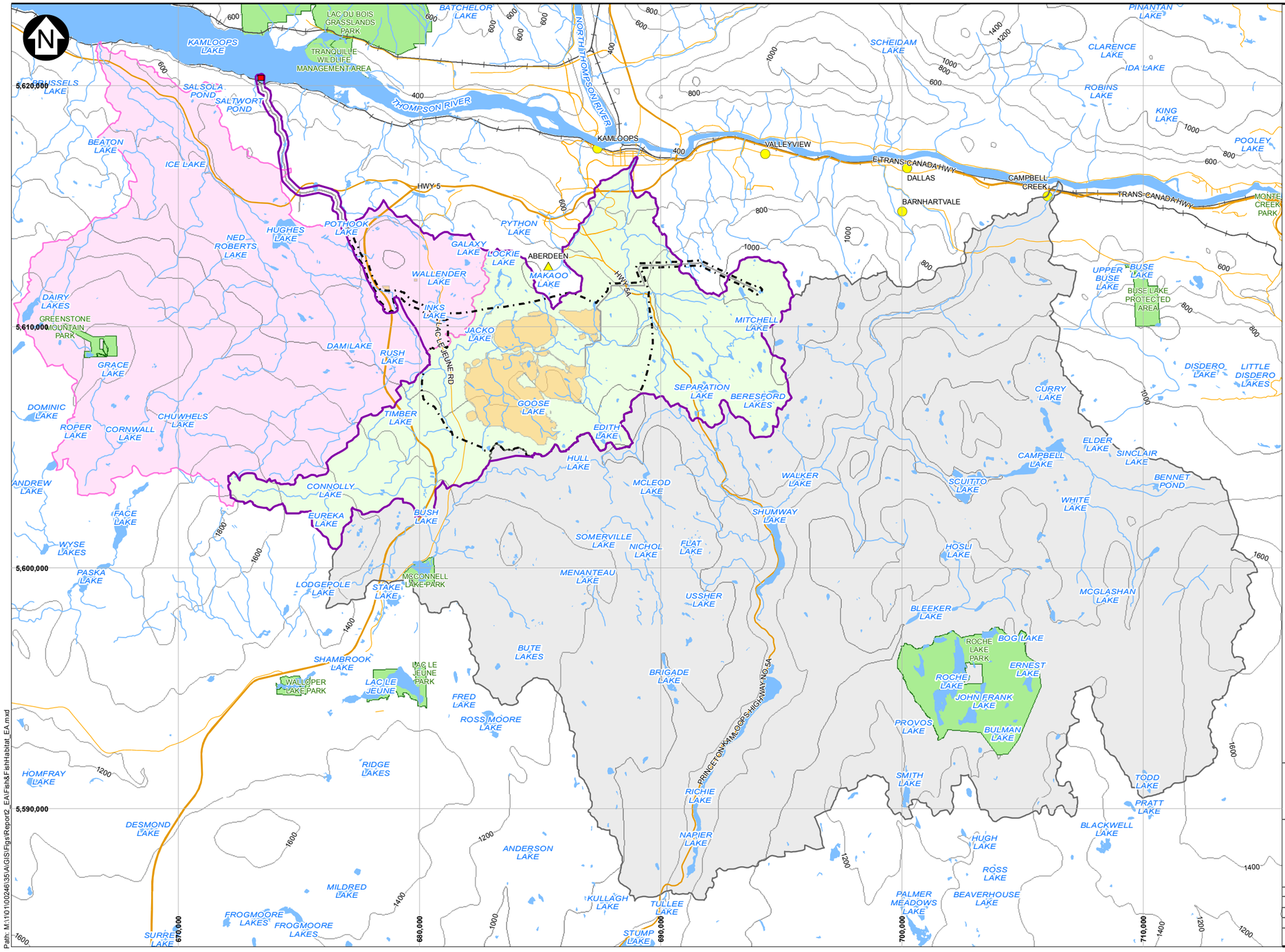
6.7.2 Background

6.7.2.1 Regional Overview

The Ajax Project is located within the Thompson Plateau, which is an extensive elevated region, with either level terrain or nearly uniform summit levels. The Thompson Plateau is located between the Cascade Mountains and Shuswap and Okanagan Highlands within the Kamloops Division of the Yale Land District (Appendix 6.7-A Ajax Project Baseline Fisheries Report). Elevations in the Peterson Creek watershed range from approximately 340 metres above sea level (masl) near the confluence with the South Thompson River to 1,450 masl at its headwaters near Eureka Lake (Appendix 6.7-A). Elevations in the Cherry Creek watershed range from approximately 340 masl near the mouth at Kamloops Lake to 1,450 masl at the creek's headwaters just upstream of Chuwhels Lake (Appendix 6.7-A). The Ajax Project will be primarily within the mid-reaches of the Peterson Creek watershed, in and around Jacko Lake. The Peterson Creek and Cherry Creek watersheds are shown on Figure 6.7-2.

Figure 6.7-2
Fish and Fish Habitat Study Area

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LEGEND:

GENERAL
- CITY/TOWN
- SUBDIVISION
- MAJOR/PAVED ROAD
- CONTOUR (200 M)
- RAILWAY
- EXISTING TRANSMISSION LINE
- RIVER/CREEK
- LAKE
- PROVINCIAL PARK
- CHERRY CREEK WATERSHED
- PETERSON CREEK WATERSHED
- CAMPBELL CREEK WATERSHED

PROPOSED FACILITIES
- INTAKE
- MINE INFRASTRUCTURE
- MINE SITE
- LOCAL STUDY AREA (LSA)
- REGIONAL STUDY AREA (RSA)

NOTES:
1. BASE MAP: BC TRIM AND CANADA NTS MAPPING.
2. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD 1983 UTM ZONE 10N.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:170,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.

SCALE 0 2 4 6 Kilometres

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KGHM Ajax Mining Inc.

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Peterson Creek and Cherry Creek are both within the Thompson River watershed. Kamloops Lake, a riverine lake, is situated downstream of the confluence of the North Thompson and South Thompson rivers. Downstream of Kamloops Lake the Thompson River flows in a southwest direction for approximately 120 km before meeting the Fraser River near the town of Lytton, BC. Kamloops Lake has a surface area of 5584 ha, a maximum depth of 150.9 m, and a mean depth of 74.1 m (Appendix 6.7-B Ajax Project 2014 Fish and Aquatic Baseline Report Update). The residence time of Kamloops Lake has been estimated as eight weeks. Due to the short residence time, seasonally high turbidity, and low available nutrient input, Kamloops Lake has relatively low biological productivity (Appendix 6.7-B). The following fish species are recorded in Kamloops Lake in the provincial database (Appendix 6.7-B):

- chinook (*Oncorhynchus tshawytscha*)
- coho (*O. kisutch*)
- sockeye (*O. nerka*)
- pink (*O. gorbuscha*)
- rainbow and steelhead trout (*O. mykiss*)
- Dolly Varden(*Salvelinus malma*)
- bull trout (*S. confluentus*)
- largescale sucker(*Catostomus macrocheilus)*
- longnose sucker(*C. catostomus*)
- mountain whitefish(*Prosopium williamsoni*)
- northern pikeminnow(*Ptychocheilus oregonensis*)
- burbot(*Lota lota*)
- prickly sculpin(*Cottus asper*)
- redside shiner(*Richardsonius balteatus*)
- peamouth chub(*Mylocheilus caurinus*)
- lamprey (Lampetra spp.)

Most of the angling lakes in the Kamloops region of BC that are 100 m or more above the valley floors of major rivers were originally fishless, with their current trout populations the result of stocking programs (Appendix 6.7-B). Provincial fisheries records indicate that no fish were present in Jacko Lake in 1939; however, anecdotal reports suggest that Jacko Lake was an important rainbow trout fishery before the arrival of Europeans, and that local Aboriginal Groups fished for rainbow trout and kokanee. Rainbow trout are currently the only fish species present in Jacko Lake. Rainbow trout are also currently the only fish species present in Peterson Creek, with the exception of coho salmon fry that have been observed in the area where Peterson Creek is confluent with the South Thompson River (Appendix 6.7-B). Rainbow trout are recorded throughout the Cherry Creek watershed; brook trout are also recorded in Dairy Lake, within the Beaton Creek watershed (a tributary to Cherry Creek), and a single record of a bull trout observation is recorded in a tributary in the headwaters of Cherry Creek (Appendix 6.7-B).

6.7.2.2 Historical Activities

The region surrounding the Project has a long history of human activity that contributes to the current 'baseline' condition, which is defined more specifically in the following section of this assessment. Kamloops derives its name from the Secwepemc word "Tk'emlúps", which refers to the meeting of the North and South Thompson rivers. The area was first inhabited by approximately 3,000 members of the Shuswap tribe, part of the Interior Salish Nation. Fur trading began in the area in the early 1800s. The fur trading posts were located in various locations in what is now Kamloops. This area has been identified as an area where rainbow trout were caught early in the season by the SSN in order to supplement protein stocks for the community.

British Columbia officially became part of Canada in 1871, and construction of the transcontinental railroad was completed in 1885, encouraging the growth of a small village on the shore of the Thompson River. The village grew rapidly and by 1893 the population had risen to approximately 500 and became incorporated as a city with public works. In the following years, there were a number of infrastructural developments, including bridges that connected villages on either side of the rivers. During this time, the timber industry was growing, and the vegetable and orchard farming industry grew, with most of the land used for this purpose located in the valley. The Canadian Northern Railway was completed in 1915, and the Kamloops airport was operational in 1939. The Trans-Canada Highway to the west of the Project area was completed in 1962, and the Yellowhead Highway in 1970. The Kamloops area grew after the First World War until development slowed during the Depression and the Second World War. After this period, the City began to grow again, and much of the land that had formerly been used for farming in the valley was used for residential development. Ranching (including cattle grazing) also developed, and is currently ongoing immediately within and adjacent to the Project.

The Project is located within the Kamloops Forest District, which is part of the Kamloops Timber Supply Area (TSA). Tree-killing bark beetles (including mountain pine beetle, spruce beetle, and Douglas fir beetle) continue to pose a threat to the forests. The Project is located in the Greenstone Beetle Management Unit, where more than 30% of the area is identified as susceptible to the mountain pine beetle. In response to the pine beetle, in 2008, the Annual Allowable Cut for the TSA was determined to be 4 million cubic metres; this harvest level (and priority for beetle management) will remain in place until 2018 unless otherwise altered.

The Domtar Pulp Mill is located immediately west of Kamloops on the Thompson River. This pulp mill was originally built by Weyerhaeuser in 1972 and became part of Domtar in 2007. Numerous capital improvements have been made to the mill over the years. One of the pulp lines was closed in 2013; Domtar reports that this closure has corresponded with a significant reduction in odour complaints, and in particulate emissions (Domtar, 2014).

Mining activity in the Project area can be traced back over 100 years with exploration in the Project area beginning in the 1880s and continuing intermittently to present. Copper, gold, and iron mineralization was discovered at the Iron Mask Mine near Kamloops in 1896. Nearby properties (including the Wheal Tamar, Ajax, and Monte Carlo claims) were explored in the following years.

The Afton Mine went into operation in 1977. Mining operations were initiated on the Ajax East and Ajax West pits in 1989 and subsequently suspended in 1991 due to depressed metal prices. A second

period of production began in 1994 and was again suspended in 1997. The raw ore from the Ajax pits was trucked approximately 10 km west to the processing plant adjacent to the Afton pit. During these periods of production, it is estimated that 17 Mt of ore was mined and 13 Mt of ore was milled. In the late 1990s, the tailings facility and project components were decommissioned and reclaimed by the Afton Mine in accordance with their closure plan. At the Ajax site, this includes reclaimed waste rock dumps adjacent to Peterson Creek in the location of the proposed Ore Stockpiles.

The New Afton Mine occupies the site of the historic Afton Mine infrastructure. New Afton began underground mining immediately beneath the historic Afton Mine open pit in June 2012. This mine is able to produce up to 11,000 tonnes per day of raw ore though the processing plant. Currently the mine is licenced to draw up to approximately 7,000 m^3/d from Kamloops Lake for water supply to the processing plant. An application to withdraw an additional approximately 5,000 m^3/d is currently in review.

6.7.2.3 Baseline Studies

Fish, fish habitat, and aquatic resource baseline studies were conducted for the Project from 2007 to 2011 (Appendices 6.7-A and 6.7-C Ajax Project Aquatic Ecology Baseline Report) and in 2014 (Appendix 6.7-B) to characterize existing conditions and support the effects assessment. The objectives of the studies were to:

- determine fish presence, community composition, and distribution in streams and lakes in the vicinity of the Project;
- characterize existing physical habitat for stream and lake resident fish;
- assess abundance and diversity of primary producers (photosynthetic organisms such as periphyton in streams and phytoplankton in lakes) and secondary producers (such as aquatic macroinvertebrates and zooplankton);
- document metal concentrations in fish tissue and sediment; and
- provide a benchmark for evaluating the potential effects of the Project.

Baseline methods as described in the Application Information Requirements / Environmental Impact Statement Guidelines (AIR/EISG) were followed.

Data Sources

The following data sources were consulted in the design and support of the baseline studies:

- Aboriginal traditional knowledge (Section 8.5);
- BC Ministry of Environment (MOE) Fisheries Information Summary System database;
- BC MOE Ecological Reports Catalogue;
- Fisheries and Oceans Canada WAVES online catalogue; and
- DataBC iMapBC 2.0.

In addition, Official Community Plans, Land and Resource Management Plans, and current or certified projects listed in the BC Environmental Assessment Office Project Information Centre in the Kamloops region were reviewed for any additional fisheries and aquatics information.

Methods

The methods used for collection of fish, fish tissue, sediment, phytoplankton, zooplankton, and benthic macroinvertebrates were adapted from the following provincial guidance documents and standards:

- Freshwater Biological Sampling Manual. 1997. Cavanagh, N., R.N. Nordin, and P. D. Warrington. Prepared for Ministry of Environment, Lands and Parks, Water Management Branch.
- Lake and Stream Bottom Sediment Sampling Manual. 1997. Published by the Resources Inventory Committee.
- Water and Air Baseline Monitoring Guidance Document for Mine Proponents and Operators. 2012. Ministry of Environment.
- Reconnaissance (1:20,000) Fish and Fish Habitat Inventory Standards and Procedures. 2001. BC Fisheries.
- Fish Collection Methods and Standards. Version 4. 1997b. Ministry of Environment, Lands and Parks.
- Assessment Methods for Aquatic Habitat and Instream Flow Characteristics in Support of Applications to Dam, Divert, or Extract Water from Streams in British Columbia. 2004. Lewis, A., T. Hatfield, B. Chilbeck, and C. Roberts.
- Watershed Restoration Program Fisheries Habitat Assessment Procedures. 1996. Johnson, N.T. and P.A. Slaney.

The following methods were used to capture fish in the streams and lakes:

- Electrofishing was conducted in streams and along the shallow margins of lakes and ponds using a Smith Root Model 12-B POW or Model LR-24 backpack electrofisher. Electrofisher voltage, duty cycle, and frequency settings varied between the sample sites and dates, and were dependant on water chemistry (temperature and conductivity) and size of fish present in each system.
- Minnow traps were used in pools and back eddies of creeks and along the shallow margins of lakes and ponds. Standard Gee Minnow traps measuring 41.9 cm long and 22.9 cm wide with 6.4 mm metal mesh and a 2 cm diameter opening were baited with dry cat food and left to soak overnight.
- Gill nets were used to capture fish in the small lakes and were set for three hours or less and monitored frequently to minimize mortality. The gill nets consist of single or multiple panels of monofilament mesh with stretched mesh sizes between 25 mm and 76 mm. Each panel is 15 m long by 2.4 m deep.
- A Fyke net with 7.5 meter wings and 5 meter lead net was used to passively capture fish moving along lake shorelines.

Collection of sediment and aquatic biota used the following methods:

- Sediment sampling in creeks and from the nearshores of shallow lakes involved collecting grab samples from the top 10 cm of the creek bed using an open ended jar and stainless steel spatula to isolate the sample and prevent fines from escaping. Three to five replicates were collected from each site, with each replicate consisting of a composite of a minimum of three grabs.
- Sediment samples from deep lake basins were collected using a 15 cm by 15 cm brass Ekman grab sampler deployed over the side of an aluminum or inflatable boat. The grab sampler was lowered slowly over the side of the boat using a nylon line and sunk slightly into the substrate; a "messenger" relayed down the rope triggered the jaws of the sampler to close and isolate the sample inside. The grab was then slowly raised back into the boat. The number of replicates collected at each site varied between years, but was typically three to five, with each replicate consisting of a composite of a minimum of three grabs.
- Benthic macroinvertebrates were collected from riffles in stream sites using a 30 cm x 30 cm Surber sampler with 210 micrometre (µm) mesh. The number of replicates collected at each site varied between years, but was typically three to five, with each replicate a composite of three Surber samples.
- Benthic macroinvertebrates from lake substrates were collected using a 15 cm by 15 cm brass Ekman grab sampler deployed from a boat. The Ekman jaws with the sediment sample were opened over a 500 µm mesh sieve box in the boat and the sediment was gently washed through the mesh using lake water; the benthic organisms that remained on the mesh were collected. The number of replicates collected varied between years, but was typically three to five, with each replicate a composite of three Ekman samples.
- Periphyton samples were collected from cobbles and boulders in streams by scraping the attached growth within a 4.91 square centimetre (cm^2) disc. Five replicates were collected within each site, with three subsamples making up each replicate.
- Phytoplankton samples were collected from deep lake sites using a vertical Van Dorn bottle deployed over the side of an aluminum or inflatable boat using a nylon line. Once the Van Dorn bottle reached the desired depth a "messenger" relayed down the rope triggered the ends of the sampler to close and isolate the water sample inside. Phytoplankton samples were collected from shallow lake sites using a 1 litre (L) bottle grab sample.
- Zooplankton samples were collected from a boat using a vertical plankton tow net with a mesh size of 256 µm and an opening of 20 cm. Three sub-samples were collected and composited per site.

The methods used for collection of fish, fish tissue, sediment, phytoplankton, zooplankton, and benthic macroinvertebrates are described in detail in Appendices 6.7-A, 6.7-B, and 6.7-C.

Characterization of Fish and Fish Habitat Baseline Condition

Fish Presence and Habitat Quality

Jacko Lake and Peterson Creek

The results of baseline studies specific to Project components and activities for fish and fish habitat, and aquatic resources are summarized in this section. Fish and fish habitat sampling sites within the

Peterson Creek watershed are described in Table 6.7-1 and shown on Figures 6.7.3-1 to 6.7.3-4. The majority of monitoring sites were established within and adjacent to the Project footprint, known as the Local Study Area (described in Section 6.7.3). Detailed results of sampling at sites within and downstream of the LSA and at control sites in the Cherry Creek watershed and Anderson Creek watershed are presented in Appendices 6.7-A, 6.7-B, and 6.7-C.

Rainbow trout are currently the only fish species present in Jacko Lake and in Peterson Creek within the Ajax Project area. Anecdotal records indicate that Jacko Lake has been impacted by human activity since at least 1925 with construction of the Jacko Lake dam. Bathymetric mapping from 1950 shows a small lake with a perimeter of 3700 m and surface area of 40 hectare (ha). The lake was raised sometime in the 1960s or 1970s and updated mapping from 1978 shows an expanded lake, with the creation of the northeast and southeast arms and expansion of the two westerly arms. During the 1978 survey Jacko Lake had a perimeter of 4925 m and surface area of 46.7 ha. The outlet dam was raised again in 1990 by Afton Operating Corporation as mitigation for development of the Ajax East and Ajax West pits adjacent to Jacko Lake. At the current maximum water elevation the lakeshore perimeter is 5120 m and the surface area is approximately 51.0 ha. In addition to raising the outlet dam as mitigation to compensate for mining impacts, Afton Operating Corporation dredged the lake discharge channel to increase storage capacity and lined a 1,000 m section of Peterson Creek to reduce water losses to seepage. The dredging and channel lining were completed in fall 1990.

When lake water surface elevations are at full pool, the northeast arm has a maximum depth of 2 m. The lake substrate is comprised of loosely consolidated fines and the lake shore is populated with cattails, bulrushes and sedge grasses (Knight Piésold Ltd. 2013). This region of the lake does not harbour any significant floating aquatic vegetation nor are there any significant collections of woody debris (Knight Piésold Ltd. 2013).

The first record of fish stocking in Jacko Lake was in 1954, and stocking has occurred annually with few exceptions since then. Recent releases have been a mix of diploid (fertile) and triploid (sterile) fish, as well as some all-female strains. The triploid and all-female strains are stocked to improve the recreational fishery, as triploid fish potentially live longer, thereby resulting in larger fish, and all-female strains minimize interactions with wild fish populations. Rainbow trout from Jacko Lake are able to access Peterson Creek downstream of the lake only when lake water levels exceed the dam spillway elevation during high flow events. Large-bodied, mature rainbow trout from Jacko Lake have been captured or observed in the channel downstream of Jacko Lake for a distance of 400 m, and in a short alluvial section of the creek between two wetland areas approximately 3 km downstream. Fish are stranded in the creek when the spillway ceases flowing, as there is no means of upstream fish passage over the dam. Peterson Creek within the Project area downstream of Jacko Lake offers marginal rainbow trout spawning and rearing habitat due to the high silt content of the substrate, lack of instream cover and low channel complexity, minimal riparian habitat, and high summer water temperatures and low dissolved oxygen concentration due to low flows. Rainbow trout in Peterson Creek in the proposed Project area therefore do not support a recreational fishery or contribute to the productivity of the Jacko Lake rainbow trout population.

Table 6.7-1. Peterson Creek Macroreach and Sample Site Locations

Fish Sampling & Habitat Assessment Sites	Macro Reach	Description	River Distance (km)	Elevation (m) Downstream - Upstream	Gradient (%)	Sinuosity	Channel Type
PC-AL-01 (2007-08)	1	From confluence with South Thompson River upstream to Columbia Street in downtown Kamloops - majority of creek flows underground.	0 - 1.2	339 - 384	3.6	n/a	Underground Alluvial Irregular
PC-AL-02 (2007-2008) PC-01 (2014)	2	Within downtown Kamloops - linear and industrial commercial along each bank. Upstream reach break at confluence with unnamed first order tributary from west.	1.2 - 1.9	384 - 405	3.3	1	Alluvial Irregular
N/A	3	High gradient, confined section; Bridal Veil Falls within reach	1.9 - 3.1	405 - 549	11.1	1.1	Rock Alluvial Irregular
PC-AL-04 (2008, 2010-11) PC-04 (2014)	4	Meandering channel; confined and entrenched sections; upper end of macroreach near Highway 5A	3.1 - 7.0	549 - 762	5.5	1.3	Alluvial Irregular
PC-AL-03 (2011) PC-AL-06 (2011) PC-AL-08 (2007-08, 2010-11) PC-2.8 (2014) PC-03 (2014) PC-06 (2014) PC-08 (2014)	5	Low gradient, unconfined sinuous channel flowing through agricultural areas; Jacko Lake at upper end	7.0 - 17.6	762 - 892	1.30	1.2	Alluvial Irregular
JACL-TN (2010) JACL-GN-F (2010) JACL-GN-S (2010) JACL-MT 01 - 04 (2007-08, 2010) JACKO-GN-01 (2014) JACKO-GN-02 (2014)	6	Jacko Lake	17.6 - 18.5	892 - 892	0.00	1.0	Lake
PC-10 (2014) PC-15 (2014)	7	Upstream of Jacko Lake to confluence with Jacko Creek; meandering channel, unconfined	18.5 - 21.2	892 - 920	0.8	1.5	Alluvial, Irregular

Notes:

[1] Abbreviations: PC: Peterson Creek; AL: Aquatic Life; JACL: Jacko Lake; TN: trap net; GN: gill net; MT: minnow trap

Small-bodied, stream-resident rainbow trout populations in Peterson Creek are limited to the open section of the creek flowing through downtown Kamloops, and the confined section of the creek above Bridal Veil Falls within Peterson Creek Park. It is likely that the stream-resident rainbow trout population above Bridal Veil Falls was initially established and continues to be maintained by juvenile rainbow trout from Jacko Lake being displaced downstream during high flow events that provide water flow (and fish passage) over the dam spillway. Juvenile coho salmon have been observed in Peterson Creek at the confluence with the South Thompson River.

Peterson Creek in downtown Kamloops and in the confined section above Bridal Veil Falls has ample cover in the form of riparian vegetation, undercut banks, large woody debris, pocket pools; defined and stable banks; continuous flow; and substrate comprised of cobbles, boulders, and gravel. Peterson Creek in the LSA has undefined banks, with little instream cover, channel complexity, or riparian vegetation. The substrate in Peterson Creek in the LSA is dominated by a thick layer of silt. Flow is ephemeral in Peterson Creek due to naturally low flows exacerbated by storage of water in Jacko Lake for irrigation and conservation (Section 6.4).

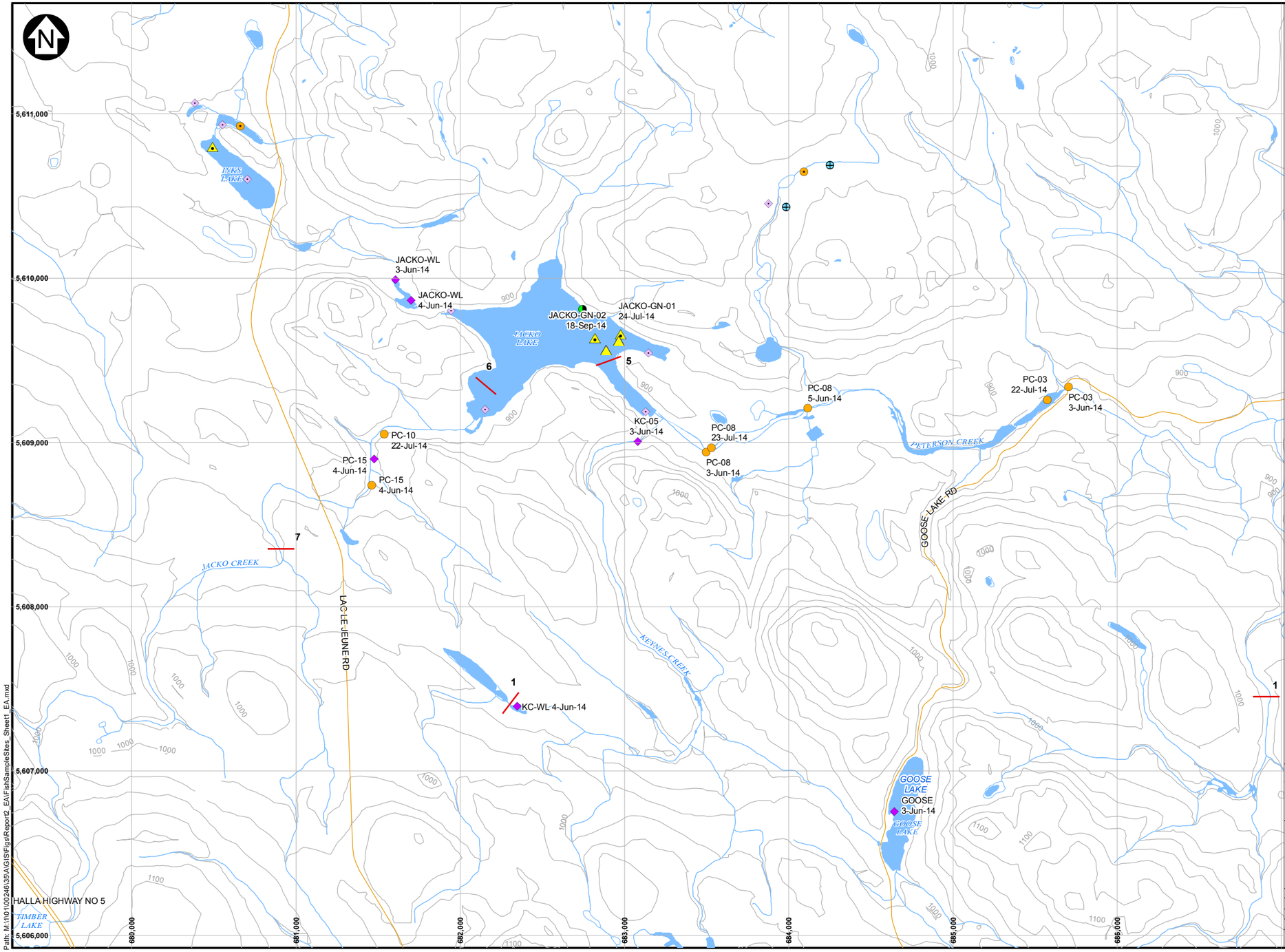
Water temperature has been measured at the Project water quality monitoring sites since 2007 (Section 6.3). Water temperature in Peterson Creek at all of the monitoring sites typically exceeds the upper optimum rainbow trout incubation temperature of 12°C by May of each year, and exceeds the optimum spawning temperature of 15.5°C by late May or early June. The upper optimum rearing temperature of 18°C is exceeded in some years between July and September.

Edith Lake

Edith Lake is the headwater lake of Humphrey Creek, a tributary of Peterson Creek downstream of Jacko Lake. The Edith Lake Dam located at the outlet serves as an irrigation weir and discharges to Humphrey Creek when additional flows are required for irrigation for water licence holders on Peterson Creek and Humphrey Creek. Rainbow trout were originally stocked in Edith Lake in 1950, were stocked intermittently between 1991 and 1994, and have been stocked annually since 1995. Eastern brook trout were originally stocked in Edith Lake in 1965, and have been stocked annually since 1978. Since 2010, all-female triploid eastern brook trout, and triploid and all-female triploid rainbow trout strains have been released into Edith Lake. No fish are reported to occur in Humphrey Creek in the provincial fisheries database, and no sampling has been conducted as part of the Project studies due to the narrow channel and low flows. During field studies in 2014, Humphrey Creek had no surface connection to Peterson Creek, with flow instead fanning out over a grassy swale before seeping into the ground approximately 70 m from Peterson Creek.

Baseline information collected to date suggests that Edith Lake contains productive fish habitat. Due to the lack of fish presence within Humphrey Creek and the lack of surface connectivity to Peterson Creek and Edith Lake, and low flows, Humphrey Creek is considered non-fish bearing.

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LEGEND:

GENERAL
- UPPER REACH BREAK
- RIVER/CREEK
- CONTOUR (20 m)
- ROAD
- LAKE

FISH AND FISH HABITAT SAMPLE SITES 2014
- ELECTROFISHING
- GILL NETTING
- MINNOW TRAPPING SITE

FISH AND FISH HABITAT SAMPLE SITES 2007 - 2011
- ELECTROFISHING
- GILL NETTING
- MINNOW TRAPPING
- SEINE NETTING
- TRAP NETTING

NOTES:
1. BASE MAP: BC TRIM AND CANADA NTS MAPPING.
2. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD 1983 UTM ZONE 10N.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:25,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.

SCALE 0 0.2 0.4 0.6 0.8 Kilometres

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KGHM Ajax Mining Inc.

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Knight Piésold CONSULTING

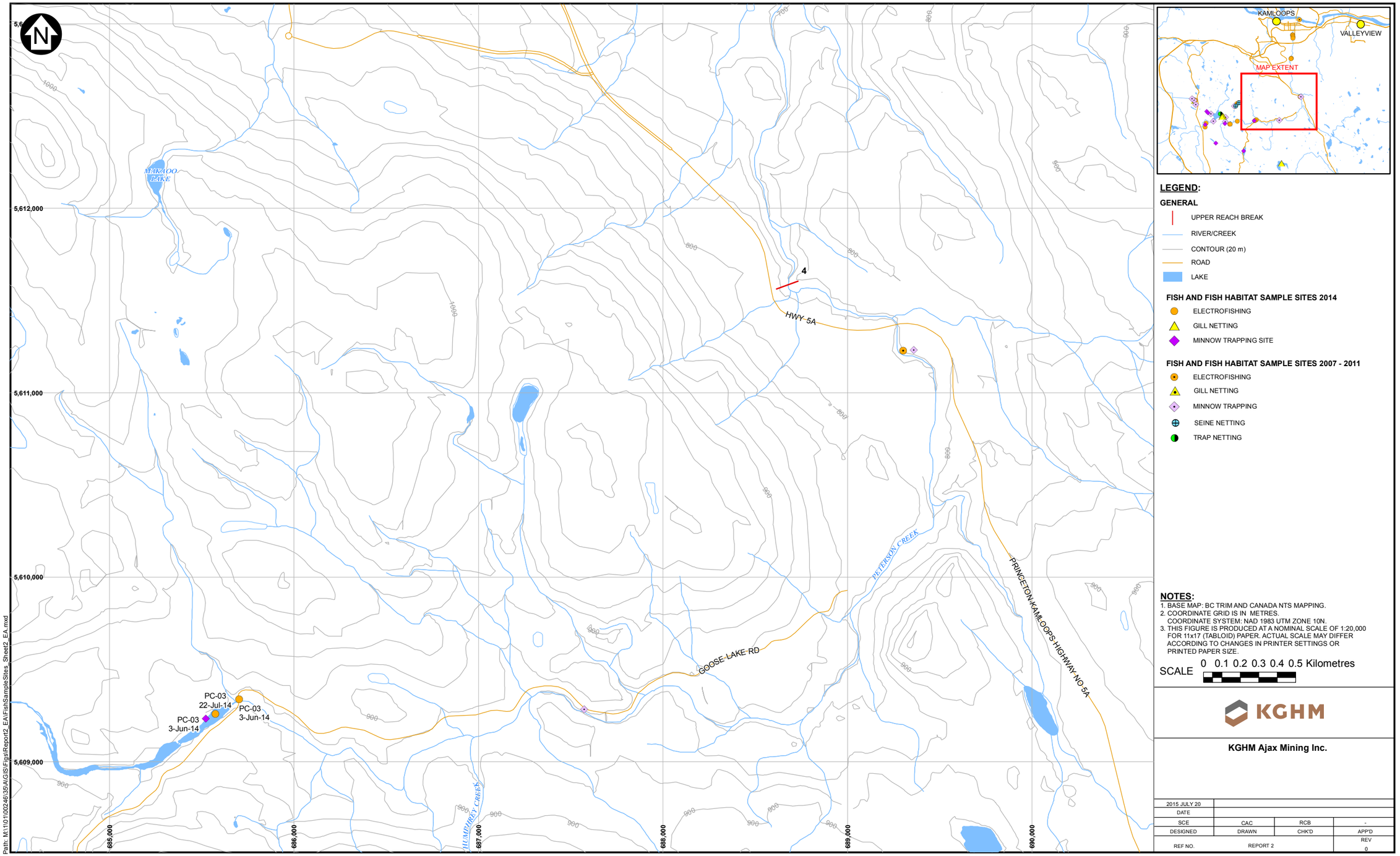
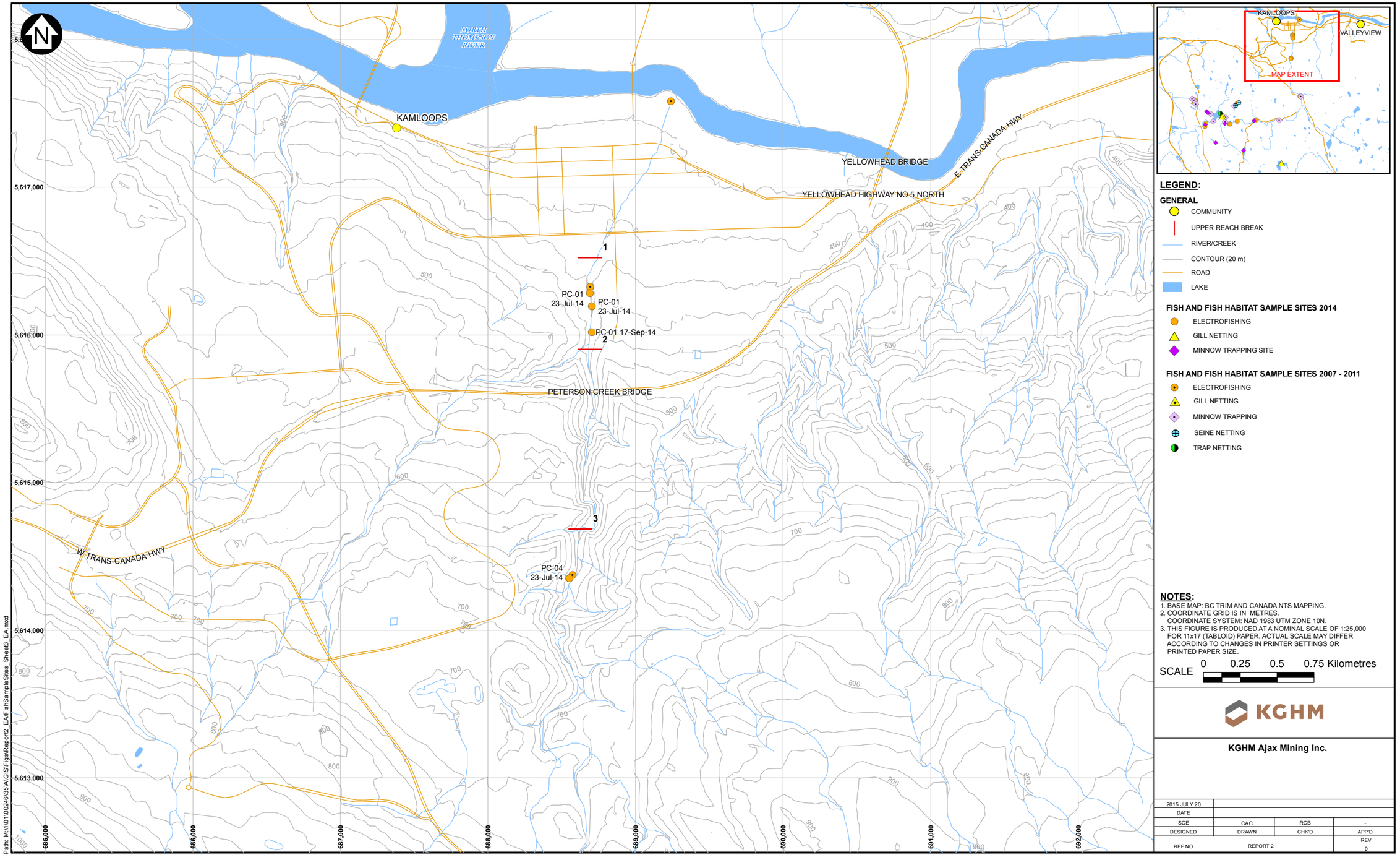


Figure 6.7.3-3
Peterson Creek Watershed Reaches and Fish and Fish Habitat Sample Sites - Sheet 3 of 4

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LEGEND:

GENERAL
- COMMUNITY
- UPPER REACH BREAK
- RIVER/CREEK
- CONTOUR (20 m)
- ROAD
- LAKE

FISH AND FISH HABITAT SAMPLE SITES 2014
- ELECTROFISHING
- GILL NETTING
- MINNOW TRAPPING SITE

FISH AND FISH HABITAT SAMPLE SITES 2007 - 2011
- ELECTROFISHING
- GILL NETTING
- MINNOW TRAPPING
- SEINE NETTING
- TRAP NETTING

NOTES:
1. BASE MAP: BC TRIM AND CANADA NTS MAPPING.
2. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD 1983 UTM ZONE 10N.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:25,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.

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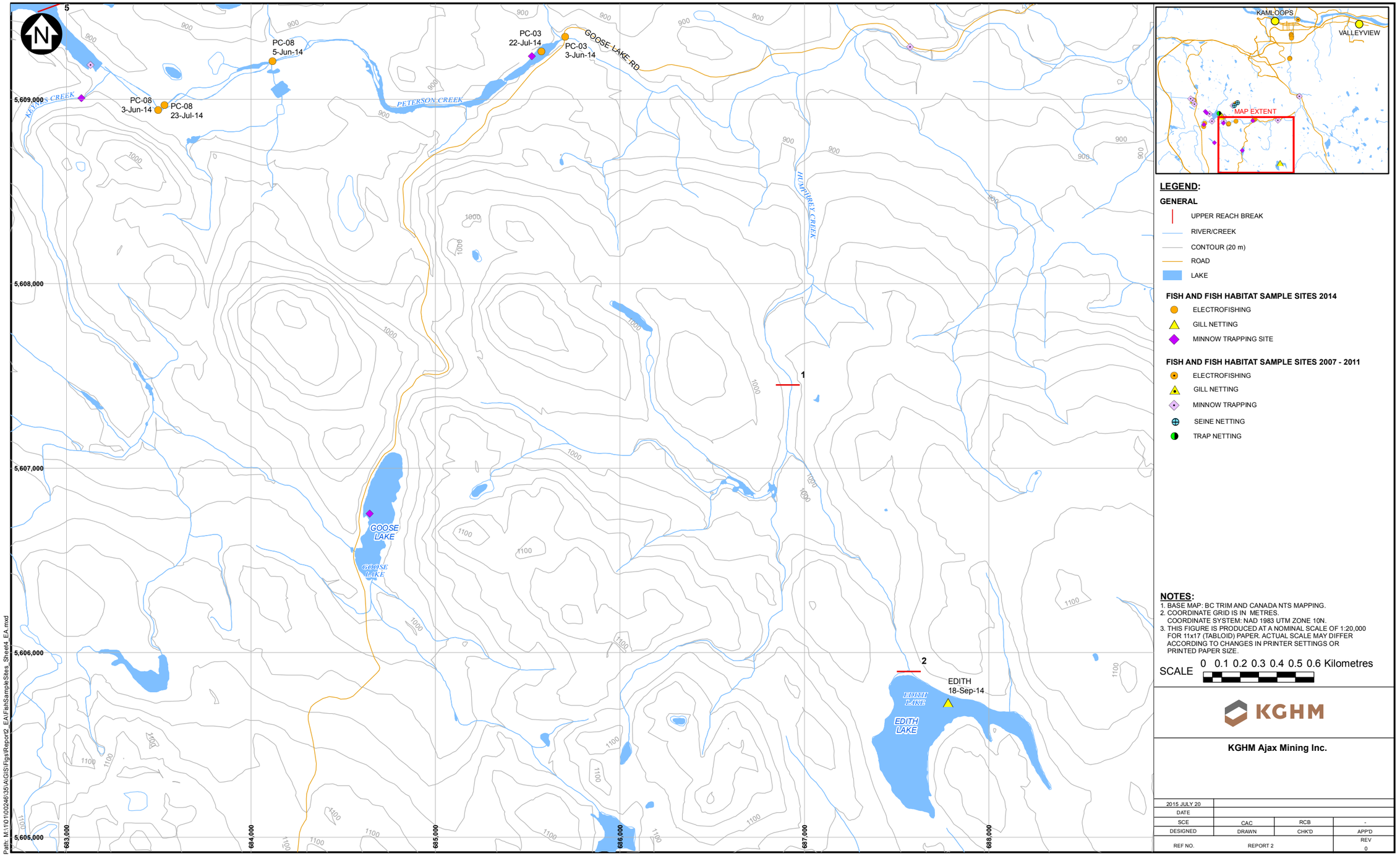
KGHM Ajax Mining Inc.

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Figure 6.7.3-4
Peterson Creek Watershed Reaches and Fish and Fish Habitat Sample Sites - Sheet 4 of 4

Knight Piésold CONSULTING



NOTES:
1. BASE MAP: BC TRIM AND CANADA NTS MAPPING.
2. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD 1983 UTM ZONE 10N.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:20,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.

SCALE 0 0.1 0.2 0.3 0.4 0.5 0.6 Kilometres

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KGHM Ajax Mining Inc.

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Keynes Creek

Provincial mapping shows an unnamed, second order creek, locally known as Keynes Creek, flowing into Peterson Creek at the downstream end of the Jacko Lake spillway. Goose Lake is mapped as the headwater lake of a tributary to Keynes Creek. No channel bed has been observed at the location where Keynes Creek is reportedly confluent with Peterson Creek and no alluvial material or signs of scour have been observed in the vicinity. Keynes Creek lacks a continuous channel bed (intermittent). As noted in Section 6.4, Keynes Creek at the hydrology monitoring site has a narrow channel with organic substrate, and was dry from mid-June through October. Fish sampling was challenging due to the low flow and shallow depths when water was present. No fish were captured or observed in Keynes Creek, Goose Lake, or in an isolated wetland within the Keynes Creek upper reaches during sampling in 2014, and there are no records of fish present in the system in the provincial database.

Based on the lack of defined channel and low flow, and the fact that this tributary shows no surface connection to Peterson Creek, Keynes Creek is considered non-fish bearing.

Goose Lake

Goose Lake is a small, shallow lake (average depth estimated as 1 m) with a north-south orientation on an unnamed tributary to Keynes Creek. The unnamed tributary is a non-classified drainage as it does not have a continuous channel bed or definable, visibly continuous banks. At the time of the field survey in June the channel was approximately 20 cm wide and the water was 2 cm deep. Provincial mapping indicates that an outlet channel is present at the southwest end of Goose Lake; however, no defined alluvial channel has been observed. Dissolved oxygen, pH, chloride, sulphate, ammonia, and dissolved arsenic are outside the respective recommended guidelines for aquatic life. There are no provincial records of fish in either Keynes Creek or Goose Lake, and no fish have been captured during the baseline program. Goose Lake is considered non fish bearing.

Kamloops Lake

Kamloops Lake near the proposed intake site, approximately 10 km west of Kamloops, has a steep rip-rap embankment and an un-vegetated mixed boulder and cobble shoreline with no aquatic macrophytes. Due to the large size of substrates along the shoreline the area provides poor quality spawning habitat for most species of fish. Substrate below the low water level is composed of very fine, mobile sediments. The only fish captured by minnow trapping and electrofishing in 2011 were northern pikeminnow, sculpins, and lamprey (as described in Appendix 6.7-B). Kamloops Lake is considered productive fish habitat.

No fish or aquatic sampling related to the Project has been conducted in Kamloops Lake because the fish presence and assemblages for this waterbody are well documented.

Metal Concentrations in Fish Tissue

Jacko Lake and Peterson Creek

Rainbow trout were captured from Jacko Lake and Peterson Creek for measurement of metal concentrations in liver, muscle, and whole-body samples. Analytical results were compared to fish tissue guidelines for human consumption for lead, mercury, and selenium, and for wildlife consumption for methyl mercury (Table 6.7-2).

Table 6.7-2. Average Tissue Metals Concentrations (2014) Compared to Guidelines for Consumption

Parameter	Fish Tissue Guidelines	PC-01			PC-04		PC-10		JACL			EDITH
		Liver	Muscle	Whole Body	Liver	Muscle	Liver	Muscle	Liver	Muscle	Whole Body	Whole Body
Aluminum		42.50	<1.0	20.51	<1.0	<1.0	<1.0	<1.0	8.70	<1.0	4.38	2.23
Antimony		0.0068	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Arsenic		0.19	0.05	0.07	0.171	0.170	0.170	0.0321	0.049	0.0249	0.06	0.0382
Barium		0.719	0.030	0.788	0.074	0.023	0.061	0.034	0.093	0.027	1.163	0.329
Beryllium		0.0021	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Bismuth		<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Boron		<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Cadmium		0.1383	0.0070	0.0146	0.1443	0.0087	0.0286	<0.0020	0.0022	<0.0020	<0.0010	0.0013
Calcium		454	393	8387	317	230	399	342	355	280	5986	3728
Cesium		0.0057	0.0031	0.0040	0.0038	0.0049	0.0013	<0.0010	0.0021	0.0016	0.0033	0.0052
Chromium		0.376	4.130	0.077	<0.040	<0.040	<0.040	<0.040	0.0410	<0.040	0.018	0.019
Cobalt		0.183	0.041	0.08	0.18	0.0356	0.07	0.0209	0.02	<0.0040	0.02	0.0133
Copper		112	0.429	2.02	104	0.515	121	0.404	38	0.243	1.65	0.712
Iron		252	9	46	195	4.7	180	5.4	177	2.3	15.9	14.1
Lead	0.8 (1)	0.042	<0.010	0.01	0.077	<0.010	<0.010	<0.010	0.332	0.21	0.147	0.0077
Lithium		<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Magnesium		287	244	393	255	257	339	248	194	248	346	292
Manganese		2.53	0.24	1.84	1.40	0.154	2.56	0.183	1.46	0.129	1.40	0.95
Mercury	0.5 - 0.1 (2)	0.05	0.03	0.03	0.0480	0.0389	0.0878	0.0667	0.1155	0.0626	0.103	0.0701
Methyl Mercury	0.033 (3)	n/a	0.0179	0.0262	0.0233	0.02		0.04	0.0773	0.04	0.0974	0.0475
Molybdenum		0.3157	0.0572	0.0219	0.2280	<0.0080	0.2575	<0.0080	0.1580	<0.0080	0.0139	0.0072
Nickel		0.216	1.530	0.083	0.080	<0.040	0.065	<0.040	<0.040	<0.040	<0.040	<0.040
Phosphorus		2930	2080	6867	3130	2190	4110	2200	2935	2315	5252	4289
Potassium		3397	4057	3400	3127	4040	6080	4345	3240	4150	3603	3436

(continued)

Table 6.7-2. Average Tissue Metals Concentrations (2014) Compared to Guidelines for Consumption (completed)

Parameter	Fish Tissue Guidelines	PC-01			PC-04		PC-10		JACL			EDITH
		Liver	Muscle	Whole Body	Liver	Muscle	Liver	Muscle	Liver	Muscle	Whole Body	Whole Body
Rubidium		0.547	0.508	0.427	0.486	0.503	0.352	0.254	0.484	0.452	0.539	0.617
Selenium	4 (4)	42.0	1.2167	1.83	24.0	0.683	11.4	0.480	3.6	0.141	0.47	0.2241
Silver		0.4063	<0.0010	0.0044	0.414	0.0014	0.156	<0.0010	0.033	<0.0010	0.0015	0.0010
Sodium		1250	656	1072	1237	580	1995	618	1065	417	727	642
Strontium		2.19	1.3747	22.67	1.138	0.520	0.450	0.308	0.582	0.398	12.5	6.53
Tellurium		0.0053	<0.0040	<0.0040	0.0110	<0.0040	0.0079	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040
Thallium		0.0334	0.0020	0.0033	0.0320	0.00279	0.0076	0.00061	<0.00040	<0.00040	<0.00040	<0.00040
Tin		<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Titanium		3.10	<0.10	2.4167	0.20	<0.10	<0.10	<0.10	<0.10	<0.10	0.681	0.484
Uranium		0.0120	0.0006	0.0129	0.0006	<0.00040	0.0004	<0.00040	<0.00040	<0.00040	0.0027	0.0011
Vanadium		0.171	0.023	0.1103	0.03	<0.020	0.03	<0.020	<0.020	<0.020	0.031	0.066
Zinc		52.0	7.68	35.0333	34.7	4.95	74.0	6.81	28.5	4.41	21.3	17.32
Zirconium		0.090	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040

Notes:

[1] *Water quality criteria for lead overview report ministry of environment 1987: total lead concentration of 0.8 mg/kg in the edible portion of fish is considered as an alert level*

[2] *Guidelines for Human Consumption based on Total Hg Concentration in the Edible Portion of Fish and Shellfish µg Total Hg/g Wet Weight. 0.5 mg/kg wet weight when weekly consumption is 210 grams wet weight to 0.1 mg/kg wet weight when weekly consumption is 1050 grams wet weight. Aquatic Life Guidelines for Fish / Shellfish when Human Diet is Based Primarily on Fish. Ministry of Environment. 2001a. Water Quality Ambient Water Quality Guidelines for Mercury. Overview Report – First Update. Prepared pursuant to Section 2(e) of the* Environment Management Act*, 1981.*

[3] *Canadian Council of Ministers of the Environment. 2000. Canadian Tissue Residue Guidelines For The Protection Of Wildlife Consumers Of Aquatic Biota: Methylmercury. In: Canadian Environmental Quality Guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg*

[4] *Selenium whole-body tissue guideline is 4 µg/g (equivalent to 4 mg/kg) Beatty, J.M. and G.A. Russo. 2014. Ambient Water Quality Guidelines For Selenium Technical Report Update. Water Protection And Sustainability Branch, Environmental Sustainability And Strategic Policy Division, British Columbia Ministry Of Environment.).*

[5] *Units are mg/kg wwt*

[6] *Non-detect values not included in the average.*

Muscle samples from Jacko Lake rainbow trout and from one of the rainbow trout from Peterson Creek upstream of Jacko Lake captured in July 2014 were above the methyl mercury guideline. None of the samples exceeded the lead or selenium guideline. All of the rainbow trout whole-body tissue samples from Peterson Creek within downtown Kamloops and from Jacko Lake in September 2014 were below the provincial guideline for lead and selenium. Five of nine Jacko Lake rainbow trout whole-body tissue samples exceeded the lower mercury guideline for human consumption (0.1 mg/kg wet weight when weekly consumption is 1050 grams wet weight); all nine samples exceeded the methyl mercury guideline for wildlife consumption (0.033 mg/kg wet weight).

Edith Lake

Eight of nine whole-body tissue samples from Edith Lake rainbow trout had methyl mercury concentrations that exceeded the wildlife consumption guideline. Lead, mercury, and selenium guidelines were not exceeded in any of the Edith Lake rainbow trout samples.

Sediment Chemistry

Substances released into the environment may enter lakes and streams and accumulate in bottom sediments, with most chemical contaminants preferentially binding to silts and clays. Sediment contaminants represent a potential hazard to the health of benthic organisms, and in turn to the organisms in higher trophic levels.

Samples were sent to an accredited laboratory for analysis of metal concentration and particle size and results were assessed against provincial and federal sediment quality guidelines for the protection of aquatic health. The guidelines are defined as:

- Probable Effect Level (PEL): federal guideline that defines the level above which adverse effects are expected to occur frequently.
- Interim Sediment Quality Guideline (ISQG): federal guideline recommended if information is not available to support a PEL guideline. The numerical ISQG is lower than the PEL guideline.
- Lowest Effect Level (LEL): provincial guideline that indicates a level of contamination that can be tolerated by the majority of sediment dwelling organisms.
- Severe Effect Level (SEL): provincial guideline setting contaminant levels that would be detrimental to the majority of benthic species.

The guideline values are shown in Table 6.7-3.

Sediment samples were collected from sites within Jacko Lake and Peterson Creek between 2007 and 2014 (in downtown Kamloops and at the outlet of Jacko Lake in 2007 to 2011, and in downtown Kamloops, Knutsford, at the outlet of Jacko Lake and upstream of Jacko Lake in 2014). Sediment samples were also collected from Edith Lake and Goose Lake in 2014.

Table 6.7-3. Average Sediment Metals Concentrations (2014) Compared to Guidelines for the Protection of Aquatic Life

	BC Working Guidelines		Canadian Environmental Quality Guidelines / BC Working Guidelines		Average Sediment Metals Concentrations - 2014						
Parameter	LEL	SEL	ISQG	PEL	PC-01	PC-03	PC-08	PC-10	JACL	EDITH	GOOSE
Aluminum					11800	13100	14933	15900	6484	9770	1200
Antimony					0.50 0	0.330	0.433	0.350	0.378	0.542	0.054
Arsenic			5.9	17	6.60	4.43	4.91	5.27	4.36	4.87	0.76
Barium					131	140.6	161	180	206	224	39
Beryllium					0.32	0.286	0	0.36	0.14	0.24	0
Bismuth					<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Boron					<10	11.00	11.00	0.00	17.20	13.00	10.87
Cadmium			0.6	3.5	0.248	0.143	0.100	0.095	0.108	0.156	0.009
Calcium					24100	16660	43100	23900	144800	103380	17170
Chromium			37.3	90	61	120	96	86	35	51	15
Cobalt					14.50	13.28	15.60	13.90	6.79	8.81	0.85
Copper			35.7	197	37.00	56.62	85.47	83.80	69.52	74.72	18.12
Iron	21,200	43,766			27400	26400	41800	35000	12360	19240	1917
Lead			35	91.3	6.07	4.89	2.77	3.57	3.41	6.32	0.33
Lithium					9.10	6.28	7.63	7.20	0.00	7.84	2.11
Magnesium					11900	12380	13600	9400	9290	12900	17830
Manganese	460	1100			646	947	583	1330	749	816	55
Mercury			0.17	0.486	0.037	0.063	0.051	0.087	0.056	0.052	0.003
Molybdenum					1.18	1.29	0.95	0.50	17.10	5.32	0.58
Nickel	16	75			54.70	73.60	58.03	38.80	34.76	42.62	9.37
Phosphorus					886	1066	1196	1340	1320	1196	78
Potassium					1750	2178	1630	2060	1174	1632	396

(continued)

Table 6.7-3. Average Sediment Metals Concentrations (2014) Compared to Guidelines for the Protection of Aquatic Life (completed)

	BC Working Guidelines		Canadian Environmental Quality Guidelines / BC Working Guidelines		Average Sediment Metals Concentrations - 2014						
Parameter	LEL	SEL	ISQG	PEL	PC-01	PC-03	PC-08	PC-10	JACL	EDITH	GOOSE
Selenium		2			0.400	0.726	0.427	0.620	1.454	0.940	0.120
Silver					0.096	0.062	0.084	0.066	0.074	0.089	0.014
Sodium					570	640	470	470	584	706	2306
Strontium					130	117	185	105	453	430	422
Sulfur					n/a	3420	2500	1500	6740	8680	2041
Thallium					0.113	0.063	0.060	0.060	0.000	0.059	0.000
Tin					0.700	0.626	0.490	0.460	1.106	0.890	0.091
Titanium					1070	1004	950	955	304	509	61
Uranium					0.742	0.549	0.508	0.487	3.874	3.600	0.435
Vanadium					59.50	66.80	156.67	106.00	44.36	66.28	7.58
Zinc			123	315	62.80	60.42	45.40	52.20	27.32	41.74	4.86

Jacko Lake and Peterson Creek

The following guideline exceedances were noted in the Jacko Lake and Peterson Creek sediment samples:

- Average arsenic concentrations exceeded the ISQG in two of three samples collected from Peterson Creek downstream of Jacko Lake between 2008 and 2011 and in the sample collected from Peterson Creek in downtown Kamloops in 2014.
- Average chromium concentrations from the Peterson Creek site in Knutsford and at the outlet of Jacko Lake exceeded the PEL guideline. Average chromium concentrations from the Peterson Creek site in downtown Kamloops exceeded the ISQG.
- Average copper concentrations matched or exceeded the ISQG guideline in samples from Peterson Creek downstream of Jacko Lake collected between 2007 and 2011 and in all samples from all sites in Peterson Creek in 2014.
- Average copper concentrations exceeded the ISQG in all Jacko Lake samples collected between 2007 and 2011 and in all samples from Jacko Lake in 2014.
- Average iron concentrations exceeded the LEL in all samples from all sites in 2014. The SEL was exceeded in one replicate from Peterson Creek at the outlet of Jacko Lake.
- Average manganese concentrations were above the LEL in all samples. One replicate each from the Peterson Creek site in Knutsford and above Jacko Lake exceeded the SEL.
- Average manganese concentrations exceeded the LEL guideline in the 2011 Jacko Lake sample and the Jacko Lake samples in 2014.
- Average mercury concentrations exceeded the PEL in the 2007 Jacko Lake sample.
- Average nickel concentrations exceeded the LEL in samples collected from Peterson Creek within downtown Kamloops and downstream of Jacko Lake between 2007 and 2011. The LEL for nickel was exceeded at all sites in 2014, with one replicate from the Peterson Creek site in Knutsford also exceeding the SEL.
- Average nickel concentrations exceeded the LEL in all Jacko Lake samples collected between 2007 and 2011, and the Jacko Lake samples in 2014.
- Selenium exceeded the SEL in one Jacko Lake sample collected between 2007 and 2011.

Edith Lake

The following guideline exceedances were noted in the Edith Lake sediment samples:

- Average chromium concentrations from Edith Lake exceeded the ISQG, with one of the replicates above the PEL guideline.
- Average copper concentrations exceeded the ISQG in all samples from Edith Lake in 2014.
- Average manganese concentrations exceeded the LEL guideline in the Edith Lake samples in 2014.
- Average nickel concentrations exceeded the LEL in all Edith Lake samples in 2014.

Goose Lake

The following guideline exceedances were noted in the Goose Lake sediment samples:

- Average copper concentrations exceeded the ISQG in all samples from Goose Lake in 2014.

Primary and Secondary Productivity

Primary and secondary productivity were assessed through collection of phytoplankton, zooplankton, and benthic macroinvertebrates in lakes, and periphyton and benthic macroinvertebrates in streams. Descriptive statistics that were used to characterize the phytoplankton, periphyton, zooplankton, and benthic macroinvertebrate were density (abundance); taxon richness, or the number of unique taxa (family or species, depending on the level of identification) at each site; and taxonomic composition (the number of individuals in each phylum compared to the total number of individuals). In addition, biological indices that incorporate abundance and richness measures were calculated for each site, including the Simpson's and Shannon-Wiener diversity and evenness indices and the Bray-Curtis Similarity index. Diversity and evenness indices give an idea of how evenly spread the individuals are in each of the taxa. The Ephemeroptera-Plecoptera-Trichoptera index was also calculated for stream sites – this index gives an indication of water quality by assessing the number of organisms belonging to the Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) orders, since these organism are sensitive to pollution.

Benthic macroinvertebrate samples were collected from the following Peterson Creek sites between 2007 and 2014:

- downtown Kamloops (2007 to 2008, 2014)
- upstream of Bridal Veil Falls (2010, 2011, 2014)
- Jacko Lake outlet (2008, 2010).

Benthic macroinvertebrates were not sampled from Peterson Creek at the outlet of Jacko Lake in 2014 due to the high silt content of the substrate and the lack of flow.

Benthic macroinvertebrate samples were collected from Jacko Lake in 2007, 2008, 2010, and 2014 and from Edith Lake in 2014.

Jacko Lake and Peterson Creek

Jacko Lake phytoplankton community metrics are shown in Table 6.7-4. Phytoplankton abundance was higher in the surface samples than in the samples collected from the euphotic zone, although taxon richness was higher in the sample from the euphotic zone. Simpson's diversity and evenness were similar between the two depths, but the Shannon-Wiener diversity and evenness values were higher in the euphotic zone samples. The abundance and community metrics were similar to those calculated for Edith Lake.

Table 6.7-4. Phytoplankton Community Indices 2014

	JACL		EDITH		
Metric / Index	Shallow	Deep	Shallow	Deep	GOOSE
Abundance (cells/ml)	8730	1180	9362	6559	55455
Taxon Richness	30	37	40	51	27
Simpson's Diversity	0.623	0.622	0.665	0.507	0.222
Simpson's Evenness	0.088	0.071	0.075	0.040	0.048
Shannon-Wiener Diversity	1.275	1.549	1.474	1.364	0.538
Shannon-Wiener Evenness	0.375	0.429	0.400	0.347	0.163

Jacko Lake zooplankton community metrics are shown in Table 6.7-5. Zooplankton abundance was lower in Jacko Lake compared to Edith Lake and Goose Lake, but taxon richness was similar in the three lakes. Jacko Lake samples had higher Simpson's diversity and evenness than Edith Lake and Goose Lake. The Shannon-Wiener diversity and evenness in Jacko Lake and Goose Lake were similar, and both were higher than in Edith Lake.

Table 6.7-5. Zooplankton Community Indices 2014

Metric / Index	JACL	EDITH	GOOSE
Abundance (cells/ml)	14	72	1338
Taxon Richness	11	12	11
Simpson's Diversity	0.820	0.585	0.813
Simpson's Evenness	0.504	0.201	0.487
Shannon-Wiener Diversity	1.910	1.379	1.921
Shannon-Wiener Evenness	0.797	0.555	0.801

Periphyton samples were collected from Peterson Creek in downtown Kamloops in 2014 and from upstream of Bridal Veil Falls in 2010, 2011, and 2014. Peterson Creek in downtown Kamloops had lower abundance and richness, but higher diversity and evenness indices in 2014 (Table 6.7-6). Periphyton abundance was highly variable upstream of Bridal Veil Falls between 2010 and 2014; taxa richness was higher in 2014 compared to the 2010 and 2011 samples, but diversity and evenness were lower.

Table 6.7-6. Periphyton Community Indices 2014

Metric / Index	PC-01	PC-04
Density (organisms per cm^2)	301602	1878692
Taxon Richness	37.2	39.6
Simpson's Diversity	0.789	0.390
Simpson's Evenness	0.134	0.048
Shannon-Wiener Diversity	1.938	0.897
Shannon-Wiener Evenness	0.536	0.245

Within Peterson Creek in 2014, benthic macroinvertebrate abundance was five times greater above Bridal Veil Falls compared to downtown Kamloops, and the taxon richness, evenness, and diversity

indices were higher (Table 6.7-7). Water quality based on the Ephemeroptera - Plecoptera – Trichoptera index was rated as marginal in downtown Kamloops and acceptable above Bridal Veil Falls.

Table 6.7-7. Benthic Macroinvertebrate Community Indices 2014

Metric / Index	JACL	EDITH	PC-01	PC-04
Density (org/m^2)	148	5677	325	1641
Family Richness	2.2	6.4	18.8	27.4
EPT Index(1)	N/A	N/A	3.8	8.4
EPT Water Quality	N/A	N/A	Marginal	Acceptable
Simpson's Diversity	0.505	0.068	0.648	0.794
Simpson's Evenness	0.660	0.176	0.162	0.185
Shannon-Wiener Diversity	0.528	0.199	1.783	2.031
Shannon-Wiener Evenness	0.505	0.110	0.613	0.614
Taxonomic Composition	Cladocera (62%) Copepoda (28%) Hydracarina (4%)	Diptera (97%) Cladocera (2%) Oligochaeta (1%)	Diptera (65%) Oligochaeta (10%) Plecoptera (5%) Ephemeroptera (4%)	Ephemeroptera (33%) Plecoptera (21%) Diptera (21%) Trichoptera (14%)

Benthic macroinvertebrate abundance and family richness were higher in Edith Lake compared to Jacko Lake, while the diversity and evenness indices were greater in Jacko Lake compared to Edith Lake.

Edith Lake

Phytoplankton abundance was higher in the surface samples than in the samples collected from the euphotic zone, although taxon richness was higher in the sample from the euphotic zone. Simpson's diversity and evenness and Shannon-Wiener diversity and evenness were greater in the surface sample.

Edith Lake had the lowest Simpson's diversity and evenness and Shannon-Wiener diversity and evenness values of the three lakes.

Goose Lake

Phytoplankton abundance was approximately six times higher in Goose Lake compared to Jacko Lake and Edith Lake, but Goose Lake had lower taxon richness, diversity, and evenness indices.

Zooplankton abundance in Goose Lake samples was an order of magnitude higher than Edith Lake samples, and almost two orders of magnitude higher than Jacko Lake samples. Simpson's diversity and evenness and Shannon-Wiener diversity and evenness in Goose Lake were similar to Jacko Lake.

Benthic macroinvertebrate abundance and family richness were higher in Edith Lake compared to Jacko Lake, while the diversity and evenness indices were greater in Jacko Lake compared to Edith Lake.

Summary

Based on the information presented in the baseline report, Jacko Lake is considered to contain productive fish rearing habitat for the rainbow trout that are stocked annually. The majority of rainbow trout tissue samples collected from Jacko Lake in 2014 exceeded the lower mercury guideline for human consumption, and all exceeded the methyl mercury guideline for wildlife

consumption. Sediment copper, manganese, nickel and selenium exceeded the guidelines for the protection of aquatic life in one or more Jacko Lake samples collected in 2014.

Peterson Creek within the LSA contains marginal habitat for spawning, incubation, and rearing, due to the low and regulated flow regime; high water temperatures and low dissolved oxygen concentration in the spring and summer; high silt load within the substrate; and lack of channel complexity. Within the LSA rainbow trout have only been captured or observed in Peterson Creek in the late spring and early summer when they are able to move downstream from Jacko Lake over the spillway, and before temperatures, dissolved oxygen concentration, and depths become restrictive. Rainbow trout from Jacko Lake are stranded in Peterson Creek when the spillway ceases flowing, as there is no means of upstream fish passage over the dam, and therefore do not contribute to the productivity of the stocked population in Jacko Lake. Sediment arsenic, chromium, copper, iron, manganese, and nickel exceeded the guidelines for the protection of aquatic life in one or more samples from Peterson Creek within the LSA in 2014. A summary of baseline water quality results compared to water quality guidelines to indicate sampling results that exceed guidelines is provided in Section 6.3 – Surface Water Quality Effects Assessment and Appendix 6.3-A – Baseline Water Quality Report.

6.7.3 Assessment Boundaries

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

6.7.3.1 Spatial Boundaries

Local Study Area

The Local Study Area (LSA) is the area within which most potential Project interactions and physical, visual, and auditory effects are expected to occur. The LSA for the purpose of the Fish and Fish Habitat effects assessment is defined as the Mine Site and infrastructure and surrounding area within which there is a reasonable potential for immediate direct and indirect effects on fish, fish habitat, and aquatic resources. The LSA boundary is shown on Figure 6.7-2. The major water bodies within the LSA are Peterson Creek, Cherry Creek, Jacko Lake, and Goose Lake.

Regional Study Area

The Regional Study Area (RSA) for Fish and Fish Habitat was selected based on the potential for direct and indirect interaction or cumulative effects to occur. It is defined as the Peterson Creek watershed to the confluence with the South Thompson River, as well as a buffer along the waterline to Kamloops Lake, as shown on Figure 6.7-2.

6.7.3.2 Temporal Boundaries

Temporal boundaries are the time periods considered in the assessment and reflect periods during which planned Project activities are reasonably expected to potentially affect a VC. Potential effects will be considered for each phase of the Project, which are:

- **Construction**: 2 years;
- **Operation**: 23 years;
- **Decommissioning and Closure**: 5 years (includes project decommissioning, abandonment and reclamation activities, as well as temporary closure, and care and maintenance); and
- **Post Closure**: 5+ years (includes ongoing reclamation activities and Post Closure monitoring).

Activities occurring during each phase are described in Section 3.

6.7.3.3 Administrative Boundaries

No administrative boundaries were applied to the Fish and Fish Habitat effects assessment.

6.7.3.4 Technical Boundaries

No technical boundaries were applied to the Fish and Fish Habitat effects assessment.

6.7.4 Potential Effects of the Project and Proposed Mitigation for Fish and Fish Habitat

6.7.4.1 Identifying Potential Effects on Fish and Fish Habitat

Potential effects of the Project identified in the AIR/EISG to be assessed include:

- loss of habitat in Peterson Creek related to the Open Pit and the mine rock storage facilities;
- impact of mining dust and vibrations on fish in Jacko Lake;
- loss of habitat and altered fish distribution and abundance in Peterson Creek downstream of the Project resulting from reduced flow;
- loss of habitat in northeast arm of Jacko Lake related to Open Pit development;
- loss of habitat in Kamloops Lake as a result of water intake upgrades;
- loss of habitat in Jacko Lake as a result of seepage or drainage of lake water into the adjacent open pit;
- water temperature variation;
- direct mortality or sub-lethal effects to fish as a result of altered water quality (increased metals loading, increased temperatures, decreased dissolved oxygen concentration, etc.) or blasting activities resulting during Project Construction, Operation and Decommissioning and Closure.
- direct and indirect mortality of fish in Kamloops Lake resulting from water withdrawal; and

- altered productive capacity (periphyton, aquatic macrophytes, plankton community, benthic invertebrates) resulting from changes in water quality (nutrients, temperature, suspended solids).

The key Project-VC interactions throughout the life of the Project that are likely or certain to result in one or more of these effects are summarized in Table 6.7-8. For the purpose of this assessment the effects are grouped into the following themes:

- direct habitat loss;
- indirect habitat loss (e.g., changes to water levels);
- mortality of fish or eggs;
- sub-lethal effects (e.g., changes in water quality including temperature, dissolved oxygen, nutrients; changes in sediment quality; behavioural changes resulting from increased noise or lighting).

Direct, indirect and induced effects are considered. Interactions that are marked red or yellow are carried forward for further analysis in this section, while those interactions that are green will not be discussed as a residual effect except to identify standard operating practises and mitigation measures that are well known and understood and will be used to address these minor concerns.

Only the effects that are likely to occur during the normal course of operations are included in this Section. The potential loss of habitat in Jacko Lake as a result of seepage or drainage of lake water into the adjacent Open Pit, and leaks and spills from machinery or creating releasing deleterious substances into nearby waterways, are discussed under Section 11.12, Risk Management Plan (Accidents and Malfunctions).

A number of the activities and components listed in Table 6.7-8 have the potential to affect Fish and Fish Habitat through one or more mechanisms or pathways. For example, Clearing and Grubbing activities typically include removal and disposal of trees, stumps, roots, shrubs, and grass. Clearing and Grubbing within riparian areas will result in direct loss of fish habitat, since "fish habitat" as defined in the *Fisheries Act* includes food supply areas. Riparian zones provide a direct food source for fish by providing habitat for terrestrial insects that fall into the water, as well as providing food for aquatic insects in the form of organic matter, leaves, and needles. Clearing of land can also lead to erosion of soils into nearby watercourses, which increases the suspended sediment load. Suspended sediment can lead to sub-lethal effects on fish through filling interstitial spaces within the substrate, thereby smothering benthic invertebrates, and reducing the availability and quality of rearing habitat. Sediments that remain suspended within the water column reduce water clarity, impairing fish foraging efficiency, and can clog and abrade fish gills, and can affect other water quality parameters such as temperature.

Table 6.7-8. Identifying Potential Project Interactions and Effects on Fish and Fish Habitat

Phase	Project Activities	Habitat Loss - Direct	Habitat Loss - Indirect	Mortality of Fish or Eggs	Sub-lethal Effects
Construction	Clearing and Grubbing	L	L	L	L
	Earthworks	L	M	M	L
	Overburden/Topsoil Stockpile	O	M	L	L
	Laydown Areas and Storage Yards	O	L	O	O
	Project Lighting	O	O	O	O
	Site Security and Fencing	O	O	O	O
	Fuel Storage and Filling Area	O	L	O	O
	Hazardous Wastes Transport, Storage, and Disposal	O	L	O	O
	Sewage Infrastructure and Disposal	O	L	O	L
	Public Road Realignment, Use, and Maintenance	O	L	O	L
	Site Road Construction, Use and Maintenance	O	L	L	L
	Haul Road Overpass	O	O	O	O
	Site Buildings and Process Plant	O	L	O	O
	Explosives Magazine and Storage Facilities	O	L	O	O
	Open Pit Development	H	H	M	O
	Drilling and Blasting	O	L	H	H
	Crushing Mine Rock	O	O	O	L
	Loading, Hauling, and Deposition of Mine Rock	H	M	O	L
	Temporary Ore Stockpile	O	M	L	L
	Tailing Storage Facility Development	H	H	H	M
	Power Transmission, Distribution	L	O	L	L
	Natural Gas Line	O	O	O	O
	Pipeline Utility Corridor (Potable Water, Sewage, and Site Water)	M	L	M	O
	Water Intake from Kamloops Lake	M	M	H	O
	Fire Suppression Infrastructure	O	L	O	O
	Contact Water	O	M	H	H
	Non-contact Water	O	M	O	O
	Peterson Creek Diversion	O	H	H	O
	Water Management Dams	O	M	M	M
	Mine Staffing (Direct Employment)	O	O	M	O
	Contracted Employment	O	O	M	O
	Taxation	O	O	O	O

(continued)

Table 6.7-8. Identifying Potential Project Interactions and Effects on Fish and Fish Habitat (continued)

Phase	Project Activities	Habitat Loss - Direct	Habitat Loss - Indirect	Mortality of Fish or Eggs	Sub-lethal Effects
Operation	Open Pit Development	H	H	O	O
	Drilling and Blasting	O	L	H	H
	Hauling Mine Rock and Ore from Pit	O	O	L	L
	Crushing and Conveying Ore	O	O	O	L
	Temporary Ore Stockpile	O	M	L	L
	Development of Mine Rock Management Facilities	H	H	O	M
	Stripping, Loading, Hauling, Deposition, and Contouring of Topsoil and Overburden	O	M	L	L
	Revegetation through Progressive Reclamation	O	L	O	O
	Process Plant Operation	O	M	O	O
	Deposition to Tailing Storage Facility	O	H	O	O
	Site Road Use and Maintenance (Materials, Personnel, Supplies)	O	L	O	L
	Concentrate Transport and Storage	O	O	O	O
	Explosives Magazine and Storage Facilities	O	O	O	O
	Fire Suppression Infrastructure	O	O	O	O
	Fuel Storage and Filling Area	O	O	O	O
	Hazardous Wastes Transport, Storage, and Disposal	O	O	O	O
	General Wastes Transport, Storage, and Disposal	O	O	O	O
	Sewage Infrastructure and Disposal	O	L	O	L
	Laydown Areas and Storage Yards	O	L	O	O
	Power Transmission, Distribution	L	O	L	L
	Project Lighting	O	O	O	O
	Site Access, Security and Fencing	O	O	O	O
	Water Intake from Kamloops Lake	M	M	H	O
	Contact Water	O	M	O	H
	Non-contact Water	O	M	O	O
	Potable Water Treatment and Use	O	O	O	O
	Peterson Creek Diversion	O	H	H	O
	Mine Staffing (Direct Employment)	O	O	M	O
	Contracted Employment	O	O	M	O
	Taxation				

(continued)

Table 6.7-8. Identifying Potential Project Interactions and Effects on Fish and Fish Habitat (completed)

Phase	Project Activities	Habitat Loss - Direct	Habitat Loss - Indirect	Mortality of Fish or Eggs	Sub-lethal Effects
Decommissioning and Closure	Dismantling of Ancillary Buildings	O	L	O	O
	Pit Lake Planning	O	H	O	H
	Site Road Decommissioning	O	L	O	L
	Tailing Storage Facility Decommissioning and Reclamation	O	O	O	O
	Mine Rock Management Facilities Reclamation	O	O	O	O
	Fuel Storage and Filling Area	O	L	O	O
	Hazardous Wastes Transport, Storage, and Disposal	O	L	O	O
	Laydown Areas and Storage Yards	O	L	O	O
	Power Transmission, Distribution	O	O	O	L
	Project Lighting	O	O	O	O
	Site Security and Fencing	O	O	O	O
	Contact Water	O	M	O	H
	Non-contact Water	O	M	O	O
	Peterson Creek Diversion	O	H	O	O
	Road use to the Project (Materials, Personnel, Supplies)	O	O	O	L
	Mine Staffing (Direct Employment)	O	O	O	O
	Contracted Employment	O	O	O	O
Post Closure	General Site Inspections and Maintenance	O	L	O	O
	Contact Water	O	M	O	H
	Non-contact Water	O	M	O	O
	Road use to the Project (Materials, Personnel, Supplies)	O	O	O	L
	Mine Staffing (Direct Employment)	O	O	O	O
	Contracted Employment	O	O	O	O

Notes:

O	*No interaction anticipated.*
L	*Negligible to minor interaction expected; implementation of best practices, standard mitigation and management measures; no monitoring required, no further consideration warranted.*
M	*Potential moderate interaction requiring unique active management/monitoring/mitigation; warrants further consideration.*
H	*Key interaction; warrants further consideration.*

In addition, a number of the activities and components have the potential to interact with the aquatic environment via the same mechanism or pathway and can be managed using the same mitigation measures. For example, activities such as Clearing and Grubbing and Site Road Construction during Construction; Stripping, Loading, Hauling, Deposition, and Contouring of Topsoil and Overburden during Operation; and Site Road Decommissioning and Decommissioning and Closure of the Power Transmission and Distribution lines can cause increased erosion and sedimentation, which are managed by implementation of measures laid out in the Erosion and Sedimentation Control Plan (Section 11.2).

Activities and components that have been identified as having negligible to minor interaction with the VC in Table 6.7-8 will be managed using industry standard best practices and mitigation measures with proven effectiveness for similar activities and regions. Potential effects associated with these Project activities and components are not carried further in this assessment. Industry standard best practices include compliance with project construction and operation permits, and guidance documents provided by provincial and federal regulatory agencies.

Project activities with the potential to result in a moderate or key interaction with Fish and Fish Habitat through one or more of the identified effects (direct or indirect habitat loss, mortality, sub-lethal effects) are discussed in Section 6.7.4.2. Mitigation measures our outlined in Section 6.7.4.3 and the significance of any residual effects are presented in Section 6.7.5.

6.7.4.2 Effects on Fish and Fish Habitat

The main impact of the Project will be on the fish and fish habitat of Jacko Lake and Peterson Creek. The current rainbow trout population within this system is stocked and water levels within the lake and flow within the creek are highly regulated. A large part of the Project will be developed in areas previously disturbed by the historic Afton Mine (the Ajax East and Ajax West pits, reclaimed waste rock dumps, haul roads). The Fisheries Protection Policy Statement (Fisheries and Oceans Canada 2013b) states that for projects with a low likelihood of causing impacts to productivity, or in which the impacts are relatively small, only a qualitative documentation of the key impacts and their associated links to components of productivity is required.

<u>Habitat Loss - Direct</u>

Project components and activities identified as resulting in the direct loss of aquatic habitat during Construction and Operation are:

- Peterson Creek Diversion
- Loading, Hauling, and Deposition of Mine Rock (Construction);
- Tailing Storage Facility Development;
- Development of Mine Rock Management Facilities (Operation);
- Pipeline Utility Corridor (Potable Water, Sewage, and Site Water);
- Water Intake from Kamloops Lake (Construction and Operation); and
- Open Pit Development (Construction and Operation).

Habitat losses are described in detail in Appendix 6.7-C.

Jacko Lake

The Open Pit will extend into the tip of the northeast arm of Jacko Lake. The existing Kinder Morgan pipeline that transects this arm of the lake will need to be removed prior to Open Pit development; therefore, a dyke will be installed to allow work to be conducted in isolation of flow. The dyke will remain in place during Project Operation to allow a steeper wall and access to ore along the west edge of the Open Pit. The southeast arm of Jacko Lake will also be affected by the Project through removal of the existing dam and construction of a new dam immediately downstream.

Direct habitat loss in the northeast arm of Jacko Lake will be approximately 2.04 ha of littoral area and 0.8 ha of riparian area. The northeast arm represents 4.2% of the total Jacko Lake area and 9.4% of the total littoral area shallower than 3 m depth. The northeast arm supports fish growth through food production and provides rearing habitat for the stocked rainbow trout in Jacko Lake. There is no natural fish recruitment or fish reproduction in the lake. The new dam in the southeast arm will increase the lake area by 0.18 ha. The overall net loss in littoral area in Jacko Lake will therefore be 1.85 ha and the overall net loss in the riparian area of Jacko Lake will be 0.8 ha.

The littoral zone of a lake is the shoreline region comprised of the area between the highest and lowest seasonal water levels (the eulittoral zone) and the adjacent region with emergent rooted vegetation (upper littoral), floating-leaved rooted vegetation (middle littoral), and submersed rooted macrophytes (lower littoral) (Wetzel 2001). Below the littoral zone is an area occupied by scattered photosynthetic algae and bacteria (the littoriprofundal zone); the exposed fine sediment free of vegetation below this is referred to as the profundal zone (Wetzel 2001). Substratum heterogeneity is much greater in the littoral zone, and species diversity and competitive interactions are more complex compared to the profundal zone (Wetzel 2001).

Submerged macrophytes in lake littoral zones provide structure and cover for protection from predators for fish as well as a rich food supply (Randall et al. 1996). Wetzel (2001) reports that bacterioplankton were generally found to be more abundant and on average grew faster in water among macrophyte stands than in open water lacking littoral fauna, and that community structure typically consists of a rich fauna with high oxygen demands in the littoral zone above the thermocline. Randall et al. (1996) also report that species diversity and density of aquatic invertebrates is generally high in macrophyte areas, and that macrophytes increase the structural complexity of the littoral habitat, which increases fish species richness. Fish biomass has also been found to be concentrated in littoral areas (Randall et al. 1996).

Peterson Creek

The Project requires that a 3.6 km section of Peterson Creek immediately downstream of Jacko Lake be diverted through the Operation phase of the Project. The diversion is primarily necessary for the development of the Open Pit which will impinge on the section of Peterson Creek downstream of the existing Jacko Lake water retention dam. Additional infrastructure including site access roads and the central collection pond also will overlap with the current alignment of the creek. Peterson Creek flows will be diverted at the outlet of Jacko Lake by a new water retaining dam (downstream of the existing dam) and the Peterson Creek Diversion System (PCDS). The PCDS will allow for

inflows into Jacko Lake to be pumped around the mine site and re-introduced to Peterson Creek to ensure adequate flow in Peterson Creek and satisfy downstream water license allocations. The PCDS comprises an intake structure and pump house, a pipeline along the north of the Ajax site, with discharge into Peterson Creek at an outlet structure located at the Goose Lake access road crossing. Flow from the diversion system will discharge into a new pond, the Peterson Creek Downstream Pond, downstream of the outlet structure. The intake will be located at the northeast end of the lake, as it allows for a relatively simple intake structure with fish protection screens in combination with larger centrifugal pumps on the shore. During the spring freshet, the normal water level of Jacko Lake will be maintained at an elevation of 892.0 masl using the PCDS (e.g. the spillway invert elevation for the existing Jacko Lake Dam is at elevation 892.0 masl). Lake water will be pumped into a pipeline and routed around the north end of the Open Pit. The pipeline outlet will discharge into an engineered open channel to provide for energy dissipation before reaching the confluence with Peterson Creek. The dewatering of a 3.6 km section of Peterson Creek will result in a loss of 3.85 ha of wetted channel and 7.71 ha of riparian vegetation. At closure, the Peterson Creek Diversion system will be decommissioned and flows to Peterson Creek will be restored via a channel located between the Open Pit and West MRSF. This alignment will be similar to the current alignment of Peterson Creek.

Peterson Creek, within the Project footprint, is a low gradient, channelized straight glide with abundant fine substrate, little channel complexity, and no riparian canopy. Like Jacko Lake, Peterson Creek has been highly modified for human use. Flows in Peterson Creek are dependent on storage and release from Jacko Lake for downstream water users; BC Rivers Consulting Ltd. (2011) describes the creek as "notoriously water-short" and notes that Peterson Creek flows have been augmented by diverting flows from the adjacent Anderson Creek watershed into Edith Lake for most of the 20th century. The lower reach of Humphrey Creek, the outlet of Edith Lake, is located approximately 3 km downstream of Jacko Lake; there is no surface connection between Humphrey Creek and Peterson Creek, as the channel disappears and flows seep into the ground or run as sheet flow downgradient. The only surface connection between Peterson Creek and Jacko Lake occurs in the spring when lake water levels overtop the spillway elevation; BC Rivers Consulting Ltd. (2011) report that the lake level did not reach the spillway crest in 2009.

Peterson Creek, within the Project footprint, is only opportunistically used by the stocked rainbow trout from Jacko Lake when water levels exceed the spillway elevation. Large-bodied adult rainbow trout from Jacko Lake have been observed in Peterson Creek in the Project area when the spillway is flowing; fish are stranded in the creek when Jacko Lake water levels drop below the spillway elevation. The SSN has identified the Jacko Lake spillway as providing an important area for spring fishing using traditional methods.

A lake survey conducted by provincial fisheries biologists in 1949 and 1950 noted that water levels were maintained in the outlet of Jacko Lake for irrigation, and that this arm provided the only suitable spawning area although no spawning was noted in the 1949 and 1950 surveys (IBB et al. 1954). Vernon (1956) noted that trout spawn in streams and therefore require both gravel for deposition and incubation of eggs as well as access for fry to the lake, and that Jacko Lake requires continuous artificial stocking to maintain the trout population due to the absence of spawning areas even in wet years. In addition to the lack of gravels for spawning in Peterson Creek at the outlet of

Jacko Lake, water temperatures typically exceed the optimum temperatures for spawning (10 °C to 15.5°C) and incubation (10°C to 12°C) by May of each year. Dissolved oxygen concentrations also make this section of Peterson Creek sub-optimal for spawning. The amount of dissolved oxygen that water can hold is partially a function of water temperature, with oxygen solubility decreasing as water temperatures rise. The instantaneous minimum recommended criteria for the protection of aquatic life is 9 mg/L for buried embryos or alevins and 5 mg/L oxygen for all other life stages. Dissolved oxygen concentrations were frequently less than 9 mg/L in spring and early summer, when embryos and alevins are typically in the gravel, at all of the fish and aquatic sample sites in Peterson Creek.

Low flow, high water temperatures, and low dissolved oxygen concentrations also make this section of Peterson Creek sub-optimal for rearing. A base flow of 50% of the average annual daily flow is considered excellent for maintaining quality rainbow trout habitat; base flows of 25% to 50% are considered fair and a base flow of less than 25% of the average annual daily flow is considered poor (Knight Piésold Ltd. 2013). Base flows in Peterson Creek downstream of Jacko Lake are generally less than 25% of annual daily flow, offering marginal rearing habitat (Knight Piésold Ltd. 2013). The upper optimum rearing temperature (18°C) is exceeded in most years, typically between May and September, with temperatures approaching the upper lethal temperature of 27°C. Dissolved oxygen concentrations were less than 5 mg/L on several occasions in Peterson Creek at the outlet of Jacko Lake.

Goose Lake

The Tailing Storage Facility and the Mine Rock Management Facilities will result in the loss of Goose Lake as well as portions of Keynes Creek and tributaries to Keynes Creek. No fish were captured in these systems, and there is no surface connection to fish-bearing waters.

Under the *Fisheries Act* neither Goose Lake nor Keynes Creek would be considered fish habitat due to the lack of surface connectivity to any fish bearing water, since they do not provide a supply of food and fish do not depend on them directly or indirectly to carry out their life processes.

Kamloops Lake

The pipeline utility corridor from the Water Intake on Kamloops Lake will follow the existing waterline to the third New Afton Booster Station. The new waterline for Project process and fire water will be adjacent to the existing Afton Haul Road and will cross a mapped unnamed tributary to Alkali Creek (a tributary to Cherry Creek) on the east side of Highway 5. No natural watercourse was observed at this location, although a ditch with large diameter rip-rap running along the south side of the Afton Haul Road connects to a ditch on the east side of Highway 5; runoff from the highway and the Afton Haul Road from high flow events would be conveyed north and west through a series of culverts under these roads. No flow has been observed in these channels during mid and late summer fish sampling programs.

The Kamloops Lake intake for the Project will utilize existing infrastructure and make use of the existing intake pump station wet well and superstructure. The existing intake pipe will need to be cleaned and re-lined. A new screen will be installed on the relined intake piping. Some work will be required around the intake line that may extend into the riparian edge (within 35 m of Kamloops

Lake), but not within wetted edge of the lake. The existing pipe along a 25 m section, wye and wet well inlet piping will be removed and replaced. A new pipe will be fed out to a new screen from a horizontal bend located approximately 25 m from the wet well structure. The proposed excavation footprint is approximately 300 m^2, assuming 1:1 slopes and shoring for excavation depths greater than 6.0 m. The location of the horizontal bend would put the end of the excavation at the average assumed low water level; a coffer dam around the edge of the excavation and a plug in the intake pipe will likely be required for this portion of the excavation to keep water out.

The area provides poor quality spawning habitat for most species of fish; northern pike, minnow, sculpins, and lamprey were the only fish captured in 2011 in an assessment for the New Afton Intake Structure. The approximate extent of wetted area that will be disturbed within Kamloops Lake is 4.5 ha. Preliminary designs indicate that the intake pipe will be installed in the lake by excavating along the foreshore to the water level and dredging a trench below the water level to ensure that the pipe is buried a sufficient depth to prevent freezing (Urban Systems 2015). The trench will be backfilled with excavated and imported material prior to restoration of the foreshore area. No permanent direct habitat loss is associated with the Kamloops Lake Water Intake, as the disturbance will be limited to the period of construction; therefore this habitat alteration is not carried further in the effects assessment.

Habitat Loss - Indirect

Flow alterations, caused by dams or other impoundments, water diversion, stream crossings or water extraction may alter habitat characteristics or cause the death of fish (Fisheries and Oceans Canada 2013b). The effects of the Project on surface water quantity and groundwater quantity are discussed in Section 6.4 and Section 6.6, respectively. This section addresses the effects of changes in hydraulic conditions (water velocity, water depth, wetted width) associated with changes in surface water on Fish and Fish Habitat in:

- Peterson Creek downstream of the Project footprint (Construction, Operation, Decommissioning and Closure, Post Closure).
- Kamloops Lake downstream of the Project area as a result of use of the Water Intake from Kamloops Lake (Operation).

The Project activities that could result in a change in surface water quantity and subsequent Indirect Habitat Loss are noted in Table 6.7-8. The pathways for these interactions are discussed in detail in Section 6.4 and for brevity will not be repeated here.

As flows in a system decline, the wetted width, depth, and velocity decrease in accordance with power functions that are defined by the channel hydraulic geometry (Bradford and Heinonen 2008). Fish species that prefer riffles or other shallow areas are impacted more by decreasing flows than species that use slower microhabitats such as pools (Bradford and Heinonen 2008). Flow reductions can conversely improve habitat at certain times of the year for specific life stages such as young of the year and juvenile fish (Fisheries and Oceans Canada 2014). Flow reductions have the potential to affect fish populations through the reduction of available habitat, which may consequently reduce the maximum sustainable carrying capacity, if it is proportional to the size of the habitat area (Fisheries and Oceans Canada 2014).

Peterson Creek

Assessment methods for fish habitat impacts due to flow modifications follow the guidance detailed in Lewis et al. (2004) and Hatfield et al. (2007), as directed by the Water and Air Monitoring Guidance from BC Ministry of Environment (Ministry of Environment 2012). These documents provide flow threshold screening criteria. If flow modifications exceed the screening level criteria, detailed instream flow studies are required. The predicted hydrologic conditions are compared to the threshold criteria and to physical habitat (depth, velocity and cover) data collected at transect locations within lower Peterson Creek (for details see Appendix 6.7-D. Instream Flow Report). The habitat transects were established at sites in Peterson Creek downstream and upstream of Bridal Veil Falls, where small-bodied rainbow trout have been captured.

In order to assess if the predicted flow regime is expected to cause a reduction in fish habitat, pre-mine and mine affected streamflow in lower Peterson Creek were compared to provincial threshold calculated as recommended in the British Columbia Instream Flow Guideline for Fish (Hatfield et al. 2003). The recommended flow threshold for BC streams was developed by Hatfield et al. (2003) as a conservative, coarse filter to assess proposed water use. This threshold is a seasonally-adjusted flow calculated as percentiles of natural mean daily flows for each calendar month and varies through the year to ensure higher protection during low flow months than during high flow months. The threshold is intended to maintain the most important features of a natural hydrograph from a biological and physical perspective. Flows that do not meet the threshold have the potential to negatively affect fish and aquatic habitat. Thus the threshold methodology is a useful screening tool to evaluate the potential impacts of flow changes resulting from the Project.

The methodology presented for the recommended flow threshold for BC streams was developed for small hydropower projects, although the authors recommended that it could be used to asses effects from other proposed water uses. A mine operates differently than a small hydropower project in terms of flow control, principally in that hydropower projects are able to leave all streamflow in the creek when flows are below the threshold, while a mine will affect streamflow at all times due to the upstream diverted catchment area (mine footprint). For the Ajax Project, the recommended flow threshold was calculated and flow reductions were determined as if the Project was to operate like a hydropower project, where flows below the threshold have been left in creek and flows above the threshold have been "diverted". The recommended flow remaining in the creek was calculated on a monthly basis following the method of Hatfield et al. (2003) and compared to the predicted Project Operation flows to assess potential water use effects.

The monthly and annual results for Construction, Operation and Post Closure, as well as the percent of pre-mine mean annual discharge are presented in Table 6.7-9. On an annual basis, the Project meets the thresholds; however, on a monthly basis the Project typically does not meet the guideline values during September to April (values that do not meet the guideline are shaded grey in Table 6.7-9).

Table 6.7-9. Recommended Instream Flow Thresholds for Lower Peterson Creek

Description	Units	Mean Monthly Discharge												Average Annual
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Pre-Mine	m^3/s	0.006	0.006	0.035	0.139	0.281	0.163	0.092	0.089	0.009	0.010	0.006	0.006	0.07
	% MAD	9	9	49	197	397	230	130	126	13	15	9	9	100
Recommended instream flow for fish bearing streams[2]	m^3/s	0.005	0.005	0.029	0.121	0.224	0.135	0.083	0.082	0.007	0.009	0.005	0.005	0.059
	% Pre-Mine MAD	7	7	42	170	317	191	117	115	10	13	7	7	83
	% Change from Pre-Mine MMD	-17	-27	-16	-14	-20	-17	-10	-8	-24	-13	-23	-18	-
Construction	m^3/s	0.005	0.005	0.025	0.103	0.253	0.149	0.087	0.085	0.006	0.007	0.005	0.005	0.061
	% Pre-Mine MAD	7	7	35	145	357	211	122	120	8	10	7	7	87
	% Change from Pre-Mine MMD	-26	-26	-29	-26	-10	-8	-6	-5	-38	-30	-26	-26	-13
Operation	m^3/s	0.004	0.004	0.022	0.077	0.245	0.145	0.086	0.084	0.005	0.006	0.004	0.004	0.058
	% Pre-Mine MAD	6	6	31	109	346	205	121	119	7	9	6	6	82
	% Change from Pre-Mine MMD	-30	-30	-37	-45	-13	-11	-7	-6	-44	-38	-30	-30	-
Post Closure	m^3/s	0.004	0.004	0.034	0.121	0.278	0.158	0.088	0.085	0.006	0.008	0.004	0.004	0.067
	% Pre-Mine MAD	6	6	48	170	393	222	125	120	8	11	6	6	94
	% Change from Pre-Mine MMD	-30	-30	-2	-14	-1	-3	-4	-5	-34	-24	-30	-30	-

Notes:

[1] Recommended flow threshold for fish bearing streams calculated as per Hatfield et al (2003) and recommended instream flow values represent flow that would remain in the creek if threshold was met.

[2] Grey shaded cells indicate months that do not meet the threshold for fish bearing streams.

[3] MAD = mean annual discharge; MMD = mean monthly discharge

However, it should be noted that the magnitude of flows during September to April are very small and the difference between the predicted flow and guideline threshold flow is often on the order 0.001 m^3/s, which is likely within the resolution of the water balance model and field validation measurements. Further, despite the threshold predictions, meso-habitat measurements were collected in lower Peterson Creek at flows as low as those predicted during September to April (0.003 m^3/s) and these data suggest that water depths and velocities suitable for small bodied rainbow trout remain at these conditions. Fish habitat in lower Peterson Creek was assessed and classified as part of the DFO Fraser River Action Plan in 1995-96 for the Thompson River in the Vicinity of Kamloops (Stalberg et al. 1997). Habitat was classified as Class 1, 2 or 3 with Class 1 ratings representing stream sections that encompassed one or more "critical" habitat types. As a result stream sections were classified based on the presence of one attribute irrespective of others (e.g. spawning substrate is deemed critical habitat; therefore habitat could be classified as Class 1 if instream spawning substrates were present irrespective of the flow regime during spawning windows). The Stalberg assessment rated the lower 150 m of Peterson Creek as "Class 1 habitat" due to the presence of instream cobble and gravel substrate that could provide coho salmon spawning habitat if water flow were adequate. However water depths and velocities during the late summer to winter periods are not suitable for upstream migration for spawning. Coho salmon adults require a minimum water depth of 0.18 m for upstream migration and velocities of 0.31 m to 0.91 m/s (Levy and Slaney 1993). Maximum water depth was 0.13 m in lower Peterson Creek even during high flows in July 2014; maximum water depths in September and November, when coho salmon typically migrate upstream, were 0.06 cm and 0.07 cm, respectively (Appendix 6.7-D).

Therefore because Project effects on water flow in lower Peterson Creek are predicted to be negligible and it is unlikely that coho salmon utilize lower Peterson Creek for spawning, no effects on coho salmon anticipated as a result of the Project and this potential effect is not carried forward in the assessment.

Kamloops Lake

Project process make-up water will be provided from Kamloops Lake via an intake, pumping and pipeline. The potential effect of reduced water quantity Fish and Fish Habitat in Kamloops Lake was therefore assessed. Project flows as a percent of average monthly flow in the Thompson River are presented in Section 6.4.5.

The 1700 m^3/h withdrawal of water from Kamloops Lake constitutes a minor component of the average monthly flow through the lake, ranging from 0.02% in June to a maximum of 0.26% during low flows in March (see Section 6.4.5). Comparison of the 1700 m^3/h withdrawal from Kamloops Lake with estimated 10-year monthly low flows also shows that withdrawals are a minor component of Kamloops Lake flows, ranging from 0.04% in June to 0.37% in January. To assess the potential effects on Thompson River wetted widths, depths, and velocities at the outlet of Kamloops Lake a one-dimensional (1D) hydraulic model was developed using Hydrologic Engineering Center River Analysis System modelling software, a 1D hydrodynamic model developed by the US Army Corps of Engineers (Appendix 6.7-E). The model covers approximately 2.5 km of the Thompson River channel extending downstream from Kamloops Lake. The model is based on cross-sections surveyed for the BC Ministry of Environment in 2000 and 2001. The model was run for flows ranging from 80 m^3/s to 150 m^3/s in order to assess how wetted width, average velocity, and

maximum depth change with discharge during low flow conditions; a flow of 110 m^3/s was selected to represent an extreme low flow under pre-Project conditions, as it is the lowest recorded 7-day low flow in the 41 years of record. During Project Operation the low flow condition would be reduced by approximately 0.4 m^3/s, to 109 m^3/s. Model results were presented for five transects – the transects were generally the shallowest and widest transects and therefore expected to show the most change in wetted width due to flow changes. The predicted changes in channel hydraulic parameters at the five transects in the Thompson River at the outlet of Kamloops Lake would vary as follows:

- 6 – 21 cm reduction in wetted width
- 0.001– 0.003 m/s reduction in average cross section velocity
- 2 mm to 4 mm reduction in water surface elevation

Since changes in flow in Kamloops Lake and the Thompson River downstream will be negligible there is no reasonable expectation that there will be an effect on Fish and Fish Habitat; effects of flow reductions on Kamloops Lake Fish and Fish Habitat are therefore not carried forward in this assessment.

The effect of the intake construction and operation on groundwater discharge to Kamloops Lake would be negligible (BGC Pers. Comm. 2015). A slight increase in local scale hydraulic gradient might be anticipated if the water level in the lake drops, which would translate into an unmeasurable local scale change in groundwater flow into the lake over time. Any effect would be masked by temporal flow rate changes and level changes in the lake due to other factors; therefore potential effects on changes to groundwater are not carried forward in this assessment.

Mortality

Mortality is defined by Fisheries and Oceans Canada (2014) as the killing of fish at any life stage by a human induced mechanism other than fishing. Direct mortality as a result of the Project could result from rapid increases in pressure as a result of blasting; crushing as a result of instream works in fish-bearing waters; entrainment or impingement on intake screens; or stranding in dewatered areas of Jacko Lake or Peterson Creek. This section discusses the potential mechanisms associated with Project activities that could result in increased fish mortality.

Increased Fishing Pressure

Although fish retained while fishing in a commercial, recreational, or Aboriginal fishery is not considered as mortality, increased fishing pressure as a result of the Project workforce could affect the size of the stocked rainbow trout population in Jacko Lake. Jacko Lake is currently accessible from Kamloops via Lac Le Jeune Road and gravel road to the boat launch on the southwest arm of the lake. Jacko Lake falls within Region 3 (Thompson-Nicola region) of the BC Fish and Wildlife Regulations. The daily catch quota for Region 3 is five rainbow trout, with not more than one fish being over 50 cm in length; the annual quota is not more than five rainbow trout over 50 cm. No ice fishing is allowed on Jacko Lake; therefore, recreational fishing typically occurs between April and October.

Jacko Lake, Jacko Creek, and Peterson Creek are valued as a trout fishery by the SSN (Pottinger Gaherty Environmental Consultants Ltd. 2015). No information on fishing methods, timing, or fish

take are provided, therefore potential effects of the Aboriginal fishery on the number of the stocked rainbow trout in Jacko Lake cannot be assessed.

Total recreational angler effort on Jacko Lake was estimated as 6285 angler days from April through October 1986 by Bison (1986) and 4245 angler days between 2000 and 2004 by Webb (2007). Average angler effort between 2008 and 2010 was estimated as 4094 angler days, a decrease of 4% from the 2000 through 2004 period (Maricle 2015). For the April through October 1986 period, total catch (killed and released) was estimated as 19,257 fish and harvest was estimated as 10,634 fish; approximately 55% of all captured fish were killed (Bison 1986). More recently (2005), the percentage of rainbow trout retained by anglers across all of BC was estimated as 31% in the Survey of Recreational Fishing in Canada 2005 (Fisheries and Oceans Canada 2007), 28% in a study by GSGislason & Associates Ltd. (2009) and 33% in the Survey of Recreational Fishing in Canada 2010 (Fisheries and Oceans Canada 2012), the latest data for which recreational fishing data are available.

The number of active resident anglers in BC freshwaters declined by approximately 28% between 1995 and 2005, from 294,439 to 211,403 (Fisheries and Oceans Canada 2007), but increased to 236,682 in 2010 (Fisheries and Oceans Canada 2012). The percentage of resident anglers in BC has ranged from 8% in 1995 to 5% in both 2005 and 2010. Assuming that the percentage of anglers remained at 5% in 2014, it is estimated that there were approximately 231,565 licenced anglers in the province (see Table 6.7-10).

Table 6.7-10. Estimated Resident Anglers in BC

Survey Year[a]	BC Population[b]	# Resident Anglers	Angler (% of population)
1995	3,777,390	294,439	8
2005	4,195,764	211,403	5
2010	4,465,924	236,682	5
2014	4,631,302	*231,565[c]*	*5*

Notes:
[a] Fisheries and Oceans Canada. 2007. Survey of Recreational Fishing in Canada 2005. Economic Analysis and Statistics Policy Sector DFO/2012-1804. Fisheries and Oceans Canada. 2012. Survey of Recreational Fishing in Canada 2010. Economic Analysis and Statistics Policy Sector DFO/2007-1303.
[b] BC Stats. 2015. British Columbia-Level Population Projections (May 2015).
[c] Assumed number of resident anglers based on 5% anglers in BC population

The peak Construction labour force will be 2145, of which 84% to 94% are estimated to be hired locally. Assuming that the percentage of anglers in the total BC population is reflected in the employee population, approximately 107 members of the Construction labour force will be active resident anglers. It is expected that any local employees currently fish on Jacko Lake and will therefore not increase the fishing pressure on the stocked rainbow trout population. The number of employees sourced outside of the area will range from 6% to 16%; 16% of the total Construction labour force would be 343. If 5% of these employees are anglers this would mean an additional 17 active anglers would potentially fish on Jacko Lake.

The peak Operation labour force will be 553, of which 65% to 80% are estimated to be hired locally. Assuming that the percentage of anglers in the total BC population is reflected in the Operation

employee population, approximately 28 of the employees will be active resident anglers. Again, it is expected that any local employees during Operation will already be accounted for in the number of estimated angler days on Jacko Lake and will therefore not increase the fishing pressure on the stocked rainbow trout population. The number of employees sourced outside of the area will range from 21% to 35%; 35% of the total Operation labour force would therefore be 194. If 5% of these employees are anglers this would mean an additional 10 active anglers who would potentially fish on Jacko Lake.

Blasting

The use of explosives will be required to develop the Open Pit and is described in detail in Section 3.5. The Open Pit will encroach into 1 ha of the northeast arm of Jacko Lake and will be approximately 50 m from the southeast arm at its greatest extent. A dyke is required across the northeast arm to contain Jacko Lake from the Open Pit and to facilitate the removal of the Kinder Morgan pipeline (Klohn Crippen Berger 2015). The dyke will be a homogeneous earthfill structure to the west of the Open Pit. A temporary sheet pile wall will be used to isolate the arm of the lake and allow dewatering for removal of the Kinder Morgan Pipeline (Klohn Crippen Berger 2015). The pit and northeast dyke together will fill in the approximately 2 ha northeast arm of Jacko Lake. Once the downstream arm of the lake has been dewatered the soft lakebed sediments will be stripped from the foundation of the dam. The embankment will be constructed with glacial till with the upstream slope armoured with a 1 m thick layer of large diameter riprap. The downstream face will be armoured with rock to mitigate erosion, or will be re-vegetated (Klohn Crippen Berger 2015). With the dyke in place, the closest blasting in the Open Pit to the edge of Jacko Lake will be 50 m.

During the detonation of explosives a rapid chemical reaction occurs that produces pressure, heat, and gas products: the detonation pressure forms a shock front that results in rock fragmentation, displacement, air and water overpressure, and ground vibration (Kolden and Aimone-Martin 2013). Buried explosives charges coupled into the ground surface ("dry" blasting) can impact nearby waterbodies by the lateral transfer of ground vibrations along the water edge to create water overpressures, as well as enter into the substrate and propagate as particle motions at the water-substrate interface (Kolden and Aimone-Martin 2013). Ground vibration measurements are reported as Peak Particle Velocity (PPV) in millimetres per second (mm/s). Water overpressure is the sudden change in water pressure from ambient pressure. Following an explosion there is a near instantaneous rise to a maximum peak pressure followed by an exponential decay to a minimum pressure; peak pressure and impulse are the most commonly reported parameters for blast strength (Kolden and Aimone-Martin 2013). Sound pressure level is the highest amplitude peak pressure and is commonly reported in pounds per square inch (psi) or Pascals (Pa); 1 psi is equivalent to approximately 6894 Pa, and 6.9 kiloPascals (kPa). Impulse is the integral of the pressure-time waveform calculated over a time interval and is reported in psi·millisecond (psi·msec) or Pa·millisecond (Pa·msec).

The effects of blasting on fish and fish habitat are outlined in Guidelines for the Use of Explosives In or Near Canadian Waters (Wright and Hopky 1998) and include:

- damage to the fish swimbladder, and potential rupture and hemorrhage of the kidney, liver, spleen, and sinus venosus when overpressure is in excess of 100 kPa;

- damage to incubating eggs from mechanical shock and from sedimentation covering spawning areas;
- changes in fish behavior;
- Sedimentation resulting from the use of explosives may reduce or eliminate bottom-dwelling life forms that fish use for food (e.g., benthic macroinvertebrates); and
- ammonia or other by-products from the detonation of explosives may be toxic to fish and other aquatic biota.

As the rainbow trout population currently in Jacko Lake is stocked annually and there is no evidence that spawning occurs in the lake or outlet stream, potential effects of blasting on fish in Jacko Lake and Peterson Creek will focus on fish mortality, rather than on incubating eggs. Changes in fish behavior and sedimentation infilling benthic invertebrate habitat are discussed as a sub-lethal effect in the following sub-section. The effect of blasting residues on water quality is addressed in Section 6.3.

Barotrauma is the physical damage caused by quick changes in ambient pressure; the swim bladder of fish is the most commonly damaged organ (Kolden and Aimone-Martin 2013). The swim bladder will expand and contract in response to positive and negative phases of the pressure wave, and exhibit over-inflation, ruptures, tears and bruises (Kolden and Aimone-Martin 2013). Other injuries associated with blasting have included hemorrhaging, which can be minor (in fins and epidermal tissue) to major (when it occurs in the gills, liver, kidney, gastrointestinal tract, heart, or brain); embolism resulting from the formation of gas bubbles; and visceral damage on other organs, muscle, and mesentery tissue from the expansion and contraction of the swim bladder (Kolden and Aimone-Martin 2013).

Blasting can also damage the auditory, equilibrium, lateral line and electrosensory systems in fish, resulting in sub-lethal effects by disrupting orientation and locomotion, predator detection, and navigation (Kolden and Aimone-Martin 2013). Exposure to blasting can cause changes in stress hormones and related behavioural changes such as bursts of jumping and rapid swimming, and the inability to express an alarm reaction, making fish more susceptible to predation.

Studies of blasting effects on fish have shown that mortality rates vary with species, life stage, blasting charge weights, and proximity to fish: rainbow trout showed no mortality at impulses of approximately 34 kPa·msec and corresponding peak pressure of 882.5 kPa, and 20% to 90% mortality at impulses between approximately 131 kPa·msec and 172 kPa·msec and corresponding peak pressures of 1965 kPa, while rainbow trout held in cages 15 m to 150 m from blasts showed 10% to 20% mortality at 85 kPa and 95% mortality at 100 kPa from overpressures resulting from blasting in bedrock below a lake (as reported in Kolden and Aimone-Martin 2013). The results of these studies do not accurately predict effects from blasting for the Project, however, since there will be no caged fish and no blasting in water.

A wide variety of instrumentations and methodologies have been used for determining impulse strength from overpressure measurements, and the data output recorded by the different instrument configurations varies depending on instrument response time, frequency response, detection capabilities, etc., making comparison of data collected from different studies very difficult (Munday et al. 1986).

In addition, the method employed to calculate impulse strength from overpressure data varies between investigations, further complicating comparison of results (Munday et al. 1986). Many of the studies reported by Kolden and Aimone-Martin (2013) are not directly applicable to the Project, since they involve underwater blasting or mid-water detonations. The detonation of explosives in the Open Pit will be 50 m from the edge of Jacko Lake at its closest point. Peak pressure measured in open water normally decays at an exponential rate inversely proportional to distance (Munday et al. 1986). Many of the studies also involved caged fish held stationary in the water column; the rainbow trout within Jacko Lake will be free to move around, so the likelihood that rainbow trout will be immediately adjacent to the eastern shore of Jacko Lake and therefore exposed to the estimated maximum 100 kPa overpressure at the edge of the lake closest to the Open Pit is small.

Instream Works

Work within the riparian area or wetted area of streams and lakes will be required for the Peterson Creek Diversion; installation of the northeast dyke and saddle dams on Jacko Lake; temporary bridges over Peterson Creek for construction access; and offsetting measures, as described in Section 3.

The Peterson Creek Diversion will involve clearing, grubbing, and topsoil stripping; cut and fill of material; concrete works; installation of a modular pump station; and in-lake water pipe. Similarly, the Kamloops Lake Intake will require civil works for the Booster Stations and installation of the pipeline on the substrate of Kamloops Lake. The use of mobile industrial equipment within the wetted areas of the lakes has the potential to cause direct mortality to fish through crushing or burial on or within the disturbed substrate.

Fish mortality in Jacko Lake could result from installation of the sheet pile dam if pile driving is used, depending on substrate type, pile size and type, hammer size and type, number of pile strikes necessary to drive a pile, and the number of piles that will be driven in a day (Stadler and Woodbury 2009).

The sheet pile wall for the northeast dyke on Jacko Lake (to allow removal of the Kinder Morgan pipeline and steeper Open Pit walls) will be driven into the till foundation to an assumed depth of 10 m below the lake and to 5 m for the abutments (Klohn Crippen Berger 2015). Underwater sounds from driving hollow steel pipes with an impact hammer can injure and kill fish (Stadler and Woodbury 2009). In the United States, Stadler and Woodbury (2009) report that the National Oceanic and Atmospheric Administration has produced interim criteria for the onset of physical injury to fish. The onset of physical injury is expected if either of peak Sound Pressure Level (SPL) or Sound Exposure Level exceeds:

- SPL: 206 decibels (dB) re: 1 microPascal (µPa) (meaning the SPL in dB at the instant of maximum absolute pressure referenced to 1 µPa);
- Sound Exposure Level: 187 dB re: 1 $\mu Pa^2 \cdot sec$ Sound Exposure Level for fish 2 grams or larger or 183 dB re: 1 $\mu Pa^2 \cdot sec$ Sound Exposure Level for smaller fish of all strikes generally occurring within a single day.

Different types of piles result in different sound pressures; peak pressure and sound exposure for single strike sound levels at a fixed distance of 10 meters reported for the California Department of Transportation (ICF Jones & Stokes and Illingworth and Rodkin, Inc. 2009) are:

- SPL ranges from 177 dB re: 1 µPa for 12 inch timber and cast-in-shell steel drop piles to 208 dB re: 1 µPa for 30 inch cast-in-shell steel impact piles;
- Sound Exposure Level range from 152 dB re: 1 µPa2·sec for 12 inch cast-in-shell steel drop piles to 180 dB re: 1 µPa^2·sec for 30 inch cast-in-shell steel impact piles.

The 30 inch cast-in-shell pipes are typically used in permanent construction projects; typical installation duration is two to four piles per day, with 1,600 to 2,400 strikes per pile per day (ICF Jones & Stokes and Illingworth and Rodkin, Inc. 2009).

The potential for fish mortality as a result of oil, grease and fuel leaks from equipment is discussed in Section 11.12 (Risk Management Plan - Accidents and Malfunctions).

Entrainment or Impingement

Direct mortality of fish could result from entrainment or impingement on the freshwater intake in Kamloops Lake or the Peterson Creek Diversion intake in Jacko Lake. Entrainment occurs when a fish is drawn into a water intake and cannot escape; impingement occurs when an entrapped fish is held in contact with the intake screen and is unable to free itself. The risk of entrainment or impingement depends on the approach velocity (the water velocity into, or perpendicular to, the face of the intake screen), which differs depending on the swimming mode of fish present in the watercourse and fish swimming performance. Approach velocities are governed by open screen area (area of all open spaces on the screen available for the free flow of water) and effective screen area (area occupied by the open screen area and the screen material available for the free flow of water).

The preliminary design for the Kamloops Lake intake for an assumed total design flow rate of 1,800 m^3/h (the Project requires 1,500 m^3/h while the New Afton mine requires 300 m^3/h) includes a 22 m^2 screen area comprised of stainless steel with a flow rate of 500 litres per second (0.5 m^3/h) and an approach velocity of 0.038 m/s (Urban Systems 2015). However, the peak water demand for the Project is approximately 1,700 m^3/h with annual average freshwater demand of 1,500 m^3/h. For the purposes of this assessment peak water demand of 1,700 m^3/h was used. Preliminary design options for the Peterson Creek Diversion on Jacko Lake include an intake on the north arm.

Fish Stranding/Isolation

Direct mortality could result from fish stranding in areas that are dewatered to allow construction in isolation of flow, or in downstream areas as a result of water withdrawals (Peterson Creek downstream of the Mine Site or in the Thompson River downstream of the intake). Reduced water depths and increased flow ramping rates (the rate of change) may also isolate fish in small pools, decreasing survival through increased predation, desiccation, freezing, or heating. Stranding and isolation of fish in creeks is typically associated with rapid reduction in flows.

Sub-lethal Effects

Altered Water Chemistry

The effects of potential changes in water chemistry on aquatic life in Jacko Lake and Peterson Creek are discussed in Section 6.3.

Sub-lethal effects to fish from changes in water quality may occur from Project activities through three pathways: direct and indirect contributions of dustfall loading to water bodies, seepage of contact water to water bodies, and soil erosion that creates increased loads of suspended solids. The Project activities associated with each of the key pathways are:

- Dustfall – the operation of construction equipment and vehicles and the development of the open pit by drilling, blasting, transporting and crushing mine rock will contribute dust to the atmosphere. Dust dispersion models predict that dust generated from the Project will fall within the Peterson Creek catchment area; dust that falls directly on the creek is expected to flow with water into Jacko Lake.
- Contact water – metal leaching and seepage from the mine rock storage facilities and from the tailings storage facility have the potential to change the concentrations of key parameters in surface water.
- Soil erosion – the reclamation activities associated with the Decommissioning and Closure phase of the Project could temporarily increase soil erosion and contribute sediments to existing surface water ways.

Rationale for the selection of these pathways for the assessment of potential sub-lethal effects was based on well-known effects of altered water quality on fish and other aquatic life. Increased concentrations of metals, other toxic substances, suspended sediment and turbidity can have both lethal and sub-lethal effects on fish. Increased concentrations can affect the ability to feed, increase susceptibility to predation and suppress immune function and reproduction. The severity of these effects is dependent on both the concentration and duration of exposure to elevated concentrations.

A water quality model was developed to quantify water quality changes that could result from the Project interactions and to measure the effectiveness of mitigation measures on potential adverse effects on aquatic life including fish and fish habitat (Section 6.3). Parameter concentrations were predicted at five water quality nodes within the LSA: Jacko Lake, Humphrey Creek, and three locations along Peterson Creek downstream of the outlet of Jacko Lake (Peterson Creek at the Goose Lake Road crossing (PC03); Peterson Creek downstream of the Peterson Creek Diversion Pond (PC02.3); Peterson Creek upstream of Long Lake Road (PC02). The five nodes are situated within all major receiving water bodies to provide a complete understanding of the potential changes to water quality throughout the LSA resulting from the interactions described above. The water quality model was developed in Microsoft® Excel using a mass balance approach, which is a generally accepted water quality modelling practice for mining projects in BC. Inputs to the model included information from hydrological, hydrogeological, geochemical, and dustfall deposition models as well as baseline water quality data. As water quality model results were produced, mitigation measures were developed to address any predicted adverse effects to water quality. Mitigation measures often included changes to the water quality model inputs, such as the water management and sediment erosion control plans. Changes to the model inputs as a result of mitigation were incorporated into the water quality model in an iterative process to optimize the Project plans. The surface water quality predictions that were considered in the effects assessment are the results of the final iteration of the water quality model, which accounts for all mitigation measures.

The effects of Project interactions on fish populations in the LSA were evaluated by assessing current and predicted surface water quality in comparison to water quality guidelines for the protection of the most sensitive aquatic life receptors. For most parameters, the provincial guidelines were used as a basis for comparison, which are based on measured effects of parameters on specific aquatic life species and include a factor of conservatism for the application to other species. Current BC water quality guidelines are designed to be protective across a wide range of conditions and are thus conservative. The intended broad-spectrum application of these water quality guidelines means that they do not adequately account for site-specific factors that can alter the toxicity of metals and other inorganic compounds, meaning these water quality guidelines can be overly protective. Site-specific water quality parameters (e.g., hardness, dissolved organic carbon [DOC]) can decrease the toxicity and/or minimize the effects of some metals and other inorganic chemicals, suggesting the BC guidelines may be overprotective under certain conditions. Exceedances of the provincial guidelines do not necessarily indicate water that is not suitable for fish habitat; some parameter concentrations currently exceed guidelines under baseline conditions in Peterson Creek, which continues to support aquatic life. Water quality benchmarks were developed for the protection of the specific aquatic life species present in the LSA for such parameters, which include chloride, arsenic, copper, molybdenum, and selenium. An additional science based environmental benchmark was developed for sulphate, based on a framework outlined in the provincial guideline for this parameter, indicating that waters exceeding a hardness threshold of 250 mg/L $CaCO_3$ require site specific toxicity testing. Since elevated hardness concentrations are common in the LSA, water from Jacko Lake was used to develop two science based environmental benchmarks, specific to the protection of adult and juvenile rainbow trout. These benchmarks are expected to be protective of fish in Jacko Lake and Peterson Creek. Details regarding the site specific water quality and science based environmental benchmarks established for to determine the significance of potentially altered water quality effects on fish are provided in Section 6.3.4.2 - Effects on Surface Water Quality, Appendix 6.3-B - Testing in Support of Development of a SBEB for Sulphate and Appendix 6.3-D - Derivation of Protective Water Quality Benchmarks.

The assessment of Project effects on fish and fish habitat requires a detailed comparison of current and predicted water quality with the water quality benchmarks and science based environmental benchmarks, developed specifically for the unique properties of the LSA, in addition to the more generic provincial water quality guidelines.

The results of the predictive water quality modelling were used in the Human Health and Ecological Risk Assessment (HHERA) presented in Section 10. Future COPC concentrations for fish, benthic invertebrates and sediment were estimated using predicted future surface water COPC concentrations. Screening ratios for the benthic invertebrate ecological receptor community were less than 1.0, therefore Project-related activities were concluded to pose no greater risk to invertebrate communities than baseline conditions. Potential health effects for benthic invertebrate communities were assessed in the HHERA by comparing COPC concentrations in sediment to sediment quality guidelines for the protection of aquatic life. Chromium was the only COPC above applicable guidelines in Peterson Creek and Jacko Lake for both the baseline case and future case. Within the LSA, the small increase in sediment chromium concentration was not considered meaningful. Downstream of the Project area, the sediment chromium concentration was not predicted to increase between baseline case and future case.

Parameters that were predicted to exceed aquatic life guidelines during any phase of the Project at any of the modelled nodes were considered potential effects on fish habitat and were evaluated based on their magnitude and probability of occurrence. Residual effects were identified as the parameters that were predicted to exceed guidelines as a result of the Project at more than one node, for duration longer than one phase of the Project, under the most probable conditions. Table 6.7-11 provides an overview of the residual effects of the Project on Surface Water Quality by site that were identified in the effects assessment, including the temporal scope, proposed mitigation and the determination of significance for the VC.

Table 6.7-11. Potential Effects, Mitigation Measures, and Determination of Significance for Water Quality Changes (Water Chemistry)

Potential Effects	Proposed Mitigation	Determination of Significance
Increased load of total parameters due to dustfall	Best management practices, specifically, the dust management plan, will minimize the amount of dust emitted by Project activities. Reclamation of the tailings storage facility and mine rock storage facilities during Decommissioning and Closure reduces dustfall.	Not Significant – Moderate • Copper at Humphrey Creek
Increased load of parameters due to tailings storage facility and mine rock storage facilities seepage	The tailings storage facility design includes a dry cover, to minimize the amount of seepage through the facility. The mine rock storage facilities are designed for minimal seepage and will be covered during reclamation, for Decommissioning and Closure and Post-Closure. Water management ponds are designed to intercept seepage from the tailings storage facility and prevent it from entering Jacko Lake. Seepage not intercepted by water management ponds is expected to report to the Open Pit.	Not Significant – Moderate • Selenium at Humphrey Creek • Sulphate at Humphrey Creek • Sulphate at PC02 • Chloride at PC02 • Selenium at PC02 Not Significant – Minor • Sulphate at PC02.3

Characterization of residual effects of surface water quality on aquatic life is detailed in Section 6.3.5.3. Within Humphrey Creek (a non-fish bearing creek with no surface connection to Peterson Creek), copper concentrations are predicted to exceed baseline concentration ranges and generic aquatic life water quality guidelines, but are not predicted to exceed the water quality benchmarks. Sulphate concentrations in Humphrey Creek are predicted to exceed baseline concentration ranges but are not predicted to exceed the science based environmental benchmark. Selenium concentrations in Humphrey Creek are predicted to slightly exceed the baseline concentration range, generic water quality guidelines, and the water quality benchmark. Importantly, Humphrey Creek is non-fish bearing and has no surface connection to Peterson Creek; water quality results are mentioned here for consistency with Section 6.3.

Within Peterson Creek at site PC02.3, sulphate concentrations are predicted to exceed baseline concentration ranges in Construction and early Operations seasonally due to slightly reduced flow conditions associated with the filling of the PCDP; sulphate concentrations are not predicted to exceed the science based environmental benchmark.

At Peterson Creek site PC02 sulphate concentrations are predicted to exceed the baseline concentration range in Construction and the first year of Operations due to slight flow reductions as the PCDP fills and are predicted to seasonally exceed baseline concentrations under low flow conditions. Chloride concentrations are predicted to exceed the baseline concentration range seasonally and the generic chronic aquatic life guidelines during winter low flow months, but are not expected to exceed the water quality benchmark. Selenium concentrations are predicted to exceed baseline concentration range and generic water quality guideline seasonally (March through May) on a continuous basis, though the water quality benchmark is not predicted to be exceeded.

Other potential effects of the Project on surface water quality that were addressed in Section 6.3 and the rationale for not carrying them forward in the significance ratings were:

- Increased load of parameters due to mine rock storage facilities runoff: water management ponds are designed to capture runoff from the mine rock storage facilities areas and prevent it from entering the receiving water. The mine rock storage facilities will be covered during reclamation, which will prevent natural precipitation from contacting the mine rock material.
- Increased load of parameters due to water management pond seepage: the Water management pond is designed to intercept seepage from the tailings storage facility and mine rock storage facilities, which is reclaimed for Project processes during the Operation Phase; during Decommissioning and Closure and Post-Closure, the water management ponds are used as an evaporative pond with no surface water flow to Jacko Lake.
- Increased suspended solids due to sediment erosion: erosion will be managed using best practices and sediment sources will be addressed with settling ponds.

Additional detail on the Surface Water Quality VC is provided in Section 6.3. To reduce duplication and prevent double counting of potential effects, the effects of the project on surface water quality with respect to aquatic life requirements are not carried forward in this assessment on fish and fish habitat.

Altered Water Temperature

In addition to the changes in water chemistry, development activities can directly affect water temperatures through (Fisheries and Oceans Canada 2014):

- changes in water depth or hydrodynamics (filling/dumping, dredging, water drawdown, impoundment or release, shoreline modifications);
- dams discharging hypolimnetic water;
- changes to groundwater exchange; or
- riparian planting or removal, aquatic vegetation removal or addition, shading structures, suspended sediments, algal blooms, or contaminants that affect light penetration or clarity.

Changes to the thermal regime beyond diurnal or seasonal averages for fish could accelerate embryo development; reduce metabolic efficiencies of food conversion into growth due to thermal stress and oxygen deficiency; and increase susceptibility to disease or parasitism (Oliver and Fidler 2001). Early life stages of many fish and some benthic organisms are more susceptible to temperature changes

because they are unable to move quickly or are immobile, while larger individuals can move to areas with more favourable conditions (Fisheries and Oceans Canada 2014).

Behavioural changes in fish in response to high temperatures reported by Oliver and Fidler (2001) include an avoidance reaction, where fish seek thermal refugia (e.g., deep pools, areas of ground water intrusion, cooler tributaries, or cooler headwater reaches). If no thermal refugia exist, fish may be susceptible to multiple stressors that reduce their performance, as metabolic energy is diverted from activities such as growth and reproduction and directed toward activities that restore homeostasis such as respiration, locomotion, and tissue repair (Oliver and Fidler 2001). Under low temperature extremes, stream-rearing juvenile salmonids have been reported to seek out cover in interstitial areas of the channel bed or in off-channel areas.

The optimum temperature range for rainbow trout rearing is 16°C to 18°C. Oliver and Fidler (2001) report that a rise in the metabolic rate of cold-blooded aquatic organisms occurs when optimum temperatures are exceeded, which increases their energy requirements, and may increase the risk of predation in juvenile salmonids due to increased foraging. Temperature extremes as high as 22°C to 24°C and as low as 0°C are considered life-threatening for salmonids. The severity of temperature shock is directly related to the acclimation temperature preceding a change in temperature, the magnitude of the temperature change, and the period of exposure. A rapid increase or decrease in temperature can result in high mortality (Oliver and Fidler 2001) Since heat exchange is a function of body size (a slower rate of heat transfer occurs in larger fish due to their proportionally larger body volume) in general, adult fish are much more sensitive to temperature extremes than juveniles (Oliver and Fidler 2001).

Reductions in flow affect water temperature by reducing the streams assimilative capacity for heat, and dams and water withdrawals can influence stream temperature by altering the discharge regime (Masonand and Metikosh 2007). The Peterson Creek Diversion will require installation of a diversion intake on the north arm of Jacko Lake and pumping of water through a 6.3 km long, 400 mm diameter waterline to a discharge location on Peterson Creek downstream of the Open Pit. The water will flow through the natural existing channel for a distance of approximately 500 m before flowing into the Peterson Creek Downstream Pond. Potential effects on temperature in Peterson Creek downstream of these Project components are described in Appendix 6.7-F; a summary is presented here.

The location and elevation of the Peterson Creek Diversion intake in Jacko Lake could affect Peterson Creek water temperature downstream. Due to seasonal differences in air temperature and solar radiation and mixing within Jacko Lake, water temperature differs throughout the water column. Typically, during warmer months water within the epilimnion (the top layer of a lake) warms up while the hypolimnion (the bottom layer) stays cooler. As fall approaches, water temperatures within the epilimnion and hypolimnion typically become more uniform. The proposed Peterson Creek diversion intake is located at a comparable depth to the existing lake outflow gate (within the epilimnion), suggesting that the temperature of water leaving the lake via the waterline will be similar to water entering Peterson Creek via the current outflow. If the intake is located within the thermocline (the transition zone between the epilimnion and hypolimnion) water

temperatures within the waterline would be cooler than the current outflow into Peterson Creek during the summer months.

Water temperature within Peterson Creek is subject to larger temperature fluctuations than Jacko Lake because it is well mixed, shallow and the relatively slow moving. Increases in water temperature result from exposure to air temperatures that are higher than water temperatures, and solar radiation; decreases in temperature are the result of lower air temperatures compared to water temperatures and possibly an increased influence from groundwater. As outflows from Jacko Lake diminish in August and September, groundwater potentially has a larger influence on stream temperature. During winter months there can be substantial snow and ice cover on Peterson Creek, so that any flow present in the channel (likely dominated by groundwater flow) would be insulated from atmospheric changes in temperature.

Water temperature change within the Peterson Creek Diversion waterline was estimated using a model that calculates steady-state heat transfer to or from the water in a pipeline. The temperature difference was estimated at less than 0.2°C between the intake and outlet, assuming that the Peterson Creek Diversion will operate at a constant flow of 0.08 m^3/s between May and September only. Compared to baseline flows in Peterson Creek, water temperature in the pipeline would be lower during summer months (since it is not exposed to air temperature and solar radiation) and higher in late summer and autumn (when the natural channel is influenced by cooler groundwater inflow). The absolute difference in temperature between the waterline and Peterson Creek is estimated to range from 0.5°C to 2.1°C between May and September, within the range of natural variability and measurement error. No measureable effects on water temperature associated with the Peterson Creek Diversion waterline are anticipated.

The Peterson Creek Downstream Pond will have a surface area of approximately 17 ha at normal operating level, an average depth of 6 m, and maximum depth at the downstream embankment of 12 m. Water temperature in the pond was assessed using a two-layer model of heat and kinetic energy budgets (Appendix 6.7-F). Model inputs are location (which defines climatic conditions), average lake depth (which affects stratification) and turbidity (which affects energy absorption). The inflow was assumed to be 0.08 m^3/s. During April to July, surface water temperatures in the pond are predicted to be warmer than Jacko Lake; between July and November surface water temperatures in the pond are predicted to be cooler than Jacko Lake. The absolute difference in temperature between Jacko Lake and the Peterson Creek Downstream Pond is estimated to range from 0.1°C to 1.3°C between May and November, within the range of natural variability and measurement error. No measureable effects on water temperature associated with the Peterson Creek Downstream Pond are anticipated. Details of the pond outlet structure are currently not known, but low level (or multi-level) outlets could be used to ensure pond outflows are comparable or cooler than Jacko Lake surface waters.

Groundwater temperature remains relatively constant, while stream water temperatures vary seasonally and diurnally. Groundwater seeps out into streams in gaining streams, and stream water moves into groundwater systems in losing streams. Project activities that affect surface or groundwater flows may affect surface water temperatures by influencing the relative contribution of groundwater to the base flow of streams. Project effects on water temperature may occur in:

- Peterson Creek downstream as a result of changes in water quantity due to water management within the Mine Site (capture and storage of contact water);
- Kamloops Lake and Thompson River as a result of water withdrawal.

Removal of riparian vegetation can affect water temperature through reduction of canopy shading, as leaves reduce the amount of radiation falling on the streambed (Mason and Metikosh 2007). Submerged macrophytes also influence water temperature by affecting light penetration.

Changes in dissolved oxygen concentration in water could result from Project activities that alter water temperatures or cause nutrient loading. Provincial guidelines for buried embryos or alevins recommend an instantaneous minimum value of 9 mg/L in the water column and 6 mg/L in the interstitial spaces of the substrate; for all other life stages the recommend instantaneous minimum value is 5 mg/L (Ministry of Environment 1997a). Under normal circumstances, dissolved oxygen concentrations in spawning media may not meet provincial criteria, and typical survival rates of incubating salmonids are known to be relatively low due to a combination of stressors, including lack of oxygen (Ministry of Environment 1997a).

Altered Sediment Quality

A change in sediment concentration can result from increases in either suspended sediment in the water column (Project activities that increase erosion in adjacent terrestrial areas) or mobilization of fine material in the streambed (Project activities disturb bank or bed sediments) (Fisheries and Oceans Canada 2014). Altered sediment quality can affect aquatic productivity through (Fisheries and Oceans Canada 2014):

- accumulation of deposited sediment in interstitial spaces reducing suitability for egg survival and larval emergence and benthic macroinvertebrate production.
- reduced foraging efficiency and growth of fish due to increased turbidity, decreased primary production and macrophyte growth, and reduced benthic invertebrates.
- behavioural avoidance of turbidity.

Altered Primary Productivity

Hartman and Miles (2001) note that "productivity", with respect to lakes, may refer to the production of phytoplankton, zooplankton, fish, or any combination of these organisms. Downing and Plante (1993) similarly note that different indices of fish production have been used, including sport fishing yield, long or short term average catch, net growth increment, fish catch, and creel censuses. Habitat variables that have been reported to be correlated with fish production indices include lake area, mean depth, alkalinity, total dissolved solids, total nitrogen, total phosphorous, chlorophyll-a concentrations, primary productivity, benthos abundance, and fishing effort (Downing and Plante 1991).

A measure of 'productivity' depends upon whether the focus is on obtaining empirically derived estimates of fish yield or measuring total fish-community production (Hartman and Miles 2001). In studies that link population dynamics and habitat capacity, productivity has been defined and measured using population traits such as maximum survival rate (Randall 2003). Fish productivity is related to life history strategy and varies over time because of changes in environmental

conditions (Randall 2003). Productive capacity for fish is determined by whole-system attributes, such as thermal characteristics and nutrient availability, as well as by attributes measured at a smaller spatial scale, that potentially act as bottlenecks (Randall 2003). Randall (2003) however, notes that habitat bottlenecks that affect production are poorly understood; for example, there is no evidence to support the contention that spawning habitat is a limiting factor. Downing et al. (1990) found that fish production was closely correlated with annual phytoplankton production, mean total phosphorous concentration, and annual average fish standing stock.

Primary productivity in Jacko Lake or Peterson Creek could be affected by Project components or activities that alter water quality (temperature, nutrients from blasting residues) or affect habitat.

Changes to the thermal regime can affect aquatic productivity. For periphyton at the community level, responses to temperature increases have been reported by Oliver and Fidler (2001) as:

- a shift in the dominance of algal classes from diatoms at temperatures less than 20°C to green algae at 15°C to 30°C, and to blue-green algae at temperatures greater than 30°C;
- species diversity increases from approximately 0°C to 25°C and decreases at temperatures greater than 30°C;
- the degree to which community composition changes with thermal input depends on the initial ambient temperature: increases in temperature in environments near 25°C to 30°C typically cause greater changes in community structure than in environments less than 25°C; and
- biomass increases with temperature from approximately 0°C to 30°C, and decreases at 30°C to 40°C.

Community structure usually recovers rapidly when temperature stress is discontinued. For aquatic insect communities, temperature fluctuations beyond threshold levels can affect diapause induction (suspension of development at the embryonic, larval, pupal, or adult stage, either obligatory or in response to environmental conditions), hatching success, larval growth, adult size and fecundity, the number of generations per year based on larval growth rate, and timing of adult emergence (Oliver and Fidler 2001).

Oligotrophic lakes are nutrient poor, and typically have clear water and high dissolved oxygen concentrations throughout the water column. Eutrophic lakes are highly productive waterbodies that have abundant macrophytes and algae and typically have deeper waters that become depleted of dissolved oxygen during the summer. Eutrophic systems are more likely to produce algal blooms, which indirectly affect fish populations through reductions in dissolved oxygen (Fisheries and Oceans Canada 2014).

Provincial water quality guideline limits are not applicable to phosphorous; a range of phosphorous concentration is used instead to define the trophic status of surface water bodies (Appendix 6.3-A). The trophic status is generally categorized by the dissolved phosphorus concentrations, as well as chlorophyll-a and Secchi depth. The ranges of total phosphorus used to define each trophic category are as follows:

- Ultra-oligotrophic <0.004 mg/L

- Oligotrophic 0.004 mg/L to 0.010 mg/L
- Mesotrophic 0.010 mg/L to 0.020 mg/L
- Meso-eutrophic 0.020 mg/L to 0.035 mg/ L
- Eutrophic 0.035 mg/L to 0.100 mg/ L
- Hyper-eutrophic >0.100 mg/L.

Trophic status is determined as a baseline against which to assess changes from current conditions; potential effects of the Project on trophic status of Jacko Lake and Peterson Creek are presented in Section 6.3. Total phosphorus concentrations in Peterson Creek were found to be highly variable, extending over several trophic status ranges at any given site. Within Jacko Lake surface waters had total phosphorous concentrations in the eutrophic category, with samples from deeper waters in the hyper-eutrophic range.

Nutrients entering a lake from the surrounding watershed, or that are produced internally, stimulate the growth of macrophytes and algae, contributing to lake productivity. Nutrient enrichment may boost primary productivity, which increases the availability of food and increases fish productivity (Fisheries and Oceans Canada 2014).

Behavioural Changes

Noise

Pile driving and dredging within and adjacent to Jacko Lake, and land-based activities like excavation, drilling, blasting, and use of mobile and stationary heavy equipment have the potential to increase noise levels in Jacko Lake.

Anthropogenic noise can result in avoidance behaviour and increased stress, which may affect fisheries productivity; the ecological significance of such effects is typically low, except where reproductive activity is involved (Fisheries and Oceans Canada 2014). Most of the effects are expected to be short-term, with the duration of the effect less than or equal to the duration of the sound exposure; there are no documented cases of population scale impacts of sound on productivity of commercial, recreational, or Aboriginal fisheries (Fisheries and Oceans Canada 2014).

Light

Lighting requirements for the Project are described in Section 3. The effect of this lighting on Dark Sky is assessed in Section 8.2.

Perkin et al. (2011) discuss the influence of artificial light on species interactions and processes in stream and riparian ecosystems. The adverse effects of artificial light on aquatic systems have been reported as (Perkin et al. 2011):

- slowing or stopping the migration of Pacific salmon;
- decreased smoltification and increased deterioration in body condition associated with smoltification in chinook salmon exposed to constant light;

- aquatic invertebrates in lotic (flowing water) systems drift at light levels below 103 lux (at 400–535 nm) to avoid predation by fish;
- Atlantic salmon change foraging strategies below light levels of 101 lux, moving to areas of slow-moving water that may have less prey but allow more time for identification of prey items and night-time foraging;
- reduced time spent by zooplankton feeding on algae in the upper euphotic water column (diel vertical migration) leads to increased algal biomass;
- change in aquatic invertebrate community composition, with higher relative abundance of armored grazers (e.g., glossosomatid caddisflies or snails) and fewer invertebrates with less physical protection (e.g., mayflies) as a result of heavy predation.

Holt and Waters (1967) reported reduced nocturnal drift for a species of mayfly and amphipod.

Most permanent light sources for the Project will be associated with infrastructure at the Plant Site, or other buildings (e.g., truck shop), which are quite distant from Jacko Lake. Since the influence of light is not noted to be a principal stressor on fisheries productivity in freshwater systems (Fisheries and Oceans Canada 2014) potential effects of light on Fish and Fish Habitat will not be carried further in this assessment.

Summary

The following potential effects associated with the Project components and activities are carried forward in this assessment:

- direct habitat loss in Jacko Lake resulting from the Open Pit development;
- direct habitat loss in Peterson Creek resulting from the Open Pit development;
- indirect habitat loss in Peterson Creek downstream of the Project footprint due to flow reductions;
- direct mortality to fish in Jacko Lake resulting from blasting;
- direct mortality to fish in Jacko Lake resulting from installation of the sheet pile dam for the northeast dam;
- direct mortality to fish in Jacko Lake and Kamloops Lake as a result of entrainment or impingement associated with the Peterson Creek Diversion and the Water Intake, respectively;
- direct mortality to fish in Jacko Lake, Kamloops Lake, and Peterson Creek from stranding as a result of dewatering of wetted areas;
- sub-lethal effects on fish in Jacko Lake and Peterson Creek resulting from changes in sediment quality;
- sub-lethal effects on fish in Jacko Lake and Peterson Creek resulting from changes in altered primary productivity.

6.7.4.3 Mitigation Measures for Fish and Fish Habitat

Mitigation measures to avoid, minimize, and/or control potential adverse effects of the Project on Fish and Fish Habitat include: design changes; implementation of Best Achievable Control Technology or management practices; and providing restoration or offsetting.

Mitigation and management plans outline a range of measures to reduce Project effects on VCs. Many of the mitigation and management measures work along the interaction pathway between the Project and the VC. In addition to the Fisheries and Aquatic Life Monitoring Plan, the following management and monitoring plans will also contain measures that will protect fish and fish habitat during the normal course of Construction and Operation:

- Surface Water Quality Management and Monitoring Plan, Section 11.23;
- Groundwater Quality Management and Monitoring Plan, Section 11.24;
- Erosion and Sedimentation Control Plan, Section 11.2;
- Metal Leaching and Acid Rock Drainage Management and Monitoring Plan, Section 11.5; Air Quality and Dust Control Management Plan, Section 11.6;
- Water Management and Hydrometric Monitoring Plan, Section 11.7;
- Explosives Management Plan, Section 11.11;
- Soil Salvage and Handling Plan, Section 11.3;
- Dark Sky Management and Monitoring Plan, Section 11.19; and
- Noise and Vibration Management Plan, Section 11.22.

The following paragraphs discuss measures that will be implemented throughout the life of the Project to minimize adverse effects on the Fish and Fish Habitat VC.

Habitat Loss - Direct

Section 35 of the *Fisheries Act* includes a prohibition against causing serious harm to fish that are part of or support a commercial, recreational or Aboriginal fishery (Fisheries and Oceans Canada 2013b). The *Fisheries Act* defines "serious harm to fish" as "the death of fish or any permanent alteration to, or destruction of, fish habitat". The Fisheries Protection Policy Statement (Fisheries and Oceans Canada 2013b) states that most waterbodies in Canada contain fish, or their habitat, that are part of or support commercial, recreational or Aboriginal fisheries. If serious harm to fish as a result of a project cannot be avoided or mitigated, an authorization under Subsection 35(2) of the *Fisheries Act* is required for the project to proceed without contravening the Act (Fisheries and Oceans Canada 2013b). Avoidance measures may include locating infrastructure or designing a project to prevent serious harm to fish (Fisheries and Oceans Canada 2013b). Mitigation measures are those that reduce the spatial scale, duration, or intensity of serious harm to fish and can include implementation of best management practices (Fisheries and Oceans Canada 2013b).

Project design measures to avoid or mitigate serious harm to fish associated with the Open Pit and the Peterson Creek Diversion are described in Section 2.5 (Alternative Means of Undertaking the Proposed Project). Development of the Project would result in the permanent loss of fish habitat and

associated productive capacity; therefore, offsetting options are required. Offsetting is required when residual serious harm to fish remains after avoidance and implementation of mitigation measures. The offsetting measures to address potential serious harm to fish in Jacko Lake and Peterson Creek will be implemented, as described in the Ajax Project Conceptual Offsetting Plan (Appendix 6.7-D). The quantitative results from the serious harm assessment are summarized in Appendix 6.7-D. Fish habitat losses in the northeast arm of Jacko Lake total 2.04 ha of littoral habitat and 0.80 ha of riparian vegetation. The littoral habitat gains in the southeast arm total 0.18 ha. The overall net loss of fish habitat in Jacko Lake is 1.85 ha of littoral habitat and 0.80 ha of riparian vegetation. Fish habitat losses in Peterson Creek below Jacko Lake include an estimated 3.85 ha of instream channel and pond habitat and 7.71 ha of riparian vegetation. Fish habitat gains associated with the Peterson Creek Downstream Pond total 6.14 ha. The overall net change of fish habitat in Peterson Creek is a habitat gain of 2.29 ha of instream channel and pond habitat and habitat loss of 7.71 ha of riparian vegetation. The total habitat losses identified as unavoidable serious harm to fish total 8.08 ha for the Ajax Project. This includes a net gain of 2.29 ha of instream habitat, a net loss of 1.85 ha of lake habitat, and a net loss of 8.51 ha of riparian habitat.

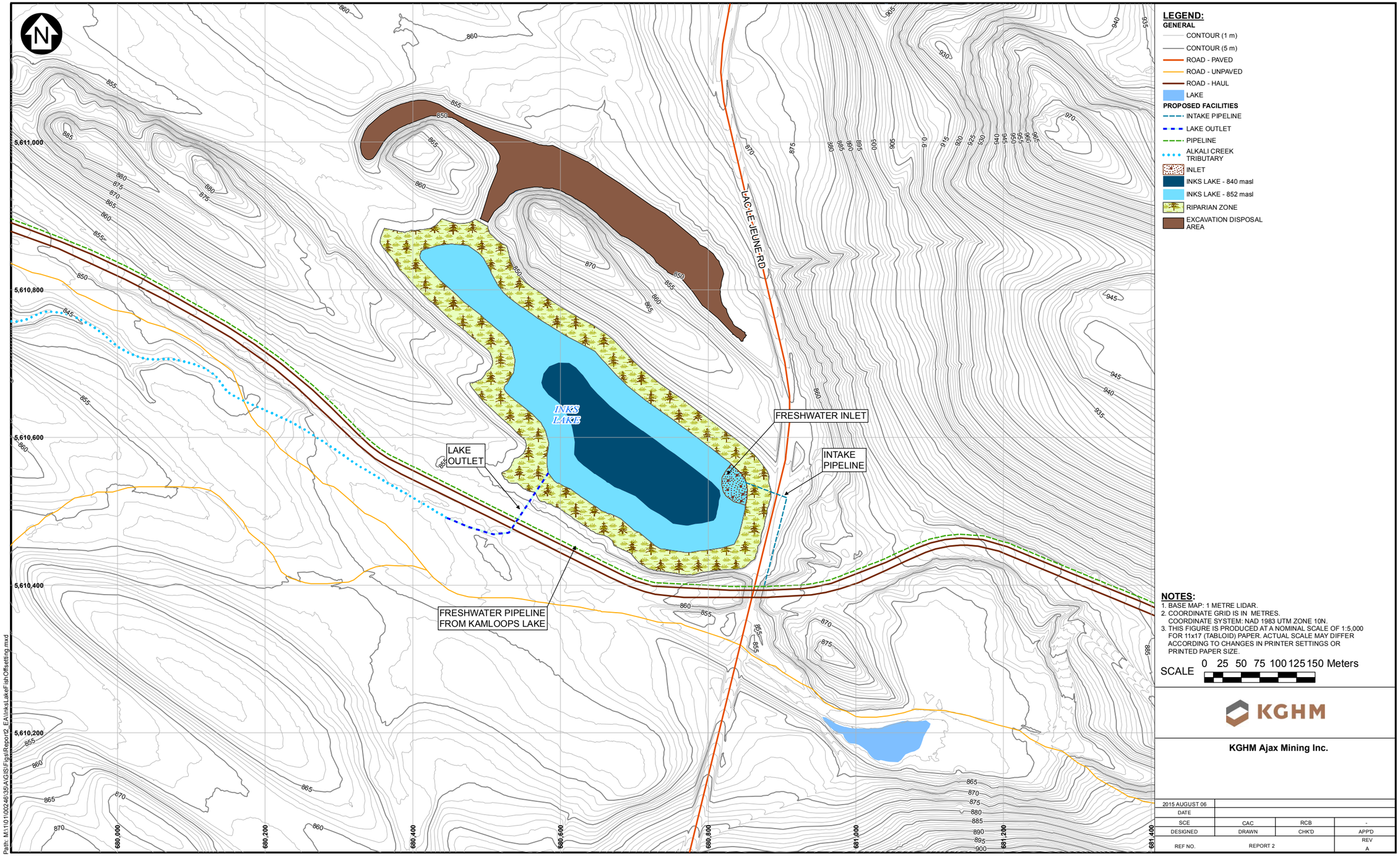
Residual effects on fish habitat may occur as a result of a lag time between habitat loss and full effectiveness of the offsetting measures. The assumption in most cases is that a 1:1 gain-to-loss ratio is necessary to satisfy DFO's Fisheries Productivity Investment Policy guidance. Offsetting ratios less than 1:1 were also used to calculate offsetting areas in consideration of the productivity, importance, and quality of lost and gained habitats. Fish habitat offsetting ratios greater than those applied may be required if the offsetting plan includes options that utilize techniques with long lag-times before they become fully functional. KAM intends to construct the agreed-upon offsetting works as quickly as possible to reduce lag-time effects. Equivalency of the proposed offsets is also considered relative to the productivity, importance, and quality of net fish habitat losses identified in the serious harm assessment.

The proposed Offsetting Plan concept is to modify the volume and depth of the south basin of Inks Lake by constructing an excavation and filling the basin using water supplied by the proposed Ajax freshwater pipeline and pumping station in Kamloops Lake. Inks Lake, located to the west of Jacko Lake, is unable to support fish without enhancement due to its shallow depth, lack of inflow, and unsuitable water quality. By increasing the depth and volume of Inks Lake and supplying appropriate water, it has the potential to support fish and create a fishery through the annual stocking of rainbow trout. The potential fish habitat gains that could be accomplished by establishing a fishery on Inks Lake have the potential to greatly exceed the fish habitat offsetting requirements for the Ajax Project.

Under the Fish Habitat Offsetting Plan, the existing lake water will be drained and the lake bottom excavated to increase the volume and maximum depth of the lake. Fresh water will be pumped using a spur from the proposed freshwater pipeline to provide process water for the Project from Kamloops Lake to fill Inks Lake. Once the lake has been refilled, the lake shoreline will be planted with native vegetation to establish a functional 30 m wide riparian zone. The lake will be stocked on an annual basis with rainbow trout from a local hatchery (similar to Jacko Lake), as no suitable stream exists in the area to allow for fish spawning and natural recruitment. The estimated lake volume at 852 masl following excavation is 450,000 m^3. The Inks Lake offsetting concept is shown on Figure 6.7-4.

Figure 6.7-4
Inks Lake Fish Habitat Offsetting Plan

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Construction of the Inks Lake offsetting habitat consists of five main stages: dewatering, excavation and spoil disposal, riparian bench construction, inlet armouring / outlet channel construction and riparian planting. An additional stage of installing a liner on the lake bottom to prevent seepage losses is not expected however will be added if necessary.

Lake filling will commence following construction of the lake basin from April to October. Once the lake basin is refilled, the water quality conditions should be acceptable to support rainbow trout and will be confirmed by monitoring. The lake inflow and outflow volume from April to October will maintain water quality in Inks Lake throughout the operational life of the Project. Inks Lake will be stocked annually in the spring with Fraser Valley, Pennask, or other local hatchery strains of rainbow trout.

The concept at mine closure is to discontinue pumping water uphill from Kamloops Lake and introduce a passive water supply system. A potential water supply option is to divert water to Inks Lake through a valve-controlled gravity fed water pipeline from the northwest arm of Jacko Lake as shown Figure 6.7-5. FLNRO has suggested that a portion of its existing water licence allocation volume for Jacko Lake could be diverted to Inks Lake for this purpose.

The net habitat balance resulting from the Offsetting Plan is 2.29 ha of instream habitat, 4.22 ha of lake habitat, and -0.12 ha of riparian habitat. The net positive value of 6.39 ha demonstrates that the proposed Conceptual Fish Habitat Offsetting Plan is larger than necessary to offset the amount of serious harm to fish and fish habitat from the Ajax Project. Pending review comments and discussion with agencies further adjustments to the Offsetting Plan will be necessary so amount of fish habitat offsetting is equivalent to the magnitude of serious harm identified for the Project.

Construction compliance monitoring will be conducted to minimize the environmental effects of construction activities. Effectiveness monitoring will be conducted to ensure the offsetting works are functioning as designed. Detailed monitoring plans will be developed in consultation with DFO to identify the appropriate metrics for assessing the performance of the offsetting works.

Habitat Loss - Indirect

An authorization under Subsection 35(2) of the *Fisheries Act* is also required for projects that have the potential to obstruct fish passage or modify flow, since these effects may cause serious harm to fish. Mitigation measures to address changes in surface water quantity in Peterson Creek downstream of the Project footprint are described in Section 6.4. The primary mitigation measure is development and implementation of the Water Management Plan.

The Fisheries and Aquatic Life Monitoring Plan and the Surface Water Quality Management and Monitoring Plan will be implemented to assess predicted flow changes against actual flow changes. Flow and hydraulic characteristics at the established transect sites will be monitored during the Project Construction, Operation, Decommissioning and Closure and Post Closure phases to assess whether the predicted changes in flow meet the recommended flow threshold for BC streams. Should monthly values be measurably different than predicted values, additional mitigation measures will be considered, which could include working with the provincial government to manage releases from the Peterson Creek Downstream Pond to meet instream flow needs.

Changes in flow in Peterson Creek downstream of the Project area will remain after implementation of the mitigation measures noted in Section 6.4, therefore there will be residual effects to the Fish and Fish Habitat VC through indirect habitat loss.

Mortality

Increased Fishing Pressure

It is anticipated that there will be a marginal increase in the number of recreational anglers on Jacko Lake as a result of the Project workforce during the Construction and Operation phases. The increased fishing pressure resulting from an additional 17 anglers during the Construction phase and 10 anglers during the Operation phase will not have a measureable effect on the stocked rainbow trout population in Jacko Lake, given that the population was sustained with the higher angler effort in 1986 (6285 angler days) compared to the 2008 through 2010 period (4094 angler days). Project employees will be prohibited from angling when they are working and access to the lake from the mine property will be restricted.

If creel surveys or angler effort estimates conducted by regional provincial fisheries biologists note an increase in the number of anglers attributed to the Project labour force and a related increase in fish mortality, KAM will explore measures to reduce this angling effort if necessary. No residual effects on mortality related to an increase in fishing pressure on Jacko Lake are anticipated.

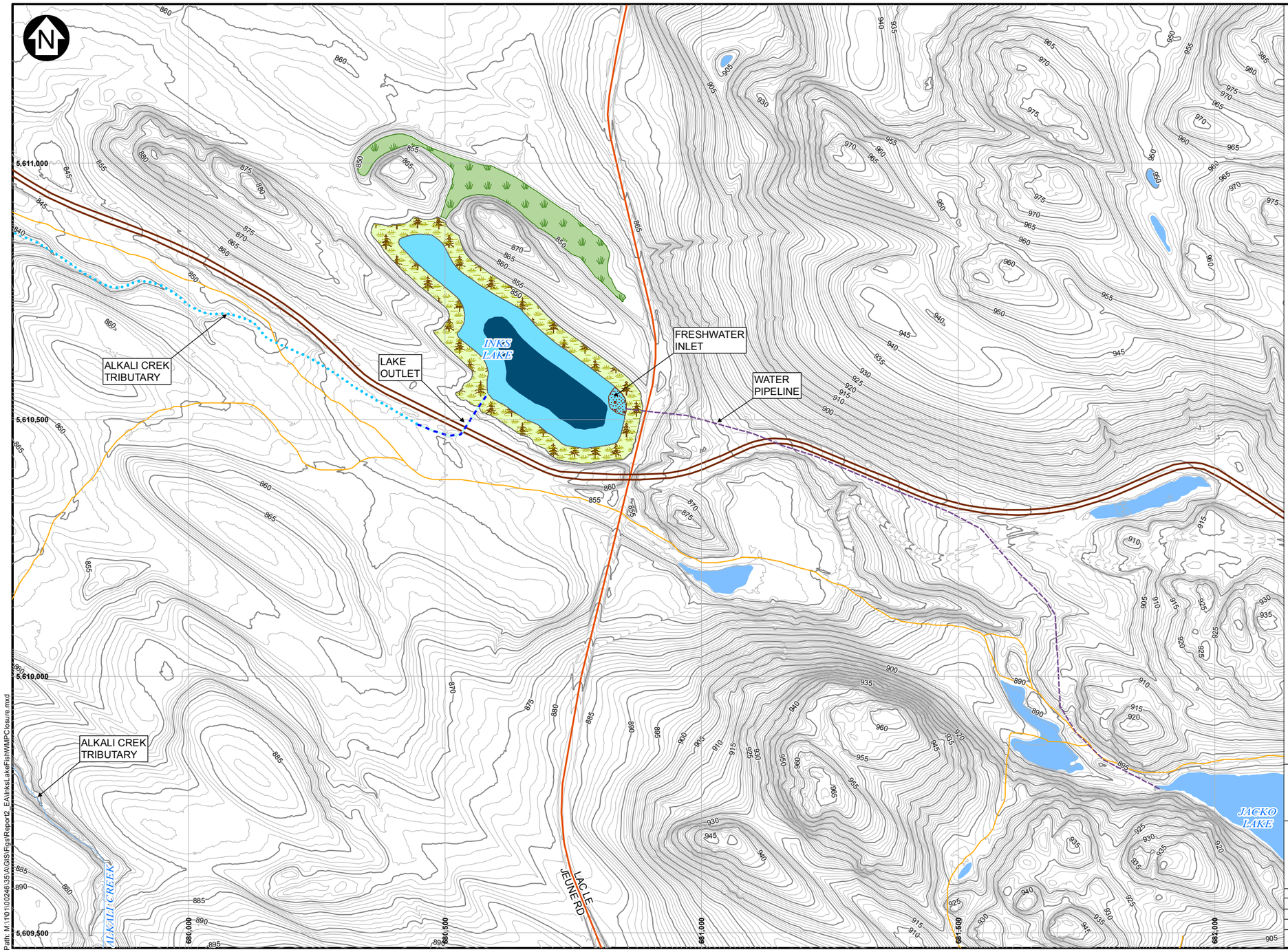
Blasting and Sheet Pile Dam Installation

The guidelines recommended by Wright and Hopky (1998) for blasting are no longer endorsed by Fisheries and Oceans Canada (C. Gibson Pers. Comm. 2015). Instead Fisheries and Oceans Canada (2013a) provides "Measures to Avoid Causing Harm to Fish and Fish Habitat" for conducting work near water, including:

- Avoid using explosives in or near water.
- Isolate the work site to exclude fish from within the blast area.
- Remove any fish trapped within the isolated area prior to initiating blasting.
- Minimize blast charge weights used and subdivide each charge into a series of smaller charges in blast holes with a minimum 25 millisecond delay between charge detonations.
- Back-fill blast holes to grade or to streambed/water interface to confine the blast.
- Place blasting mats over top of holes to minimize scattering of blast debris around the area.
- Do not use ammonium nitrate based explosives in or near water.
- Remove all blasting debris and other associated equipment/products from the blast area.

Figure 6.7-5
Inks Lake Water Management Plan at Mine Closure

Knight Piésold CONSULTING



LEGEND

GENERAL
- CONTOUR (1 m)
- CONTOUR (5 m)
- ROAD - PAVED
- ROAD - UNPAVED
- ROAD - HAUL
- RIVER/CREEK
- LAKE

PROPOSED FACILITIES
- LAKE OUTLET
- WATER PIPELINE
- ALKALI CREEK TRIBUTARY
- INLET
- INKS LAKE - 840 masl
- INKS LAKE - 852 masl
- RIPARIAN ZONE
- RECLAIMED DISPOSAL AREA

NOTES:
1. BASE MAP: 1 METRE LIDAR.
2. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD 1983 UTM ZONE 10N.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:8,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.

SCALE 0 50 100 150 200 250 300 Meters

KGHM

KGHM Ajax Mining Inc.

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These measures have been used to develop blast designs and procedures to minimize risks of harm to fish and fish habitat. The detonation of explosives in the Open Pit will be 50 m from the edge of Jacko Lake at its closest point. Blasting at the closest point to the lake will be limited to a specific mining phase; therefore blasting in close proximity to the lake will be temporary. The northeast dyke will be installed to separate fish near the eastern shore Jacko Lake from blasting near the edge of the Open Pit (Klohn Crippen Berger 2015). Activities required for installation of the dyke will follow the mitigation measures outlined for instream works.

The blast charge weights will be reduced and smaller diameter holes will be used as the edge of the Open Pit (and associated blast patterns) approaches the eastern shore of Jacko Lake. A full column of explosives in 311 mm boreholes with a maximum explosives mass/delay of 1020 kg will be used up to approximately 482 m (up to Zone 1 - horizontal distance along the surface plus the pit slope distance) from the nearest sections of Jacko Lake, as described in Chiappetta (2014). As the edge of the Open Pit approaches Jacko Lake the explosives mass per delay, borehole diameter, and stem deck separations will decrease, and the number of explosives decks will increase. Within Zone 3 (in which the average distance to the edge of Jacko Lake is 130 m), the explosives mass per delay will be reduced to 68 kg, the borehole diameter will be reduced to 152 mm, the stem deck separation will decrease to 2.3 m, and three explosives decks will be used. The delay between holes will also vary as the edge of the Open Pit approaches Jacko Lake:

- For blasts up to Zone 1, there will be one explosives column and a stem charge, and both the stem charge and explosive column will be initiated simultaneously; the delay in these blasts would be 8ms between holes;
- For blasts between Zone 1 and 2, there will be two explosive columns and a stem charge. The stem charge will be fired, followed by an 8 ms delay for the first explosive column and another 8 ms for the second column; the total delay would be two 8 ms delays within the hole plus the 8 ms inter hole delay, for a 24 ms delay between holes;
- For blasts between Zone 2 and 3, there will be two explosive columns and an 8 ms delay between the columns. Total delay will be the one 8 ms delay within the hole plus one 8 ms inter hole delay, giving 16 ms between holes.
- Beyond Zone 3 (closest to Jacko Lake) the holes will contain three explosive columns, the top column will be initiated, 8 ms later the middle column will be initiated, and 8 ms later the bottom column will be initiated. With the 8 ms delay between holes, this will give a 24 ms total delay between holes.
- No blasts will be detonated at the streambed/water interface.

Blasts will be confined by top stemming, blasting mats or other applications such as stemming plugs to minimize scattering of blast debris. All blasting debris and other associated equipment and products will be removed from the blast area to allow mining to proceed safely. Ammonium nitrate-based explosives will not be used in water or within 50 m of water.

In addition to these measures, setback distances for maximum overpressures of 100 kPa and peak particle velocities of 13 mm/s at the closest shoreline of Jacko Lake were calculated by Chiappetta (2014) to comply with overpressure and peak particle velocity criteria previously endorsed by DFO

and presented in Wright and Hopky (1998). Blast designs in three zones within the pit were developed to minimize impacts on fish in Jacko Lake by varying borehole diameter, using explosive decks, and firing only one hole and/or explosive deck per delay to meet the maximum overpressures of 100 kPa and peak particle velocities of 13 mm/s, as shown in Table 6.7-12 (Chiappetta 2014). Blast overpressure levels are the result of the size of the charge in each delay, rather than the sum of charges detonated in all holes. Explosive decks, in which two or three decks are included in one hole separated by a non-explosive material, allow more precise control during detonation (Munday et al. 1986).

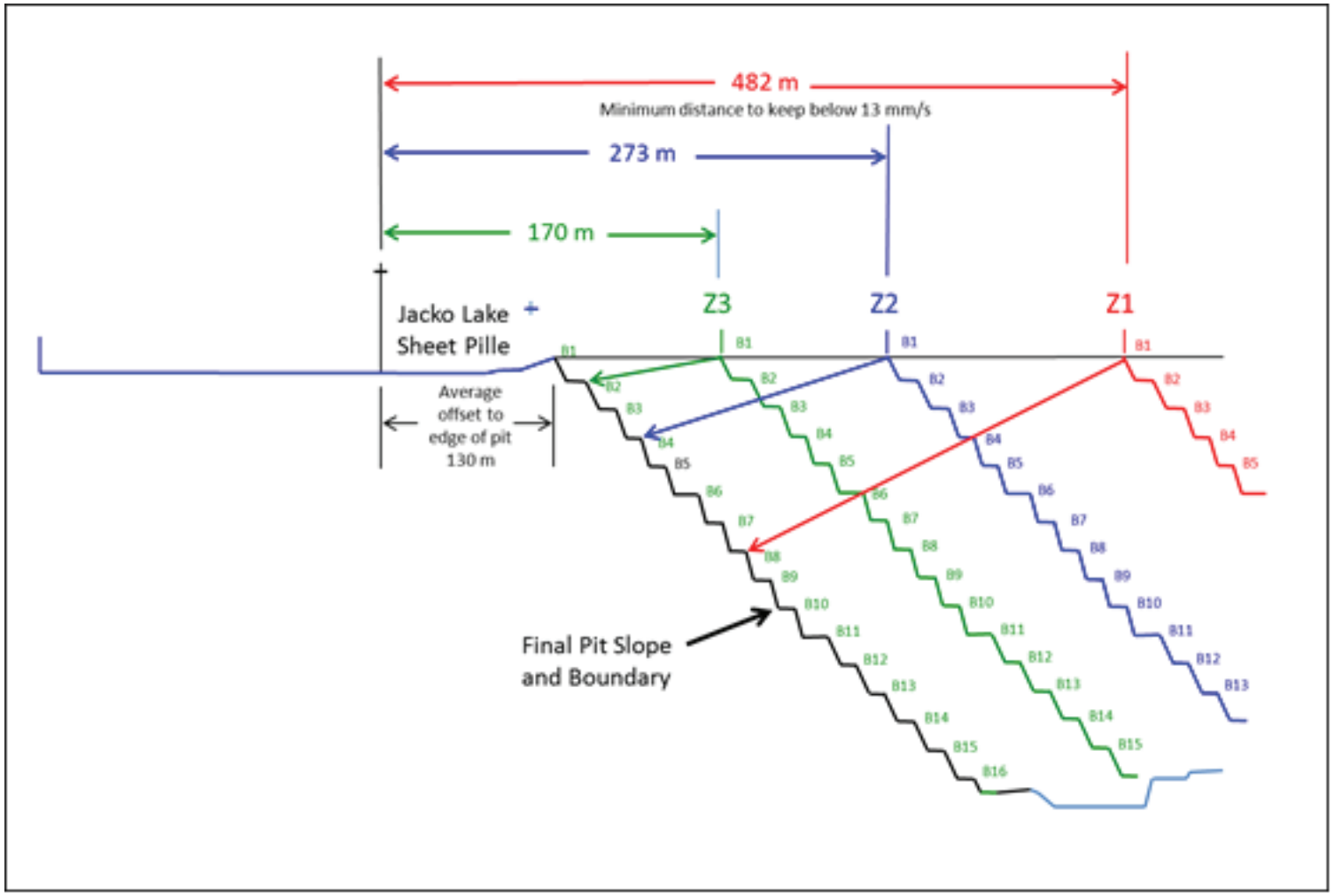
Table 6.7-12. Blast Design to Meet 100 kPa Overpressure and 13 mm/s Peak Particle Velocity

	Up to Zone 1	Zone 1 - Zone 2	Zone 2 - Zone 3	Zone 3 to Jacko Lake
Distance to Jacko Lake northeast Dyke (m)	482	273	170	130
Borehole diameter (mm)	311	311	152	152
Explosive decks	Full	2	2	3
Stem deck separation (m)		3.3	2.3	2.3
Explosives mass/delay (kg)	1,020	325	127.5	68

The objective in the Zone 1 blasts is to always maintain a minimum total distance of 482 m from Jacko Lake, where minimum total distance is the horizontal distance along the surface plus the pit slope distance. As mining and blasting move deeper into the Open Pit from the surface elevation, blast designs stipulated for Zone 1 can be used up to Zone 2 when the Open Pit is at least four benches down from the surface, up to Zone 3 when the Open Pit is at least six benches down from the surface, and at the final pit boundary when the Open Pit is at least eight benches down from surface (Chiappetta 2014). This is illustrated on Figure 6.7-6.

As well as varying the borehole diameters, number of explosive decks, and explosive masses, the in-hole delay sequence for all holes using explosive decking has been changed to fire top down, which will result in less ground vibrations by relieving the confinement conditions (Chiappetta 2014). Additional mitigation includes implementation of the Fisheries and Aquatic Life Monitoring Plan. Monitoring during Operation to assess the effects of blasting on fish will include measuring the instantaneous pressure rise in the water column as the Open Pit edge approaches the eastern shore of Jacko Lake and visual observation of the lake following the blasts. Although no longer endorsed by DFO, the overpressure and peak particle velocity criteria used to develop the blasting design for the Project are appropriate, based on mortality studies reported in the literature. No residual effects of blasting on the rainbow trout population in Jacko Lake are therefore anticipated. This potential effect is not carried forward in the assessment.

Figure 6.7-6
Ajax Project Fish and Fish Habitat
Cross Section of Blast Zones Approaching Jacko Lake at the Final Pit Boundary



NOTES:
1. REPRODUCED FROM CHIAPPETTA, R.F. 2014. AJAX MINE BLAST REVIEW, CONCLUSIONS AND RECOMMENDATIONS. PREPARED BY BLASTING ANALYSIS INTERNATIONAL INC. PREPARED FOR KGHM INTERNATIONAL.

To mitigate against mortality of fish in Jacko Lake associated with installation of the sheet pile dam for the northeast dyke, installation procedures will be designed to comply with the National Oceanic and Atmospheric Administration interim criteria for the onset of physical injury to fish. These criteria are:

- SPL: 206 dB re: 1 µPa (meaning the SPL in dB at the instant of maximum absolute pressure referenced to 1 µPa);
- Sound Exposure Level: 187 dB re: 1 µPa2·sec Sound Exposure Level for fish 2 grams or larger or 183 dB re: 1 µPa2·sec Sound Exposure Level for smaller fish of all strikes generally occurring within a single day.

Additional mitigation includes implementation of the Fisheries and Aquatic Life Monitoring Plan. Monitoring during Construction to assess the effects of sheet pile installation on fish could include measuring SPL and Sound Exposure Level in the water column and visual observation of the lake for any fish mortalities.

Residual effects on the Fish and Fish Habitat VC from fish mortality associated with changes in pressure from installation of the sheet pile dam could potentially remain following implementation of the recommended mitigation measures. Potential effects of installation of the sheet pile dam are carried forward in the assessment.

Instream Works

Implementation of the Fisheries and Aquatic Life Monitoring Plan and Spill Contingency Plan, as well as industry standard best practices will be the key mitigation measures to reduce fish mortality that could result from Project activities within the wetted area of Jacko Lake, Peterson Creek, or Kamloops Lake. Any riparian or instream work will adhere to the management plans and provincial and federal standards and advice outlined in Ministry of Water, Land and Air Protection (2004) and Fisheries and Oceans Canada (2013a), including but not limited to:

- a fish and amphibian salvage will be completed before the start of works where a wetted channel or waterbody will be isolated or dewatered;
- all in-water work areas will be isolated by temporarily diverting, enclosing, or pumping the water around the worksite, with the point of discharge immediately downstream of the worksite to minimize disturbance to downstream populations and habitats;
- all equipment and machinery will be in good operating condition and free of leaks, excess oil, and grease;
- whenever possible, machinery will be operated on land above the high water mark, on ice, or from a floating barge to minimize disturbance to the banks and bed of the waterbody;
- no equipment refuelling or servicing will be undertaken within 30 m of any watercourse or surface water drainage;
- all hydraulic machinery entering a stream or waterbody will use hydraulic fluids that are non-toxic to aquatic life and that are readily or inherently biodegradable;

- any sediments, debris, concrete, concrete fines, wash or contact water associated with any concrete works will not be deposited, directly or indirectly, into or about any watercourse. A CO_2 tank with regulator, hose and gas diffuser will be readily available during concrete work to neutralize pH levels in the event of a spill;
- material such as rock, riprap, or other materials placed on the banks or within the active channel will be inert and free of silt, overburden, debris, or other deleterious substances;
- excavated material and debris will be removed from the site or placed in a stable area above the high-water mark as far as possible from the waterbody;
- vegetation clearing for access to the site and work area will be minimized to the extent possible. Following any work within a waterbody or riparian area, any adjacent shoreline or banks disturbed by the work will be stabilized through re-vegetation with native species suitable for the site; and
- any water that contacts uncured or partly cured concrete will be contained and monitored until the pH is between 6.5 and 8.0 pH units and the turbidity is less than 25 nephelometric turbidity units measured to an accuracy of +/- 2 nephelometric turbidity units.

For the Project, no equipment refuelling or servicing will be undertaken within 50 m of any watercourse or surface water drainage. Construction activities in or near any waterbody will be monitored full-time to the completion of the project by an appropriately qualified professional. The monitor will have written authority to modify or halt any construction activity if deemed necessary for the protection of fish and wildlife populations or their habitats.

No residual effects on the Fish and Fish Habitat VC from instream works are anticipated with implementation of the management plans and best management practices.

Entrainment or Impingement

To prevent mortality of fish in Jacko Lake and Kamloops Lake associated with entrainment or impingement on fresh water intakes, screens will be installed and design of the intakes will adhere to the advice outlined in Fisheries and Oceans Canada (2013a), including but not limited to:

- screens will be located in areas and depths of water with low concentrations of fish throughout the year;
- screens will be located away from natural or artificial structures that may attract fish;
- the screen face will be oriented in the same direction as the flow;
- screens will be located a minimum of 300 mm above the bottom of the watercourse to prevent entrainment of sediment and benthic aquatic organisms;
- structural support will be provided to the screen panels to prevent sagging and collapse of the screen;
- large cylindrical and box-type screens will have a manifold installed in them to ensure even water velocity distribution across the screen surface, with the ends of the structure made out of solid materials and the end of the manifold capped;

- intakes will be designed to allow removal, inspection, and cleaning of screens; pumps will be shut down when fish screens are removed for inspection and cleaning;
- regular maintenance and repair of all cleaning apparatus, seals, and screens will be carried out to prevent debris-fouling.

In addition, the intakes will be designed to distribute the approach velocity (the velocity component perpendicular to the screen face) uniformly across the face of the screen; the approach velocity will be determined based on the size and swimming mode of fish present in the vicinity. For fish such as trout, the approach velocity for water diversions of 0.125 m^3/s or less is 0.038 m/s (Fisheries and Oceans Canada 1995). No residual effects on the Fish and Fish Habitat VC from entrainment or impingement are anticipated.

Fish Stranding/Isolation

Stranding and isolation of fish in creeks is typically associated with rapid reduction in flows. Flow regulation from the Peterson Creek Downstream Pond to meet the requirements of existing water licences will be managed by the provincial water bailiff. The Project will not affect the rate of release, therefore no effect on Fish and Fish Habitat as a result of stranding in Peterson Creek downstream of the Mine Site is anticipated and no mitigation measures are required.

Construction of the new outlet dam on Jacko Lake will prevent the stocked rainbow trout from moving downstream into Peterson Creek during high flow events, since there will not be a spillway. This may result in the isolation of the small population that currently exists within Peterson Creek upstream of Bridal Veil Falls. It is not certain if this population is self-sustaining or if sustained via migrants during high flow events that allow passage of fish in Jacko Lake over the existing dam spillway. If monitoring indicates that the small population in Peterson Creek experiences decreased abundance, it may be sustained by intermittent seeding from Jacko Lake rainbow trout during high flow events. Mitigation to address this potential effect includes monitoring abundance and, as an adaptive management measure, in accordance with Section 20.(2)(c) of the *Fisheries Act*, implementing a system of catching fish in the outlet arm, transporting them downstream of the Peterson Creek Diversion Pond, and releasing them back into Peterson Creek as required. No residual effects on the Fish and Fish Habitat VC from isolation of the downstream population are anticipated.

Instream works will be conducted in the dry, either by scheduling the work for low flow periods or by isolating (e.g. using cofferdams) and dewatering the work area. Fish salvage will be conducted in any work areas that will be dewatered. No residual effects on the Fish and Fish Habitat VC associated with mortality from fish stranding or isolation are anticipated.

Sub-lethal effects

Changes in Water Temperature and Dissolved Oxygen

Assuming that the Peterson Creek Diversion intake is located at a comparable depth to the existing lake outflow gate and that the diversion will operate at a constant flow of 0.08 m^3/s from May through September, no mitigation measures are proposed, as the estimated differences between the waterline and creek are within the range of natural variability and measurement error. Similarly, the absolute difference in temperature between Jacko Lake and the Peterson Creek Downstream Pond is

estimated to range from 0.1°C to 1.3°C between May and November, which is within the range of natural variability and measurement error. No mitigation measures other than those incorporated into the design of the intake depth are proposed.

Residual effects on surface water temperature and dissolved oxygen concentration associated with reduced flows in Peterson Creek downstream of the Mine Site are anticipated; however, as explained in Section 6.7.4.2, the magnitude of flows during September to April are currently very small and the rainbow trout population in Peterson Creek upstream of Bridal Veil Falls is maintained with the existing thermal regime. No residual effects on surface water temperature and dissolved oxygen concentration associated with reduced flows in Kamloops Lake downstream of the water intake are anticipated.

Water temperature and dissolved oxygen concentration will be monitored in Peterson Creek, as outlined in the Surface Water Quality Management and Monitoring Plan. If increases in summer water temperatures are noted in Peterson Creek downstream of the Peterson Creek Downstream Pond than adaptive management will be considered, which could include releasing flows from deeper in the water column.

Changes in Sediment Quality

Implementation of the Erosion and Sediment Control Plan is anticipated to fully mitigate any effects on Fish and Fish Habitat associated with changes in sediment quality. No residual effects to Fish and Fish Habitat are therefore anticipated.

Changes in Primary Productivity

Changes in primary productivity as a result of an altered thermal regime from reduced flows in Peterson Creek downstream of the Mine Site, or from nutrient additions from blasting residues entering a waterbody from surface runoff can affect Fish and Fish Habitat. Mitigation measures to address these potential effects are implementation of the Surface Water Quality Management and Monitoring Plan, the Erosion and Sediment Control Plan, the Air Quality Management Plan, and the Explosives Management Plan. Residual effects associated with an altered thermal regime due to reduced flows may occur.

6.7.5 Residual Effects and Their Significance

6.7.5.1 Summary of Residual Effects

The residual effects that are anticipated to remain after the implementation of mitigation measures are:

- direct habitat loss for rainbow trout in Peterson Creek and Jacko Lake within the Project footprint due to a lag time for the offsetting measures to become functional;
- indirect habitat loss in Peterson Creek downstream of the Project associated with flow reductions;

- fish mortality in Jacko Lake associated changes in pressure from installation of the sheet pile dam for removal of the Kinder Morgan pipeline and development of the Open Pit; and
- sub-lethal effects on fish populations in Peterson Creek downstream of the Project from changes in water temperature and primary productivity associated with reduced flows.

The potential Project effects by phase, mitigation measures, and residual effects are summarized in Table 6.7-13.

6.7.5.2 Criteria for Characterization of Residual Effects

Residual effects are characterized using the following criteria:

- **Magnitude.** This refers to the expected severity of the residual effect.
- **Geographic Extent**. This refers to the spatial scale over which the residual effect is expected to occur. The geographic extent of biophysical effects can be local (within the Project footprint, landscape/watershed, regional or beyond regional. Local effects may have a lower impact than regional effects.
- **Duration.** This refers to the length of time the effect lasts; the duration of an effect can be short-term to long-term. Short-term effects may have a lower impact than long-term effects.
- **Frequency.** This refers to how often the effect occurs; the frequency of an effect can be frequent to infrequent. Infrequent effects may have a lower impact than frequent effects.
- **Reversibility.** This refers to the degree to which the effect is reversible. Effects can be fully reversible, partially reversible, or permanent. Reversible effects may have a lower impact than irreversible or permanent effects.
- **Ecological Context.** This refers to the current condition of the VC and its sensitivity. For example, an effect may have more of an impact in an area that is ecologically sensitive or a greenfield site, rather than a disturbed or brownfield location.

Ratings for each of the criteria are shown in Table 6.7-14.

6.7.5.3 Characterization of Residual Effects

The characterization of each of the adverse residual effects based on these criteria is summarized in Table 6.7-15 and discussed in the paragraphs below.

<u>Direct Habitat Loss in Northeast Arm of Jacko Lake and in Peterson Creek from Open Pit Development</u>

The magnitude of the direct loss of habitat in the northeast arm of Jacko Lake and Peterson Creek from Open Pit Development affecting the productivity of the fish population is characterized as Minor, since the 2 ha northeast arm comprises approximately 4.2% of the total area of the lake at full pool and approximately 9.4% of the lake littoral area.

Table 6.7-13. Summary of Residual Effects on Fish and Fish Habitat

Project Phase (Timing of Effect)	Project Component/ Physical Activity	Description of Cause-Effect[1]	Description of Mitigation Measure(s)	Description of Residual Effect
Operation, Decommissioning and Closure, Post Closure	Open Pit	Direct loss of habitat in northeast arm of Jacko Lake affecting the productivity of the fish population	Offsetting Measures, Fisheries and Aquatic Life Monitoring Plan	Direct loss of habitat in northeast arm of Jacko Lake from Open Pit Development affecting the productivity of the fish population
Operation	Open Pit	Direct loss of habitat in Peterson Creek affecting the productivity of the fish population	Offsetting Measures, Fisheries and Aquatic Life Monitoring Plan	Direct loss of habitat in Peterson Creek from Open Pit Development affecting the productivity of the fish population
Operation, Decommissioning and Closure, Post Closure	Project Footprint, Contact Water	Indirect habitat loss in Peterson Creek downstream of the Project area associated with flow reductions	Water Management Plan, Fisheries and Aquatic Life Monitoring Plan, Surface Water Quality Management and Monitoring Plan	Indirect habitat loss in Peterson Creek downstream of the Project area associated with flow reductions from Project Footprint and Contact Water
Construction	Open Pit	Fish mortality in Jacko Lake associated with changes in pressure from installation of the sheet pile dam	Design in accordance with National Oceanic and Atmospheric Administration interim criteria for the onset of physical injury to fish	Fish mortality in Jacko Lake associated with changes in pressure from installation of the sheet pile dam for Open Pit Development
Construction, Operation, Decommissioning and Closure, Post Closure	Project Footprint, Contact Water	Change in water temperature and primary productivity associated with reduced flows	Water Management Plan, Fisheries and Aquatic Life Monitoring Plan, Surface Water Quality Management and Monitoring Plan	Sub lethal effects on fish populations in Peterson Creek downstream of the Project area associated with change in water temperature and primary productivity from reduced flows resulting from Project Footprint and Contact Water

[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 VC.*

Peterson Creek will be diverted around the north side of the Open Pit. The Magnitude of this direct loss of habitat is characterized as minor, since rainbow trout from Jacko Lake are only able to access this section of the creek when Jacko Lake discharges over the spillway. When lake levels fall the fish are stranded in this section of the creek, as water levels decline and sections of the creek become dry. The Duration of the effect is characterized as Medium-term, since the proposed offsetting ratios (habitat loss: habitat gain) will address any lag time between the habitat loss and the time required for offsetting to become fully functional. Frequency of the direct habitat loss is characterized as Once, since the habitat alteration will occur during the Construction phase. The extent of the direct habitat loss is Local.

Implementation of the two Jacko Lake offsetting options and Inks Lake Option 1 would result in a gain in wetted area of 7.31 ha and a gain in riparian area of 1.28 ha; no impacts on the productivity of the stocked rainbow trout population from direct habitat loss are anticipated, therefore the recreational or Aboriginal fishery will not be affected.

The northeast arm of Jacko Lake will be restored to the extent possible following Project Operation; this will be evaluated prior to closure. For the purpose of this assessment the direct habitat loss is characterized as Irreversible. Flow will be restored to Peterson Creek during the Decommissioning and Closure phase, resulting in a characterization of Reversible Long-term.

According to provincial records Jacko Lake was barren prior to the 1940s; however, Aboriginal Groups have indicated that Jacko Lake was an important trout fishery before the arrival of Europeans. Rainbow trout were initially stocked in Jacko Lake in 1954, and, with the exception of one year, the stocking program has continued on an annual basis. The lake level has been raised at least twice, with the upgrade of the outlet dam around 1970 and with the dam raise around 1990, resulting in increased lake area and creation and expansion of the arms of Jacko Lake. Between 1954 and 1970, an average of 30,735 rainbow trout were stocked annually (for a stocking density of 760 rainbow trout/ha). Between 1971 and 1990, an average of 21,612 rainbow trout were stocked annually (for a stocking density of 463 rainbow trout/ha). Since 1992 an average of 10,626 rainbow trout have been stocked annually (for a stocking density of 209 rainbow trout/ha). Therefore, the Resiliency of the rainbow trout population in Jacko Lake to the imposed stress of direct habitat loss is characterized as High, since the lake was presumably able to maintain the larger numbers of stocked fish within the smaller area between 1954 and 1990 compared to the current area. The ecological context is considered Low for this same reason.

The Significance of direct habitat loss of the northeast arm of Jacko Lake and the section of Peterson Creek within the Project footprint is anticipated to be Not Significant (minor). With the proposed offsetting ratios (habitat loss: habitat gain) and the similarity of the offsetting measures with the historical and ongoing mitigation and management measures in Jacko Lake (fish stocking, installation of outlet dams to raise the water level and increase water storage) the effectiveness of the offsetting plan to address serious harm to fish associated with direct habitat loss in Jacko Lake and Peterson Creek is assumed to be high. The Probability of the residual habitat loss is therefore deemed Low; the Confidence in the analysis is characterized as Medium.

Table 6.7-14. Definitions of Characterization Criteria for Residual Effects on Fish and Fish Habitat

Magnitude	Duration	Frequency	Geographic Extent (Physical/Biophysical)	Reversibility	Resiliency	Ecological Context	Likelihood of Effects	
							Probability	Confidence Level
How severe will the effect be?	*How long will the effect last?*	*How often will the effect occur?*	*How far will the effect reach?*	*To what degree is the effect reversible?*	*How resilient is the receiving environment or population?*	*What is the current condition of the ecosystem and how commonly is it represented in the LSA?*	*How likely is the effect to occur?*	*How certain is this analysis?*
Negligible: No or very little detectable change from baseline conditions represents <10% change in area.	**Short-term:** Effect lasts 1 to 5 years. e.g., during Construction	**Once:** Effect is confined to one discrete period in time during the life of the Project.	**Local:** Effect limited to the immediate area of infrastructure or activity.	**Reversible Short-term:** Effect can be reversed relatively quickly following removal of interaction or pathway.	**Low:** The receiving environment or population has a low resilience to imposed stresses, and will not easily adapt to the effect.	**Low:** The receptor is considered to have little to no unique attributes, or can adapt to the ongoing interaction and return to a pre-disturbance state.	**High:** It is highly likely that this effect will occur.	**High:** < 80% confidence. There is a good understanding of the cause-effect relationship and all necessary data are available for the Project area. There is a low degree of uncertainty and variation from the predicted effect is expected to be low.
Minor: Detectable change from baseline conditions but within the range of natural variation; represents >10% but ≤25% change in area.	**Medium-term:** Effect lasts 6 to 25 years. e.g., during Operations	**Sporadic:** Effect occurs at sporadic or intermittent intervals during any phase of the Project.	**Landscape:** Effect is limited to the LSA.	**Reversible Long-term:** Effect can be reversed within 20 years following removal of interaction or pathway (partially reversible).	**Neutral:** The receiving environment or population has a neutral resilience to imposed stresses and may be able to respond and adapt to the effect.	**Neutral:** The receiving environment considered to have some unique attributes, or may be able to adapt to the ongoing interaction and return to a pre-disturbance state.	**Medium:** This effect is likely, but may not occur.	**Medium:** 50 to 80% confidence. The cause-effect relationships are not fully understood, there are a number of unknown external variables, or data for the Project area are incomplete. There is a moderate degree of uncertainty; while results may vary, predictions are relatively confident.
Medium: Predicted change is beyond the range of natural variation ; represents 25% to ≤50% change in area.	**Long-term:** Effect lasts between 26 and 28 years; e.g., extends Decommissioning and Closure	**Regular:** Effect occurs on a regular basis during the life of the Project.	**Regional:** Effect extends across the Peterson Creek watershed downstream to the mouth, e.g. the RSA.	**Irreversible:** Effect is permanent.	**High:** The receiving environment or population has a high natural resilience to imposed stresses, and can respond and adapt to the effect.	**High:** The receiving environment or population is uncommon and will not easily adapt to the effect or will not return to a pre-disturbance state.	**Low:** This effect is unlikely but could occur.	**Low:** < 50% confidence. The cause-effect relationships are poorly understood, there are a number of unknown external variables, and data for the Project area are incomplete. High degree of uncertainty and final results may vary considerably.
Major: Differs substantially from baseline conditions, resulting in a detectable change beyond the range of natural variation; represents >50% change in area.	**Far Future:** Effect lasts more than 50 years e.g., extends through Post- Closure	**Continuous:** Effect occurs constantly during the life of the Project.	**Beyond Regional:** Effect extends beyond the RSA.					

Table 6.7-15. Characterization of Residual Effects, Significance, Likelihood and Confidence on Fish and Fish Habitat

Residual Effect	Residual Effects Characterization Criteria							Significance of Adverse Residual Effects	Likelihood and Confidence	
	Magnitude	Duration	Frequency	Geographic Extent	Reversibility	Resiliency	Context		Probability	Confidence
Direct loss of habitat in northeast arm of Jacko Lake from Open Pit Development affecting the productivity of the fish population	Minor	Far Future	Once	Local	Irreversible	High	Low	Not Significant (minor)	Low	Medium
Direct loss of habitat in Peterson Creek from Open Pit Development affecting the productivity of the fish population	Minor	Medium-term	Once	Local	Reversible Long-term	High	Low	Not Significant (minor)	Low	Medium
Indirect habitat loss in Peterson Creek downstream of the Project area from flow reductions associated with Project Footprint and Contact Water	Minor	Medium-term	Once	Regional	Irreversible	High	Low	Not Significant (moderate)	Medium	Medium
Fish mortality in Jacko Lake associated with changes in pressure from installation of the sheet pile dam for Open Pit Development	Minor	Short-term	Sporadic	Local	Reversible Short-term	High	Low	Not Significant (minor)	Low	High
Sub-lethal effects on fish populations in Peterson Creek downstream of the Project area associated with changes in primary productivity from reduced flows resulting from Project Footprint and Contact Water	Minor	Medium-term	Regular	Regional	Reversible Long-term	Neutral	Neutral	Not Significant (minor)	Medium	Medium

Indirect Habitat Loss in Peterson Creek downstream from the Project Area related to Flow Reduction

The Magnitude of the indirect loss of habitat in Peterson Creek on the productivity of the rainbow trout population downstream of the Project area is characterized as Minor for the Construction and Operation phases and Negligible during the Post Closure phase. The average Mean Annual Discharge is estimated to be reduced by 13% during the Construction phase, 18% during the Operation phase, and 6% during the Post Closure phase. The Magnitude of the indirect loss of habitat in Peterson Creek is rated as Minor; therefore, no impacts on the recreational or Aboriginal fishery are anticipated.

The Duration of the effect is characterized as Far Future, since the reduced flows will continue into the Post Closure phase. Since the mean monthly discharge in Peterson Creek downstream of the Project area typically will not meet the threshold values during September to April, the frequency is considered Regular. The extent of the indirect habitat loss is characterized as Regional, since the effect will be downstream of the Project area but within the Peterson Creek watershed. Since the reduced flows will continue into the Post Closure phase, the indirect habitat loss is characterized as Irreversible. The Resiliency of the rainbow trout population in Peterson Creek downstream from the Project Area is characterized as High, since meso-habitat measurements collected at flows similar to those predicted during September to April (0.003 m^3/s) suggest that water depths and velocities are suitable for the small bodied rainbow trout that inhabit this section of the creek. The ecological context is considered Low for this same reason.

The Significance of indirect direct habitat loss in Peterson Creek resulting from reduced flow is anticipated to be Not Significant (moderate). The Probability that the residual indirect habitat loss will occur is deemed Low, since the magnitude of flows during September to April are very small and the difference between the predicted flow and guideline threshold flow is often on the order of 0.001 m^3/s, which is likely within the resolution of the water balance model and field validation measurements. The Confidence in the analysis is characterized as High.

Fish Mortality in Jacko Lake from Open Pit Development

The Magnitude of fish mortality on the productivity of the rainbow trout population within Jacko Lake from installation of the sheet pile dam is characterized as Minor. No impacts on any recreational or Aboriginal fishery are anticipated as a result of any loss of productivity.

The Duration of the effect of installation of the sheet pile dam is characterized as Short-term, since the activity will be restricted to the Construction phase. Fish mortality from pressure changes associated with installation of the sheet pile dam is expected to be Sporadic in Frequency. The extent of fish mortality is characterized as Local, confined to an area adjacent to the overpressure source. Reversibility is characterized as Reversible Short-term, since adverse effects of mortality at the population level will be ameliorated by annual stocking of hatchery rainbow trout. The Resiliency of the rainbow trout population in Jacko Lake is characterized as High, since the rainbow trout population can respond and adapt to the overpressure source by avoidance behaviour. The Ecological Context is considered Low for this same reason, as well as the fact that the rainbow trout are stocked within the lake.

The Significance of fish mortality on the productivity of the rainbow trout population within Jacko Lake from installation of the sheet pile dam is anticipated to be Not Significant (minor). The

Probability that there will be a measureable change on the productivity of the rainbow trout population is deemed Low. The Confidence in the analysis is characterized as High.

Sub-lethal Effects on Fish in Peterson Creek Downstream from the Project Area related to Changes in Primary Productivity

Residual effects on primary productivity (periphyton) from surface water temperature and dissolved oxygen concentration associated with reduced flows in Peterson Creek downstream of the Project area are anticipated. Flow alterations during the main summer growing period (May through August) range from 5% to 10% of the mean monthly discharge during the Construction phase; 6% to 13% of the mean monthly discharge during the Operation phase; and 1% to 3% of the mean monthly discharge during the Post Closure phase. The Magnitude of the greatest change on primary productivity is therefore characterized as Minor. The Duration of changes on primary productivity is characterized as Medium-term, since the magnitude of reduced flows during the Post-Closure phase is predicted to be negligible during the summer growing season. Frequency is characterized as Regular. Since the Magnitude of change in primary productivity is characterized as Minor, no impacts on the recreational or Aboriginal fishery in Peterson Creek are expected.

The extent of the indirect habitat loss is characterized as Regional, since the effect will be downstream of the Project area but within the Peterson Creek watershed. Since the reduced flows during the summer growing season will be similar to baseline values during the Post Closure phase the effect on primary productivity is characterized as Reversible Long-term, since community structure usually recovers rapidly when temperature stress is discontinued. The Resiliency of the primary producers (periphyton) is characterized as Neutral, since the degree to which community composition changes with thermal input depends on the initial ambient temperature, with increases in temperature in environments near 25°C to 30°C typically causing greater changes in community structure than in environments less than 25°C. The Ecological Context is considered Low for this same reason.

The Significance of changes in primary productivity on the productivity of the rainbow trout population Peterson Creek is anticipated to be Not Significant (minor). The Probability that there will be a measureable change on primary productivity is deemed Low, since the magnitude of flow changes are likely within the resolution of the water balance model and field validation measurements. The Confidence in the analysis is characterized as High.

6.7.5.4 Significance of Residual Effects

Based on the residual effects characterization performed in Section 6.7.5.3, a significance conclusion of 'not significant' or 'significant' is assigned for each residual effect. Examples of combinations of characterization criteria to assign a rating of not significant (minor/moderate) or significant (major) include:

- Not Significant (Minor): Residual effects have no or low magnitude; local geographic extent; short- or medium-term duration; and occur sporadically if at all. The effects on the Fish and Fish Habitat VC at a species or population level are indistinguishable from background conditions (i.e., occur within the range of natural variation as influenced by physical, chemical, and biological processes).

- Not Significant (Moderate): Residual effects have medium magnitude; have local, watershed, or regional geographic extent; are short-term to chronic; and occur at all frequencies. Residual effects on the Fish and Fish Habitat VC may be distinguishable at the population, community, and/or ecosystem level.
- Significant (Major): Residual effects have high magnitude; have regional or beyond regional geographic extent; are chronic; and occur at all frequencies. Residual effects on the Fish and Fish Habitat VC could potentially result in structural and functional changes in populations, communities, and ecosystems.

The significance of each of the adverse residual effects based on these criteria is summarized in Table 6.7-15.

6.7.5.5 Characterization of Likelihood and Confidence

Once a significance determination is made, the probability (likelihood) of the residual effect occurring and the confidence in the significance predictions and use of mitigation measures are made. The Likelihood and Confidence of each of the adverse residual effects based on these criteria are summarized in Table 6.7-15.

6.7.5.6 Summary of Residual Effects Assessment and Significance

A summary of residual effects, mitigation, and significance on Fish and Fish Habitat is presented in Table 6.7-16.

6.7.6 Cumulative Effects Assessment

6.7.6.1 Introduction

Residual effects from multiple projects/activities can interact in different ways that are specific to Fish and Fish Habitat. These interactions can include direct, indirect, additive, and synergistic effects.

6.7.6.2 Identification of Other Actions that May Affect Fish and Fish Habitat

A list of projects and activities ("Other Human Actions") that were assessed for consideration in the CEA are summarized in Table 6.7-17, and the spatial locations are presented on Figure 5.3-2. The attributes of these projects and activities (location, lifespan, footprint area, etc.) are described in Section 5.3.1.

This information was assessed based on the information presented in Section 5.3.2. Other projects and activities were screened out if there was no spatial or temporal overlap between the assumed residual effects of these other projects and activities and the residual effects of the Ajax Project on the Fish and Fish Habitat VC (denoted by (-) in Table 6.7-17). Other Actions that are within the Fish and Fish Habitat RSA but are not anticipated to have an effect on fish and fish habitat, or are already captured as part of the fish and fish habitat baseline characterization are indicated with an "O" in Table 6.7-17. Since there are not anticipated to be any residual effects of the Project on Kamloops Lake, potential effects of these Other Human Activities on Kamloops Lake are not included in the Cumulative Effects Assessment of the Project on Fish and Fish Habitat.

Table 6.7-16. Summary of Residual Effects, Mitigation, and Significance on Fish and Fish Habitat

Residual Effects	Project Phase	Mitigation Measures	Significance	Effects on Recreational / Aboriginal Fishery
Direct loss of habitat in northeast arm of Jacko Lake from Open Pit Development affecting the productivity of the fish population	Operation, Decommissioning and Closure, Post Closure	Offsetting Measures, Fisheries and Aquatic Life Monitoring Plan	Not Significant (minor)	Magnitude of change anticipated to be Minor therefore no effect anticipated
Direct loss of habitat in Peterson Creek from Open Pit Development affecting the productivity of the fish population	Operation	Offsetting Measures, Fisheries and Aquatic Life Monitoring Plan	Not Significant (minor)	Magnitude of change anticipated to be Minor therefore no effect anticipated
Indirect habitat loss in Peterson Creek downstream of the Project area from flow reductions associated with Project Footprint and Contact Water	Operation, Decommissioning and Closure, Post Closure	Water Management Plan, Fisheries and Aquatic Life Monitoring Plan, Surface Water Quality Management and Monitoring Plan	Not Significant (moderate)	Magnitude of change anticipated to be Minor therefore no effect anticipated
Fish mortality in Jacko Lake associated with changes in pressure from installation of the sheet pile dam for Open Pit Development	Construction	Design in accordance with National Oceanic and Atmospheric Administration interim criteria for the onset of physical injury to fish	Not Significant (minor)	Magnitude of change anticipated to be Minor therefore no effect of fish mortality anticipated.
Sub-lethal effects on fish populations in Peterson Creek downstream of the Project area associated with changes in primary productivity from reduced flows resulting from Project Footprint and Contact Water	Construction, Operation, Decommissioning and Closure, Post Closure	Water Management Plan, Fisheries and Aquatic Life Monitoring Plan, Surface Water Quality Management and Monitoring Plan	Not Significant (minor)	Magnitude of change anticipated to be Minor therefore no effect anticipated

The rationale for inclusion or exclusion of each of these projects or activities include:

- Kinder Morgan Pipeline – existing: the pipeline is buried under the northeast arm of Jacko Lake, and anecdotal reports suggest that it was in place prior to the dam level raise on Jacko Lake which created the northeast arm. It is assumed that any effects related to normal pipeline operations are captured as part of the baseline characterization; therefore, this activity is not carried forward in the CEA. In addition, removal of the pipeline from the northeast arm of Jacko Lake has already been included in the effects assessment.
- Kinder Morgan Pipeline – expansion: the pipeline will pass east of Jacko Lake. It is assumed that it will be buried and that best management practices will be implemented and fully effective during installation (e.g., erosion and sediment control measures) such that there will be no residual effects on any watercourse crossing that flows into Jacko Lake from the east. For these reasons it is not carried forward in the CEA.
- City of Kamloops - expansion and growth: None of the ongoing or future residential developments of the Kamloops city expansion and growth described in Section 5.3 are located near either Peterson Creek or Jacko Lake; therefore, this activity is not carried forward in the CEA.
- Agriculture – well documented effects of agriculture on lake and river systems include nitrogen and phosphorus release from fields, leading to aquatic nutrient eutrophication and subsequent shifts in the structure of food chains and impairment of fisheries. Water licence diversions for irrigation are present on Jacko Lake and Peterson Creek. Since agricultural activities are identified as occurring immediately adjacent to the Project area and will be on-going throughout the life of the mine, they are carried forward in the CEA.
- Ranching - livestock grazing has been identified as the cause of stream and riparian habitat impacts (e.g., reduction of shade and cover through grazing; addition of sediment through bank degradation and soil erosion), and is known to have resulted in increased phosphates, nitrates, decreased dissolved oxygen, increased temperature, turbidity, and eutrophication events in freshwater systems. Since ranching activities are identified as occurring within and immediately adjacent to the Project area and will be on-going throughout the life of the mine, they are carried forward in the CEA.
- Recreational fishing – Jacko Lake is a popular fishing location for local residents. A percentage of the recreational anglers retain captured fish, thereby affecting the population of rainbow trout in Jacko Lake. However, since the lake is stocked and managed by provincial fisheries biologist for the purpose of angling on the lake, and there are not expected to be residual effects of the Project on the rainbow trout population as a result of angling, this effect is not carried forward in the CEA.
- Lac le Jeune Road and Coquihalla Highway – use and management of these transportation corridors has the potential to introduce sediment and road salts into downstream environments. Lac le Jeune Road, located 3 km west of the Ajax Project, crosses Peterson Creek upstream of Jacko Lake. It is unlikely that effects of runoff from this roadway extend downstream to Jacko Lake; therefore, it is not carried forward in the CEA.

Table 6.7-17. Ranking Potential for Residual Effects to Interact Cumulatively with Effects of Other Human Actions on Fish and Fish Habitat

Residual Effect	Industrial Projects/Activities													Natural Resources and Land Use			Tourism and Commercial Recreation Activities					Community Infrastructure			Transportation					
	Vidette Lake Mine	Afton Mine (Historical)	Iron Mask Mine	Bonaparte Mine	New Afton Mine (New Gold)	Highland Valley Copper Mine (Teck)	Domtar Kamloops Pulp Mill	Tolko-Hefley Creek Plywood and Veneer	LaFarge Cement Plant	Trans Mountain Pipeline System (Kinder Morgan)	Trans Mountain Pipeline System - Expansion (Kinder Morgan)	Harper Creek	Highland Valley Copper - Bethlehem Expansion	Kamloops Forest District	Agriculture	Ranching	Tranquille on the Lake	Lac Le Jeune Resort	Tobiano Golf Course	Recreational Hunting, Fishing, Foraging	Recreational Trails	City of Kamloops Wastewater Management	Water Treatment Centre	City Expansion and Growth	Lac le Jeune Road	Highway 1	Highway 5A	Highway 5 (Coquihalla Highway)	Kamloops Airport	Rail Yards and Lines (CP and CN)
Direct loss of habitat in northeast arm of Jacko Lake from Open Pit Development affecting the productivity of the fish population	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	O	O	(-)	(-)	(-)	O	O	O	O	(-)	(-)
Direct loss of habitat in Peterson Creek from Open Pit Development affecting the productivity of the fish population	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	L	L	(-)	(-)	(-)	O	O	(-)	(-)	(-)	O	O	O	O	(-)	(-)
Indirect habitat loss in Peterson Creek downstream of the Project area from flow reductions associated with Project Footprint and Contact Water	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	L	L	(-)	(-)	(-)	(-)	O	(-)	(-)	(-)	O	O	O	O	(-)	(-)
Fish mortality in Jacko Lake associated with changes in pressure from installation of the sheet pile dam for Open Pit Development	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	O	(-)	(-)	(-)	O	O	O	O	(-)	(-)
Sub- lethal effects on fish populations in Peterson Creek downstream of the Project area associated with changes in primary productivity from reduced flows resulting from Project Footprint and Contact Water	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	L	L	(-)	(-)	(-)	(-)	O	(-)	(-)	(-)	O	O	O	O	(-)	(-)

Notes:

(-)	*No spatial or temporal overlap.*
O	*Spatial or temporal overlap, but no interaction anticipated OR No change from current condition anticipated, and already captured as part of baseline characterization. No further consideration warranted.*
L	*Negligible to minor interaction expected; implementation of best practices, standard mitigation and management measures; no monitoring required, no further consideration warranted.*
M	*Potential moderate interaction requiring unique active management/monitoring/mitigation; warrants further consideration.*
H	*Key interaction; warrants further consideration.*

6.7.6.3 Interactions between Residual Project Effects and Other Project or Activity Effects

The projects and activities located within the RSA that will temporally overlap with the Ajax Project and have a reasonable likelihood of residual effects on the Fish and Fish Habitat VC are Agriculture and Ranching.

6.7.6.4 Proposed Mitigation Measures

Ranching will be excluded from the Mine Site for the lifespan of the Project for safety reasons. Fencing and gates will prevent cattle from accessing grasslands within the Mine Site, thereby preventing habitat degradation within Jacko Lake along the eastern shore; however, cattle will still be able to access the south and west shores of Jacko Lake.

No additional mitigation measures for the Ajax Project are proposed to address potential cumulative effects on fish of water quality in Jacko Lake associated with agriculture or ranching, as there are not anticipated to be any residual effects of the Project on Jacko Lake water quality (see Section 6.3). The Water Management Plan and Fisheries and Aquatic Life Monitoring Plan will be implemented to document any changes in the aquatic habitat. Erosion and sediment control measures will be implemented to address any concerns with suspended solids within waterbodies.

6.7.6.5 Evaluation of Significance of Residual Cumulative Effects

The effects of water extraction and eutrophication affecting primary productivity cannot be fully mitigated and therefore will be carried forward and evaluated. A summary of the interaction of both the Ajax Project and Agriculture and Ranching on the Fish and Fish Habitat VC is presented in Table 6.7-18.

The significance of the residual cumulative effect on primary productivity is assessed using the same criteria presented in Section 6.7.5. The significance assessment is shown in Table 6.7-19.

6.7.7 Conclusion

Fish and Fish Habitat was selected as a VC for consideration in the environmental effects assessment for the Ajax Project based on early consultation with government agencies, members of the public and stakeholder groups, and Aboriginal groups. The Project has the potential to affect fisheries and aquatic resources (including habitat) upon which they rely due to the proximity of Project components to Jacko Lake and Peterson Creek, and the location of the water intake pipe on Kamloops Lake.

A Local Study Area was defined for the Fish and Fish Habitat VC in order to focus the assessment in the area in which most potential Project interactions and physical, visual, and auditory effects are expected to occur. The Local Study Area is delineated as the Mine Site and infrastructure and surrounding area within the Peterson Creek watershed and downstream to the confluence of the creek with Davidson Brook. The Regional Study Area was selected based on the potential for direct and indirect interaction or cumulative effects on Fish and Fish Habitat to occur. It is defined as the Peterson Creek watershed to the confluence with the South Thompson River, as well as a buffer along the waterline to Kamloops Lake.

Table 6.7-18. Summary of Cumulative Effects Mitigation Measures and Residual Effects on Fish and Fish Habitat

Ajax Project Activity	Other Human Action Activity	Description of Potential Cumulative Effect	Description of Mitigation Measure(s)	Description of Residual Cumulative Effect
Direct loss of habitat in Jacko Lake affecting the productivity of the fish population	Agriculture and Ranching	Direct loss of habitat in Jacko Lake	Fencing Fisheries and Aquatic Life Monitoring Plan	Loss of habitat
Direct loss of habitat in Peterson Creek affecting the productivity of the fish population	Agriculture and Ranching	Direct loss of habitat in Peterson Creek	Fencing Fisheries and Aquatic Life Monitoring Plan	Loss of habitat
Indirect habitat loss in Peterson Creek downstream of the Project area	Agriculture and Ranching	None expected	Not applicable	None expected
Fish mortality in Jacko Lake	Agriculture and Ranching	None expected	Not applicable	None expected
Sub- lethal effects associated with changes in primary productivity	Agriculture and Ranching	Changes in water quality downstream	Erosion and sediment control plan	Changes in primary productivity

Table 6.7-19. Characterization of Residual Cumulative Effects, Significance, Likelihood and Confidence on Fish and Fish Habitat

Residual Cumulative Effect	Residual Effects Characterization Criteria							Significance of Adverse Residual Effects	Likelihood and Confidence	
	Magnitude	Duration	Frequency	Geographic Extent	Reversibility	Resiliency	Context		Probability	Confidence
Direct loss of habitat in Jacko Lake and Peterson Creek	Minor	Medium-term	Sporadic	Local	Reversible Long-term	Neutral	Neutral	Not Significant (minor)	Medium	Medium
Change in primary productivity	Minor	Medium-term	Sporadic	Local	Reversible Long-term	Neutral	Neutral	Not Significant (minor)	Medium	Medium

Based on an assessment of the preliminary Project design and the Project Activity list, the likely mechanisms or pathways through which interactions between the Project and Fish and Fish Habitat VC were identified. Project Activities for which there would be no potential interaction, or which would likely have negligible to minor interaction with the VC and could be managed using industry standard best practices and mitigation measures were not carried forward in the assessment. Project Activities with the potential to result in a moderate or key interaction with Fish and Fish Habitat were carried forward in the assessment. Potential effects on the VC were grouped into the following categories:

- Direct Habitat Loss
- Indirect Habitat Loss
- Mortality
- Sub lethal effects

Mitigation measures to avoid, minimize, or control potential adverse effects of the Project on Fish and Fish Habitat were identified, including: design changes; implementation of industry best management practices; and provision of restoration or offsetting. These measures will be described and presented in detail in the environmental management and monitoring plans required prior to Construction and Operation.

Residual effects (effects anticipated to remain after implementation of mitigation measures) were identified as:

- direct habitat loss for rainbow trout in Peterson Creek and Jacko Lake within the Project footprint;
- indirect habitat loss in Peterson Creek downstream of the Project area associated with flow reductions;
- fish mortality in Jacko Lake associated with changes in pressure from blasting in the Open Pit;
- fish mortality in Jacko Lake associated with changes in pressure from installation of the sheet pile dam for development of the Open Pit; and
- sub-lethal effects on fish populations in Peterson Creek downstream of the Project area from changes in water temperature and primary productivity associated with reduced flows.

Residual effects were characterized using the criteria of magnitude, geographic extent, duration, frequency, reversibility, and ecological context. Based on this characterization, each residual effect was assessed for significance using three categories: Not Significant (Minor); Not Significant (Moderate); and Significant (Major).

Because the Magnitude of the direct loss of habitat in Jacko Lake and Peterson Creek is rated as Minor, no impacts on the recreational or Aboriginal fishery are anticipated. Similarly, the Magnitude of the indirect loss of habitat in Peterson Creek is rated as Minor; therefore, no impacts on any recreational or Aboriginal fishery are anticipated. The Magnitude of fish mortality on the productivity of the rainbow trout population within Jacko Lake from Blasting and from installation

of the sheet pile dam is characterized as Minor. Fishing within Jacko Lake will be restricted during Blasting events in the Open Pit, which will affect the ability of recreational anglers and Aboriginal Groups to utilize the resource. Since the Magnitude of change in primary productivity is characterized as Minor, no impacts on the recreational or Aboriginal fishery in Peterson Creek are expected.

All residual effects were then carried forward into the Cumulative Effects Assessment.

The residual Project effects by phase, the proposed mitigation measures, and the Significance determination for both residual Project and Cumulative effects are summarized in Table 6.7-20.

Table 6.7-20. Summary of Project and Cumulative Residual Effects, Mitigation, and Significance for Fish and Fish Habitat

Residual Effects	Project Phase	Mitigation Measures	Residual Effect Significance	Residual Cumulative Effect Significance	Effects on Recreational / Aboriginal Fishery
Direct loss of habitat in northeast arm of Jacko Lake from Open Pit Development affecting the productivity of the fish population	Operation, Decommissioning and Closure, Post Closure	Offsetting Measures, Fisheries and Aquatic Life Monitoring Plan	Not Significant (minor)	Not Significant (minor)	Magnitude of change anticipated to be Minor therefore no effect anticipated
Direct loss of habitat in Peterson Creek from Open Pit Development affecting the productivity of the fish population	Operation	Offsetting Measures, Fisheries and Aquatic Life Monitoring Plan	Not Significant (minor)	Not Significant (minor)	Magnitude of change anticipated to be Minor therefore no effect anticipated
Indirect habitat loss in Peterson Creek downstream of the Project area from flow reductions associated with Project Footprint and Contact Water	Operation, Decommissioning and Closure, Post Closure	Water Management Plan, Fisheries and Aquatic Life Monitoring Plan, Surface Water Quality Management and Monitoring Plan	Not Significant (moderate)	-	Magnitude of change anticipated to be Minor therefore no effect anticipated
Fish mortality in Jacko Lake associated with changes in pressure from Blasting	Operation	Blast Design, Fish and Aquatic Life Management Plan	Not Significant (minor)	-	Magnitude of change anticipated to be Minor therefore no effect of fish mortality anticipated; access to lake will be restricted during Blasting resulting in reduced angler hours
Fish mortality in Jacko Lake associated with changes in pressure from installation of the sheet pile dam for Open Pit Development	Construction	Design in accordance with National Oceanic and Atmospheric Administration interim criteria for the onset of physical injury to fish	Not Significant (minor)	-	Magnitude of change anticipated to be Minor therefore no effect of fish mortality anticipated.
Sub lethal effects on fish populations in Peterson Creek downstream of the Project area associated with changes in primary productivity from reduced flows resulting from Project Footprint and Contact Water	Construction, Operation, Decommissioning and Closure, Post Closure	Water Management Plan, Fisheries and Aquatic Life Monitoring Plan, Surface Water Quality Management and Monitoring Plan	Not Significant (minor)	Not Significant (minor)	Magnitude of change anticipated to be Minor therefore no effect anticipated

6.8 RARE PLANTS

6.8.1 Rationale

This section includes a description of the scoping process used to identify Rare Plants for inclusion in the assessment. Scoping is fundamental to focusing the Application/EIS on those issues where there is the greatest potential to cause significant adverse effects. Valued components (VCs) are components of the natural and human environment that are considered to be of scientific, ecological, economic, social, cultural, or heritage importance (CEAA 2006; EAO 2013). To be included in the EA, there must be a perceived likelihood that the VC will be affected by the proposed Project. Valued components are scoped into the environmental assessment based on the best available knowledge and consultation with stakeholders.

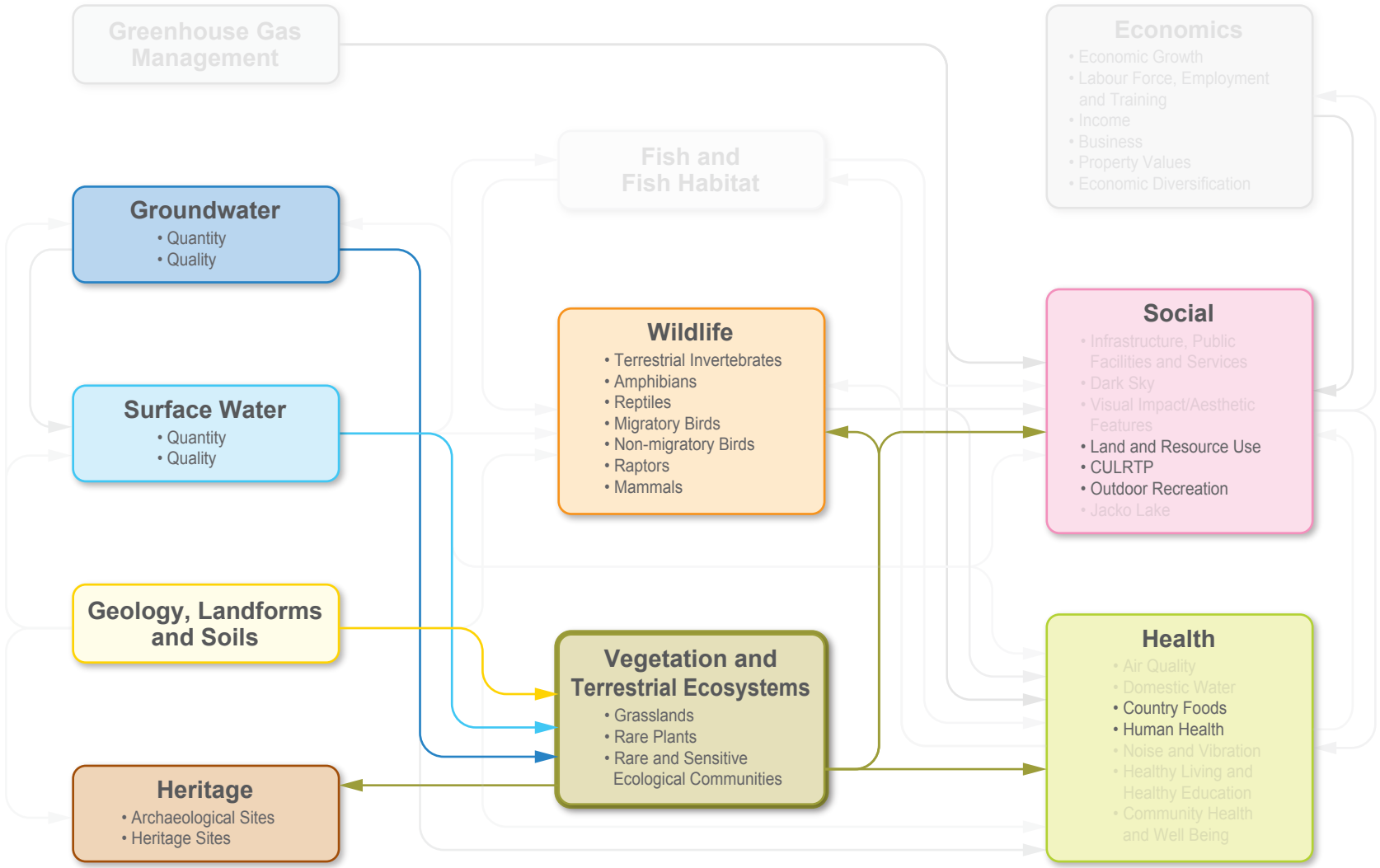
For rare plants the following was considered for inclusion as a valued component in the environmental assessment:

- Federal or provincial listing or regulation, including:
  - Lists of Red[1]- and Blue[2]-listed plant taxa thought to occur within the Kamloops Forest District as provided by the BC Conservation Data Centre;
  - Information on known occurrences of Red- and Blue-listed species in or near the study area (provided by the BC Conservation Data Centre);
  - Information on SARA-taxa available from the Government of Canada;
- Aboriginal interest;
- Public or other stakeholder input;
- Scientific/professional knowledge; and
- Relevant legislation or policy concerning the VC.

Rare plants grow in habitats determined by surface and ground water, geology, landform and soils. The assessment of effects to Rare Plants is largely related to disturbances from Project activities (as described further in Section 6.8.4). The effects assessment associated with this VC also contributes to Wildlife VCs (Sections 6.11 – 6.17), Land and Resource Use (Section 8.4), Current Land and Resource Use for Traditional Purposes (Section 6.5) and Country Foods (Section 10.3, Figure 6.8-1).

[1] Extirpated, endangered, or threatened in BC
[2] Considered to be of special concern (formerly vulnerable) in BC

Figure 6.8-1
Vegetation and Terrestrial Ecology



6.8.1.1 Selection of Rare Plants as a Valued Component

The VC "Rare Plants" was selected as there is an expected interaction between rare plants and the Project. Rare plants have been included in the assessment because known listed plant taxa occur on the project site or specific habitat associated with rare plants is present. Because there is limited information available on rare plants within the local and regional study areas further assessment was required to determine if additional taxa occur within the LSA that could be directly affected by Project activities. In addition, although species identified as important to Aboriginal communities are not necessarily considered rare plants, investigations to determine effects of the Project on these plant communities was also considered in the effects assessment. Vegetation clearing for Project footprints will potentially remove rare plant populations or result in loss of microhabitats that support them. Aquatic-associated rare plants may be sensitive to water-borne contaminants, and epiphytic lichen or mosses are susceptible to dust deposition (Farmer 1993; Padgett et al. 2007). Specific justification for the selection of rare plants as a VC includes: Federal or provincial listing or regulation guidelines:

  - 120 Red and 91 Blue-listed vascular plants, mosses or lichens were identified as potentially occurring within the Project area based on biogeoclimatic variants (BC Conservation Data Centre 2014a) and professional judgement;
  - 21 SARA and/or COSEWIC listed taxa potentially occurring within the Project area;
- Government agencies: Environmental Assessment Office (EAO), Canadian Environmental Assessment (CEA) Agency, Environment Canada (EC), and Ashcroft Indian Band identified rare plants as a concern;
- Stakeholders: Rare plants were identified during aboriginal group consultation and stakeholder engagement and by the public and Kamloops Naturalist Club;
- Information sources: Rare plants were documented in the Project area during baseline studies and regionally by the BC Conservation Data Centre (CDC);
- Spatial scope (species range): several rare plants are known to occur in the region;
- Temporal scope; and
- Expected interaction with Project/potential effects (professional knowledge).

6.8.1.2 Selection of Indicators

For this study, "rare plants" were defined as vascular plants, mosses, lichens and traditional plants:

- listed on Schedule 1 of the Canadian Species at Risk Act (SARA) as amended (Government of Canada 2012);
- assigned a status of Extinct, Extirpated, Endangered, Threatened, or Special Concern by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2014); and
- on the British Columbia Ministry of Environment's provincial Red- or Blue-lists (BC Conservation Data Centre 2014a).

A list of rare plant taxa (i.e. species, subspecies, and varieties) known from the biogeoclimatic zones present in the Project area was generated using the BC Species and Ecosystem Explorer (BC Conservation Data Centre 2014a). This list was refined based on the biogeoclimatic subzone, habitat types and elevation range present in the Project area as identified by the preliminary habitat mapping. Taxa were excluded if there were no known populations in the Kamloops area and if no suitable habitat was present. The final target rare plant species list is presented in Appendix 6.8-A, and includes 154 vascular plants, 26 mosses and 31 lichens.

Aboriginal use of traditional plants in the LSA is considered in Chapter 12, Background and Aboriginal Group Settings. All traditional plant species used by the Stk'emlupsemc te Secwepemc Nation (SSN), Skeetchestn Indian Band, Nlaka'pamux Nation, and Metis Nation of British Columbia (MNBC) were common (yellow-listed) or are considered an introduced or exotic species. One hundred and twenty-five harvested plants were identified as potentially occurring within the LSA, with various uses (food, technology, and/or medicinal) and none were rare.

The selection rationale for each of this indicator groups (vascular plants, mosses, lichens, and traditional plants) is summarized in Table 6.8-1.

Table 6.8-1. Summary of Indicator Species Selection Rationale and Stakeholder Issues Raised

Indicator Species Groups	Feedback by*				Issues Raised	Rationale
	AG	G	P/S	S/P		
Vascular Plants	✓	✓	✓	✓	Loss of rare vascular plants and alteration of microhabitat that could support them	154 species of Rare vascular plants were considered indicators for the rare plants VC
Mosses	✓	✓	✓	✓	Loss of rare mosses and alteration of microhabitat that could support them	26 rare moss species were considered an indicator for the rare plants VC
Lichens	✓	✓	✓	✓	Loss of rare lichens and alteration of microhabitat that could support them	31 lichen species were considered indicators for the rare plants VC
Traditional Plants	✓				Loss or decrease in availability of traditional plants	125 harvested plants were considered indicators for the rare plants VC

**AG = Aboriginal Group (Stk'emlupsemc Te Secwepemc Nation (SSN) and Nlaka'pamux Nation); G = Government; P/S = Public/Stakeholder (e.g., LRMP); S/P = Scientific/Professional Knowledge*

6.8.2 Assessment Boundaries

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

Assessment boundaries were determined by:

- Project footprint: the area anticipated to receive direct effects relating to Project activities;
- Local Study Area: the area anticipated to receive potential indirect effects relating to Project activities; and
- Regional Study area: the area anticipated to receive potential cumulative effects associated with Project activities.

6.8.2.1 Spatial Boundaries

Infrastructure Footprints

The Project infrastructure footprints (IF) include the Open Pit, ancillary buildings and facilities, roads, truck stop, Tailings Storage Facility (TSF), Water Management Ponds, Mine Rock Storage Facilities (MRSFs), and stockpiles (Figure 6.8-2). The Project infrastructure footprints are 1,705 ha in size.

Infrastructure Disturbance Area

The Project infrastructure footprints and linear features (transmission line and water line) were buffered by at least 50 m (Henderson, 2011) to determine the Project Infrastructure Disturbance Area (IDA). The 3,185 ha IDA will be used to assess maximum direct Project effects (e.g., mortality, habitat loss, habitat alteration, etc.). The IDA includes the Project IF (1,705 ha) used to calculate direct loss of habitat, plus a 1,480 ha buffer around the Project IF that represents a zone of influence for potential disturbance associated with habitat alteration resulting from effects pathways such as contaminants, silt or dust, noxious weeds, and changes in drainage pattern (Figure 6.8-2).

The use of a buffered polygon area rather than individual infrastructure footprints will provide an overestimate of the direct effects of the Project for the assessment. The advantage of this approach is that it enables individual footprints to be moved and/or resized without changing the results of the effects assessment.

The IDA was modified from the General Arrangement Polygon to follow a section of the Kamloops city boundary to more accurately represent the current Project IF.

Habitat alteration by dust and water quantity is accounted for under potential habitat loss within the IDA. Areas outside of the IF that are not lost will be subject to potential alteration effects. However as plant species present in the area are adapted to the dry, dusty environmental conditions, these effects were considered mitigable.

Regional Study Area

The Regional Study Area (RSA) is the area for which cumulative effects will be assessed. The RSA will include portions of the South Kamloops Landscape Unit and Campbell Landscape Unit, including areas south of the Thompson River and west of Highway 97 (Figure 6.8-3). Landscape units were selected for the RSA as they are the geographical framework within which sustainable forest management regimes to maintain biodiversity are implemented. The RSA also includes local watershed basins and is 158,415 ha in size.

BEC mapping was used to provide context within the RSA as rare plant micro-habitats cannot be mapped.

6.8.2.2 Temporal Boundaries

The temporal boundaries of the assessment will include the construction phase (short-term), operations (life of the mine), decommissioning and closure (short-term) and post-closure (short-term). The temporal phases of the Project are:

- **Construction**: 2 years (Year -2 to 1);
- **Operation**: 23 years (Year 1 to 23);
- **Decommissioning and Closure**: 5 years (Year 24 to 29, includes Project decommissioning, abandonment and reclamation activities, as well as temporary closure, and care and maintenance); and
- **Post Closure**: 5+ years (includes ongoing reclamation activities and post-closure monitoring).

6.8.2.3 Administrative Boundaries

Much of the land adjacent to the Ajax site is privately owned. This title typically conveys ownership of the land surface, as well as rights to use or work the property. Surveys respected these areas.

6.8.2.4 Technical Boundaries

Limited data is available on the occurrence and abundance of rare plants in most areas of the province. The limited information on the distribution of rare plants in the region is a knowledge gap, resulting in the use of professional judgement for some components of this assessment.

6.8.3 Background

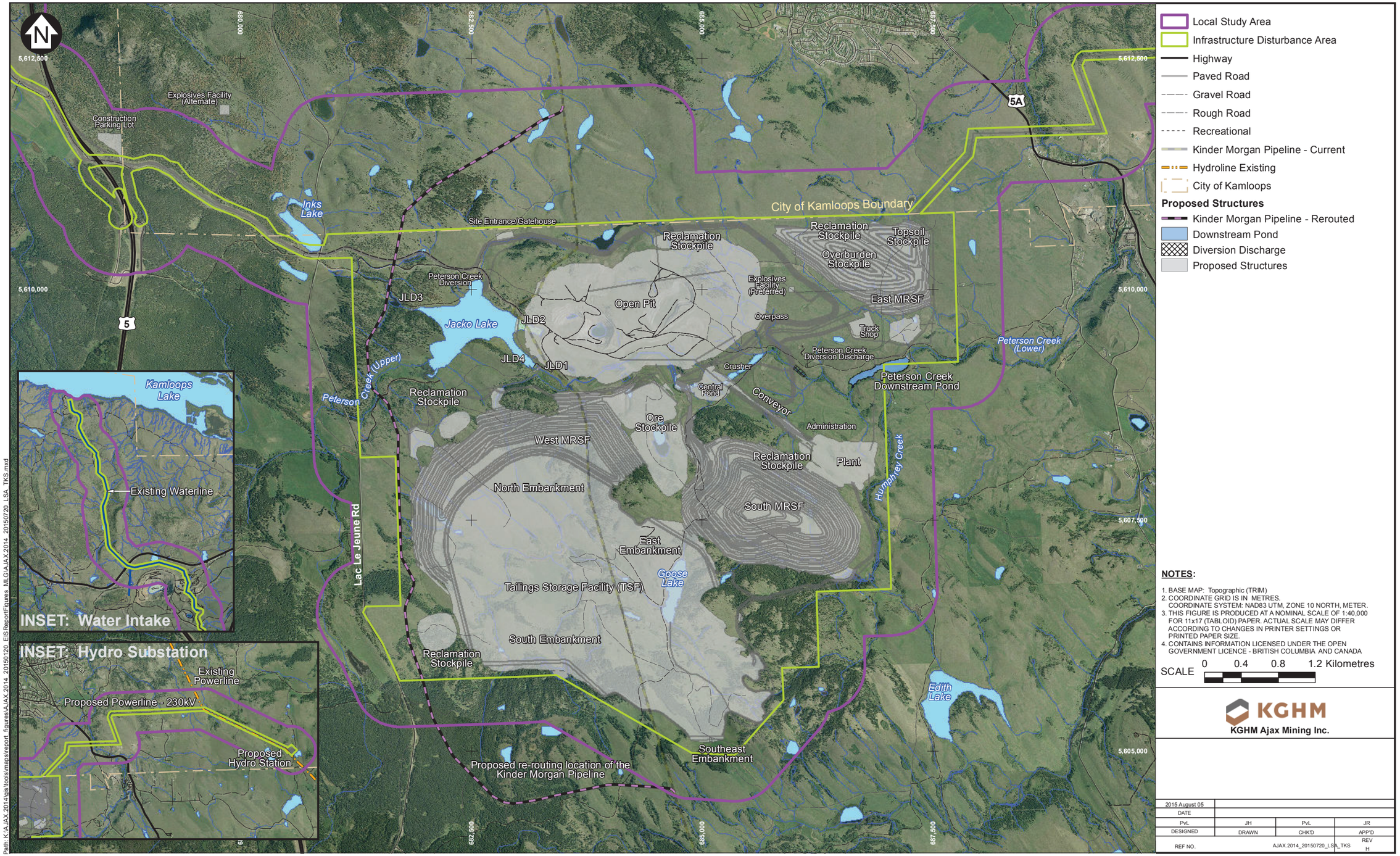
6.8.3.1 Regulatory and Policy Framework

The Nicola Thompson Fraser Sustainable Forest Management Plan (SFMP) (2015) aims to conserve species diversity by ensuring that habitats for a particular species are maintained, including habitats for rare plants. Forest practices and planning will promote a diversity of ecosystems while maintaining "rare attributes". Identified localized sites should be maintained in an undisturbed state to ensure that the potential rare plants or plant communities found within them are not lost.

Local Study Area

In accordance with the AIR the General Arrangement Polygon was buffered by 500 m to determine the Local Study Area (LSA). This area is the expected area of potential disturbance associated with all Project facilities, and includes the IDA and IF (BC Environmental Assessment Office 2015). The LSA is 7,167 ha and will be used to assess indirect Project effects (e.g., disturbance) and provide context on the amount of habitat available adjacent to the Project IF (Figure 6.8-2).

Figure 6.8-2
Local Study Area, Infrastructure Disturbance Area and Project Infrastructure



NOTES:

1. BASE MAP: Topographic (TRIM)
2. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD83 UTM, ZONE 10 NORTH, METER.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:40,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
4. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENCE - BRITISH COLUMBIA AND CANADA

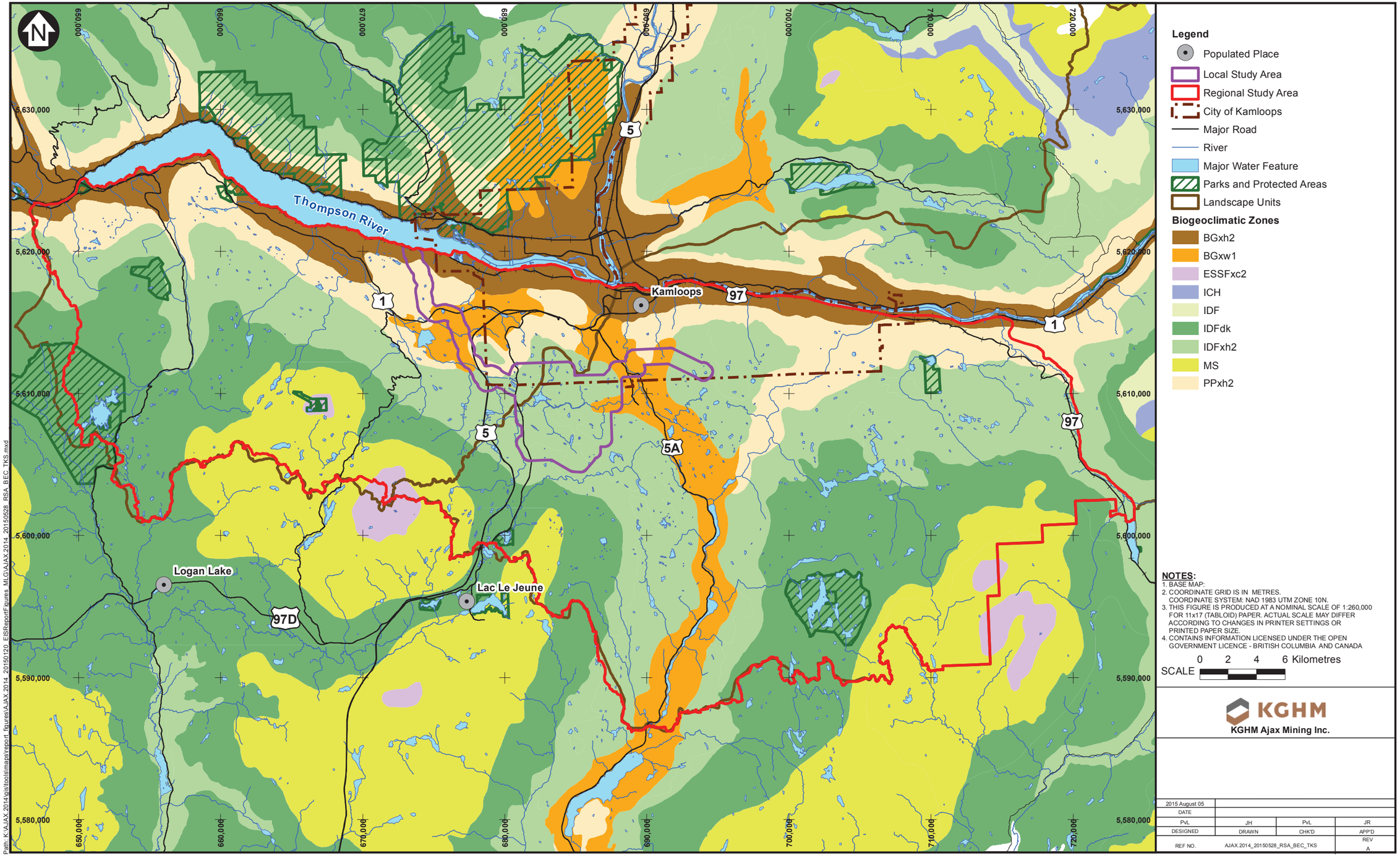
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KGHM Ajax Mining Inc.

2015 August 05			
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Figure 6.8-3
Regional Study Area



Legislation regarding rare plants falls under the *Species at Risk Act* (SARA)(Government of Canada 2012), and the Committee of the Status of Endangered Wildlife in Canada (COSEWIC 2014). The purpose of *SARA* is to "manage species of special concern to prevent them from becoming endangered or threatened". Of the 211 Red or Blue-listed vascular plants, mosses and lichens that potentially occur in the study area, 18 of these rare plant species are federal SARA Schedule 1 and COSEWIC ranked. This includes several vascular plants and mosses: scarlet ammannia (*Ammannia robusta*), stoloniferous pussytoes (*Antennaria flagellaris*), Mexican mosquito fern (*Azolla mexicana*), Lyall's mariposa lily (*Calochortus lyallii*), slender collomia (*Collomia tenella*), bent spike-rush (*Eleocharis geniculata*), small-flowered lipocarpha (*Lipocarpha micrantha*), grand coulee owl-clover (*Orthocarpus barbatus*), branched phacelia (*Phacelia ramosissima* var. *ramosissima*), showy phlox (*Phlox speciosa ssp. occidentalis*), mountain holly fern (*Polystichum scopulinum*), dwarf woolly-heads (*Psilocarphus brevissimus* var. *brevissimus*), toothcup meadow-foam (*Rotala ramosior*), short-rayed alkali aster (*Symphyotrichum frondosum*), Columbian carpet moss (*Bryoerythrophyllum columbianum*), rusty cord-moss (*Entosthodon rubiginosus*), nugget moss (*Microbryum vlassovii*), and alkaline wing-nerved moss (*Pterygoneurum kozlovii*). Two additional COSEWIC ranked vascular plants may occur in the study area and include: giant helleborine (*Epipactis gigantea*), and false-mermaid (*Crossidium seriatum*). Recovery strategies or management plans have been developed for the majority of these species (Table 6.8-2).

Table 6.8-2. SARA Schedule 1 Rare Plant Recovery Planning Documents

English Name	Scientific Name	SARA Schedule/ Status[1]	BC	SARA
Vascular Plants				
Scarlet Ammannia	*Ammannia robusta*	1-E	RS-2008	
Stoloniferous Pussytoes	*Antennaria flagellaris*	1-E	RS-2008*	RS-2013*
Mexican Mosquito Fern	*Azolla mexicana*	1-T	RS-2008	
Lyall's Mariposa Lily	*Calochortus lyallii*	1-T	RS-2008	
Slender Collomia	*Collomia tenella*	1-E	RS-2008*	RS-2013*
Bent Spike-rush	*Eleocharis geniculata*	1-E		
Small-flowered Lipocarpha	*Lipocarpha micrantha*	1-E	RS-2011	
Grand Coulee Owl-clover	*Orthocarpus barbatus*	1-E	RS-2007	RS-2012
Branched Phacelia	*Phacelia ramosissima var. ramosissima*	1-E	RS-2008	RS-2012
Showy Phlox	*Phlox speciosa ssp. occidentalis*	1-T	RS-2012	
Mountain Holly Fern	*Polystichum scopulinum*	1-T	RS-2009	
Dwarf Woolly-heads	*Psilocarphus brevissimus var. brevissimus*	1-E	RS-2008*	RS-2013*
Toothcup Meadow-foam	*Rotala ramosior*	1-E	RS-2008	
Short-rayed Aster	*Symphyotrichum frondosum*	1-E	RS-2009	RS-2013
Mosses				
Columbian carpet moss	*Bryoerythrophyllum columbianum*	1-SC	MP-2010	MP-2012
Rusty cord-moss	*Entosthodon rubiginosus*	1-E	RS -2008	RS-2012
Nugget moss	*Microbryum vlossovii*	1-E	RS -2009	RS-2012
Alkaline wing-nerved moss	*Pterygoneurum kozlovii*	1-T	RS - 2009	

[1] *T = Threatened, SC = Special Concern, E = Endangered*

* *Multi species recovery strategy for the Princeton Landscape Including dwarf woolly-heads (Psilocarpjus brevissimus var. brevissimus), slender collomia (Collomia tenella), and stoloniferous pussytoes (Antennaria flagellaris) in British Columbia.*

6.8.3.2 Regional Overview

The Thompson Basin Ecosection area is a warm and exceptionally dry, broad low elevation basin. The vegetation in this ecosection reflects the warm, dry climate within the bunchgrass zone, mainly consisting of sagebrush-steppe and bunchgrass-steppe occupying the valley and lower slopes. Meadow-steppe and Ponderosa Pine forest are found at higher elevations, with Douglas-fir occurring on the cooler aspects and narrow draws. The pine stands have been adversely affected by the recent mountain pine beetle outbreak.

Sparsely vegetated, non-forested habitats that permanently inhibit dense tree and shrub growth (various non-forested wetlands and shorelines, grassland, shrub steppe, scree, and rock outcrops) are vital habitats for most of the native plants of British Columbia, as well as many of the mosses and lichens. A number of vegetative macrohabitats were identified in the Project area. These included: sagebrush steppe, grasslands, wetlands (saline wetlands, creek shores, marshes), aspen groves, shrub copses, sparsely vegetated outcrops and cliffs, forested outcrops, talus, fine scree, dry gullies, close-canopy Douglas-fir forests, open-canopy Douglas-fir forest, and human disturbed sites (Appendix 6.8-A). No rare plant surveys have previously been conducted in the Project area.

<u>Macrohabitats</u>

The sagebrush steppes are habitat for a very large number of native plant taxa, including some of the rarest in the province. Grasslands, when treated as a different habitat from shrub steppe, are one of the rarest habitat classes in BC. A large proportion of these habitats within the region have been converted to agricultural or range land. This has likely influenced the regional population of rare plants.

Saline wetlands, creek shore, and marsh habitats differ in their mineral content, soil texture and organic matter content. These habitats have a wide variety of vegetation, including plants that are highly adapted to their aquatic life. Historically wetlands in the Thompson have been drained for agricultural purposes. Remaining wetland habitat is often highly influenced by cattle that damage the shoreline and aquatic vegetation (Government of Canada, 1991).

Sparsely vegetated outcrops are those that have no significant overarching tree canopy, and for similar reasons to tree-growth inhibition, shrub cover is also minimal. Exposures of bedrock can provide unique chemistry to the roots of plants that are dependent on high calcium, magnesium or heavy-metal concentrations. Lichen diversity is often high in this habitat. Conversely, forested outcrops generally have far fewer vascular plant and lichen species than sparsely vegetated outcrops, since most plants and lichens are not shade-adapted. Moss diversity may be high on forested outcrops.

Talus habitat consists of loose rocks along slopes where soil accumulation is slow. This makes this habitat inhospitable for most plants, though some are specialists in the challenge of germinating on small soil pockets and growing their roots deep down into the talus, where deeper soils and water are available. Fine scree differs in having greater nutrient and water potential. A large number of plants native to British Columbia grow only on fine scree, particularly in alpine elevations, but also at lower elevations.

Aspen groves and shrub copses occur along small drainages or in moist hollows within the RSA. Aspen grove plant communities are worth noting for its high species richness. Far more plant diversity can occur in forests having a sparse canopy of conifers than in closed-canopy forest. The additional light that reaches the understory, and the thinner accumulation of acidic, low-nutrient conifer duff make this habitat less inhospitable to most plants. Forested habitat in the RSA is threatened by forestry and fire.

6.8.3.3 Historical Activities

Historical activities considered in the section include mining, mills, pipelines, rail lines, agriculture, forestry, urban space, water treatment and recreation/tourism. Only those historical activities expected to interact with rare plants have been discussed below. The data collected during Baseline studies considers the effect to the landscape from Historical activities as these effects shape the current landscape as it is known today.

Mining has removed suitable macro and micro -habitats that could support rare plants. Historical reclamation of these sites focused on providing forage for cattle or restore native habitat for wildlife, as well as stabilizing disturbed areas. If colonization from neighbouring intact habitats is allowed, these areas could provide habitat for a greater variety of species, including rare plant species.

Construction and maintenance of the pipeline corridor and rail line has likely removed habitat that could have supported rare plants, though no historical rare plant surveys have occurred in those areas. These features are also known to be vectors for invasive plants (BC Ministry of Forests and Range 2010), which has likely altered the distribution and abundance of plant species in the area.

Agricultural, ranching and forestry practices have altered large areas of habitat that could have supported rare plants. These activities remove and degrade rare plant habitat though the introduction of invasive species, tramping and consumption of plants and compaction/ alteration of the soil.

Urban expansion removes habitat that could support rare plants.

6.8.3.4 Baseline Studies

In accordance with the Application Information Requirements/Environmental Impact Assessment Guidelines AIR/EIS, surveys for rare plants were undertaken throughout the LSA to: a) establish presence of target species and key habitat features within the LSA, and b) provide information to KGHM Ajax Mining Inc. (KAM) to use during the Project design phase to avoid or minimize impacts to target species.

Data Sources

The following references were consulted for vascular plant identification:

- ***Illustrated Flora of British Columbia*** Volumes 1-8 (Douglas et al. 1998a; Douglas et al. 1998b; Douglas et al. 1999b; Douglas et al. 1999a; Douglas et al. 2000; Douglas et al. 2001a; Douglas et al. 2001b; Douglas et al. 2002a);
- ***Flora of the Pacific Northwest*** (Hitchcock and Cronquist 1973);

- Published volumes of the ***Flora of North America*** (Flora of North America Editorial Committee. 1993; Flora of North America Editorial Committee. 2006; Flora of North America Editorial Committee. 2007; Flora of North America Editorial Committee 2009; Flora of North America Editorial Committee 2010; Flora of North America Editorial Committee. 1997; Flora of North America Editorial Committee. 2000; Flora of North America Editorial Committee. 2002; Flora of North America Editorial Committee. 2003; Flora of North America Editorial Committee. 2004; Flora of North America Editorial Committee 2005; Flora of North America Editorial Committee 2006a; Flora of North America Editorial Committee 2006b; Flora of North America Editorial Committee 2007) and draft treatments for unpublished volumes);
- Online databases (Klinkenberg 2006; BC Conservation Data Centre 2014a; NatureServe 2014);
- Occurrence records of rare plans in the RSA were obtained from the BC Conservation Data Centre (BC Conservation Data Centre 2014b) and from the provincial Species Inventory Database (BC Ministry of Environment 2014); and
- Additional species-specific taxonomic literature where available.

Moss, liverwort and lichen species were identified in the field, or laboratory based on:

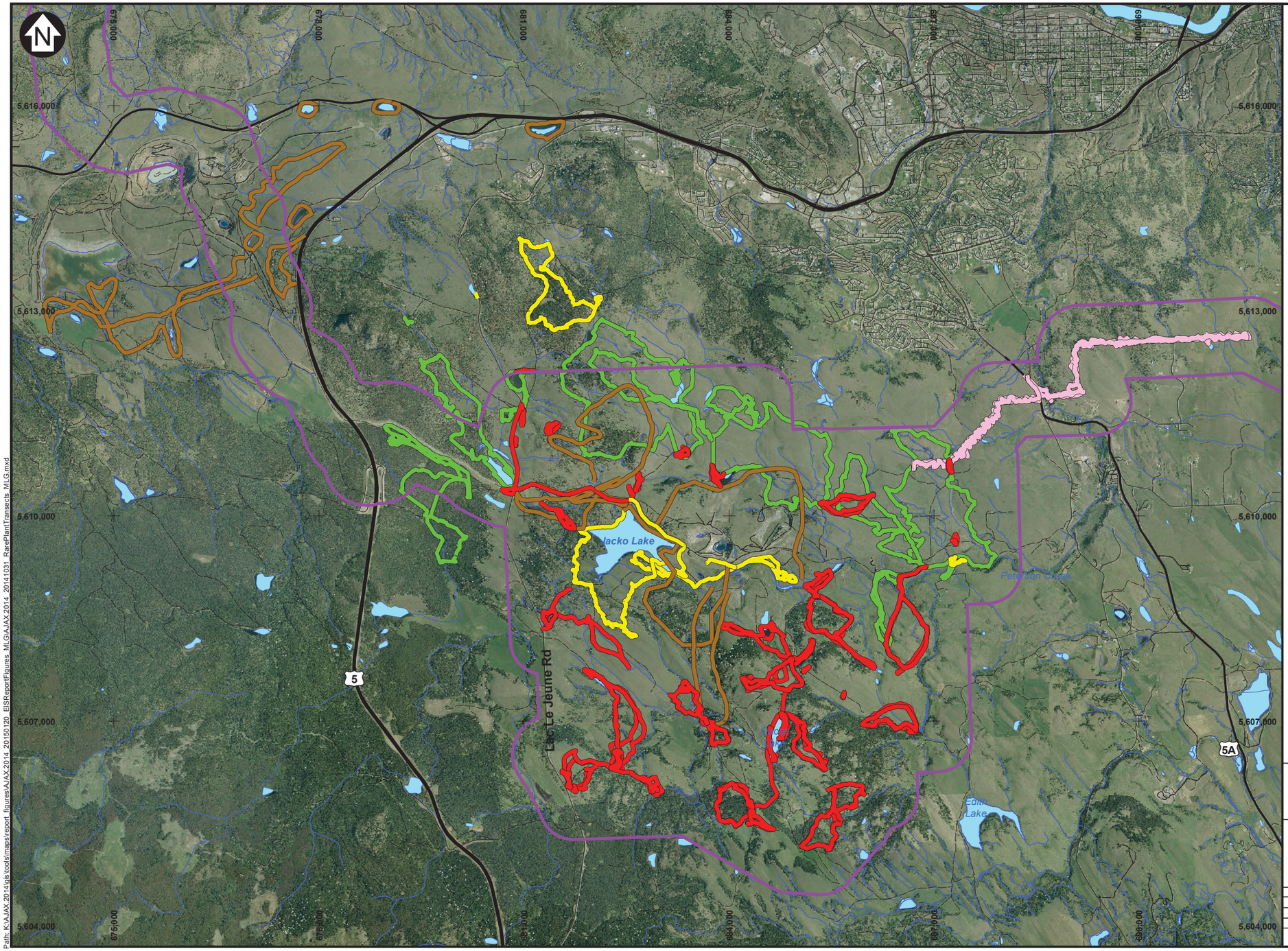
- *Bryoflora of North America* (2007, and draft treatments for unpublished volumes);
- *Moss Flora of the Pacific Northwest* (Lawton 1971);
- *Contributions toward a Bryoflora of California III* (Doyle and Stotler 2006);
- *The Lichens of British Columbia*, volumes 1 and 2 (Goward et al. 1994; Goward 1999);
- *Keys to Epiphytic Crust Lichens of British Columbia* (Björk unpublished);
- *Materials for an Epiphytic Crust Lichen Flora of Northwest North America* (Spribille 2006); and
- Additional original taxonomic literature.

Methods

The BC Resources Information Standards Committee (RISC) has not issued standards for conducting rare plant surveys, other than for the collection of voucher specimens (Resources Inventory Committee (RIC) 1999). However, a number of organizations in North America have developed guidelines for these studies. The methods used for rare plant work are based on a synthesis of several of these guidelines (Bizecki-Robson 1998; Whiteaker et al. 1998; California Native Plant Society 2001; Henderson 2009; Alberta Native Plant Council 2012; Penny and Klinkenberg 2012).

TEM mapping was conducted within the LSA and RSA to identify potential ecosystems that were identified in relation to specific rare plants known to occur within area. Sites within the LSA were surveyed on foot using an intuitive meander search pattern, staying primarily within habitats thought to contain the highest potential for rare plant occurrence. Surveys targeted the IDA during the entire growing season, as plant phenology varies between species (Figure 6.8-4). A representative cross-section of lower-probability habitats was also surveyed. Surveys were conducted by at least one botanist. Targeted surveys for traditional use plants were not conducted; however, all vascular plant, moss, liverwort, and lichen taxa encountered within the Project area were recorded.

Figure 6.8-4
Rare Plant Transect Survey Locations



Field sampling for traditionally used plants followed protocols described in BC Ministry of Environment, Lands and Parks and BC Ministry of Forests (1998). Crews completed full plots, Ground Inspection Forms (GIFs) and visual inspections which recorded indicator plant species present. Efforts were made to sample all major habitat types within all BEC zones, however, availability of access and private land restrictions constrained sampling distribution. All field data were entered into the provincial standard VENUS software.

Characterization of Rare Plant Baseline Condition

Baseline studies were conducted for rare plants in the spring and summer of 2007, 2008, 2010, 2011, 2012, and 2014 for a total of 384 botanist hours (Table 6.8-3). Surveys concentrated on the LSA and were conducted over a range of dates during the growing season as plants vary in their phenology. In total, 681 plant and lichen taxa (species, subspecies, and varieties) were recorded (Appendix 6.8-A). These include 491 vascular plants, 2 liverworts, 45 mosses, and 143 lichens.

Table 6.8-3. Survey Effort for Rare Plants

Year	Survey Dates	Total Time (hrs)
2007	various dates in May	approx. 48
2008	July 31, August 1	18
2010	August 20 to 26	40
2011	June 1 to 4, August 30 to September 2	66
2012	August 21 to 22	16
2014	June 18 to 25, August 9 to 13	196

Of the 211 listed rare plant species that could occur in the study area, 16 taxa were found including five vascular plants, two mosses, and eight lichens (Table 6.8-4). These 16 rare plant taxa were found in 27 total occurrences (Figure 6.8-4), where an occurrence is defined as any population or sub-populations found within 1 km of each other. An occurrence can contain several sub-populations (NatureServe Explorer 2004). Detailed descriptions of these rare plant species can be found below.

Table 6.8-4. Rare Plant Occurrences Found Within the LSA

Taxon	Common Name	BC List	Provincial[2]	SARA	COSEWIC	Occurrences[1]
Vascular Plants						
Atriplex truncata	Wedgescale Orache	Blue	S3			1
Bouteloua gracilis	Blue Grama	Red	S2			2
Epilobium hallaneum	Hall's willowherb	Blue	S2S3			1
Hornungia procumbens	Ovalpurse	Blue	S3			2
Orobanche ludoviciana var. arenosa	Suksdorf's Broomrape	Red	S1			8
Stuckenia vaginata	Sheathing Pondweed	Blue	S2S3			1

Taxon	Common Name	BC List	Provincial[2]	SARA	COSEWIC	Occurrences[1]
Mosses						
Amblystegium varium	[no common name]	Blue	S2S4			1
Pterygoneurum kozlovii	Alkaline Wing-nerved Moss	Blue	S2S3	1-T	T	1
Stegonia latifolia var. pilifera	[no common name]	Red	S1S2			1
LICHENS						
Collema crispum	Ten-Cent Tarpaper	Red	S1			1
Dermatocarpon leptophyllodes	Jigsaw Stippleback	Blue	S2S4			1
Fulgensia bracteata	Goldnugget Sulphur	Blue	S3?			1
Neofuscelia subhosseana	Erupting Toad	Blue	S2S3			1
Peltula euploca	Powder-Lined Rock-Olive	Red	SIS2			1
Phaeophyscia decolor	Lesser Eye Shadow	Blue	S2S3			1
Physcia dubia	Grinning Rosette	Blue	S3			3

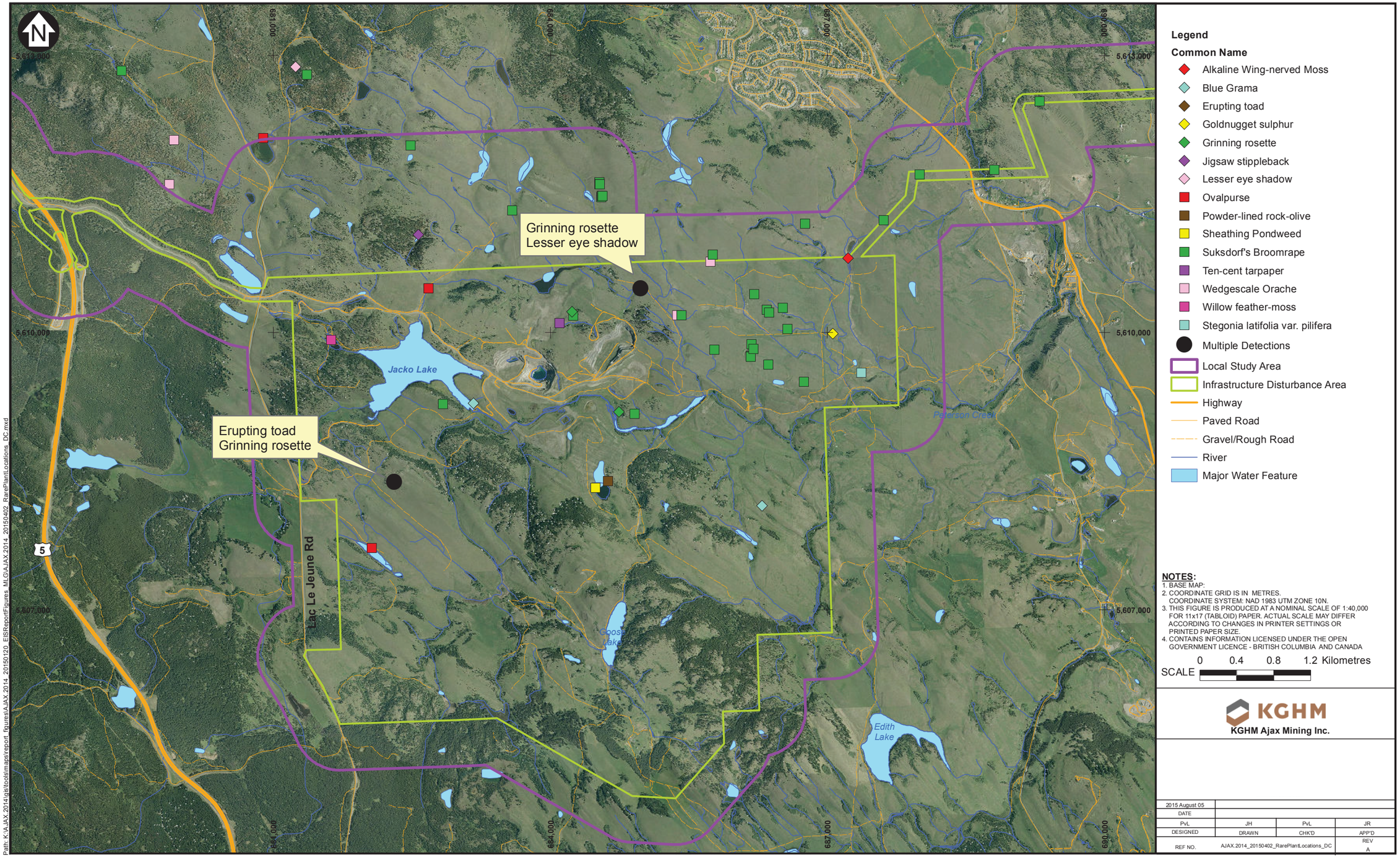
[1] Total number of known occurrences within the LSA
[2] S1 – critically imperiled, S2 – imperiled, S3 – special concern, S4 – apparently secure. S#S# - indicated a range of uncertainty, ? – Denotes inexact or uncertain numeric value.

Species Descriptions

Atriplex truncata **(Wedgescale orache) (Blue-listed**). Wedgescale orache is a tall annual of the Chenopodiaceae (goosefoot family). Wedgescale orache is found in saline habitats in limited areas of temperate western North America, from BC east to Saskatchewan, south to California and New Mexico; but few sites are reported in Canada (Welsh 2007; BC Conservation Data Centre 2014a; NatureServe 2014). In British Columbia wedgescale orache is known only from the driest portions of the Central Interior and has been previously recorded in the Chilcotin Grasslands and Osoyoos (BC Conservation Data Centre 2015; Douglas et al. 2002b). One wedgecale orache was found within the IDA, and two sub-populations were found in the RSA (Figure 6.8-5).

Bouteloua gracilis **(blue grama) (Red-listed):** Blue grama is a densely-tufted perennial grass (Fontaine & Douglas 1999). This member of the Poaceae (grass family) is the only species of its genus in BC and reaches the northwestern limit of its range here (Douglas et al. 2001b; Wipff 2003). Blue grama is a common dominant species of the North American short grass prairie, which extends from BC east to Manitoba and the eastern United States, and south to Mexico. In these regions, the species grows in open grassland of various types (Wipff 2003). In British Columbia, blue grama is known only from a few sites in the Fraser River basin (east of Clinton) and in the southern part of the Rocky Mountain trench, and is restricted to pockets of dry lands bounded by forested ridges (Fontaine and Douglas 1999). Overgrazing, fire suppression, expanding development, and invasive plant species pose significant threats to this taxon (Fontaine & Douglas 1999). Two occurrences of blue grama were recorded in the LSA, one within the IDA, the other within the IF (Figure 6.8-5). No other occurrences have been recorded in the RSA.

Figure 6.8-5
Rare Plant Occurrences



***Epilobium halleanum* (Hall's willowherb) (Blue-listed):** Hall's willowherb is a perennial vascular plant in the Onagraceae (evening-primrose family). Hall's willowherb is found across western North America, in various montane habitats such as open forests, moist slopes, and wet meadows (Cronquist et al. 1997; Douglas et al. 1999b; NatureServe 2014). In BC, the taxon is documented from a number of sites in the southern interior regions of the province (BC Conservation Data Centre 2014a). One occurrence was found east of Inks Lake in the LSA; it has not been previously recorded in the RSA.

***Hornungia procumbens* (ovalpurse) (Blue-listed):** Ovalpurse is a diminutive annual vascular plant of the Brassicaceae (mustard family). Ovalpurse has a very broad distribution in temperate regions of the Northern Hemisphere, and has also been introduced into Mexico, S. America, S. Africa, and Australia (Al-Shehbaz 2002). However, the species is irregularly distributed and rare across Canada and in BC (Al-Shehbaz 2002; BC Conservation Data Centre 2014a; NatureServe 2014). Ovalpurse grows in moderately to strongly saline soil in arid and semi-arid regions (Al-Shehbaz 2002). In British Columbia the taxon is threatened primarily by habitat loss and livestock grazing (BC Conservation Data Centre 2014a). Several occurrences of ovalpurse have been recorded near Kamloops, including one on the east side RSA, and another north of the RSA in the Lac Du Bois Grassland Protected Area. Two occurrences of oval purse occur within the LSA, both within the IF. An additional occurrence was recorded within the RSA at the northern border of the LSA (Figure 6.8-5).

***Orobanche ludoviciana* var. *arenosa* (Suksdorf's broomrape) (Red-listed):** Suksdorf's broomrape is a small parasitic vascular plant of the Orobanchaceae (Broomrape family). Suksdorf's broomrape generally parasitizes plants of the Asteraceae (sunflower family), particularly species of *Artemisia* (sage) (Douglas et al. 1999a). The species as a whole ranges across much of west-central North America (NatureServe 2014), but several subdivisions have been delineated of which two varieties are recognized by the BC CDC (M. Donovan pers. comm. 2013). The BC CDC reports variety *ludoviciana* from locations in southeast BC, and variety *arenosa* from sites near Kamloops (BC Conservation Data Centre 2014a). Eight occurrences of Suksdorf's broomrape, and over 20 sub-populations were observed around the LSA (Figure 6.8-5).

***Stuckenia vaginata* (sheathing pondweed) (Blue-listed):** Sheathing pondweed is a perennial aquatic vascular plant belonging to the Potamogetonaceae (horned pondweed family). The species is found submerged in shallow to deep ponds and lakes in northern regions of the northern hemisphere (Les and Haynes 2007; BC Conservation Data Centre 2014a; NatureServe 2014). Occurrences of sheathing pondweed are known from throughout the province (BC Conservation Data Centre 2014a), including several occurrences in the Thompson-Nicola Region (Douglas et al. 2002b). The taxon is sensitive to changes in water quality, and is threatened by water pollution from mining and agriculture. Other threats include shoreline development, invasive exotic plant species, and changes in hydrology (NatureServe 2014). One occurrence of sheathing pondweed was recorded in the IF (Figure 6.8-5). Sheathing pondweed has not been recorded elsewhere in the RSA.

***Amblystegium varium* (willow feather-moss) (Blue-listed):** Willow feather-moss, also known as *Hygroamblystegium varium*, is a delicate, irregularly branched moss of the Amblystegiaceae (Amblystegium family). The taxon is highly variable in form, and is found world-wide in a variety of mesic to aquatic habitats (Vanderpoorten 2009). Willow feather-moss occurrences are known from

Central and Southwest BC (BC Conservation Data Centre 2014a). One occurrence of willow feather moss was recorded in the IDA; this is the only known occurrence in the RSA (Figure 6.8-5).

***Pterygoneurum kozlovii* (alkaline wing-nerved moss) (Blue-listed, SARA-listed Threatened):** Alkaline wing-nerved moss is a tiny clump-forming perennial of the Pottiaceae (pottia family). The taxon grows on soil at the margins of alkaline wetlands, and is known from disparate sites in western North America and Eurasia (McIntosh 1986; COSEWIC 2004). In BC, alkaline wing-nerved moss has been documented in scattered locations across the southern part of the province (BC Conservation Data Centre 2014a). Threats to the specialized habitat of this moss include overuse by livestock, urban and highway development, recreational use, and drought (COSEWIC 2004; BC Conservation Data Centre 2014a). One occurrence of alkaline wing-nerved moss was recorded in the IDA, no additional occurrences have been recorded in the RSA (Figure 6.8-5).

***Stegonia latifolia* var. *pilifera* (stegonia moss) (Red-listed):** Stegonia moss variety *pilifera*, also known as *Stegonia pilifera*, is a member of the Pottiaceae (pottia family). Stegonia moss is found growing on soil and rock in tundra and arctic alpine locations across the northern hemisphere (Zander 2007; NatureServe 2014). In North America, var. *pilifera* is found in the arctic regions of Canada, and in moderate to high-elevation sites in BC, Alberta, Manitoba, Colorado and California (Zander 2007). In BC, the taxon is known from the far northeast region of the province (BC Conservation Data Centre 2014a). This moss has not been previously recorded in the region (BC Conservation Data Centre 2014a). One occurrence of stegonia moss was recorded in the IDA (Figure 6.8-5).

***Collema crispum* (ten-cent tarpaper) (Red-listed)**: Ten-cent tarpaper is a cyanolichens, which are on average more sensitive to environmental conditions than are the green algal lichens, owing to higher pollution sensitivity and narrower ranges of suitable pH and moisture-temperature interactions. As with most soil-dwelling lichens, ten-cent tarpaper is sensitive to overgrazing. Remaining populations in British Columbia are in sites that either have not received heavy grazing pressure, or are in microsites that are avoided by cattle. Invasive plant species may also bear an impact on this species, owing to the smothering thatch formed by weedy introduced grasses and forbs. It grows on rock and, especially, soil in open, dry habitats, mostly in grassland (Goward et al. 1994). Ten-cent tarpaper is widely distributed around the northern hemisphere, but is nowhere common. In British Columbia the taxon is known from eight populations: in the Okanagan Valley, the Chilcotin and the Thompson Plateau. One occurrence of ten-cent tarpaper was recorded in the IF, and no additional occurrences have been recorded in the RSA (Figure 6.8-5).

***Dermatocarpon leptophyllodes* (jigsaw stippleback) (Blue-listed):** In British Columbia, the jigsaw stippleback lichen is found in few sites scattered through the Southern Interior, and from there it is distributed south sporadically and rarely to California, and rarely also in northwestern Europe (Heiömarsson 2000). The species is found on firm, slow-eroding rock faces, mostly with a neutral pH, but sometimes on alkaline rock such as limestone. One occurrence of jigsaw stippleback was recorded in the LSA (Figure 6.8-5).

***Fulgensia bracteata* (goldnugget sulphur) (Blue-listed):** Goldnugget sulphur is a soil-dwelling lichen distributed widely in the northern hemisphere (McCune and Goward 1995), but is nowhere abundant. In British Columbia, the taxon is found in the Thompson Plateau, Chilcotin Grasslands and the Peace River Grasslands. It favours calcareous soil (McCune & Goward 1995), or lower-pH

soil that is modified by wind-blown accumulations of calcareous dust. This species, as with so many that are soil-dwelling in grasslands, appears to be sensitive to overgrazing and other human-caused disturbances. *Fulgensia* requires a stable soil veneer in sparsely vegetated sites. That veneer is easily destroyed by trampling cattle, and overgrazing often results in the spread of dense patches of thatch-forming invasive plants that may smother soil-dwelling lichens or increase fire frequency and intensity (McCune and Goward 1995). One occurrence of goldnugget sulpher was recorded in the IF, there are no other known observations within the RSA (Figure 6.8-5).

Neofuscelia subhosseana **(erupting toad) (Blue-listed):** This lichen is a member of a large genus found mostly in dry climates in the southern hemisphere. All three species of the genus that occur in British Columbia are currently tracked by the BC CDC. Erupting toad grows in desert, grassland, shrub steppe, and savannah, where it occupies acidic rock surfaces (Goward, et al. 1994). It is currently known from three populations in the province, one each in the Okanagan Valley, Thompson Plateau, and Chilcotin Grasslands. Despite its apparent rarity, it is given a lower ranking priority owing to the security of its habitat. It grows on rock surfaces where it is less sensitive to effects of human-caused disturbances. One occurrence of erupting toad was recorded in the IDA (Figure 6.8-5).

Peltula euploca **(powder-lined rock-olive) (Red-listed):** The lichen genus *Peltula* is found mostly in desert regions and is an oddity among lichens because its photosynthetic partner is the cyanobacterium *Anacystis*. In BC, it is known only from six sites in two small clusters of three populations each, one along the Fraser River in the Chilcotin, and the other in the southern Okanagan. Powder-lined rock-olive grows on dry or seepy rock faces in dry climates (Goward et al. 1994). The rock type may be acidic or pH-neutral. One occurrence of powder-lined rock-olive was recorded in the IF (Figure 6.8-5).

Phaeophyscia decolor **(lesser eye shadow) (Blue-listed):** This lichen species is mostly found on basalt boulders and promontories that are usually nutrient-enriched by birds (i.e. where they frequently perch and defecate) (Goward, et al. 1994). In British Columbia, this species ranges rarely through the central Interior, south to the western U.S. and northwest Mexico. It also is sporadically distributed through Eurasia. Changes to populations of perching birds could alter the habitat usually occupied by this species. One occurrence of lesser eye shadow was recorded in the IF (Figure 6.8-5).

Physcia dubia **(grinning rosette) (Blue-listed):** Grinning rosette grows on rock, usually on surfaces of underhangs, where it can be sheltered from direct rain-splash, and where nutrient-rich dust can accumulated without being washed away by rain water. The sites it occupies are also characterized by being nitrogen-enriched by bird guano or rodent droppings. Grinning rosette has a wide global range and may be locally common (Goward et al. 1994). It is known currently from 19 populations in British Columbia, scattered from northwestern portions of the province, in the Chilcotin, Thompson Plateau, Coast Ranges, and Okanagan Valley. Despite its wide geographical extent in the province, it is rarely seen. With its requirement for nitrogen enrichment from birds and rodents, it may have an extra degree of environmental sensitivity. Also, it is likely to be sensitive to air pollution. Three occurrences of grinning rosette were recorded in the IDA and IF (Figure 6.8-5).

Traditional Plants

Of the 125 traditional plants identified as potentially occurring, 114 were recorded within the LSA during rare plant surveys but no location information was recorded.

Common indicator species were recorded during habitat field truthing. Habitat field-truthing took place from August 16 to 21, 2007, June 23 to 26, 2010, and August 12 to 15, 2014. In total, 15 full plots, 159 Ground Inspection Forms (GIFs) and 319 visual checks were completed. These include GIF and visual plots that were done during wildlife surveys. The distributions of TEM field plots by BEC variant are listed in Table 6.8-5.

Table 6.8-5. Summary of TEM Field-truthing Plot Types

BEC Variant	Full Plot	Ground Inspection	Visual Inspection	Grand Total
BGxw1	3	10	53	66
IDFxh2	9	137	221	367
PPxh2	3	12	45	60
Grand Total	15	159	319	493

Traditional plants that had confirmed presence in the LSA, multiple traditional uses and also recorded as an indicator species during habitat plots were selected to represent the traditional plant VC (Table 6.8-6). Species were yellow listed provincially (secure and not at risk) and frequently found within preferred habitat.

Table 6.8-6. Traditional Used Plants VC Indicator Species

Taxon	Common Name	No. Trad Uses	Locations
Achillea millefolium var. lanulosa	Yarrow	2	60
Amelanchier alnifolia	Saskatoons	5	34
Arctostaphylos uva-ursi	Kinnikinnick	4	3
Artemisia tridentata ssp. tridentata	Big sagebrush	3	51
Carex	Sedges	4	8
Cornus stolonifera	Red-osier Dogwood	6	12
Hieracium scouleri	Scouler's Hawkweed	5	1
Juniperus scopulorum	Rocky Mountain Juniper	5	32
Lithospermum ruderale	Lemonweed	4	29
Lomatium macrocarpum	Qweoewile / Large-fruited Desert-parsley	1	20
Pinus ponderosa	Ponderosa Pine	3	28
Pseudotsuga menziesii	Douglas fir	5	82
Salix	Willows	4	7
Shepherdia canadensis	Soapberries	5	10
Typha latifolia	Cattail	3	3

Invasive Plants

During the 2014 rare plant surveys, BC noxious weed occurrences were also recorded when they were encountered in the field. It should be noted that the 2014 surveys were not an exhaustive inventory of all noxious weed infestations within the LSA, and additional occurrences are most likely present. Eleven noxious weed species were found, in a total of 209 occurrences (Table 6.8-7). Many of the occurrences covered several hectares.

Table 6.8-7. Noxious Weeds Recorded in the LSA during 2014 Surveys

Taxon	Common Name	Total Sites	Total Area (m²)
Centaurea stoebe ssp. micranthos	Spotted Knapweed (SK)	59	152,944
Cynoglossum officinale	Common Hound's-tongue (HT)	57	32,111
Cirsium arvense	Canada Thistle (CT)	42	86,088
Arctium minus	Common Burdock (BU)	18	83
Sonchus arvensis	Perennial Sow Thistle (PS)	10	32,246
Leucanthemum vulgare	Oxeye Daisy (OD)	9	331
Linaria genistifolia ssp. dalmatica	Dalmatian Toadflax (DT)	5	5,026
Potentilla recta	Sulphur Cinquefoil (SC)	3	45
Cardaria sp.	Hoary Cress (HC)	2	120
Centaurea diffusa	Diffuse Knapweed (DK)	2	10,020
Acroptilon repens	Russian Knapweed (RK)	2	600

6.8.4 Potential Effects of the Project and Proposed Mitigation for Rare Plants

6.8.4.1 Identifying Potential Effects on Rare Plants

An interaction matrix (Table 6.8-8) was used to help scope potential effects by considering potential interactions with Project activities/components, consistent with approach outlined in the assessment methodology (Section 5.2.4.1.). Further rationale for the scoping of potential effects is provided below.

Since plants are sedentary, habitat loss and habitat alteration are the two potential effects on this VC. Habitat loss results in loss of the plant population present in the area, while habitat alteration is considered habitat degradation resulting in a decrease in the number of individual plants present in a population.

Table 6.8-8. Identifying Potential Project Interactions and Effects on Rare Plants

	Project Activities	Potential Effects on Rare Plants	
		Habitat Loss	Habitat Alteration
Construction	Clearing and Grubbing	H	O
	Earthworks	H	M
	Overburden/Topsoil Stockpile	O	O
	Laydown Areas and Storage Yards	O	O
	Project Lighting	O	O
	Site Security and Fencing	O	O
	Fuel Storage and Filling Area	O	O
	Hazardous Wastes Transport, Storage, and Disposal	O	O
	Construction Wastes Transport, Storage, and Disposal	O	O
	Sewage Infrastructure and Disposal	O	O
	Public Road Realignment, Use, and Maintenance	O	M
	Site Road Construction, Use and Maintenance	O	M
	Haul Road Overpass Construction, Use, and Maintenance	O	O
	Site Buildings and Process Plant	O	O
	Explosives Magazine and Storage Facilities	O	O
	Open Pit Development	O	O
	Drilling and Blasting	O	M
	Crushing Mine Rock	O	M
	Loading, Hauling, and Deposition of Waste Rock	O	O
	Temporary Ore Stockpile	O	O
	Tailing Storage Facility Development	O	O
	Power Transmission, Distribution	O	O
	Natural Gas Line	O	L
	Pipeline Utility Corridor (Potable Water, Sewage, and Site Water)	O	L
	Water Intake from Kamloops Lake	O	O
	Fire Suppression Infrastructure	O	O
	Contact Water	O	L
	Non-contact Water	O	O
	Haul Road Overpass	O	O
	Water Management Dams	M	O
	Mine Staffing (Direct Employment)	O	O
	Contracted Employment	O	O
	Taxation	O	O

	Project Activities	Potential Effects on Rare Plants	
		Habitat Loss	Habitat Alteration
Operation	Open Pit Development	O	O
	Drilling and Blasting	O	M
	Hauling Mine Rock and Ore from Pit	O	O
	Crushing and Conveying Ore	O	M
	Temporary Ore Stockpile	O	O
	Development of Waste Rock Management Facilities	O	O
	Stripping, Loading, Hauling, Deposition, and Contouring of Topsoil and Overburden	O	O
	Revegetation through Progressive Reclamation	O	O
	Process Plant Operation	O	O
	Deposition to Tailing Storage Facility	O	O
	Site Road Use and Maintenance (Materials, Personnel, Supplies)	O	M
	Concentrate Transport and Storage	O	O
	Explosives Magazine and Storage Facilities	O	O
	Fire Suppression Infrastructure	O	O
	Fuel Storage and Filling Area	O	O
	Hazardous Wastes Transport, Storage, and Disposal	O	O
	General Wastes Transport, Storage, and Disposal	O	O
	Sewage Infrastructure and Disposal	O	O
	Laydown Areas and Storage Yards	O	O
	Power Transmission, Distribution	O	M
	Project Lighting	O	O
	Site Access, Security and Fencing	O	O
	Water Intake from Kamloops Lake	O	O
	Contact Water	O	L
	Non-contact Water	O	O
	Potable Water Treatment and Use	O	O
	Haul Road Overpass	O	O
	Mine Staffing (Direct Employment)	O	O
	Contracted Employment	O	O
	Taxation	O	O

	Project Activities	Potential Effects on Rare Plants	
		Habitat Loss	Habitat Alteration
Decommissioning and Closure	Dismantling of Ancillary Buildings	O	O
	Pit Lake Planning	O	O
	Site Road/Bridge Decommissioning	O	O
	Tailing Storage Facility Decommissioning and Reclamation	O	O
	Mine Rock Management Facilities Reclamation	O	O
	Fuel Storage and Filling Area	O	O
	Hazardous Wastes Transport, Storage, and Disposal	O	O
	General Wastes Transport, Storage, and Disposal	O	O
	Sewage Infrastructure and Disposal	O	O
	Laydown Areas and Storage Yards	O	O
	Power Transmission, Distribution	O	L
	Project Lighting	O	O
	Site Access, Security and Fencing	O	O
	Contact Water	O	L
	Non-contact Water	O	O
	Potable Water Treatment and Use	O	O
	Haul Road Overpass	O	O
	Road use to the Project (Materials, Personnel, Supplies)	O	L
	Mine Staffing (Direct Employment)	O	O
	Contracted Employment	O	O
	Taxation	O	O
Post-Closure	General Site Inspections and Maintenance	O	O
	Contact Water	O	L
	Non-contact Water	O	O
	Road use to the Project (Materials, Personnel, Supplies)	O	L
	Mine Staffing (Direct Employment)	O	O
	Contracted Employment	O	O

Notes:

O	*No interaction anticipated.*
L	*Negligible to minor interaction expected; implementation of best practices, standard mitigation and management measures; no monitoring required, no further consideration warranted.*
M	*Potential moderate interaction requiring unique active management/monitoring/mitigation; warrants further consideration.*
H	*Interaction; warrants further consideration.*

Habitat Loss

For the purposes of this assessment habitat loss is defined as the process by which suitable habitat is rendered functionally unable to support the indicator species. Habitat loss will occur during the construction phase of the Project, specifically during vegetation clearing, land excavation, dams for water management and any other changes to the physical landscape. Permanent loss results from the replacement of habitat by Project infrastructure footprints (IF) and is considered the minimum area where habitat loss is expected to occur. All rare plants within the IF will be lost as a result of project construction. Habitat outside of, but in close proximity to the Project IF, may not be permanently lost but is functionally compromised due to interactions with the Project IF. The IDA defines this area and is considered the maximum area where habitat loss is expected to occur during Project construction and operation. Rare plants found within the IDA may be lost as a result of project construction. Thus a range of habitat loss is predicted occur within the LSA. Additional Project effects will not be considered for the Project IFs where habitat has been permanently removed (i.e., a species cannot be displaced from habitat that has already been permanently lost).

An interaction between rare plants and the Project is anticipated to lead to habitat loss. Twenty-seven Red- and Blue-listed rare plant occurrences and 114 traditional plants were reported in the LSA and have the potential to interact with the Project. Consequently, Project activities associated with habitat loss was given a ranking of "high" due to the high likelihood of an adverse interaction with the Project. This warranted further consideration. The methods of a quantitative analysis of habitat loss for rare plants are described in Section 6.8.4.2.

Habitat Alteration

Habitat alteration is defined as a reduction in habitat suitability. Activities that affect the physical characteristics of an area, either permanently or temporarily can result in a change in habitat suitability. Habitat alteration will occur throughout the construction and operation phases of the Project, specifically as a result of drilling, blasting, crushing and road use (fugitive dust deposition), soil compaction, linear feature use and maintenance (invasive species introduction, vegetation maintenance) and changes in drainage and water quantity. Included within the IDA is a minimum 50 metre buffer between the edge of the Project IF and the IDA. This buffer incorporates habitat alteration resulting from edge effects into the maximum habitat loss effect (Gieselman et al. 2013). As all suitable habitat within the IF will be lost during initial Project construction activities (minimum effect); the maximum habitat alteration will be considered in the IDA and LSA. The minimum habitat alteration effect will only consider areas in the LSA.

Mosses and lichens are considered particularly susceptible to fugitive dust (Farmer 1993; Walker and Everett 1987). However, the area is known to be frequented by dust storms so the species present are expected to have some tolerance to dust. Air Quality modelling has been conducted for the Project area and the LSA (Appendix 10.1-A) to provide the predicted dust deposition as a result of Project activities during Construction and Operations. The predicted metals uptake in plants is modelled in the Human Health and Ecological Risk Assessment (Appendix 10.4-A). A ranking of "moderate" was given for those activities that are expected to generate fugitive dust above baseline conditions in construction and operations phases. This ranking was reduced to "low" in the decommissioning and closure phases due to reduced use of the site and reduced dust deposition

and associated metals uptake. Although multiple activities may cause increased dust, all those associated with transportation will be considered under site and public road use. A qualitative analysis of dust impacts on rare plants is described in section 6.8.4.2.

Increased road use, development of pipeline corridors and transmission line corridors may create vectors for invasive plant species throughout all phases of the Project. Invasive species out-compete the native vegetation and may negatively impact traditional and rare plants. See Appendix 6.8-A for a list of invasive species present within the LSA. A ranking of "moderate" was given to those Project activities that could result in an increase in invasive species. This warranted further consideration. The methods of a quantitative analysis of habitat alteration for rare plants are described in section 6.8.4.2.

Chemical contaminants such as lead, copper and selenium can be absorbed into plants, causing toxic effects (World Health Organization 1989). The presence of rare plants in and around contact water may result in the accumulation of these elements, as well as others, in plant tissue. However, no red or blue-listed plants were recorded in proximity to wetlands that are expected to have water quality issues (See Section 6.9), therefore a ranking of "low" was given for contact water. A qualitative analysis of chemical impacts on rare plants is described in section 6.8.4.2.

Chemical contaminants coming into direct contact with soil is the primary exposure pathway for terrestrial plants, while direct contact with surface water is the primary exposure for aquatic plants, with some likely affected by direct contact with sediment. Terrestrial plants are potentially affected by transport of chemical contaminants through groundwater runoff and leaching from soil, while aquatic plants are potentially affected by groundwater discharge and surface water drainage mixing with surface water and sediment. For stoloniferous or rhizomatous species (those connected by above ground or below ground roots), chemical contaminants are passed from one ramet to another, along with nutrients and water. It is not feasible to assess the effects of every plant species found in the project area, therefore this discussion will focus on plant communities.

6.8.4.2 Effects on Rare Plants

Key effects were identified for habitat loss and habitat alteration on rare plants. Additional analysis described below, will be completed to quantify the impacts of Project activities on rare plants.

Habitat Loss

Methods to Predict Impacts of Project Activities on Rare Plants

The presence of a rare plant is often associated with microhabitat features that cannot be mapped. Since these features are not characteristic of the broader habitat type an assessment based on the ecosystem mapping would not be reliable. Therefore the local assessment of habitat loss for rare plants focuses on the loss of rare plant sub-populations rather than ecosystem units that might provide habitat.

The loss of rare plant sub-population as a result of Project construction was calculated by determining the maximum and minimum potential effects on rare plants. The maximum effect was calculated by overlaying the IDA footprint on the map of rare plant locations, while the minimum effect was determined by overlying the Project IFs on the map of rare plant locations. The potential

exists for an adverse effect on rare plants if a sub-population is present within the IDA or IF. The total number of rare plants within the IDA or IF will then be compared to the total amount of rare plants within the LSA to calculate the percent of loss within the LSA. As so few rare plant surveys have been conducted in the RSA, this same method would not accurately represent the loss of rare plants in the RSA. Instead a qualitative method based on professional judgement was used to predict impact of the project on rare plants in the RSA.

Similarly, impacts to traditionally used plants were based on plant location recorded at habitat plots.

Predicted Impacts of Project Activities on Rare Plants

Between 38 and 78% (19 rare plants lost in the IF, and an additional 20 occur in the IDA) of rare plant sub-populations within the LSA may be lost as a result of Project construction (Figure 6.8-6, Table 6.8-9). Specifics for each rare plant species is outlined below.

Table 6.8-9. Locations of Rare Plant Sub-populations within Project Study Area

Common Name	# in RSA-LSA	# in LSA-IDA	# in IDA-IF	# in IF	Comments (i.e., Other Observations within RSA)
Wedgescale orache	2		1	1	This rare plant has not been previously recorded in the region
Blue grama			1	1	This rare plant has not been previously recorded in the region
Hall's willowherb		1			This species has been observed in the in the region
Ovalpurse	1		1	1	Two other occurrences in region, one on the east side of the RSA, the other in Lac Du Bois Grassland Protected Area
Suksdorf's broomrape	2	10	10	10	This species only occurs in the Kamloops area
Sheathing pondweed				1	This species has been previously observed in the region
Willow feather-moss			1		Further investigation is ongoing to confirm the identification.
Alkaline wing-nerved moss			1		Multiple other occurrences in region, including one on the east side of the RSA, and another in Lac Du Bois Grassland Protected Area
Stegonia moss				1	This moss has not been previously recorded in the region
Ten-cent tarpaper				1	This species has been previously recorded in the region
Jigsaw stippleback		1			This species range includes the southern interior
Goldnugget sulphur				1	This species has been previously observed in the region
Erupting toad			1		This moss has been previously recorded in the region
Powder-lined rock-olive				1	Has not been previously recorded in the Kamloops area

Common Name	# in RSA-LSA	# in LSA-IDA	# in IDA-IF	# in IF	Comments (i.e., Other Observations within RSA)
Lesser eye shadow	1		1		This species range includes central interior
Grinning rosette			3	1	This species has been previously observed in the region
Total	**6**	**11**	**20**	**19**	

One occurrence of Blue-listed wedgescale orache was found within the Pit and will be lost as a result of Project construction, and another occurs along the north border in the IDA. Four other occurrences were recorded in the RSA during baseline surveys. These are the only known occurrences in the Thompson-Nicola Region, though it been found from the Chilcotin Grasslands to the U.S. border (BC Conservation Data Centre 2015; Douglas et al. 2002b).

Two populations of the Red-listed blue grama were found within the LSA. One will be lost as a result of Project construction (occurs within the proposed Plant), and the other may be lost as it occurs within the IDA. These are the only known occurrences in the Thompson-Nicola Region (BC Conservation Data Centre 2015; Douglas et al. 2002b).

Observations of Hall's willowherb populations were reported from the study area in 2008. This occurrence is in the LSA east of Inks Lake and construction of the Project is not expected to impact this rare plant.

Three populations of the Blue-listed ovalpurse found occur within the IDA and one will be lost as a result of the West MRSF. An additional occurrence was recorded north of Wallender Lake in the RSA during baseline surveys. Several other occurrences of ovalpurse have been recorded near Kamloops, including one on the east side RSA, and another north of the RSA in the Lac Du Bois Grassland Protected Area.

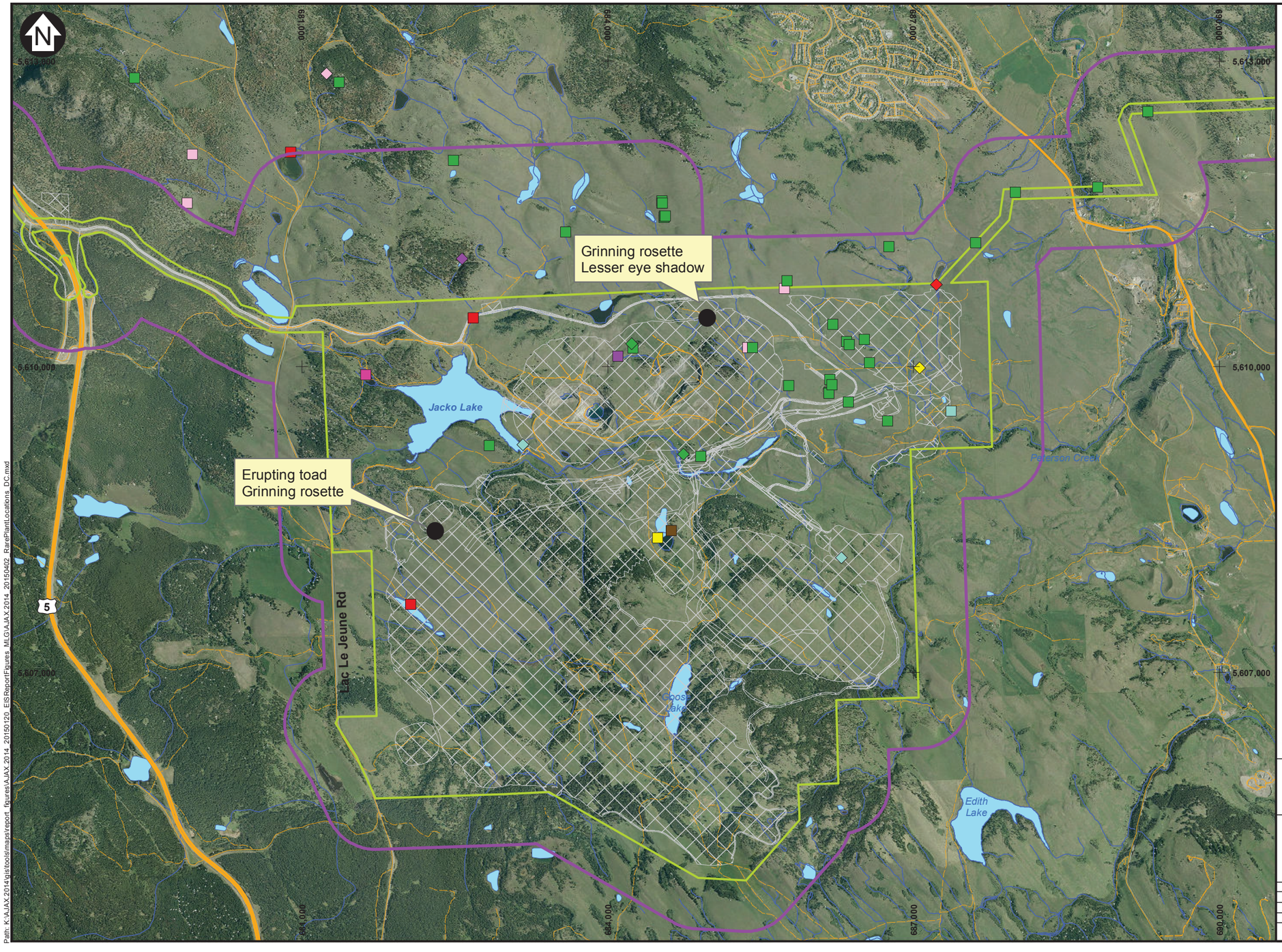
Thirty sub-populations of the Red-listed Suksdorf's broomrape var. *arenosa* were recorded across the central and northeastern sections of the Ajax LSA. Eleven sub-populations occur in the IF and will be lost. An additional 10 sub-populations were recorded in the IDA and may be impacted by Project construction. Thirteen sub-populations have been observed within the LSA, and an additional two have been recorded in the RSA during baseline studies. These occurrences are the only recorded observations of this variety in the Province.

The only known observation of Blue-listed sheathing pondweed within the LSA is found in the IF (Ore Stockpile) and will be lost as a result of Project construction. Several other occurrences of sheathing pondweed have been observed in the Thompson-Nicola Region (Douglas et al. 2002b).

A specimen of feather-moss was collected and identified as the Blue-listed willow feather-moss. This occurrence was found in the IDA west of Jacko Lake.

The Blue-listed, *SARA* Threatened alkaline wing-nerved moss was found in the IDA (East MRSF), within the 50 m buffer of a Project footprint. This occurrence may be lost as a result of Project construction. Several observations of this moss have been recorded near Kamloops, including four in the LSA, and another in the Lac Du Bois Grassland Protected Area.

Figure 6.8-6
Potential Loss of Rare Plant Occurrences



Legend

Common Name

- Alkaline Wing-nerved Moss
- Blue Grama
- Erupting toad
- Goldnugget sulphur
- Grinning rosette
- Jigsaw stippleback
- Lesser eye shadow
- Ovalpurse
- Powder-lined rock-olive
- Sheathing Pondweed
- Suksdorf's Broomrape
- Ten-cent tarpaper
- Wedgescale Orache
- Willow feather-moss
- Stegonia latifolia var. pilifera
- Multiple Detections
- Local Study Area
- Infrastructure Disturbance Area
- Infrastructure Footprints
- Highway
- Paved Road
- Gravel/Rough Road
- River
- Major Water Feature

NOTES:
1. BASE MAP:
2. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD 1983 UTM ZONE 10N.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:40,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
4. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENCE - BRITISH COLUMBIA AND CANADA

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The Red-listed *Stegonia latifolia* var. *pilifera* was observed in the IDA on soil at the mouth of a badger hole near the northeast border of the IF (Water Management Dam), and may be lost as a result of Project construction. This lichen has not been previously recorded in the region (BC Conservation Data Centre 2014a).

The only known occurrence of Red-listed ten-cent tarpaper was found in the IF, and will be lost as a result of Project construction. In British Columbia the taxon is known from only eight populations within the Okanagan Valley, the Chilcotin and the Thompson Plateau.

The jigsaw stippleback lichen (Blue-listed) was found within the LSA and is not anticipated to be impacted by Project construction.

An occurrence of Blue-listed goldnugget sulphur was found near the northeast corner of the IF (East MRSF), and is expected to be lost as a result of Project construction. This lichen has been previously found in the Thompson Plateau.

One occurrence of the Blue-listed erupting toad lichen was recorded in the IDA, between two footprints, and may be removed during clearing and grubbing activities. This lichen has been previously found in the Thompson Plateau.

The Red-listed powder-lined rock-olive population reported here is the first from the Kamloops area, and is the only population in BC found to be fertile (spore-bearing). This species was found within a proposed ore stockpile near the center of the IF, and is anticipated to be lost as a result of Project construction.

The Blue-listed lesser eye shadow lichen is found in the central interior British Columbia. This lichen was found in the north-central section of the IF and is anticipated to be lost during Project construction.

Four occurrences of the Blue-listed grinning rosette were observed during baseline studies. One sub-population was recorded in the IF and is anticipated to be lost as a result of Project construction, whereas the three others found within the IDA may be lost, as they are currently found between two Project footprints.

Predicted Impacts of Project Activities on Traditional Plants

There were 380 observations of the fifteen indicator Traditional Use plant species (Figure 6.8-7). Total predicted impacts to traditional use plants range from 27% (within IF) to 43% (within IDA). Only two species, cattail and willows, exceeded a minimum loss threshold of 50% (Table 6.8-10).

Willows and cattails are associated with wetland habitats. Wetlands were assessed in Section 6.9. Willows are associated with swamps and cattail is an indicator of marshes and there will be additional habitat around the LSA in which these species could still be collected.

Habitat Alteration

Methods to Predict Impacts of Project Activities on Rare Plants

Linear features (roads, pipelines, transmission lines) were buffered by 100 metres to determine the area where habitat alteration effects resulting from invasive plant species could occur. The 100 m buffer was determined based on literature review and the prominence of grassland habitat (Tyser

and Worley 1992; Hansen and Clevenger 2005). This buffer was overlayed on the map of rare plants locations to determine the number of sub-populations effected. Habitat alteration cannot occur in areas were habitat has been lost, including the IF (minimum habitat loss effect) and the IDA (maximum habitat loss effect).

The maximum dust fall (see Air Quality - Section 10.1) is not expected to exceed the MoE Ambient Air Quality Objectives lower range (applying to sensitive environmental situations) of 1.7 mg/dm^3/day (British Columbia Ministy of Environment 2014). As such, habitat alteration resulting from dust fall is not expected to occur.

Water quality impacts on rare plants was calculated by first determining which water bodies are expected to contain levels of heavy metals and other elements. If rare plants have been found in or near these water bodies (<50 m), then the tolerance of that particular plant, or plant group was reviewed.

Predicted Impacts of Project Activities on Rare Plants

Of the 20 rare plant observations in the IDA, 13 rare plant observations are found within the 100 m linear feature buffer (Figure 6.8-8, Table 6.8-11). Introduction of invasive species is more likely during construction and operations, when traffic volume will be greater. Construction of the pipeline and transmission line may also contribute to the spread of invasive species throughout the LSA.

Table 6.8-10. Locations of Traditional Use Plants within Project Study Area

Common Name	Occurrences	# in IDA-IF	# in IF	Range of Loss
Yarrow	60	13	20	33-55%
Saskatoons	34	9	9	26-53%
Kinnikinnick	3	0	0	0%
Big sagebrush	51	7	14	27-41%
Sedges	8	1	2	25-38%
Red-osier Dogwood	12	1	5	42-50%
Scouler's Hawkweed	1	0	0	0%
Rocky Mountain Juniper	32	0	3	9%
Lemonweed	29	7	10	34-59%
Qweoewile / Large-fruited Desert-parsley	20	3	6	30-45%
Ponderosa Pine	28	3	2	7-18%
Douglas fir	82	17	22	27-48%
Willows	7	0	4	57%
Soapberries	10	0	4	40%
Cattail	3	0	3	100%
Totals	**380**	**60**	**104**	**27-43%**

Table 6.8-11. Rare Plants Found within 100 m Linear Feature Buffer

Scientific Name	Common Name	# of Sub-populations
Hornungia procumbens	Ovalpurse	1
Orobanche ludoviciana var. *arenosa*	Suksdorf's Broomrape	10
Physcia dubia	Grinning rosette	1
Pterygoneurum kozlovii	Alkaline Wing-nerved Moss	1

Figure 6.8-7
Impacts to Traditional Plants

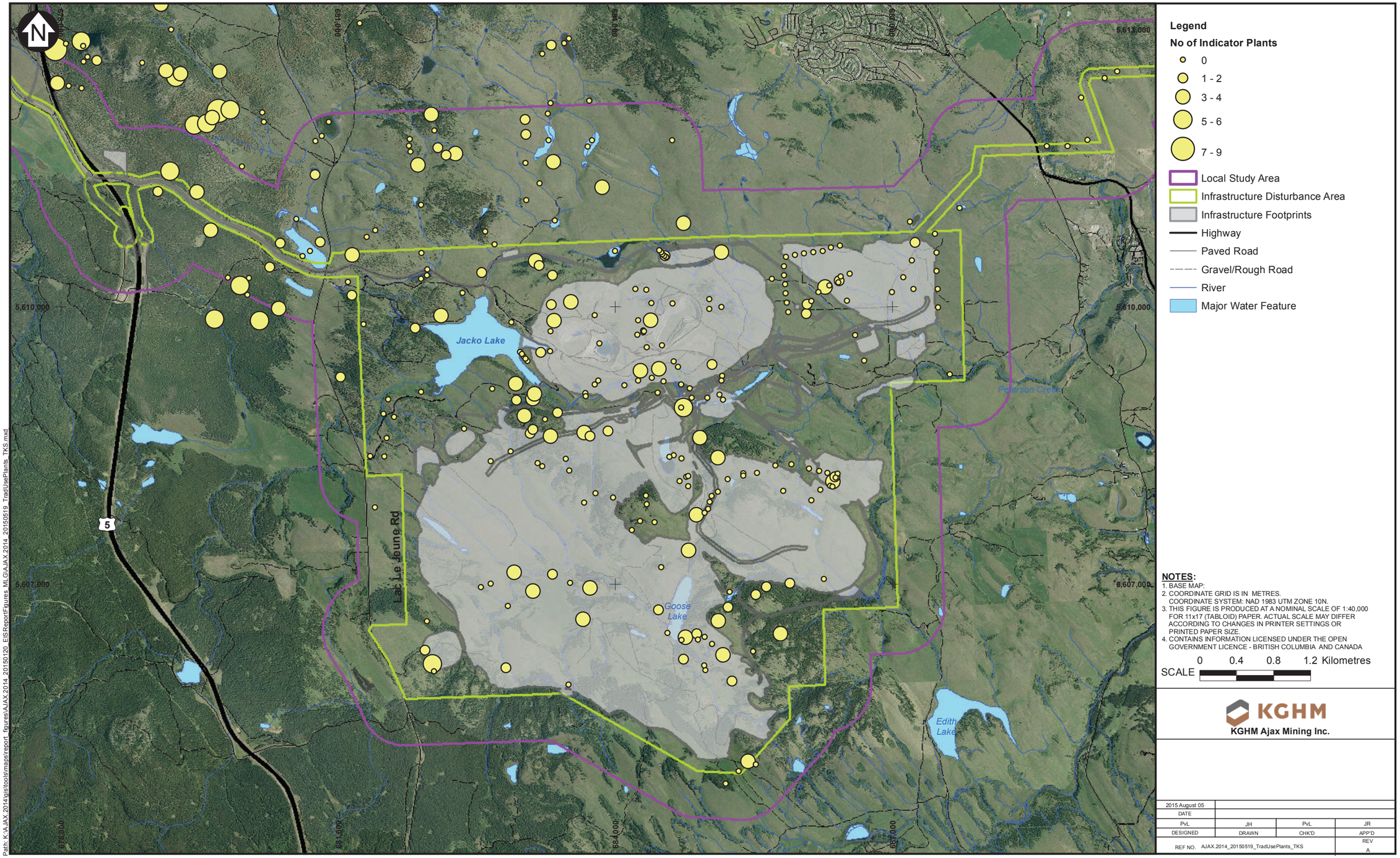
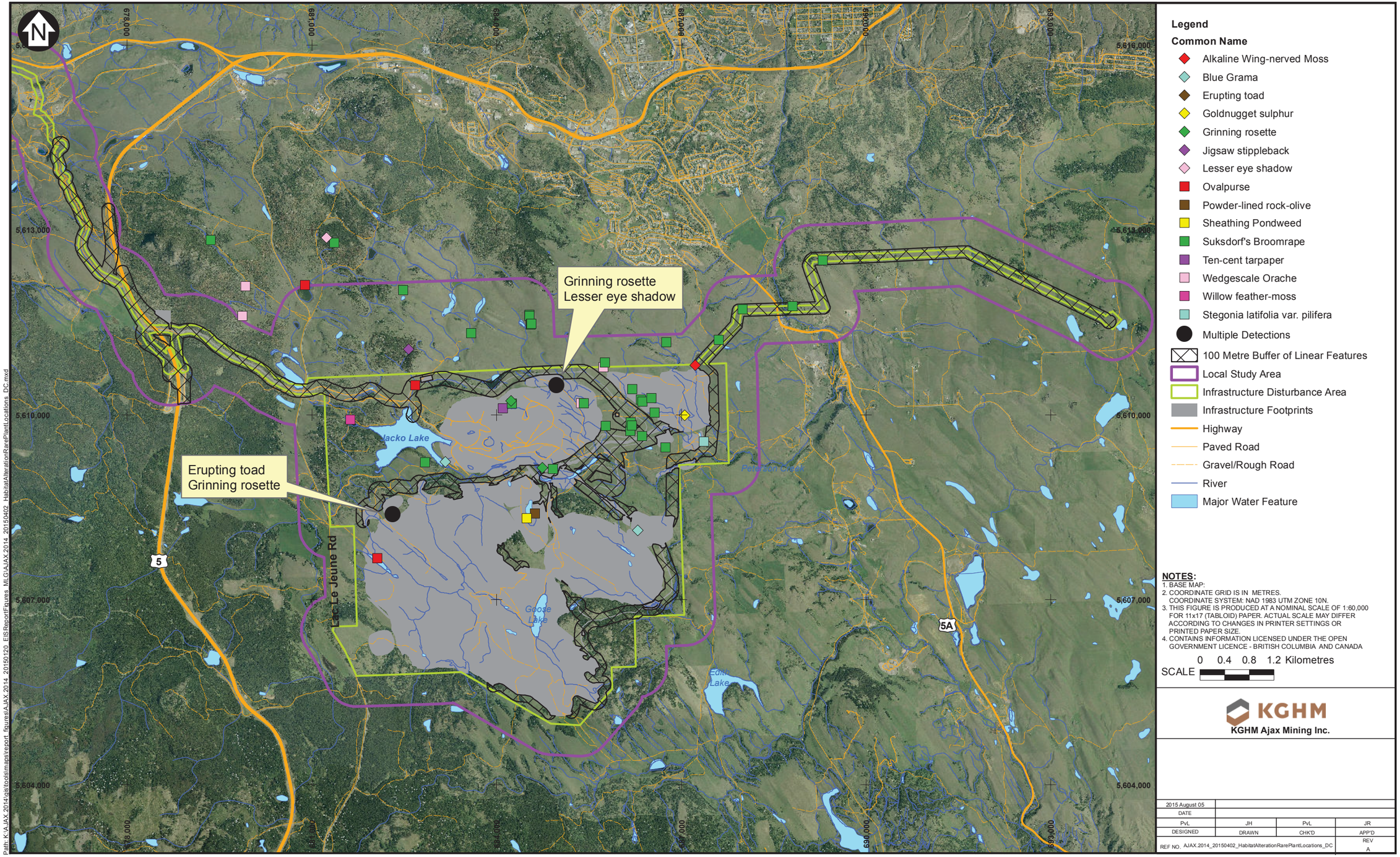


Figure 6.8-8
Potential Invasive Plant Habitat Alteration and Rare Plant Locations



6.8.4.3 Mitigation Measures for Rare Plants

Habitat Loss

During Project planning, specific mine footprints were redesigned to ensure the minimum possible impact on the surrounding environment would occur. During the Construction phase Project footprints will be kept to the minimum size required. During Decommissioning and Closure phases, habitat will be restored through reclamation and revegetation processes. Even if reclamation restores native habitats, it is unlikely that rare plants will recolonize the reclaimed habitat.

Impact avoidance and reduction mitigation proposed for the Project will be described in detail in the *Wildlife and Vegetation Monitoring Plan* (Section 11.27), and will include:

- Known rare plant occurrences will be used as inputs during the final design and Construction phase. Where feasible, Project IF will be placed so as to avoid direct impacts to these occurrences.
- East WMP Dam will be altered to avoid Stegonia moss occurrence
- Maps and a spatial database of known rare plant locations in the vicinity of Project facilities should be maintained and consulted to avoid impacts during Operations and maintenance activities. Ongoing monitoring by QEP or Project environmental manager will occur. The database should be actively updated as new information becomes available.
- Exclusion areas will be created at all known rare plant occurrences located adjacent to construction and operation areas. These areas will be clearly flagged to discourage accidental encroachment with machines. Signage will be added where necessary to indicate the boundaries of the exclusion area.
- Construction personnel will attend a field-based orientation session where the exclusion areas will be explained, and avoidance of these areas will be mandatory.
- Roads and transmission lines will be designed to minimize the number of water crossings and to avoid running parallel to watercourses. They will also be designed to minimize the removal of known rare plant occurrences.
- Erosion prevention and bank stabilization techniques will be used (Section 11.2).

For those rare plant occurrences that cannot be avoided, transplantation of these rare plants will be considered based upon the guiding principles laid out in the BMP: *Guidelines for Translocation of Plant Species at Risk in British Columbia.*

KAM will support regional rare plant surveys and research to determine the distribution of these rare plant species throughout the RSA.

Mitigation cannot fully compensate for the loss of rare plants and rare plant macrohabitat as a result of the Project. A residual effect is anticipated.

Habitat Alteration

Fugitive Dust Mitigation

No potential effects of fugitive dust are expected to alter rare plant populations or rare plant habitat. Dust mitigation measures will be addressed under several management and monitoring plans. Mitigation measures to protect air quality are described in Section 10.1 and in the *Air Quality Monitoring and Dust Control Plan* (Chapter 11.6).

Invasive Species Mitigation

Development and implementation of an invasive plant species plan in the *Wildlife and Vegetation Monitoring Plan* (Chapter 11.27) are integral to reducing invasive species introduction. Avoiding the introduction of invasive species is central to circumventing costly measures required for their eradication. Reducing traffic by implementing the *Access Management Plan* (Chapter 11.21) on site is also a key measure to help reduce the introduction of invasive plant species.

The plan for invasive species will manage for the priority species throughout the Project area. A site-specific plan will be developed by the Project's Environmental Manager through discussion (as needed) with the Invasive Plant Council, environmental scientists, and local governing agencies. The plan will draw upon the *Invasive Alien Plant Program: Reference Guide* (BC MOFR 2010) and *Invasive Plant Pest Management Plan for the Southern Interior of British Columbia* (BC Ministry of Forests and Range 2010), which outline an Integrated Pest Management approach for invasive alien plants, under the authority of several partnering ministries.

Reclamation to restore affected areas after Project activities have ceased will reduce the establishment of invasive species, which prefer disturbed sites. The reclamation plan will prioritize the rapid re-vegetation of all temporarily disturbed areas and will use appropriate seed mixes that minimize the spread of invasive plants. The Invasive Plant Management *P*lan *(*Section *11.17)* will also include objectives for limiting invasive species, monitoring the presence and possible spread of invasive plants in temporarily disturbed areas, and monitoring the success of re-vegetation programs.

Water Quality

Water quality mitigation will be addressed under several management and monitoring plans: the *Surface Water Quality Management and Monitoring Plan* (Section 11.23), the *Groundwater Quality Management and Monitoring Plan* (Section 11.24), and the *Water Management and Hydrometric Monitoring Plan* (Section 11.7).

Once mitigation is in place, no adverse residual effects associated with habitat alteration are expected for rare plants.

Chemicals of potential concern to ecological health, associated with the proposed project were identified in the Human Health and Ecological Risk Assessment - Technical Data Report (Appendix 10.4-A) by assessing four criteria: 1) assessing baseline concentrations in relation to exceeding relevant soil quality guidelines 2) selecting metals with concentrations in ore that are less than the regional background concentrations 3) the toxic potential metal constituents in mined ore 4) selecting metals with the

potential for measured and predicted Future Case concentrations of metals in surface water to exceed applicable guidelines for the protection of freshwater aquatic life, drinking water and agricultural uses. The resulting contaminants of potential concern for plant community exposures in the project area were identified as follows: aluminum, antimony, arsenic, chromium, cobalt, copper, lead, manganese, mercury, molybdenum, nickel, selenium, thallium and uranium. Plants are complex biochemical machines using a few of these elements as micronutrients (copper, manganese, molybdenum) with different taxa having a range of tolerances for all of these elements. A detailed analysis and discussion on the range of tolerances by different plant taxa is not required here due to the fact that the Ecological Risk Assessment conducted by Stantec found that the risk posed by the chemicals of potential concern to plant communities is below the applicable threshold, with the exception of manganese indicating that the adverse health risks to plant communities is negligible. In the case of manganese, the findings of this study suggest that the Project related activities pose no greater risk to plant communities than present day baseline conditions.

6.8.5 Residual Effects and Their Significance

6.8.5.1 Summary of Residual Effects

Mitigation and reclamation to reduce the impact of the Project on rare plants cannot fully compensate for the loss of rare plant occurrences during Project construction. Consequently a residual effect of habitat loss is anticipated (Table 6.8-12).

Table 6.8-12. Summary of Residual Effects on Rare Plants

Valued Component	Project Phase (timing of effect)	Project Component/ Physical Activity	Description of Cause-Effect[1]	Description of Mitigation Measure(s)	Description of Residual Effect
Rare Plants	Construction	Clearing and Grubbing, Earthworks	Habitat Loss	Reclamation, revegetation	Loss of known rare plant occurrences, loss of rare plant macrohabitat

[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 VC.*

Implementation of management and monitoring plans associated with fugitive dust, invasive species and water quality is anticipated to mitigate for any adverse effects on rare plants. Once mitigation plans are in place no residual effects as a result of habitat alteration are expected for rare plants.

6.8.5.2 Criteria for Characterization of Residual Effects

Specific criteria used to characterize residual effects are outlined in Section 5.5.5.2. Definitions of these criteria are provided in Table 6.8-13.

6.8.5.3 Characterization of Residual Effects

Characterization of residual effects is described in Table 6.8-14. The magnitude of habitat loss is considered medium for several species of rare plants as 38% of all rare plants found within the LSA are located within the IF and will be lost, including all observations of the Red-listed ten-cent tarpaper, Red-listed powder-lined rock-olive, and Blue-listed goldnugget sulphur (see Table 6.8-9). The remaining 40% of rare plants found in the IDA will be preserved through proposed mitigation.

The duration of habitat loss will likely last into the far future as revegetation and reclamation efforts will attempt to restore the variety of macro and micro habitats required to support these rare plants, recolonization is unlikely. Habitat loss was assumed to only occur in any given area once during construction; the geographic extent will be local. Several of the rare plants lost are the only known recorded occurrences in the region. Conditions in the IDA are not expected to return to baseline, therefore the loss of these rare plant occurrences within the IF is likely permanent. Rare plants will not be able to "adapt" to this habitat loss, as they require specific environmental conditions and microhabitats that cannot be recreated during reclamation. Several of these plants have been recorded in the region, outside of the IDA, whereas others have not previously been recorded in the area. Consequently, the ecological context is considered high.

6.8.5.4 Significance of Residual Effects

Loss of rare plant occurrences is considered a medium magnitude, as 38% of rare plants found within the LSA occur in the IF and will be lost as a result of Project construction, including all observations of the Red-listed ten-cent tarpaper and Red-listed powder-lined rock-olive. The residual effect is of local extent, even though several of these lost species have not been previously recorded in the region (i.e. wedgescale orache, blue grama, and powder-lined rock-olive). The loss of these rare plants may impact the regional population and translocation off these plants will be examined. The impacts of the Project will extend into the far-future. Consequently, the impact of the Project on rare plants is expected to be Not Significant (Moderate).

6.8.5.5 Characterization of Likelihood and Confidence

It is highly likely that this effect will occur on rare plants. Extensive surveys were conducted through the LSA, including the IDA and IF. All rare plant occurrences within IF will be potentially lost. The confidence associated with this analysis is moderate. There is a high degree of certainty that Project construction will result in the loss of rare plants that are found in the IF but rare plant data for the RSA is not currently available. The success of translocation is also currently uncertain; however research on translocation and additional occurrences will increase the probability of success.

6.8.5.6 Summary of Residual Effects Assessment and Significance

All rare plants found within the Project IF may be lost as a result of Project construction. Reclamation and revegetation will not be able to fully mitigate this adverse effect, and it is expected that the loss of these occurrences is permanent (Table 6.8-15)

6.8.6 Cumulative Effects Assessment

6.8.6.1 Introduction

The cumulative effects assessment (CEA) considers the effects on rare plants that are likely to result from the residual environmental effects of the Project in combination with the effects of other projects and activities (past, present or future). The CEA spatial boundary is the same as the RSA. The CEA methodology is based on the framework outlined in Section 5.3.

Table 6.8-13. Definitions of Characterization Criteria for Residual Effects on Rare Plants

Magnitude	Duration	Frequency	Geographic Extent (Physical/Biophysical)	Reversibility	Resiliency	Ecological Context	Likelihood of Effects	
							Probability	Confidence Level
How severe will the effect be?	*How long will the effect last?*	*How often will the effect occur?*	*How far will the effect reach?*	*To what degree is the effect reversible?*	*How resilient is the receiving environment or population?*	*What is the current condition of the ecosystem and how commonly is it represented in the LSA?*	*How likely is the effect to occur?*	*How certain is this analysis?*
Negligible: No or very little detectable change from baseline conditions.	**Short-term:** Effect lasts 1 to 5 years.	**Once:** Effect is confined to one discrete period in time during the life of the Project.	**Local:** Effect extends less than 500 m from infrastructure or activity.	**Reversible Short-term:** Effect can be reversed relatively quickly.	**Low:** The receiving environment or population has a low resilience to imposed stresses, and will not easily adapt to the effect.	**Low:** The receptor is considered to have little to no unique attributes or provision of functions is severely degraded.	**High:** It is highly likely that this effect will occur.	**High:** < 80% confidence. There is a good understanding of the cause-effect relationship and all necessary data are available for the Project area. There is a low degree of uncertainty and variation from the predicted effect is expected to be low.
Minor: Differs from the average value for baseline conditions to a small degree.	**Medium-term:** Effect lasts 6 to 25 years.	**Sporadic:** Effect occurs at sporadic or intermittent intervals during any phase of the Project.	**Landscape:** Effect is limited to the LSA or one watershed (i.e., Sub-area).	**Reversible Long-term:** Effect can be reversed within 20 years of Post Closure.	**Neutral:** The receiving environment or population has a neutral resilience to imposed stresses and may be able to respond and adapt to the effect.	**Neutral:** The receiving environment considered to have some unique attributes and provides most functions that an undisturbed environment would provide.	**Medium:** This effect is likely, but may not occur.	**Medium:** 50 to 80% confidence. The cause-effect relationships are not fully understood, there are a number of unknown external variables, or data for the Project area are incomplete. There is a moderate degree of uncertainty; while results may vary, predictions are relatively confident.
Medium: Differs substantially from the average value for baseline conditions and approaches the limits of natural variation.	**Long-term:** Effect last 26 to 50 years.	**Regular:** Effect occurs on a regular basis during the life span of the Project.	**Regional:** Effect extends across the broader region (e.g., RSA, multiple watersheds, etc.).	**Irreversible:** Effect cannot be reversed (i.e., is permanent).	**High:** The receiving environment or population has a high natural resilience to imposed stresses, and can respond and adapt to the effect.	**High:** The receiving environment or population is uncommon and occurs in a natural state and provides functions at a maximum capacity.	**Low:** This effect is unlikely but could occur.	**Low:** < 50% confidence. The cause-effect relationships are poorly understood, there are a number of unknown external variables, and data for the Project area are incomplete. High degree of uncertainty and final results may vary considerably.
Major: Differs substantially from baseline conditions, resulting in a detectable change beyond the range of natural variation.	**Far Future:** Effect lasts more than 50 years.	**Continuous:** Effect occurs constantly during the life of the Project.	**Beyond Regional:** Effect extends beyond the regional scale, and may extend across or beyond the province.					

Table 6.8-14. Characterization of Residual Effects, Significance, Likelihood and Confidence on Rare Plants

Residual Effect	Residual Effects Characterization Criteria							Significance of Adverse Residual Effects	Likelihood and Confidence	
	Magnitude	Duration	Frequency	Geographic Extent	Reversibility	Resiliency	Context		Probability	Confidence
Habitat Loss	Medium	Far Future	Once	Local	Irreversible	Low	High	Not Significant (moderate)	High	Medium

Table 6.8-15. Summary of Residual Effects, Mitigation, and Significance on Rare Plants

Residual Effects	Project Phase	Mitigation Measures	Significance
Habitat loss	Construction	Reclamation, revegetation	Not Significant (Moderate)

Past land use activities (e.g., agriculture, forestry, urban development) has shaped much of the regions current ecosystem distribution. Many past, present and future projects have, and will continue to contribute to the presence and distribution of rare plants in the RSA. Several projects have been identified as occurring in the region, and could potentially interact with the Project. Each of these projects will be considered in combination with the result of our residual effects assessment to determine if there is an interaction, and consequently, if there is the potential for a cumulative residual effect to occur. These interactions can include direct, indirect, additive and synergistic effects. To be included in the CEA projects must occur within the spatial boundary of RSA, must have a residual effect, and must have the potential to act cumulatively with the residual effects for rare plants described in Section 6.8.5

Habitat loss was considered a residual effect for rare plants. All projects that could potentially occur in the region have been included in Table 6.8-16. Those projects that could have a residual effect associated with rare plant habitat loss should be included in the CEA.

6.8.6.1 Identification of Other Actions that May Affect Rare Plants

A list of past, present, and anticipated future projects and activities known to occur in the region are identified and described in Section 5.3 (Figure 6.8-9). Projects/activities were initially scoped out if there was no perceived spatial interaction (i.e. the project/activity occurs outside of the RSA). Other projects/activities were scoped into the CEA on a VC by VC basis. If a residual effect from the Project was determined, the likelihood of other projects/activities resulting in the same effect were assessed using reports generated from those projects/activities; in the absence of any data indicating specific effects, professional judgement was used. Other projects/activities considered for cumulative effects on rare plants are listed below (Table 6.8-16).

6.8.6.2 Interactions between Residual Project Effects and Other Project or Activity Effects

Rare plant habitat loss is expected to interact with additional projects/activities in the region. Habitat loss associated with past, present and future project activities cannot be quantified. In the majority of cases, no information is available on the historical locations of rare plants in the region. Consequently, a qualitative analysis was conducted to determine potential interactions based on professional judgement, location of these projects/activities, and the likelihood that rare plants will be impacted.

Agriculture, ranching and forestry has occurred in the region since the 1800s. Agriculture and ranching has converted fertile grassland habitats into commercial crops, and lower quality rangeland. Blue grama (Red-listed), has likely lost a significant proportion of potential suitable habitat as a result of agriculture and/or ranching. Blue grama is found in open grasslands of various types (Wipff 2003). The conversion of these grasslands for agricultural andrange purposes has potentially reduced their population in the region. Conversion of these grasslands for agricultural and range use has also potentially impacted soil-dwelling lichen, such as ten-cent tarpaper and goldnugget sulphur. Past forestry practices has also removed a large portion of old-growth and late structural stage forests in the region. This activity has reduced the amount of suitable habitat, which supports several rare plants including Hall's willowherb. Hall's willowherb are found in various montane habitats including open forests. Continued active timber harvesting and agriculture expansion could remove additional rare plants from the landscape (Table 6.8-16). Due to a lack of knowledge of rare plant locations in the region, it is impossible to accurately rank the potential for

these activities to interact cumulatively with the project. A ranking of "Moderate" was given due to this knowledge gap

Future projects/activities, such as Kamloops city expansion or the Kinder Morgan pipeline, have not been finalized, and therefore, footprints are not finalized. The expansion of the city of Kamloops and the construction of Kinder Morgan's Trans Mountain pipeline will likely result in the loss of habitat that could support rare plants. Aberdeen (a neighbourhood of Kamloops adjacent to the LSA) is expected to continue expanding, from an approximate population of 10,000 people in 2011 to over 16,000 by 2036 years (TRUE Consulting Group 2008; City of Kamloops 2012). Several observations of Suskdorf's broomrape have been recorded less than 1 km south of this area, additional studies within the Aberdeen Urban Growth Boundary may discover additional observations. If approved, construction of the Trans Mountain pipeline twinning is anticipated to commence as early as 2016. The current proposed reroute of the Kinder Morgan's Trans Mountain pipeline currently overlaps the only known occurrence of Jigsaw stippleback lichen in the RSA. The number of rare plants that will be lost as a result of this future development is unknown, but some loss is expected. A ranking of "Moderate" was given to both these actions due to the knowledge gap.

6.8.6.3 Proposed Mitigation Measures

Habitat Loss

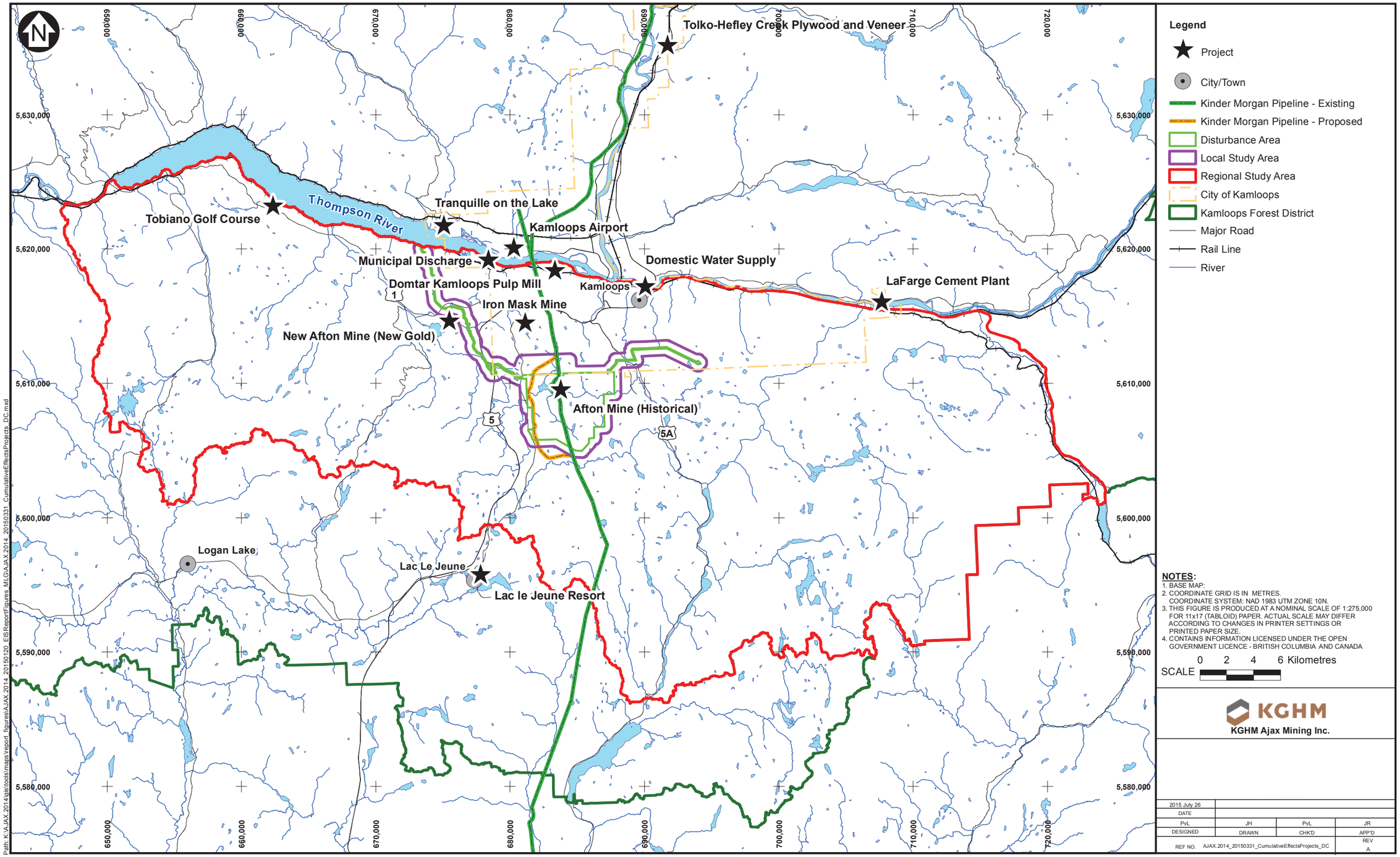
Ecosystem management and mitigation plans are designed to avoid and minimize adverse effects to rare plants resulting from project activities within the feasible limits of project design and activities. Other projects would have had or will have different mitigation and management for rare plants; however, it is assumed any present and future projects will take into consideration the goals and objectives outlined in the Nicola Thompson Fraser Sustainable Forest Management Plan (SFMP) (2015). It is also assumed that the following general mitigation measures will be common amongst any present and future projects or activities:

- 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; and
- ensure clearing activities are coordinated with other management plans.

Table 6.8-16. Ranking Potential for Residual Effects to Interact Cumulatively with Effects of Other Human Actions on Rare Plants

	Industrial Projects/Activities													Natural Resources and Land Use			Tourism and Commercial Recreation Activities					Community Infrastructure			Transportation					
Residual Effect	Vidette Lake Mine	Afton Mine (Historical)	Iron Mask Mine	Bonaparte Mine	New Afton Mine (New Gold)	Highland Valley Copper Mine (Teck)	Domtar Kamloops Pulp Mill	Tolko-Hefley Creek Plywood and Veneer	LaFarge Cement Plant	Trans Mountain Pipeline System (Kinder Morgan)	Trans Mountain Pipeline System - Expansion (Kinder Morgan)	Harper Creek	Highland Valley Copper – Bethlehem Expansion	Kamloops Forest District	Agriculture	Ranching	Tranquille on the Lake	Lac Le Jeune Resort	Tobiano Golf Course	Recreational Hunting, Fishing, Foraging	Recreational Trails	City of Kamloops Wastewater Management	Water Treatment Centre	City Expansion and Growth	Lac le Jeune Road	Highway 1	Highway 5A	Highway 5 (Coquihalla Highway)	Kamloops Airport	Rail Yards and Lines (CP and CN)
Loss of Rare Plant Habitat	-	O	O	-	O	-	O	-	-	O	M	-	-	L	M	L	-	-	O	O	O	-	-	L	O	O	O	O	-	O

Figure 6.8-9
Cumulative Effects Regional Study Area



NOTES:
1. BASE MAP:
2. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD 1983 UTM ZONE 10N.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:275,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
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Additional rare plant surveys to establish regional populations would likely reduce the significance of the cumulative effect. At present there is not enough knowledge of the regional population to be able to accurately predict the impact of the Project in conjunction with past, present and future projects in the area. In many cases, the rare plants found in the LSA are the only known occurrences of those plants in the Thompson Region. However, as so few rare plant surveys have been conducted in the region, it is very likely that additional populations occur in the RSA, outside of the LSA. Based on the lack of information, the potential for cumulative effect of forestry, agriculture, city expansion and the Kinder Morgan Pipeline was ranked high. It is very likely that additional surveys in the RSA will substantially reduce this ranking. KAM will support regional rare plant surveys in the IDFxh2.

Because of the unknown regional context of rare plants, it should be assumed that habitat loss cannot fully be mitigated, and therefore will be carried forward and evaluated in Section 6.8.6.5.

6.8.6.4 Evaluation of Significance of Residual Cumulative Effects

Habitat loss as a result of Project construction is expected to result in an adverse residual cumulative effect (Table 6.8-17). The loss of habitat associated with this Project as well as other projects in the RSA has likely reduced the number of occurrences in the region. As very few rare plant surveys have been conducted in the area, it is difficult to determine if and how many rare plants and how much rare plant habitat has been lost.

Table 6.8-17. Summary of Cumulative Effects Mitigation Measures and Residual Effects on Rare Plants

Ajax Project Activity	Other Human Action Activity	Description of Potential Cumulative Effect	Description of Mitigation Measure(s)	Description of Residual Cumulative Effect
Clearing and Grubbing/ Earthworks	Forestry, Agriculture, Future construction	Loss of habitat associated with rare plants	Regional rare plant surveys	Loss of rare plant habitat, and of rare plant occurrences

Very little information regarding rare plants is available for the RSA. Several rare plants including Wedgescale orache, oval purse, Suksdorf's broomrape, alkaline wing-nerved moss and lesser eyeshadow were recorded in the RSA during baseline rare plant surveys (Figure 6.8-10). CDC records show two additional rare plant occurrences in the RSA; alkaline wing-nerved moss and ovalpurse in the eastern most portion (BC Conservation Data Centre 2014a). Several other rare plants have not been previously observed in the RSA, but are known to occur in the region. As surveys targeted the LSA, additional surveys within the RSA would likely result in the discovery of additional populations. Several other rare plants have been found within the Thompson Plateau, and are likely to occur elsewhere in the RSA. Although all known occurrences of erupting toad, goldnugget sulphur, and ten-cent tarpaper within the RSA may be lost as a result of the Project, these lichens have been found elsewhere in the region, and likely would be discovered elsewhere in the RSA if additional surveys outside of the LSA were conducted.

Several rare plants recorded in the LSA have not been previously recorded in the region. Blue grama is known from only six sites in the Fraser River basin and in the southern part of the Rocky

Mountain trench (Fontaine & Douglas 1999). Two occurrences of blue grama were found in the LSA, additional surveys may determine that other populations exist. One occurrence of sheathing pond weed was recorded in the IDA. Previously this rare plant was only known to occur in the northern part of the province. Similarly, other occurrences of *Stegonia latifolia* var *pilifera* were also only know from northern BC. The willow feather moss occurrences are known from Central and Southwest BC (BC Conservation Data Centre 2014a). The specimen found within the IDA would be the first known occurrence in the Kamloops forest district. The powder-line rock-olive is not only unique in that the population reported is the first from the Kamloops area, but also it is the only occurrence in BC found to be fertile (spore-bearing). It is unknown if these "new to the region" species occur throughout the RSA, additional rare plant surveys within the RSA would be required to substantiate the regional impact of the Project on these rare plant communities.

The amount of rare plant habitat lost within the RSA as a result of different Projects and activities would be difficult to quantify since these plants are found in unique microsites. Based on known occurrences of rare plants in the RSA, the number of rare plants lost as a result of the Project would be considered moderate. Any loss would last into the far-future, as these microsites are often rare or unique on the landscape. Any habitat loss would occur once, but for several of the activities (for example agriculture and forestry) that extent is regional, and has occurred throughout the RSA. Loss of rare plants is irreversible, and rare plants have low resiliency. The region is home to several rare plant species, therefore the ecological context is considered neutral. The probability that rare plant habitat loss has occurred was ranked "medium". This is because although a great deal of grassland, forests and wetland ecosystem have been lost as a result of different projects and activities in the RSA, the likelihood that the macrohabitats and microsites associated with rare plants was removed is only moderate. Several rare plants are associated with rock outcrops and other landscape features which are not typically altered as a result of forestry or agriculture. Since so few studies in the region have looked at rare plants, their abundance and distribution within the RSA is currently unknown, therefore we have a poor understanding of the potential impacts of other projects and activities on rare plants. The confidence level of this qualitative analysis was considered low (Table 6.8-18).

For several of the rare plants found within the RSA, those occurrences are the only known occurrences in the region. Their loss could have adverse residual effects on the regional population. Given the limited information, and the lack of regional knowledge of rare plant locations, the confidence of this rating is considered low.

6.8.7 Conclusion

Rare plants were addressed as a VC to determine if an interaction with Project activities could result in an adverse residual effect. All potential effects, habitat loss and habitat alteration, were identified and evaluated in relation to anticipated Project activities. After the implementation of mitigation measures habitat loss was found to have a potential residual effect, and was assessed in combination with other projects and activities in the area to determine if a cumulative residual effect may occur as a result of Project construction. Several of the rare plants recorded in the LSA are the only known occurrences in the region. The loss of these plants may have an adverse residual effect on the regional population. However, there is limited information on the abundance and distribution of these rare plants in the province. Therefore the confidence in these rating is considered low. The summary of this assessment is presented in Table 6.8-19.

Figure 6.8-10
Rare Plant Locations in the Regional Study Area

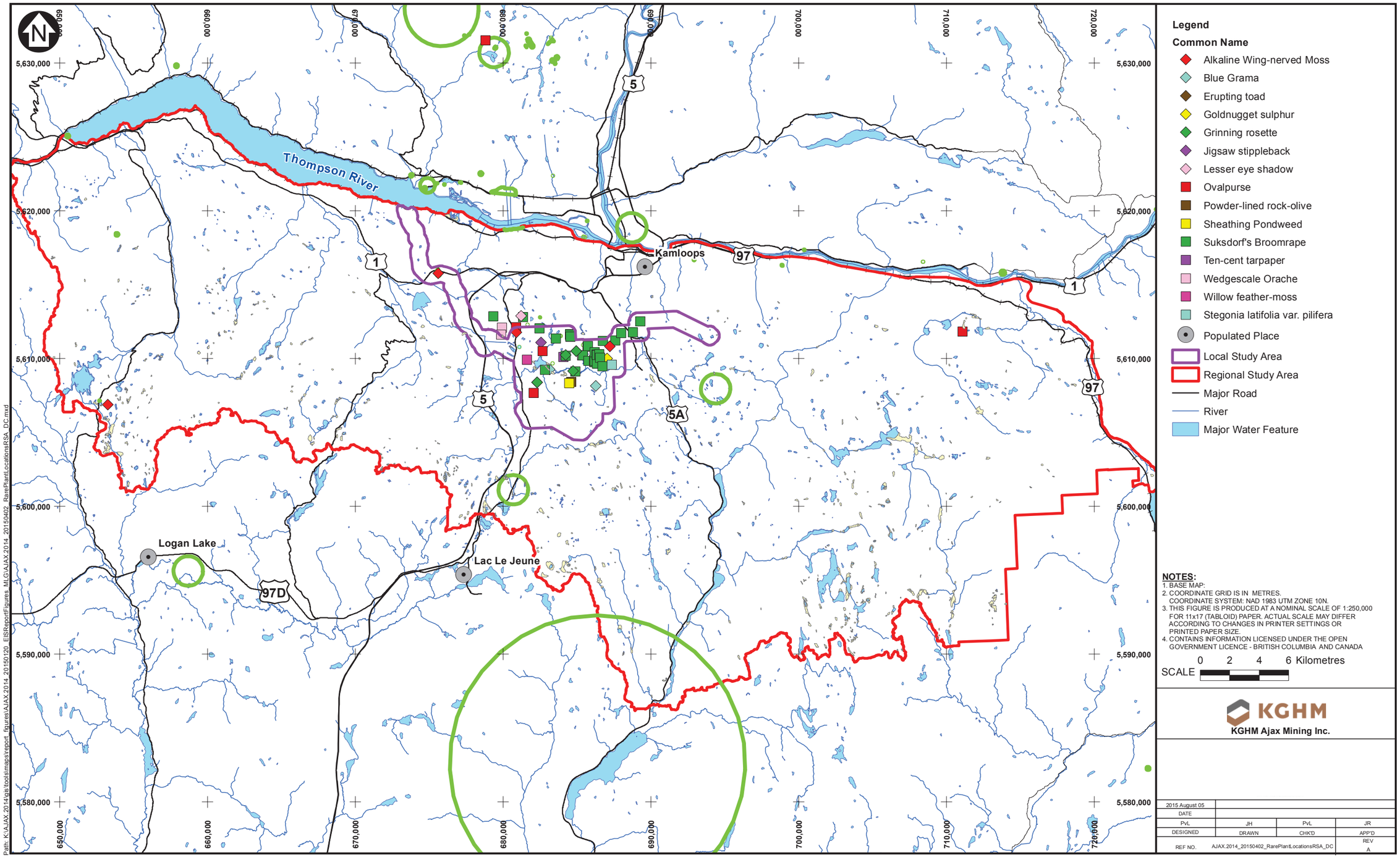


Table 6.8-18. Characterization of Cumulative Residual Effects, Significance, Likelihood and Confidence on Rare Plants

Cumulative Residual Effect	Cumulative Residual Effects Characterization Criteria							Significance of Adverse Residual Effects	Likelihood and Confidence	
	Magnitude	Duration	Frequency	Geographic Extent	Reversibility	Resiliency	Context		Probability	Confidence
Habitat Loss	Medium	Far Future	Sporadic	Regional	Irreversible	Low	Neutral	Not Significant (Moderate)	Medium	Low

Table 6.8-19. Summary of Project and Cumulative Residual Effects, Mitigation, and Significance for Rare Plants

Residual Effects	Project Phase	Mitigation Measures	Residual Effect Significance	Residual Cumulative Effect Significance
Habitat loss	Construction	Avoidance through re-design where possible. Establish exclusion areas. Transplantation. Regional research on plant distribution. Invasive species management.	Not Significant (Moderate)	Not Significant (Moderate)

6.9 RARE AND SENSITIVE ECOLOGICAL COMMUNITIES

6.9.1 Rationale

This section includes a description of the scoping process used to identify Rare and Sensitive Ecological Communities (RSEC) for inclusion in the assessment. Scoping is fundamental to focusing the Application/EIS on those issues where there is the greatest potential to cause significant adverse effects. Valued components (VCs) are components of the natural and human environment that are considered to be of scientific, ecological, economic, social, cultural, or heritage importance (CEAA 2006; EAO 2013). To be included in the EA, there must be a perceived likelihood that the VC will be affected by the proposed Project.

For RSEC the following was considered for inclusion as a valued component in the environmental assessment:

- Federal or provincial listing or regulation;
  - Lists of Red- and Blue-listed ecological communities believed to occur within the Kamloops Forest District (BC Conservation Data Centre (2010);
  - Information on actual known location records of Red or Blue-listed ecological communities within the Project area (provided by the BC Conservation Data Centre);
  - Communities of regional concern
- Aboriginal interest;
- Public or other stakeholder input;
- Scientific/professional knowledge; and
- Relevant legislation or policy concerning the VC.

Terrestrial ecosystems are determined by surface and ground water, geology, landform and soils. Rare and sensitive ecological communities occupy habitats based soil moisture and soil nutrient regimes. The assessment of effects to RSEC is largely related to disturbances from Project activities (as described further in Section 6.9.4). The information developed to support the analysis of this VC also contributes to Wildlife (Chapters 6.11 – 6.17), Land and Resource Use (Chapter 8.4), Outdoor Recreation (Chapter 8.6), Country Foods (Chapter 10.3), and Heritage (Chapter 9.2). See Figure 6.9-1 for VC interactions for Rare and Sensitive Ecological Communities.

6.9.1.1 Selection of Rare and Sensitive Ecological Communities as a Valued Component

Rare and sensitive ecological communities includes sensitive habitats such as wetlands, alkali ponds, old-growth forests and rock outcrops, and rare habitats including ecological communities at risk (ECAR). Grasslands are also sensitive ecosystems but are discussed as a separate VC (Chapter 6.10). Other habitats were assumed to be common on the landscape and not included as they would experience negligible effects. Ecological communities at risk are ecosystems designated as Red- or Blue-listed and tracked by the BC Conservation Data Centre (2014a). ECARs are usually (but not

always) correlated with site series defined within the provincial Biogeoclimatic Ecosystem Classification (BEC) system. Rare plants are discussed as a separate VC (Chapter 6.9).

The VC "Rare and Sensitive Ecological Communities" was selected based on anticipated interactions with the Project. RSEC have a key role in wildlife habitat, nutrient cycling, productivity, biodiversity, site stabilization, and carbon sequestration. Aboriginal groups place value on all ecosystems and their interconnections. RSEC are defined by the plant association present at a site and loss or degradation of plant species can affect the ecological integrity of the community. Vegetation clearing for Project footprints will likely damage /remove RSEC and habitat alteration resulting from spread of invasive species could alter the plant composition. Aquatic habitats (wetlands) are sensitive to water-borne contaminants. Ecosystems dominated by epiphytic lichen or mosses are susceptible to dust deposition (Farmer 1993; Padgett et al. 2007). Degradation of these rare and sensitive habitats may cause a reduction in forage and security cover for wildlife, and loss or changes in vegetative cover. Specific justification for the selection of RSEC as a VC includes:

1. Federal or provincial listing or regulation:
   - Eighteen Red and Blue-listed ecological communities (excluding grasslands Chapter 6.10) are thought to occur within the Kamloops forest district (BC Conservation Data Centre 2010);
   - Two plant communities have been identified under FRPA - IWMS
   - Federal Policy on Wetland Conservation (Government of Canada 1991)
2. Aboriginal interest (AIB, SSN)
3. Applicable Government Agencies (MoE, EC); wetlands were identified as a concern
4. Stakeholder input (Public and Kamloops Naturalist Club).
5. Information Sources (baseline studies, professional judgement);
6. Interaction with Project/Potential Effects (professional knowledge).

6.9.1.2 Selection of Indicators

A draft correlation with the TEM units and the Red- and Blue- listed ecological communities was prepared in consultation with the Regional Ecologist and ecologists at the BC Conservation Data Centre. Eighteen Red- and Blue-listed ecological communities were identified as potentially occurring within the region based on BEC Variant (Table 6.9-1). Two plant communities, water birch / roses and alkali saltgrass herbaceous vegetation, are listed under the Identified Wildlife Management Strategy (BC Ministry of Water, Land and Air Protection 2004a). Note that not all of the site series listed in Table 6.9-1 were mapped in the Project area (listed in parenthesis). Traditional use plants may be present in these communities but effects are considered in Chapter 6.8.

Figure 6.9-1

VC Interactions for Vegetation and Terrestrial Ecology (Rare and Sensitive Ecological Communities)

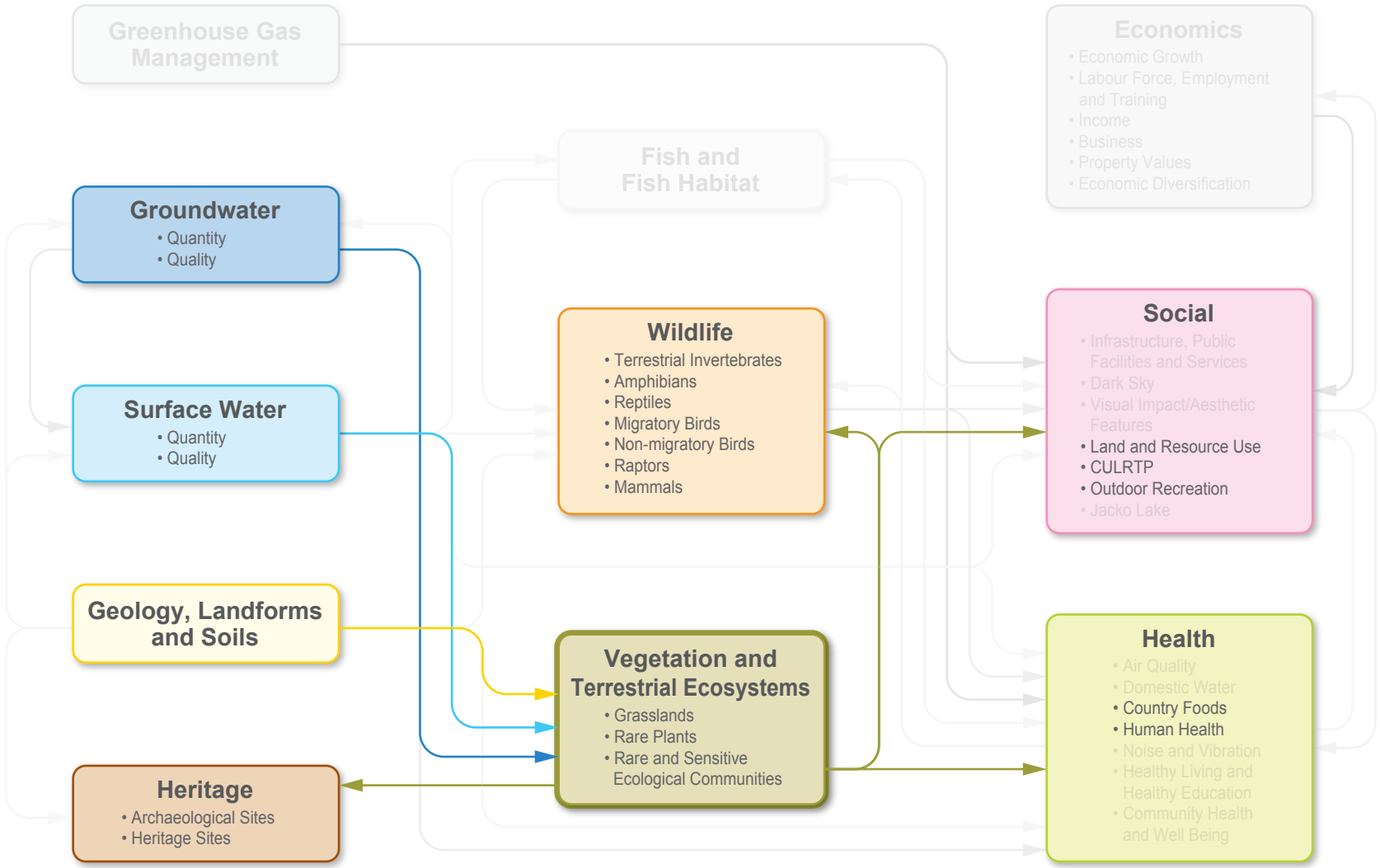


Table 6.9-1. Ecological Communities at Risk (Excluding Grasslands) Potentially Occurring in the Project Area and Associated Site Series in each Biogeoclimatic Subzone

Scientific Name	English Name	BC List*	Associated Site Series		
			BGxw1	PPxh2	IDFxh2
Betula occidentalis / Rosa spp.	water birch / roses	Red	n/a	Fl30	n/a
Distichlis spicata var. stricta Herbaceous Vegetation	alkali saltgrass Herbaceous Vegetation	Red	Gs01	Gs01	Gs01
Pinus ponderosa / Pseudoroegneria spicata	ponderosa pine / bluebunch wheatgrass	Blue	02	04	n/a
Pinus ponderosa / Pseudoroegneria spicata - Festuca campestris	ponderosa pine / bluebunch wheatgrass - rough fescue	Red	03	01	n/a
Populus balsamifera ssp. trichocarpa - Betula occidentalis	black cottonwood - water birch	Red	n/a	(07)	n/a
Populus tremuloides / Symphoricarpos albus / Poa pratensis	trembling aspen / common snowberry / Kentucky bluegrass	Red	05	n/a	10
Pseudotsuga menziesii - Pinus ponderosa / Calamagrostis rubescens	Douglas-fir - ponderosa pine / pinegrass	Blue	n/a	n/a	01
Pseudotsuga menziesii - Pinus ponderosa / Pseudoroegneria spicata	Douglas-fir - ponderosa pine / bluebunch wheatgrass	Red	n/a	n/a	02
Pseudotsuga menziesii - Pinus ponderosa / Pseudoroegneria spicata - Calamagrostis rubescens	Douglas-fir - ponderosa pine / bluebunch wheatgrass - pinegrass	Blue	n/a	n/a	04
Pseudotsuga menziesii / Symphoricarpos albus - Amelanchier alnifolia	Douglas-fir / common snowberry - saskatoon	Red	n/a	06	n/a
Typha latifolia Marsh	common cattail marsh	Blue	Wm05	Wm05	Wm05
Salix exigua Shrubland	narrow-leaf willow Shrubland	Red	(Fl06)	n/a	n/a
Thuja plicata - Pseudotsuga menziesii / Cornus stolonifera	western redcedar - Douglas-fir / red-osier dogwood	Blue	n/a	n/a	09
Populus balsamifera ssp. trichocarpa / Symphoricarpos albus - Rosa spp.	black cottonwood / common snowberry - roses	Red	(Fm01) (06)	n/a	n/a
Carex atherodes Fen - Marsh	awned sedge Fen - Marsh	Red	(Wm03)	n/a	n/a
Juncus balticus - Potentilla anserina	Baltic rush - common silverweed	Red	Wm07	n/a	n/a
Schoenoplectus acutus Deep Marsh	hardstemmed bulrush deep marsh	Blue	Wm06	Wm06	Wm06
Salix bebbiana / Calamagrostis canadensis	Bebb's willow / bluejoint reedgrass	Blue	Ws03	n/a	n/a

**as of September 2014, n/a indicates that the ECAR does not occur in the BGC zone.*

For the purpose of this assessment, rare and sensitive ecological communities will be grouped into four indicator communities based on similarities between ecosystems, similar threats to ecosystem integrity and similar Project effects (Table 6.9-2). Several wetland ecosystems are also classified as ecological communities at risk, these ECAR will be discussed as part of the wetland indicator community.

Table 6.9-2. Indicator Ecosystem Selection Rationale and Issues Raised

Indicator Ecosystems	Feedback by*				Issues Raised	Proponent Response
	AG	G	P/S	S/P		
Rock Outcrops		✓		✓	Loss of Rock Outcrop Habitat	Inclusion of Rock Outcrops as an Indicator
Old-growth Forest		✓		✓	Loss of Old-growth Forests	Inclusion of Old-growth Forests as an Indicator
Wetlands and Alkaline Ponds	✓	✓		✓	Loss of Wetlands	Inclusion of Wetlands as an Indicator
ECARs		✓		✓	Loss of At-risk Ecological Communities	Inclusion of ECARs as Indicators

**AG = Aboriginal Group (Stk'emlupsemc Te Secwepemc Nation (SSN) and Nlaka'pamux Nation); G = Government; P/S = Public/Stakeholder (e.g., LRMP); S/P = Scientific/Professional Knowledge*

6.9.2 Assessment Boundaries

Assessment boundaries define the maximum limit within which the effects assessment is conducted. They encompass the areas within, and times during which, the Project is expected to interact with the Rare and Sensitive Ecosystems VC, as well as the constraints that may be placed on the assessment of those interactions due to political, social, and economic realities (administrative boundaries), and limitations in predicting or measuring changes (technical boundaries). The definition of these assessment boundaries is an integral part in scoping for RSEC, and encompasses possible direct (Project Footprint), indirect (Local Study Area), and induced effects (Regional Study Area) of the Project on RSEC, as well as the trends in processes that may be relevant.

6.9.2.1 Spatial Boundaries

Infrastructure Footprints

Project infrastructure footprints (IF) include the Open Pit, ancillary buildings and facilities, roads, truck shop, Tailings Storage Facility (TSF), Water Management Ponds, Mine Rock Storage Facilities (MRSFs), and stockpiles (Figure 6.9-2). The Project infrastructure footprints are 1,705 ha in size.

Infrastructure Disturbance Area

The Project infrastructure footprints and linear features (transmission line and water line) were buffered by at least 50 m (Henderson, 2011) to determine the Project Infrastructure Disturbance Area (IDA). The 3,185 ha IDA will be used to assess maximum direct Project effects (e.g., mortality, habitat loss, habitat alteration, etc.). The IDA includes the Project IF (1,705 ha) used to calculate direct loss of habitat, plus a 1,480 ha buffer around the Project IF that represents a zone of influence for potential disturbance associated with habitat alteration resulting from effects pathways such as such as contaminants, silt or dust, noxious weeds, and changes in drainage pattern (Figure 6.9-2).

The use of a buffered polygon area rather than individual infrastructure footprints will provide an overestimate of the direct effects of the Project for the assessment. The advantage of this approach is

that it enables individual footprints to be moved and/or resized without changing the results of the effects assessment.

The IDA was modified from the General Arrangement Polygon to follow a section of the Kamloops city boundary to more accurately represent the current Project IF.

Habitat alteration by dust and water quantity is accounted for under potential habitat loss within the IDA. Areas outside of the IF that are not lost will be subject to potential alteration effects. However as plant species present in the area are adapted to the dry, dusty environmental conditions, these effects were considered mitigable.

Local Study Area

In accordance with the AIR, the General Arrangement Polygon was buffered by 500 m to determine the Local Study Area (LSA). This area is the expected area of potential disturbance associated with all Project facilities (BC Environmental Assessment Office 2015). The LSA is 7,167 ha and will be used to assess indirect Project effects (e.g., disturbance) and provide context on the amount of habitat available adjacent to the Project IF (Figure 6.9-2).

Terrestrial Ecosystem Mapping (TEM) was prepared for 97% of the IDA and the entire IF (Figure 6.9-3). TEM was not deemed necessary for other areas as the water line is existing infrastructure and disturbance to grasslands along the proposed transmission line will be negligible.

Regional Study Area

The Regional Study Area (RSA) is the area for which cumulative effects will be assessed. The RSA includes portions of the South Kamloops Landscape Unit and Campbell Landscape Unit, including areas south of the Thompson River and west of Highway 97 (Figure 6.9-3). Landscape units were selected for the RSA as they are the geographical framework within which sustainable forest management regimes to maintain biodiversity are implemented. The RSA also includes local watershed basins and representative biogeoclimatic zones with similar habitats. The RSA is 158,415 ha in size.

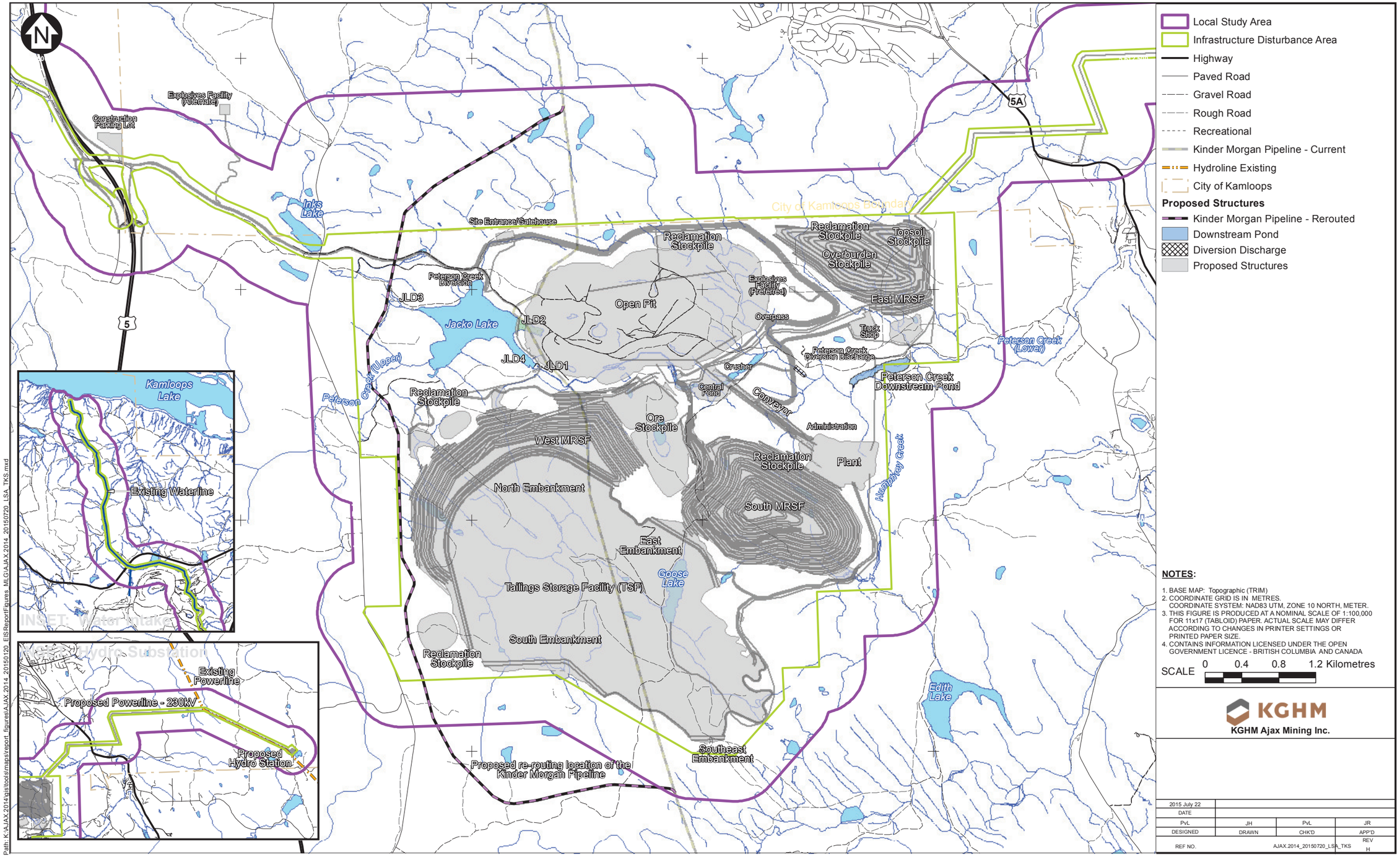
6.9.2.2 Temporal Boundaries

The temporal boundaries of the assessment will include the construction phase (short-term), operations (life of mine), de-commissioning and closure (short-term) and post-closure (short-term) activities.

The temporal phases of the Project are:

- **Construction**: 2 years (Year -2 to 1);
- **Operation**: 23 years (Year 1 to 23);
- **Decommissioning and Closure**: 5 years (Year 24 to 29, includes Project decommissioning, abandonment and reclamation activities, as well as temporary closure, and care and maintenance); and
- **Post Closure**: 5+ years (includes ongoing reclamation activities and post-closure monitoring).

Figure 6.9-2
Local Study Area, Disturbance Area and Project Infrastructure



NOTES:

1. BASE MAP: Topographic (TRIM)
2. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD83 UTM, ZONE 10 NORTH, METER.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:100,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
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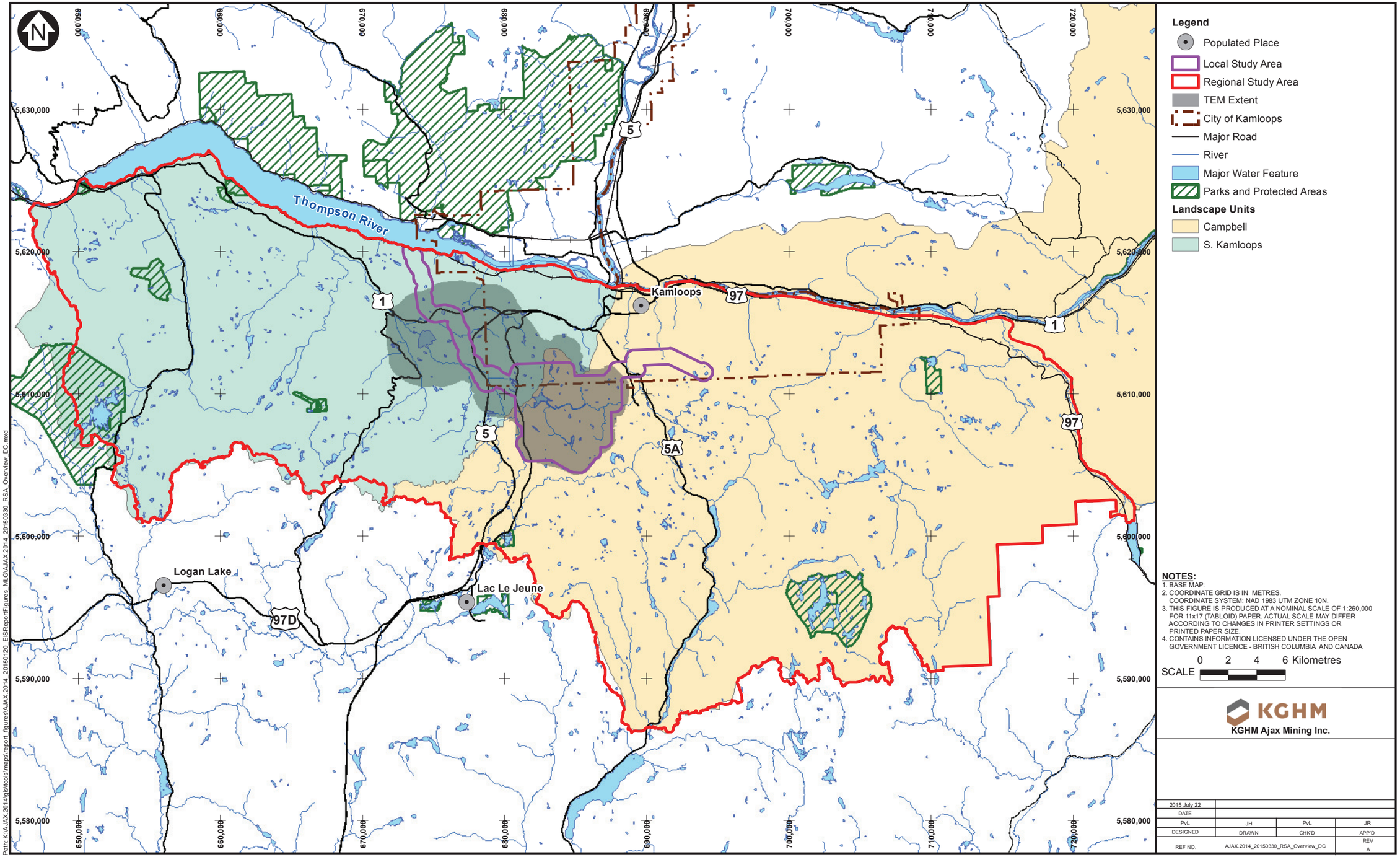
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Figure 6.9-3
Regional Study Area



6.9.2.1 Administrative Boundaries

The Project is situated just south of the City of Kamloops. The Project is located in the Thompson Rivers Forest District of the Southern Interior Forest Region. A land and Resource Management Plan (LRMP) has been prepared for the area (1995).

Old Growth Management Areas (OGMAs) are legally and spatially defined areas of old growth forest where forestry development is prevented or constrained. These areas are used to achieve Biodiversity Targets within a Landscape Unit. Portions of three OGMAs are present in the LSA totalling 43 ha of overlap while 9064 ha occur in the RSA (Figure 6.9-3).

6.9.2.2 Technical Boundaries

Terrestrial Ecosystem Mapping (TEM) was completed within the LSA since this is the area expected to be affected by the Project and thus requires detailed mapping. Areas outside of the LSA were quantified using VRI and other mapping sources (BEC, CWB, FWHA).

Red- and Blue-listed ecological communities are correlated with site series; however, ECAR do not necessarily occur in all areas mapped as the site series. Site series occupy a location on the ground that has the potential to produce particular plant associations, but to be considered an ECAR the site must have specific ecological and vegetative characteristics. Actual occurrences of ECAR are based on specific site vegetative characteristics. As such, an ECAR does not necessarily occur in all areas mapped as the associated site series. Since this assessment is based on the assumption that sites mapped as a specific site series will contain the ECAR the effects of the Project on ECAR will be a conservative estimate. Dedicated field sampling is required to determine if a site represents a current occurrence of an ECAR.

6.9.3 Background

6.9.3.1 Regulatory and Policy Framework

The Kamloops Land and Resources Management Plan (LRMP) (1995) outlines that: special attention to red- and blue-listed species should be considered; forests are to be managed to ensure diversity, as well as to ensure critical habitat is identified and managed appropriately through local level planning; and habitat improvement projects should be conducted where appropriate. RSEC related objectives include: protecting aquatic environments, maintaining the structure and integrity of streamside riparian vegetation, maintain and/or enhance ecosystem health, maintain old growth attributes within landscape units, maintain natural stand attributes in managed forests, and employ wildlife tree management strategies.

The Nicola Thompson Fraser Sustainable Forest Management Plan (SFMP) (2015) aims to conserve ecosystem diversity by ensuring that healthy, connected and representative ecosystems are conserved. Ecosystem specific objectives include: conserving forest ecosystem condition and productivity, replacing any OGMAs in areas where incursions have occurred, and ensuring operational activities do not impact the potential contribution of rare ecosystems.

The Identified Wildlife Management Strategy (IWMS) provides direction, policy, procedures and guidelines for managing Identified Wildlife. The goals of the Strategy are to minimize the effects of forest and range practices on Identified Wildlife situated on Crown land and to maintain their limiting habitats throughout their current ranges and, where appropriate, their historic ranges. Two communities, water birch / roses (previously Water Birch-Red-Oiser Dogwood) and alkali saltgrass – Nutall's Alkaligrass (Previously Alkali Saltgrass Herbaceous Vegetation), are listed under the IWMS (BC Ministry of Water, Land and Air Protection 2004a). General measures for these communities include:

- maintain or restore plant community to a natural state and natural plant composition of this plant community;
- minimize or avoid access;
- prevent physical disturbance, especially of soil;
- maintain or restore to a late seral stage;
- maintain hydrological regime (which may include natural flood cycles);
- minimize the introduction and spread of invasive species; and
- minimize forest encroachment.

Best management practices relevant to RSEC include:

- develop with Care (BC Ministry of Environment 2014)
- instream works (BC Ministry of Water, Land and Air Protection 2004b);
- wetland ways: interim guidelines for wetland protection and conservation in British Columbia (Cox & Cullington 2009); and
- lakeshore stabilization (British Columbia Ministry of Environment 2006).

6.9.3.2 Regional Overview

The RSA lies within the Kamloops Forest District, in the Thompson Okanagan Natural Resource Operations Region and Ministry of Environment Region 3 (Thompson). Much of it is within the Agricultural Land Reserve (see Figure 6.9-9). The RSA lies within the area covered by the Kamloops Land and Resource Management Plan (LRMP). Much of the habitat around the Project is also located within a Visually Sensitive Area where the maintenance of visual quality is important (Kamloops Interagency Management Committee 1995).

The Thompson Basin Ecosection area is a warm and exceptionally dry, broad low elevation basin. The vegetation in this ecosection reflects the warm, dry climate with the Bunchgrass zone mainly consisting of sagebrush-steppe and bunchgrass-steppe occupying the valley and lower slopes, giving way to meadow-steppe and finally to ponderosa pine forest, at higher elevations, Douglas-fir occurs on the cooler aspects and narrow draws (Figure 6.8-2). The pine stands have been adversely affected by the recent mountain pine beetle outbreak.

ECAR

Ecological communities are defined as "the assemblage of species that co-occur in defined areas at certain times and that have the potential to interact with each other" (McPeek and Miller 1996), (BC CDC 2004). Ecological communities at-risk are defined and ranked by the BC Conservation Data Centre and placed on the provincial Red- or Blue-list according to the degree of threat, trend in the area, number of protected and managed occurrences, intrinsic vulnerability, specificity of habitat requirements and other considerations (BC Conservation Data Centre 2014).

Three ecological communities have been identified around Valleyview in the RSA during a 1992 Botany BC field trip – PPxh2/01 Pinus ponderosa/Pseudoroegneria spicata – Festuca capestris; BGxh2/01 Artemisia tridentate / Pseudoroegneria spicata; BGxh2/06 Festuca capestris - Pseudoroegneria spicata.

Wetlands and Alkali Ponds

Wetlands are defined as areas of land saturated by water, permanently or intermittently, for a long enough time that the excess water and subsequent anoxic conditions result in a change in the plants and wildlife inhabiting the area to those that are adapted to aquatic conditions (BC MOF 2000; The Wetland Stewardship Partnership 2010). Wetlands include five primary freshwater types: bogs and fens (both are peatlands), swamps, marshes, and shallow open waters such as sloughs and ponds (BC MOF 2000). Wetlands are vulnerable to changes in hydrological regime, pollutants, siltation, compaction, and the effects of invasive plant species (MacKenzie and Moran 2004; Cox and Cullington 2009). Loss of wetlands is a concern to both provincial and federal governments. Environment Canada has identified the goal of maintaining wetland functions and values through a policy of no net loss of wetland function (Government of Canada 1991).

Akaline or saline ponds are ecosystems with a distinctive flora dominated by halophytes and water with a pH greater than 7.4. They usually occur in shallow depression in the grassland landscape, often adjacent to marshes. They are characterized by cycles of flooding and drying, which draws mineral salts to the soil surface (BC Conservation Data Centre 2004).

Wetlands may not be Red- or Blue-listed, but are ecologically fragile (Resource Information Standards Committee 2006). No surveys for wetlands have been conducted in the RSA. Several large water bodies (e.g. Jacko Lake, Goose Lake) have been mapped. Wetlands are a highly valued resource to many First Nations and Aboriginal Groups for whom they provide a myriad of cultural and traditional uses.

Old-growth Forest

Old-growth forests are climax ecosystems characterized by relatively tall, old trees, and structural diversity. Old-growth forests provide valuable habitat for plant and animal species that prefer large-diameter trees, multi-layered stands, high densities of snags, and other characteristics that require many years to develop. Losing these ecosystems can negatively impact the species that depend on them, including critical habitat for species at risk.

Similar to wetlands, old-growth forest communities may not be Red- or Blue-listed, but are ecologically fragile (Resource Information Standards Committee 2006). Old-growth forest was defined as structural stage 7. OGMAs were also used as an indicator of old-growth forests.

Rock Outcrops

Rock outcrop ecosystems are areas of exposed rock, characterized by shallow, poorly developed soil, high summer temperatures, drought, and sparse vegetation cover (Ware 1990). They are often limited in their distribution on the landscape. Their rocky substrates have been shown to support high taxonomic richness, particularly for non-vascular plants (Vitt and Belland 1997; Sadler and Bradfield 2010), and provide specialized habitat for some wildlife species such as bats and snakes. Rock-outcrop communities may not be Red- or Blue-listed, but are ecologically fragile (Resource Information Standards Committee 2006).

6.9.3.3 Historical Activities

Historical activities considered in this section include mining, mills, pipelines, rail lines, agriculture, forestry, urban space, water treatment and recreation/tourism as presented in *Rare Plants* Chapter 6.8. Only those activities expected to interact with RSEC have been discussed here. The data collected during baseline studies considers the effect to the landscape from historical activities as these effects shape the current landscape as it is known today.

Mining and subsequent revegetation activities has removed macro and micro -habitats that could support rare and sensitive ecological communities, and replaced it with unvarying habitat that focused on providing forage for wildlife and cattle as well as stabilizing disturbed areas. Given time, and colonization from neighbouring intact habitats, these areas could turn into at-risk ecological communities, or old-growth forest.

Construction and maintenance of the pipeline corridor removed habitat that could have supported RSEC. Furthermore, pipeline corridors are known to be vectors for invasive plants (BC Ministry of Forests and Range 2010), which has likely altered the distribution and abundance of invasive species in the area.

Much like the pipelines, construction and maintenance of the rail lines have removed habitat that could have supported RSEC, as well as provided a vector for the introduction of invasive plants (BC Ministry of Forests and Range 2010).

Agriculture and ranching in the region has likely removed and degraded wetlands in the area. Agricultural and ranching practices over time have removed and altered large areas of habitat that could have supported rare and sensitive communities. Unmanaged ranching practices may continue to impact remaining habitat such that the plant association no longer represents the listed ecological community.

Forestry has removed and altered large areas of habitat that could have supported rare and sensitive ecological communities. Continued forestry practices will have the greatest effect on forested ECAR and old growth forest.

Urban development may have reduced the amount of wetlands along the Thompson River. Much like forestry and agriculture, urban expansion will remove habitat that could support rare and sensitive ecological communities.

6.9.3.4 Baseline Studies

In accordance with the AIR, surveys for RSEC included the preparation of Terrestrial Ecosystem Mapping (TEM).

Data Sources

General information on species status and distribution was drawn from on-line sources such as the BC Ministry of Environment's Species Explorer and NatureServe (BC Conservation Data Centre 2014a; NatureServe 2014). Occurrence records of RSEC in the RSA were obtained from the BC Conservation Data Centre (BC Conservation Data Centre 2014b) and from the provincial Species Inventory Database (BC Ministry of Environment 2014a).

Data sources used for this VC included:

- terrestrial ecosystem mapping prepared for the Project;
- colour aerial photos (2000; 1:15,000): 30BCC00009 #35-41, 70-77, 135-139; 30BCC00052 #87-91, 93-97; 30BCC00051 #194-199; 30BCC00010 #2-8, 69-76; 30BCC00022#28-32
- digital TRIM base mapping;
- regional soils mapping (Young et al. 1992);
- 1:20,000 Vegetation Resources Inventory (VRI) mapping;
- 1:250,000 BEC zone mapping;
- 493 habitat plots completed to field truth the TEM; and
- ecosystems (excluding grasslands) listed by the BC CDC as at-risk ecological communities.

Methods

Terrestrial Ecosystem Mapping (TEM) is a provincial method of classifying the landbase into ecosystems, which are mapped as polygons. TEM is based on standardized methodologies described in provincial standards (Resources Inventory Committee (RIC) 1996, 1998; BC Ministry of Environment 2007) and includes a terrain component (landforms and soils) as well as a vegetation component. TEM at 1:20,000 scale was completed for most of the LSA. The ecosystems mapped for the Project were those defined in the draft ecosystem field guide for the Southern Interior Forest Region at the time of mapping (Lloyd et al. 2005). Field sampling followed protocols described in BC Ministry of Environment, Lands and Parks and BC Ministry of Forests (1998). Two or three-person crews completed full plots, Ground Inspection Forms (GIFs) and visual inspections to truth the draft mapping Assessment of RSEC was completed by theming the ecosystem map to identify polygons containing a site series associated with an ECAR in any decile. Old-growth forest was quantified by summing the area of TEM mapped as structural stage 7. More detailed information on TEM methodology can be found in the Terrestrial Wildlife and Vegetation Baseline Report (Appendix 6.8-A).

Characterization of Rare and Sensitive Ecological Communities Baseline Conditions

Site series associated with RSEC were classified into one of 4 indictor communities due to differences in habitat and spatial representation. Red- and Blue-listed forested communities that were not considered wetlands or grasslands were included in the ECAR indicator community. Wetlands (including wetland ECAR) and alkaline ponds were included in the wetland indicator community. Rock outcrops and old-growth forests were included in like named indicator communities. Within the old-growth forest indicator community there is 11.9 ha that is also included in the ECAR group. Grassland ECAR communities are being addressed under the Grasslands VC in Chapter 6.10.

Ecological Communities At-risk

Excluding wetlands and grasslands, 1,248 ha were mapped as a site series associated with a Red- or Blue-listed ecological communities within the LSA (Figure 6.9-4, Table 6.9-3). Three ECAR associated with floodplains and one moist forest did not occur and were not mapped in the LSA. Most site series associated with ECAR were mapped in the IDFxh2 subzone variant and 01 was the most commonly mapped site series.

Wetlands and Alkaline Ponds

In total 123 ha were mapped as alkaline wetlands, open water, marshes and swamps (Table 6.9-3, Figure 6.9-5). Non-vegetated lakes and ponds are not considered wetlands and were not included; however the function of these waterbodies to migratory birds will be considered in Chapter 6.14. Some wetland site series are also associated with Red- and Blue-listed ecological communities (Table 6.9-3).

Rock Outcrops

Rock outcrops were usually mapped as polygon components rather than pure polygons. In total 65 ha were mapped as rock outcrop, primarily in the IDFxh2 (Table 6.9-3, Figure 6.9-5).

Old-growth Forest

Structural stage 7 (old-growth) forests are rare in the LSA due to the history of timber harvest and fire. Only 19.8 ha of old-growth forest was mapped in LSA, all in the IDFxh2 (Table 6.9-3, Figure 6.9-5). Large old veteran trees may be present in forests and grasslands but these isolated trees are not identified in the mapping. Two site series associated with ECAR, totalling 11.9 ha, were mapped as structural stage 7 forest.

Portions of Old Growth Management Areas are present in the LSA; TKA725 on the southern border of the LSA (38 ha overlap), TKA703 in the southwest corner of the LSA (5 ha overlap), and a very small fragment (0.07 ha overlap) of TKA694 on the southern border of the LSA (Figure 6.9-5).

Figure 6.9-4
Ecological Communities at Risk in the Local Study Area

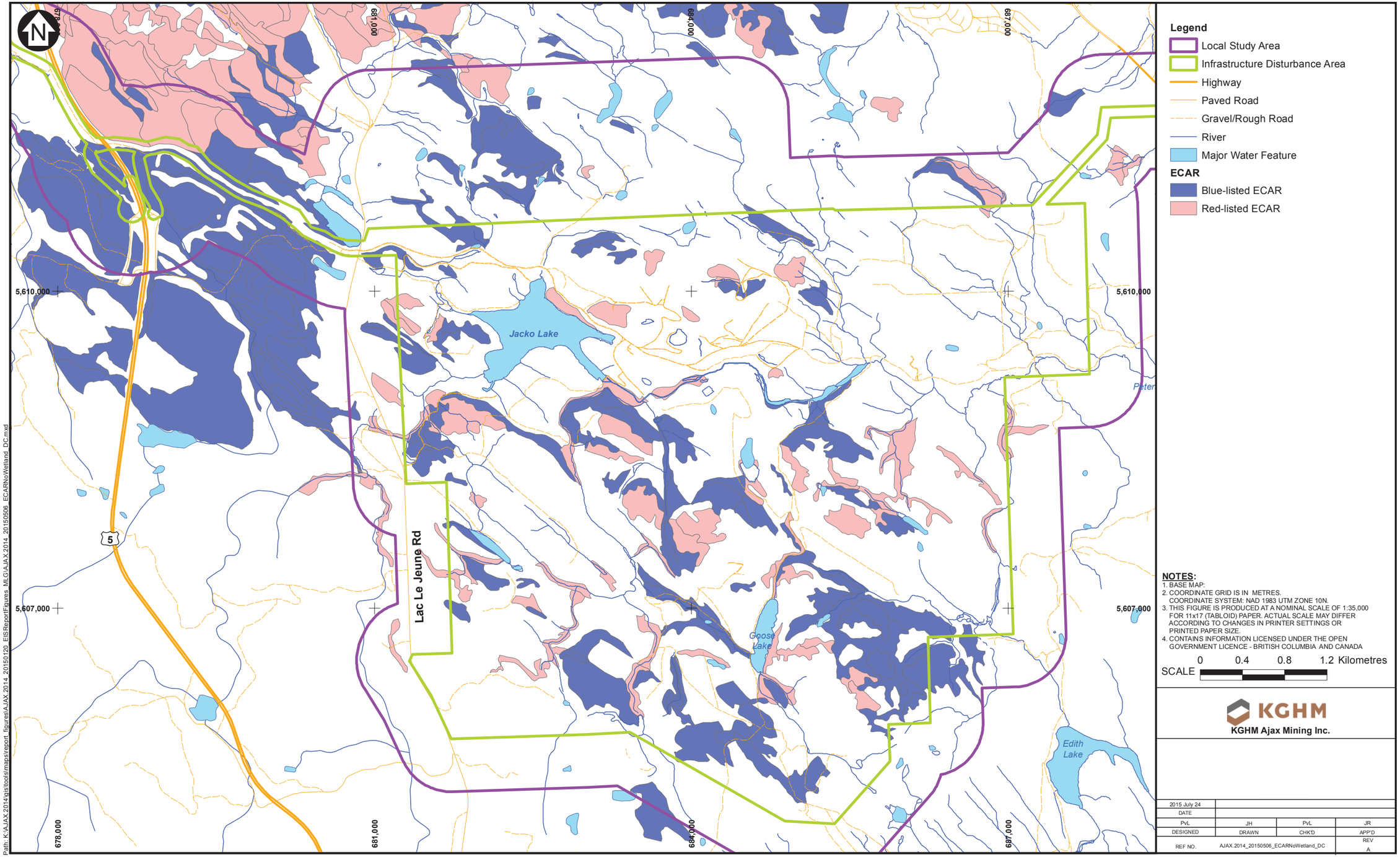


Figure 6.9-5
Sensitive Ecological Communities

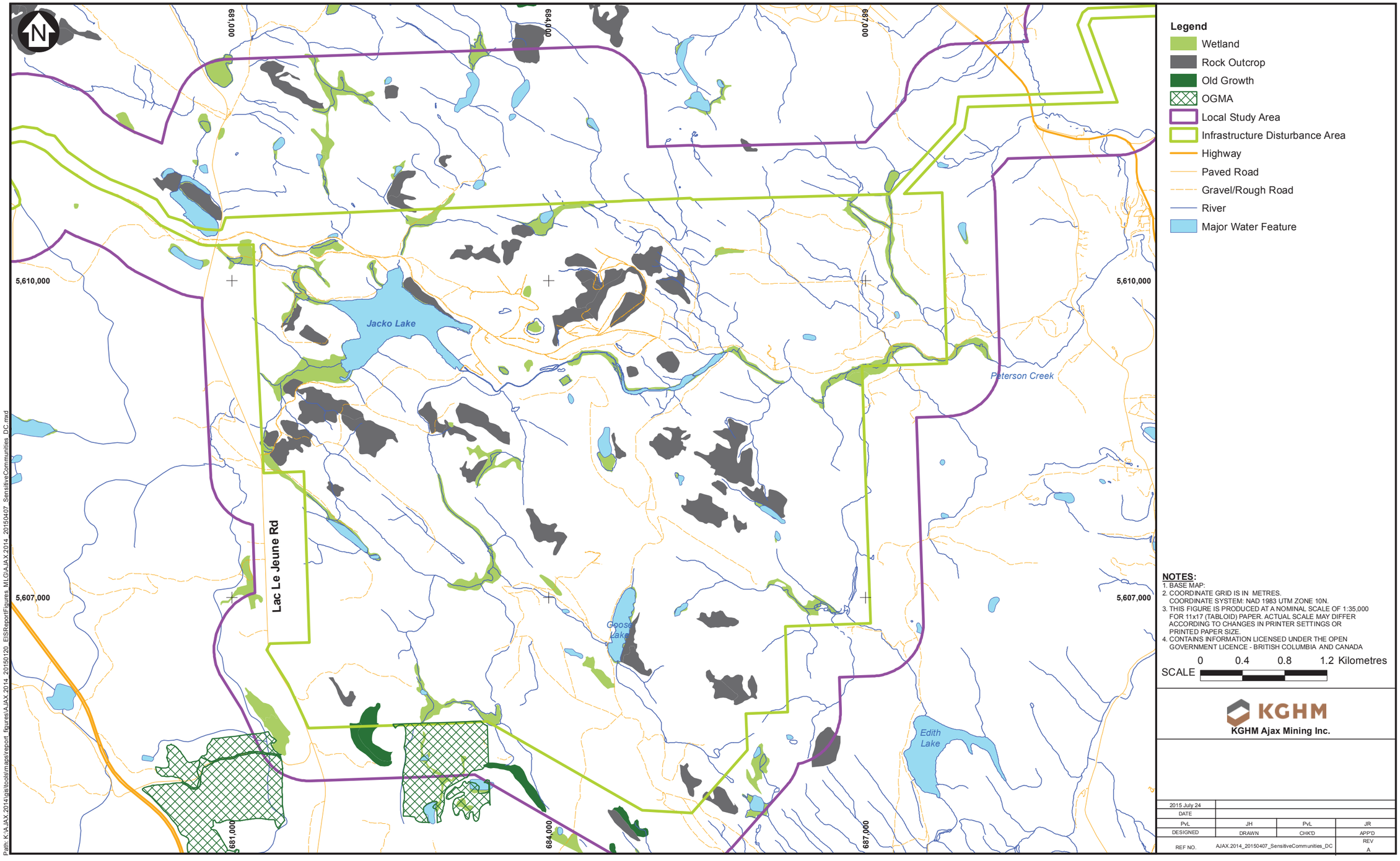


Table 6.9-3. Rare and Sensitive Ecological Communities Mapped in the LSA

Biogeoclimatic Subzone Variant	Site Series	Ecological Community	BC List	Total Mapped in LSA (ha)
Forested Ecological Communities At Risk				
BGxw1	03	ponderosa pine / bluebunch wheatgrass - rough fescue	Red	5.4
	05	trembling aspen / common snowberry / Kentucky bluegrass	Red	11.7
BGxw1 Total				**17.1**
IDFxh2	01	Douglas-fir - ponderosa pine / pinegrass	Blue	699.2
	02	Douglas-fir - ponderosa pine / bluebunch wheatgrass	Red	70.7
	04	Douglas-fir - ponderosa pine / bluebunch wheatgrass - pinegrass	Blue	79.4
	09	western redcedar - Douglas-fir / red-osier dogwood	Blue	24.4
	10	trembling aspen / common snowberry / Kentucky bluegrass	Red	93.2
IDFxh2 Total				**966.9**
PPxh2	01	ponderosa pine / bluebunch wheatgrass - rough fescue	Red	196.4
	04	ponderosa pine / bluebunch wheatgrass	Blue	55.1
	06	Douglas-fir / common snowberry - saskatoon	Red	13.4
PPxh2 Total				**264.9**
			ECAR Total	**1248.9**
Wetlands				
BGxw1	AK	Alkaline Pond		3.7
	OW	Open water		5.3
	Gs01	Alkali Saltgrass herbaceous meadow	Red	5.6
	Wm01	Beaked sedge -Water sedge		0.9
	Wm05	Common Cattail marsh	Blue	8.0
BGxw1 Total				**23.4**
IDFxh2	AK	Alkaline Pond		7.7
	OW	Open water		15.1
	Gs01	Alkali Saltgrass herbaceous meadow	Red	2.6
	Gs02	Nuttall's alkaligrass-Foxtail barley		9.9
	Wm01	Beaked sedge -Water sedge		7.4
	Wm05	Common Cattail marsh	Blue	12.2
	Wm06	Great bulrush marsh	Blue	10.9
	Wm07	Baltic rush saline marsh		7.7
	Ws03	Bebb's willow-Bluejoint		16
	Ws04	Drummond's willow-Beaked sedge		2.5
IDFxh2 Total				**91.9**
PPxh2	AK	Alkaline Pond		5.2
	Gs01	Alkali Saltgrass herbaceous meadow	Red	3.1
PPxh2 Total				**8.3**
			Wetland Total	**123.6**
Rock Outcrop				
IDFxh2	73	Selaginella -Clad lichens		64.1
PPxh2	Ro02	Bluebunch wheatgrass - Selaginella		0.9
			Rock Outcrop Total	**65**

Biogeoclimatic Subzone Variant	Site Series	Ecological Community	BC List	Total Mapped in LSA (ha)
Old Growth Forest				
IDFxh2	01	Douglas-fir - ponderosa pine / pinegrass	Blue	9.7
	03	Douglas-fir - ponderosa pine / bluebunch wheatgrass - Balsamroot		7.2
	04	Douglas-fir - ponderosa pine / bluebunch wheatgrass - pinegrass	Blue	2.2
	06	Douglas-fir / feathermoss		0.7
		Old Growth Forest Total		**19.8**

6.9.4 Potential Effects of the Project and Proposed Mitigation for RSEC

6.9.4.1 Identifying Potential Effects on RSEC

The AIR identified the potential effects of habitat alteration and loss on RSEC. An interaction matrix (Table 6.9-4) was used to help scope potential effects by considering potential interactions with Project activities/components, consistent with the approach outlined in the assessment methodology (Section 5.2.4.1.). Further rationale for the scoping of potential effects is provided below.

Habitat Loss

For the purposes of this assessment habitat loss is defined as the process by which habitat is rendered functionally unable to support the indicator ecosystems. Habitat loss will occur during the Construction phase of the Project, specifically during vegetation clearing, land excavation, dams for water management and any other changes to the physical landscape. Permanent loss resulting from the replacement of habitat by Project infrastructure footprints (IF) will be considered the minimum effect. Habitat outside, but in close proximity to the Project IF, may not be permanently lost but may be functionally compromised due to interactions with the Project IF. The IDA defines this area and is considered the maximum effect for habitat lost during Construction and Operation. Additional alteration effects will not be considered for the Project IF where habitat has been permanently removed.

Table 6.9-4. Identifying Potential Project Interactions and Effects on RSEC

	Project Activities	Potential Effects on RSEC: Habitat Loss	Potential Effects on RSEC: Habitat Alteration
Construction	Clearing and Grubbing	H	O
	Earthworks	H	L
	Overburden/Topsoil Stockpile	O	L
	Laydown Areas and Storage Yards	O	L
	Project Lighting	O	O
	Site Security and Fencing	O	O
	Fuel Storage and Filling Area	O	L
	Hazardous Wastes Transport, Storage, and Disposal	O	L
	Construction Wastes Transport, Storage, and Disposal	O	L
	Sewage Infrastructure and Disposal	O	O
	Public Road Realignment, Use, and Maintenance	O	L

Project Activities		Potential Effects on RSEC	
		Habitat Loss	Habitat Alteration
Construction (*cont'd*)	Site Road Construction, Use and Maintenance	O	L
	Haul Road Overpass Construction, Use, and Maintenance	O	O
	Site Buildings and Process Plant	O	O
	Explosives Magazine and Storage Facilities	O	O
	Open Pit Development	O	O
	Drilling and Blasting	O	L
	Crushing Mine Rock	O	L
	Loading, Hauling, and Deposition of Mine Rock	O	L
	Temporary Ore Stockpile	O	O
	Tailing Storage Facility Development	O	O
	Power Transmission, Distribution	O	M
	Natural Gas Line	O	M
	Pipeline Utility Corridor (Potable Water, Sewage, and Site Water)	O	L
	Water Intake from Kamloops Lake	O	O
	Fire Suppression Infrastructure	O	L
	Contact Water	O	M
	Non-contact Water	O	O
	Haul Road Overpass	O	L
	Water Management Dams	M	O
	Mine Staffing (Direct Employment)	O	O
	Contracted Employment	O	O
	Taxation	O	O
Operation	Open Pit Development	O	O
	Drilling and Blasting	O	L
	Hauling Mine Rock and Ore from Pit	O	L
	Crushing and Conveying Ore	O	L
	Temporary Ore Stockpile	O	L
	Development of Mine Rock Storage Facilities	O	O
	Stripping, Loading, Hauling, Deposition, and Contouring of Topsoil and Overburden	O	L
	Revegetation through Progressive Reclamation	O	O
	Process Plant Operation	O	O
	Deposition to Tailing Storage Facility	O	O
	Site Road Use and Maintenance (Materials, Personnel, Supplies)	O	L
	Concentrate Transport and Storage	O	O
	Explosives Magazine and Storage Facilities	O	O
	Fire Suppression Infrastructure	O	O
	Fuel Storage and Filling Area	O	L
	Hazardous Wastes Transport, Storage, and Disposal	O	L
	General Wastes Transport, Storage, and Disposal	O	L
	Sewage Infrastructure and Disposal	O	L
	Laydown Areas and Storage Yards	O	L
	Power Transmission, Distribution	O	M
	Project Lighting	O	O
	Site Access, Security and Fencing	O	O

Project Activities		Potential Effects on RSEC	
		Habitat Loss	Habitat Alteration
Operation *(cont'd)*	Water Intake from Kamloops Lake	O	O
	Contact Water	O	M
	Non-contact Water	O	O
	Potable Water Treatment and Use	O	O
	Haul Road Overpass	O	L
	Mine Staffing (Direct Employment)	O	O
	Contracted Employment	O	O
	Taxation	O	O
Decommissioning and Closure	Dismantling of Ancillary Buildings	O	O
	Pit Lake Planning	O	O
	Site Road Decommissioning	O	O
	Tailing Storage Facility Decommissioning and Reclamation	O	O
	Mine Rock Storage Facilities Reclamation	O	O
	Fuel Storage and Filling Area	O	L
	Hazardous Wastes Transport, Storage, and Disposal	O	L
	General Wastes Transport, Storage, and Disposal	O	L
	Sewage Infrastructure and Disposal	O	L
	Laydown Areas and Storage Yards	O	L
	Power Transmission, Distribution	O	M
	Project Lighting	O	O
	Site Access, Security and Fencing	O	O
	Contact Water	O	M
	Non-contact Water	O	O
	Potable Water Treatment and Use	O	O
	Haul Road Overpass	O	L
	Road use to the Project (Materials, Personnel, Supplies)	O	L
	Mine Staffing (Direct Employment)	O	O
	Contracted Employment	O	O
	Taxation	O	O
Post-Closure	General Site Inspections and Maintenance	O	O
	Contact Water	O	M
	Non-contact Water	O	O
	Road use to the Project (Materials, Personnel, Supplies)	O	L
	Mine Staffing (Direct Employment)	O	O
	Contracted Employment	O	O

Notes:

O	*No interaction anticipated.*
L	*Negligible to minor interaction expected; implementation of best practices, standard mitigation and management measures; no monitoring required, no further consideration warranted.*
M	*Potential moderate interaction requiring unique active management/monitoring/mitigation; warrants further consideration.*
H	*Interaction; warrants further consideration.*

Several site series associated with RSEC have been mapped within the IDA and may be impacted by Construction activities. A ranking of "High" was assigned for Project activities (Table 6.9-4**)** that will remove ECAR, rock-outcrops, wetlands or old-growth forests; and warrants analysis as described in Section 6.9.4.2.

Habitat Alteration

Habitat alteration is defined as a reduction in ecosystem function. Activities that affect the physical characteristics of an ecosystem, either permanently or temporarily can result in a change in the vegetative structure or composition. Habitat alteration will occur throughout the construction and operation phases of the Project, specifically as a result of drilling, blasting, crushing and road use (fugitive dust deposition), soil compaction, linear feature use and maintenance (invasive species introduction, vegetation maintenance) and changes in drainage and water quantity. Included within the IDA is a minimum 50 metre buffer between the edge of the Project IF and the IDA. This buffer incorporates habitat alteration resulting from edge effects into the maximum habitat loss effect (Gieselman et al. 2013). Since habitat alteration cannot occur in habitat that has been permanently removed, habitat alteration will be considered excluding the IF for the minimum habitat loss effect and excluding the IDA for the maximum habitat loss effect.

Mosses and lichen are considered particularly susceptible to fugitive dust (Farmer 1993; Walker and Everett 1987), however very few RSEC found in the LSA contain mosses or lichen as indicator species so the effect of dust deposition will be restricted to a few ecosystems. The area is known to be frequented by dust storms so the species present are expected to have some tolerance to dust. Air Quality modelling has been conducted for the Project area and the LSA (Appendix 10.1-A) to provide the predicted dust deposition as a result of Project activities during Construction and Operations. The predicted metals uptake in plants is modelled in the Human Health and Ecological Risk Assessment (Appendix 10.4-A). Rock outcrop communities are home to several lichen communities and are most likely to be altered by dust deposition. Fugitive dust can also change a wetlands biochemical, ecological, and habitat functions (Eller 1977; Dale & Freedman 1982; Walker & Everett 1987; Farmer 1993).

Construction and Operation activities that are expected to generate fugitive dust above baseline conditions include public and site road construction, use and maintenance; drilling and blasting; crushing mine rock; loading, hauling and deposition of mine rock; hauling mine rock and ore from pit; and crushing and conveying ore (Chapter 10.1). Site series associated with RSEC are present in the LSA and an interaction with the Project is anticipated. A ranking of "low" was assigned for Project activities (Table 6.9-4) that will introduce fugitive dust to RSEC, and further analysis is included in Section 6.9.4.2.

Invasive species out-compete the native vegetation and may negatively impact RSEC. Construction and Operation activities that may introduce invasive species include use and maintenance of site and public roads and linear corridors (power transmission, natural gas and pipeline corridors). A ranking of "moderate" was given to those Project activities (Table 6.9-4) that may introduce invasive species to RSEC, and further analysis is described in Section 6.9.4.2.

Ecosystems can also be altered by changes to the physical environment. Activities that alter soil conditions can change the plant community present at a site. Contamination of wetlands has the

potential to alter the vegetative community present. Changes to surface and subsurface hydrology patterns can alter the timing and quantity of water entering wetlands, influencing wetland function (Mitsch and Gosselink 2000). Alterations to wetland functions will continue to occur as new hydrological regimes in affected wetlands become established. Possible changes to wetland functions may include alteration of habitat due to altered successional pathways, hydrodynamics, and hydrological connectivity; water quality treatment; and nutrient and organic export (Odland and del Moral 2002; Sheldon 2005). Project activities that can result in soil compaction include earthworks; overburden stockpile; and laydown areas and storage yards may also alter ecosystems, additional discussion is provided in Section 6.9.4.2.

Chemical hazards were also considered under habitat alteration. Chemical hazards are defined as chemicals that result from Project related activities that have the potential to cause an adverse effect on wetlands and the plants that occur in these areas. Vegetation may absorb chemicals (e.g., dissolved metals) or be smothered by chemical substances.

During Construction, the fuel storage and filling area has the potential to result in a chemical hazard. Hazardous waste transport, concentrate transport, and sewage infrastructure, as well as site road use as oil, fuel, other petroleum-based fluids and antifreeze from machinery can cause direct habitat contamination if they are allowed to escape into the environment. Petroleum compounds can affect organisms physically (smothering, reduced light), via habitat modification (alterations in pH) or via toxic action (Albers 2003). Similarly, the pipeline utility corridor and chemicals associated with fire suppression infrastructure may negatively impact the environment. Tailings deposition to the TSF as well as TSF decommissioning and reclamation could also result in a chemical hazard. These Project activities were given a ranking of "low" as they are considered accidents and malfunctions, and policies/procedures will be in place to ensure the chemical hazards associated with these project activities are minimized (Table 6.9-4).

Contact water, which is any water that may have come in contact with potentially toxic materials, may have a negative effect on RSEC, particularly wetland communities. Heavy metals such as copper, cadmium, lead, selenium and mercury are known to be persistent and mobile in the environment, and to be potentially toxic to many forms of life. Potential sources of metal contamination within the LSA include terrestrial (i.e., Mine Rock Storage Facilities (MRSF)) and aquatic (Tailings Storage Facilities (TSF)). Contact water was given the ranking of "Moderate" during all Project phases, and warrants further consideration (Table 6.9-4). Details of this analysis are presented in Section 6.9.4.2.

6.9.4.2 Effects on RSEC

Key effects were identified for habitat loss and habitat alteration on RSEC. Additional analysis will be completed to quantify the impacts of Project activities.

Habitat Loss

Methods to Predict Impacts of Project Activities on RSEC in LSA

The amount of area mapped as a site series associated with an ECAR, a rock outcrops, a wetland, or an old-growth forest was determined by calculating the maximum and minimum potential effects.

The maximum effect was calculated by overlaying the IDA footprint on the TEM, while the minimum effect was determined by overlying the Project IFs on the TEM. The potential exists for an adverse effect on these rare and sensitive ecosystems if that ecosystem is present (or community potentially present) within the IDA or IF. The amount of each ecosystem lost within the IDA or IF was compared to the total amount of each ecosystem within the LSA, to calculate the percent of each ecosystem lost within the LSA.

Methods to Predict Impacts of Project Activities on RSEC in RSA

To determine the amount of ECAR potentially available in the RSA a proportional analysis was completed. It was assumed that the proportional representation of site series associated with ECAR within each biogeoclimatic subzone variant was equivalent between the LSA and RSA. This assumption was based on the uniform climatic and geographical characteristics found in each Biogeoclimatic subzones variant and the fact that the RSA and LSA have relatively uniform terrain, elevation and weather patterns. Within the LSA the proportion of site series associated with an ECAR was calculated for each subzone variant. These proportions were then scaled up to the amount of the subzone variant in the RSA. The amount of habitat lost in the IF and IDA as a result of Construction was then compared to the estimated total habitat within the RSA to establish what percentage of the site series associated with ECAR could be lost.

To put sensitive communities into a regional context, the Vegetation Resources Inventory (VRI) mapping was used to assess the presence and distribution of wetlands, rock outcrops, and old-growth forests within the RSA. VRI (2012) mapping was overlaid with a spatial file of the RSA. Wetlands were identified as non-vegetated water wetlands in the VRI. Old-growth forests were identified using the projected age >141, with a canopy closure of >25%. Amounts within the LSA are presented for comparison. Regional wetlands also quantified with BC Corporate Watershed Base and Freshwater Atlas.

Predicted Impacts of Project Activities on RSEC in LSA

ECAR

Excluding wetlands, 8 of 12 site series associated with ECARs were mapped in the LSA. Total loss within the LSA ranged from a minimum effect of 23% (285 ha) to a maximum effect of 43% (536 ha) for all ECARs (Table 6.9-5, Figure 6.9-6). The total maximum effect to ECARs within the LSA in the BGxw1 and the PPxh2 was 43% and 32%, respectively. The effect to ECARs in the IDFxh2 ranged from 29% to 54% and the Project will have the greatest effect on ECARs in this subzone variant.

Prior to mitigation the potential effect to individual ECARs within the LSA ranged from 0 to maximum of 84%. Specific ecosystems in the IDFxh2 with a maximum habitat loss effect greater than 50% in the LSA include the Douglas-fir - ponderosa pine / bluebunch wheatgrass; Douglas-fir - ponderosa pine / bluebunch wheatgrass – pinegrass, western redcedar - Douglas-fir / red-osier dogwood and the trembling aspen / common snowberry / Kentucky bluegrass. The minimum effect to the site series associated with the trembling aspen / common snowberry / Kentucky bluegrass is also greater than 50%.

Wetlands

Total wetland loss within the LSA ranged from a minimum effect of 28% (35 ha) to a maximum effect of 50% (62 ha) (Table 6.9-5, Figure 6.9-6**)**. The total maximum effect to wetlands within the LSA was in the BGxw1 and PPxh2 which were35% and 5% respectively. The total effect to wetlands in the IDFxh2 ranged from a minimum effect of 34% to a maximum effect of 58% in the LSA and the Project will have the greatest effect on wetlands in this subzone variant.

Table 6.9-5. Area of each Indicator Community Mapped in the Infrastructure Footprints (IF), IDA, and Local Study Area (LSA)

Biogeoclimatic Subzone Variant	Site Series	At-risk Ecological Community	BC Listing	Total Mapped in LSA (ha)	Max area lost (ha) IDA	Min Area lost (ha) IF
Ecological Communities At Risk						
BGxw1	03	ponderosa pine / bluebunch wheatgrass - rough fescue	Red	5.4	0	0
	05	trembling aspen / common snowberry / Kentucky bluegrass	Red	11.7	5.5	2.2
BGxw1 Total				**17.1**	**5.5**	**2.2**
IDFxh2	01	Douglas-fir - ponderosa pine / pinegrass	Blue	699.2	327.7	169.3
	02	Douglas-fir - ponderosa pine / bluebunch wheatgrass	Red	70.7	56.5	31.7
	04	Douglas-fir - ponderosa pine / bluebunch wheatgrass - pinegrass	Blue	79.4	41.6	15
	09	western redcedar - Douglas-fir / red-osier dogwood	Blue	24.4	16.4	8.2
	10	trembling aspen / common snowberry / Kentucky bluegrass	Red	93.2	77.9	54.1
IDFxh2 Total				**966.9**	**520.1**	**278.3**
PPxh2	01	ponderosa pine / bluebunch wheatgrass - rough fescue	Red	196.4	10.7	4.6
	04	ponderosa pine / bluebunch wheatgrass	Blue	55.1	0.2	0
	06	Douglas-fir / common snowberry - saskatoon	Red	13.4	0	0
PPxh2 Total				**264.9**	**10.9**	**4.6**
			ECAR Total	**1248.9**	**536.5**	**285.1**
Wetlands						
BGxw1	AK	Alkaline Pond		3.7	0.3	0
	OW	Open water		5.3	1.4	0
	Gs01	Alkali Saltgrass herbaceous meadow	Red	5.6	0.8	0
	Wm01	Beaked sedge -Water sedge		0.9	0.7	0.1
	Wm05	Common Cattail marsh	Blue	8	5	3.4

Biogeoclimatic Subzone Variant	Site Series	At-risk Ecological Community	BC Listing	Total Mapped in LSA (ha)	Max area lost (ha) IDA	Min Area lost (ha) IF
BGxw1 Total				**23.5**	**8.2**	**3.5**
IDFxh2	AK	Alkaline Pond		7.7	0.5	0.3
	OW	Open water		15.1	10.9	8
	Gs01	Alkali Saltgrass herbaceous meadow	Red	2.6	1.6	1.4
	Gs02	Nuttall's alkaligrass-Foxtail barley		9.9	0.9	0.9
	Wm01	Beaked sedge -Water sedge		7.4	4.7	3.6
	Wm05	Common Cattail marsh	Blue	12.2	11.1	5.4
	Wm06	Great bulrush marsh	Blue	10.9	9.6	8
	Wm07	Baltic rush saline marsh		7.7	2.4	1.9
	Ws03	Bebb's willow-Bluejoint		16	9	0
	Ws04	Drummond's willow-Beaked sedge		2.5	2.5	2.1
IDFxh2 Total				**92**	**53.2**	**31.6**
PPxh2	AK	Alkaline Pond		5.2	0	0
	Gs01	Alkali Saltgrass herbaceous meadow	Red	3.1	0.4	0
PPxh2 Total				**8.3**	**0.4**	**0**
		Wetland Total		**123.5**	**61.8**	**35.1**
Rock Outcrop						
IDFxh2	73	Selaginella -Clad lichens		64.1	55.3	34.1
PPxh2	Ro02	Bluebunch wheatgrass - Selaginella		0.9	0	0
		Rock Outcrop Total		**65**	**55.3**	**34.1**
Old Growth Forest						
IDFxh2	01	Douglas-fir - ponderosa pine / pinegrass	Blue	9.7	0.4	0
	03	Douglas-fir - ponderosa pine / bluebunch wheatgrass -Balsamroot		7.2	2.8	0
	04	Douglas-fir - ponderosa pine / bluebunch wheatgrass - pinegrass	Blue	2.2	0	0
	06	Douglas-fir / feathermoss		0.7	0	0
		Old Growth Forest Total		**19.8**	**3.2**	**0**

Effects to individual wetland types varied with a maximum effect within the LSA greater than 50% for 8 of 17 wetlands in all three subzone variants. The minimum effect exceeded 50% for two ECAR wetlands within the LSA, namely Alkali Saltgrass herbaceous meadow and the Great bulrush marsh, although the total area affected is only 11 ha.

Rock Outcrops

Rock outcrops were primarily mapped within the LSA in the IDFxh2 where loss ranged from a minimum effect of 53% (34 ha) to a maximum effect of 86% (55 ha, Table 6.9-5, Figure 6.9-7). The minimum effects to the Selaginella - Clad lichens community exceeds 50%.

Old-growth Forest

In total, 20 ha were mapped as structural stage 7 (old-growth) in the LSA (Table 6.9-5, Figure 6.9-7). The maximum effect of loss of old-growth forests is 16% (3.2 ha). Large old veteran trees may also be present in forests and grasslands but these isolated trees would not be identified by the mapping.

Predicted Impacts of Project Activities on RSEC in RSA

ECAR

Assuming the proportion of habitat that can support ECAR in the RSA is equal to the proportion in the LSA it is estimated that up to 7.2% of ECAR habitat in the RSA could be affected by the Project (Table 6.9-6). Loss of ECAR habitat in the IDF will have the greatest effect.

Table 6.9-6. Estimation of Total Red- and Blue-listed Communities within RSA Effected by Project Construction

Biogeoclimatic Subzone	% of subzone that supports ECAR	Predicted amount (ha) of RSA that supports ECAR	Max(ha) of ECAR lost -IDA	Min (ha) of ECAR lost -IF	Range of % loss in RSA
BCxw1	4.2%	526.8	11.3	5.6	1.1-2.1 %
IDFxh2	20.7%	7481.9	542.4	293.1	3.9-7.2 %
PPxh2	65.8%	13,109.2	11.3	4.6	<0.1 %

Sensitive Ecosystems

The analysis of VRI indicates that Project activities will affect 0.4 % of wetlands, 0.2 % of old-growth forest, and 0.7 % of Rock Outcrops in the RSA (Table 6.9-7).

Table 6.9-7. Estimation of Loss of Sensitive Ecosystems within the RSA

RSEC	Area IF (ha)	Area LSA (ha)	Area RSA (ha)	% loss in RSA
Wetlands (VRI)	2.8	13.4	640.9	0.4 %
Wetlands (CWB)	10.5	27.2	1007	1.0%
Old-growth Forest	52.5	424.2	28,059.5	0.2 %
OGMAs	0.0	43.2	8,563.6	0.0 %
Rock Outcrops	24.7	52.7	3,303.8	0.7 %

Figure 6.9-6
Habitat Loss of Ecological Communities at Risk in the Local Study Area

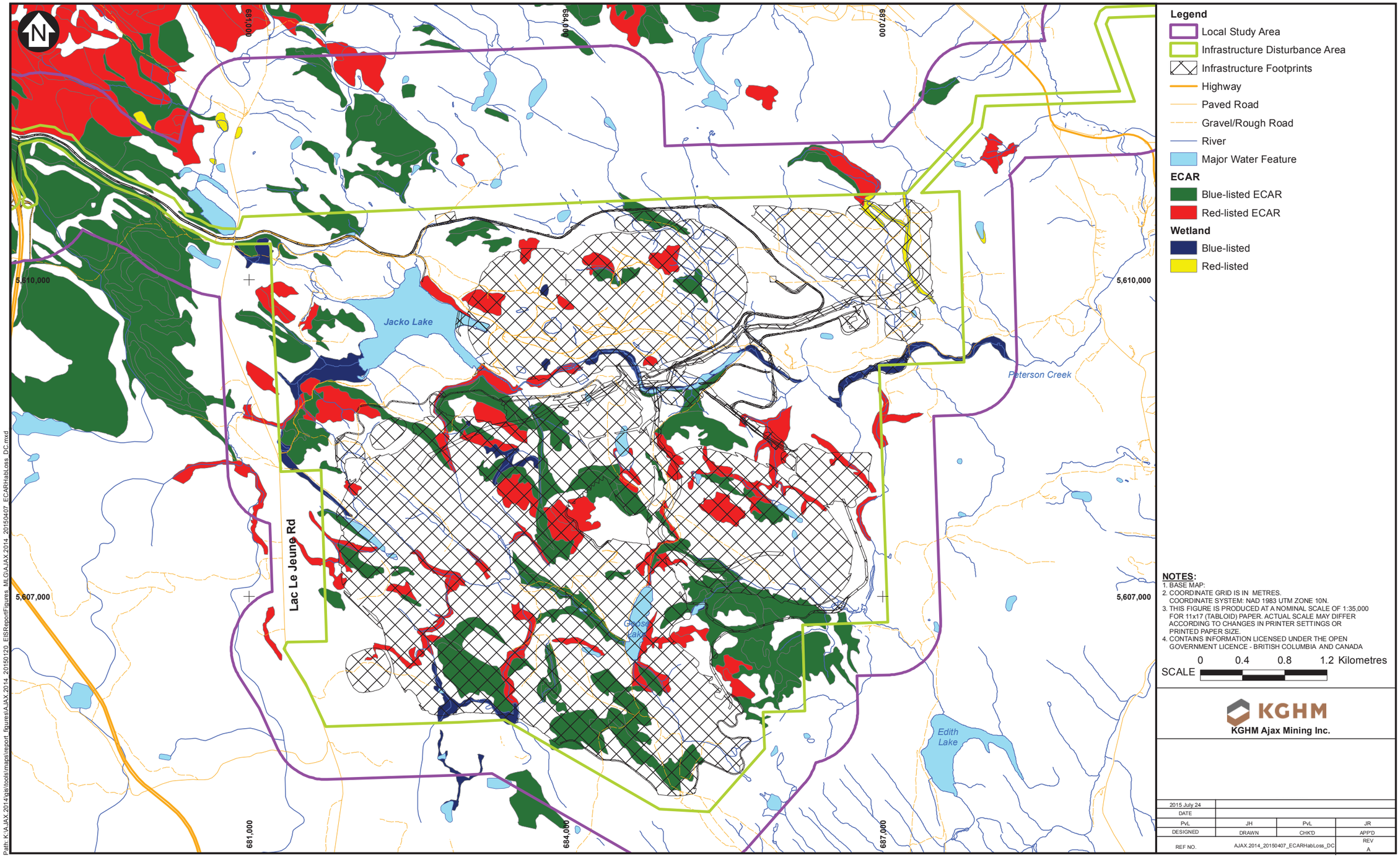
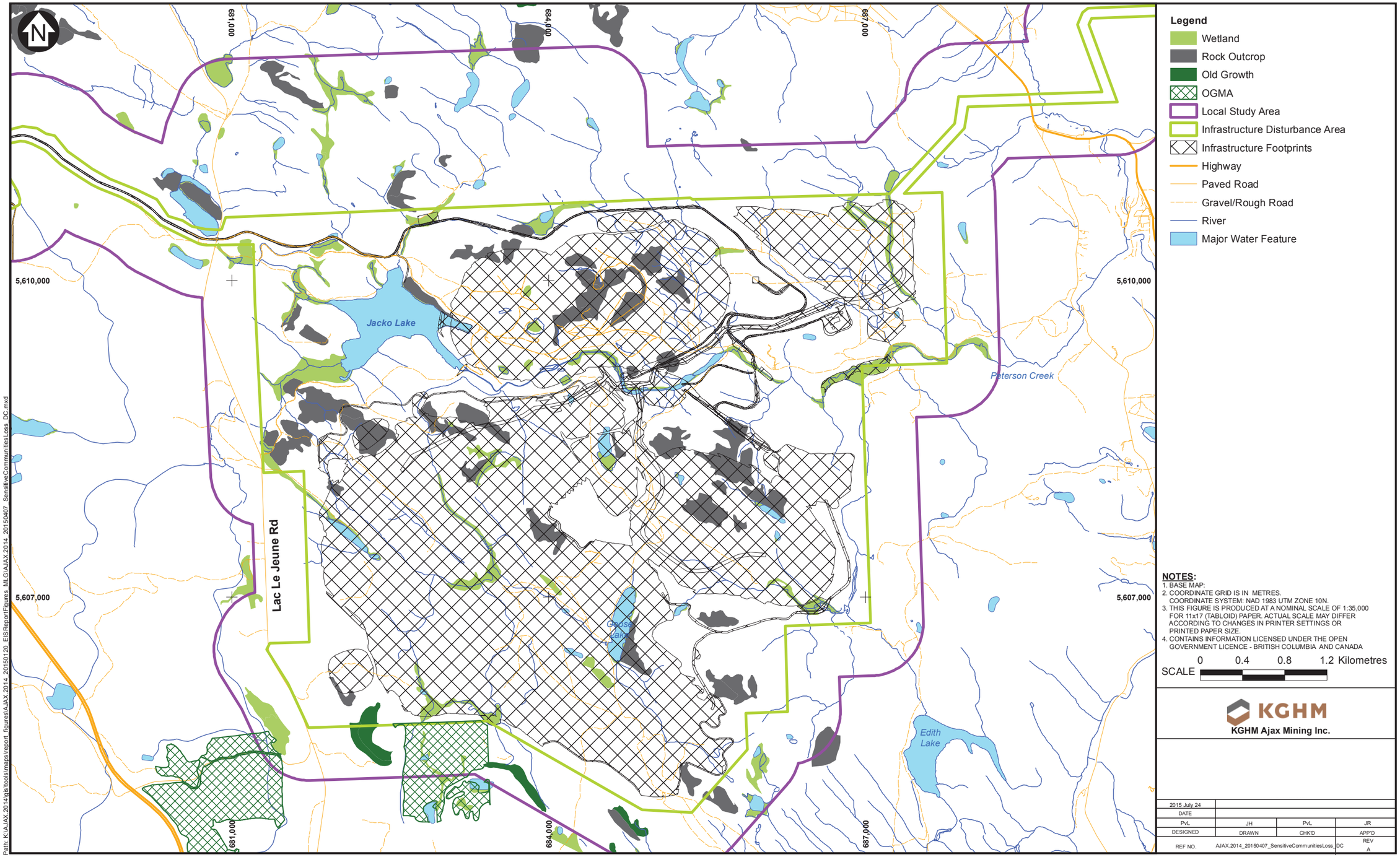


Figure 6.9-7
Habitat Loss of Sensitive Ecological Communities



Habitat Alteration

Methods to Predict Impacts of Project Activities on RSEC

Linear features (roads, pipelines, transmission lines) were buffered by 100 metres to determine the area where habitat alteration effects resulting from invasive plant species could occur. The 100 m buffer was determined based on literature review and the prominence of grassland habitat in the LSA (Tyser & Worley 1992; Hansen & Clevenger 2005). This buffer was overlaid on the TEM to determine the amount of RSEC affected. Habitat alteration cannot occur in areas were habitat has been permanently lost. Habitat alteration was calculated in the LSA excluding the IF (minimum habitat loss effect) and the IDA (maximum habitat loss effect).

The maximum dust fall (see *Air Quality* Chapter 10.1) is not expected to exceed 1.12 mg/dm^3/day, which is well below the MoE Ambient Air Quality Objectives lower range (applying to sensitive environmental situations) of 1.7 mg/dm^3/day (British Columbia Ministry of Environment 2014)Baseline studies indicate the arid climate contribute to soil erosion from wind. The regional ecosystems are tolerant of these dry, dusty conditions.

The Air Quality and Dust Control Plan (Section 11.6) provides mitigations that will limit fugitive dust from impacting ecosystems within the vicinity allowing air quality objectives to be met and ecosystem function preserved. As such, habitat alteration resulting from dust fall is not expected to occur.

Hydrological changes will affect wetlands within the IDA and LSA, since all wetlands within the IF will be permanently lost. The location and Project activity was considered to determine the potential effect of hydrological changes to wetlands in the IDA and LSA.

Predicted Impacts of Project Activities on RSEC

ECAR

The effect that invasive species will have on RSEC was measured by calculating how much additional area could be altered in the LSA. Forested sites are not as susceptible to invasive species as grasslands (Tyser & Worley 1992; Hansen & Clevenger 2005). Rock outcrops are not expected to be affected by invasive species because of the poor soil conditions. Aquatic plant invasive species are not likely to increase as a result of Construction, as the vectors for aquatic invasive plants are more likely to be boats and recreational users rather than roads and other non-aquatic corridors.

The total additional area affected ranges from a minimum effect of 2% (30 ha) to a maximum of 11% (136 ha). Individual ecosystems will be affected up to 21%. Considering the maximum habitat loss effect, the additional habitat altered is less than 5% (Table 6.9-8).

Table 6.9-8. Total ha of ECAR within the LSA that may be Altered as a Result of Invasive Species

Biogeoclimatic Subzone Variant	Site Series	At-risk Ecological Community	BC List	Total Mapped in LSA (ha)	Altered Area (ha) – (exclude IF)	Altered Area (ha) – (excluding IF & IDA)
BGxw1	03	ponderosa pine / bluebunch wheatgrass - rough fescue	Red	5.4	0	0
	05	trembling aspen / common snowberry / Kentucky bluegrass	Red	11.7	1.7	0
	Gs01	alkali saltgrass Herbaceous Vegetation	Red	5.6	0.2	0.1
BGxw1 Total				**22.7**	**1.9**	**0.1**
IDFxh2	01	Douglas-fir - ponderosa pine / pinegrass	Blue	699.2	88.8	24.7
	02	Douglas-fir - ponderosa pine / bluebunch wheatgrass	Red	70.7	7.9	0.6
	04	Douglas-fir - ponderosa pine / bluebunch wheatgrass - pinegrass	Blue	79.4	4.3	0
	09	western redcedar - Douglas-fir / red-osier dogwood	Blue	24.4	4.6	0.1
	10	trembling aspen / common snowberry / Kentucky bluegrass	Red	93.2	8.8	0
IDFxh2 Total				**966.9**	**114.4**	**25.4**
PPxh2	01	ponderosa pine / bluebunch wheatgrass - rough fescue	Red	196.4	20	4.6
	04	ponderosa pine / bluebunch wheatgrass	Blue	55.1	0.3	0
	06	Douglas-fir / common snowberry - saskatoon	Red	13.4	0	0
PPxh2 Total				**264.9**	**20.3**	**4.6**
		Grand Total		**1254.5**	**136.6**	**30.1**

Wetlands

Hydrological changes to wetlands outside of the IDA are expected to be minimal (See *Water Quantity* - Chapter 6.3). Several wetlands are present in the IDA on the west side of Jacko Lake. The hydrology of these wetlands is expected to be maintained since they are connected to Jacko Lake which provides a constant source of water to maintain the hydrological condition of margin wetlands. Several wetlands are also present along the Peterson creek. Since water is being diverted the hydrological condition of wetlands along Peterson Creek are expected to be altered. Since wetlands are particularly sensitive to change, an additional 3.2 ha of wetlands are expected to be lost.

Rock Outcrops

Rock Outcrops are not expected to be impacted by invasive species.

Old Growth Forest

No old-growth forest is present in areas where invasive species are expected to alter habitat.

Chemical Hazards

Methods to Predict Impacts of Project Activities on RSEC

To determine potential impacts of the Project on water quality within the LSA five sites within the IDA and LSA were modelled. This included Jacko Lake, three sites along Peterson Creek (Peterson Creek Downstream Pond, Peterson Creek node 2.3 and 2.0) and Humphrey Creek (Figure 6.9-8). Modelling considered year 1 (start of Construction) to year 124 (100 years Post Closure). Major ions, nutrients and dissolved metals were modelled for each month. Only those elements that exceed aquatic guidelines will be discussed (BC Ministry of Environment 2014b). Aquatic guidelines take into account the chronic effects of exposure to potentially harmful elements, as well as consider the bioaccumulation and the sensitivity of species along the food chain. These guidelines determine what levels of substances found in surface water are safe for the environment. Exceeding water quality guidelines does not imply that unacceptable risks exist, but rather that the potential for adverse effects may be increased and additional investigation may be required. Details of the modelling are provided in Chapter 6.3.

Predicted Impacts of Project Activities on RSEC

Water quality within Jacko Lake and in the Peterson Creek Downstream Pond are not expected to exceed aquatic water quality guidelines for any dissolved metals (Chapter 6.3).

Less than a kilometre downstream of the Peterson Creek Downstream Pond, at Peterson Creek node 2.3, sulphate and dissolved iron levels are anticipated to exceed aquatic guidelines (Table 6.9-9). Dissolved iron will be greater than 0.35 mg/L in 14 months between January of year 80 and December of year 82. Sulphate will be above 429 mg/L in March of year one of Operations.

Table 6.9-9. Modelled Median Water Quality for Peterson Creek Node 2.3

Dissolved Metals	Aquatic Guideline (mg/L)	No of Months Guidelines Exceeded	Max Modelled Value (mg/L)
Iron (Fe)	0.35	14	0.542
Sulphate (SO_4^{2-})	429	1	667

Further downstream at Peterson Creek node 2.0, chloride, selenium, and sulphate will exceed aquatic water quality guidelines (Table 6.9-10). Chloride will exceed 150 mg/L in January and February of year 1 of Construction, and every September between year 2 and year 29 of Operations. Selenium levels at this node exceeded the aquatic water quality guideline of 0.002 mg/L in April of 2011 and 2013, with a maximum level of 0.0029 mg/L. Selenium levels at this node are expected to be above this baseline maximum starting in April and May of year 1 of Operations and every April and May thereafter until year 124. Sulphate will be above 429 mg/L in the majority of months of the Project, from year 1 of Construction until the end of year 124.

Table 6.9-10. Modelled Median Water Quality for Peterson Creek Node 2.0

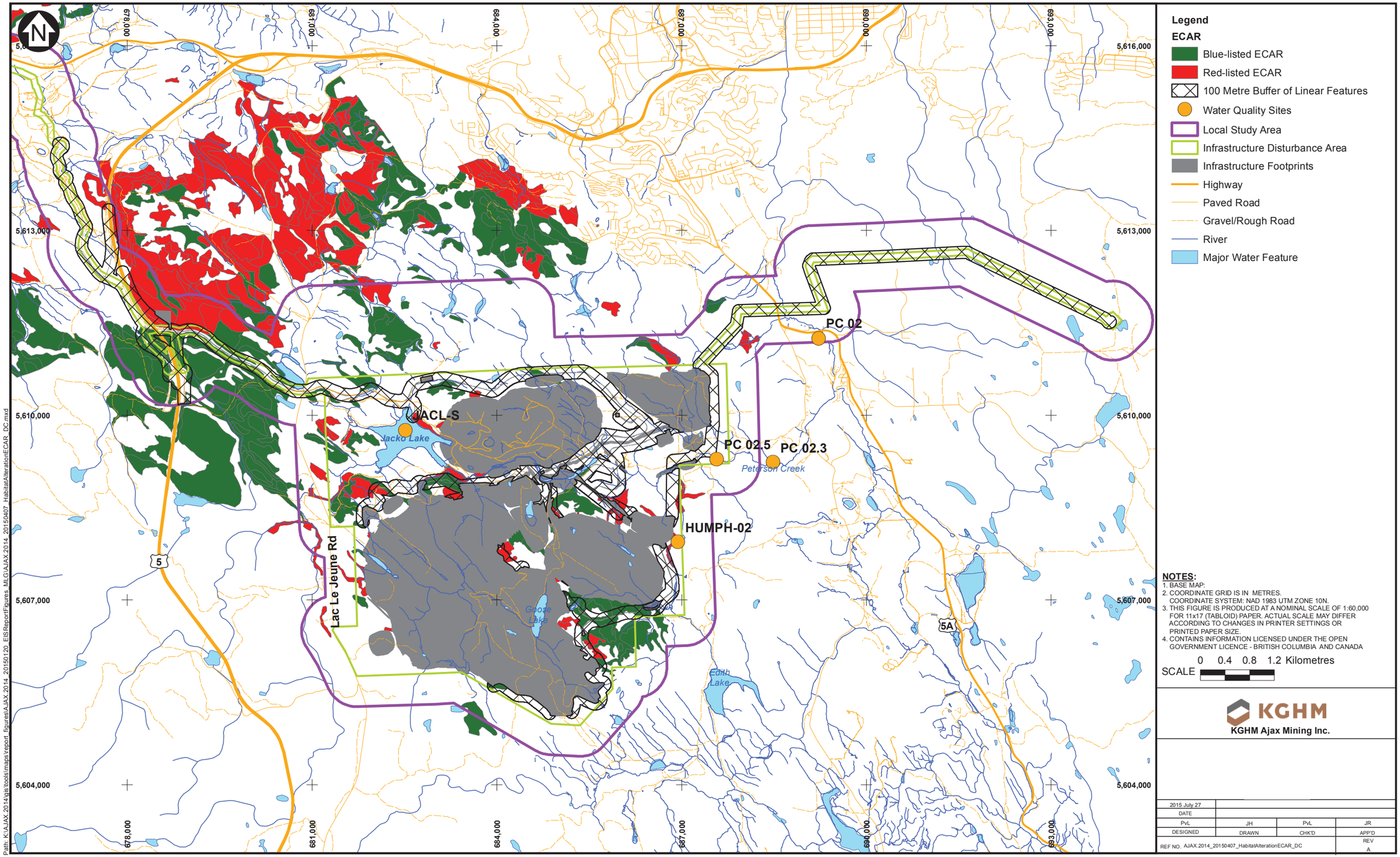
Dissolved Metals	Aquatic Guideline (mg/L)	No of Months Guidelines Exceeded	Max Modelled Value (mg/L)
Chloride (Cl^-)	150	30	183
Selenium (Se)	0.002	249	0.0034
Sulphate (SO_4^{2-})	429	1,098	989

Aluminum (Al), copper (Cu), mercury (Hg), selenium, and sulphate are anticipated to exceed aquatic water quality guidelines along Humphrey Creek (Table 6.9-11). Aluminum is anticipated to exceed 0.05 mg/L in May of year 25. Copper is anticipated to exceed aquatic guidelines in every August from year 1 to year 29 and every November from year 3 to year 25. Mercury levels will exceed 0.00002 mg/L in various months starting in Construction and continuing until the end of year 29. Baseline Selenium levels along Humphrey Creek were found to be above aquatic guidelines from March to June in 2014 with a maximum value of 0.00618 mg/L. Selenium levels along Humphrey Creek are expected to be above aquatic guidelines starting in year 1 and continuing through to year 124. However, selenium levels are only expected to be greater than baseline maximums between December to February of years 41 to 46 and 87 to 102.

Table 6.9-11. Modelled Median Water Quality for Humphrey Creek

Dissolved Metals	Aquatic Guideline (mg/L)	No. of Months Guidelines Exceeded	Max predicted Value
Aluminum (Al)	0.05	1	0.0815
Copper (Cu)	0.01	52	0.0108
Mercury (Hg)	0.00002	120	0.000082
Selenium (Se)	0.002	775	0.0065
Sulphate (SO_4^{2-})	429	104	493

Figure 6.9-8
Potential Habitat Alteration of Ecological Communities at Risk



NOTES:
1. BASE MAP:
2. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD 1983 UTM ZONE 10N.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:60,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
4. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENCE - BRITISH COLUMBIA AND CANADA

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KGHM
KGHM Ajax Mining Inc.

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Aquatic macrophytes are relatively tolerant to Aluminum in water. Terrestrial plant root growth can be reduced by up to 50 % in areas with high Aluminum concentrations (2.5 mg/L), though terrestrial plants have varying tolerance (Swain 1986). Aluminum levels along Humphreys Creek is not expected to affect the wetland and riparian ecosystems.

Selenium can be toxic to plants at high concentrations, though research in this area is scarce. Macrophytes are very effective in bioaccumulating Selenium, with increases in concentration occurring rapidly, sometimes within weeks (Beatty & Russo 2014). It is unlikely that Selenium levels along Peterson Creek downstream and Humphreys Creek will be sufficient to cause a negative effect as there is a lack of wetland associated plant species. Many of these exceedances can be attributed to conservative assumptions that were made within the water quality model (Appendix 6.3-C)

Ecological Risk Assessment also indicated that Project related activities pose no greater risk to plant communities than present day baseline conditions (Appendix 10.4-A).

Based on the water quality modeling completed for several wetlands present in the LSA, effects of chemical hazards on RSEC are not anticipated to occur.

6.9.4.3 Mitigation Measures for RSEC

Mitigation measures and Best Management Practices are summarized below.

General goals for the alkali saltgrass – Nutall's Alkaligrass ECAR include (BC Ministry of Water, Land and Air Protection 2004a):

- maintaining and recovering the plant community to a natural state and natural plant composition;
- minimizing or avoiding access to areas where the community is known to occur;
- preventing physical disturbance of the community;
- maintaining or restoring the community to a late seral stage, maintaining the hydrological regime in areas where the community is found;
- minimizing the introduction and spread of invasive species; and
- minimizing forest encroachment.

General goals for the water birch / roses ECAR include (BC Ministry of Water, Land and Air Protection 2004a):

- maintaining and recovering the plant community to a natural state;
- setting the following species as the Desired Plant Community: shrub cover >70%, composed of water birch (>15% cover), mountain alder (>5%), willows (as above, >7% cover), red-osier dogwood (>15% cover), poison ivy (>5% cover), roses (wood rose or Nootka rose, >5% cover), and sparse presence of star-flowered false Solomon's seal;
- managing to maintain and increase the species named above;

- maintaining or restoring natural hydrological regimes;
- allowing for natural flood cycles, sediment and nutrient deposition, and annual accumulations of plant litter;
- preventing physical disturbance, especially of soil;
- minimizing the introduction and spread of invasive species; and
- maintaining or restoring to properly functioning conditions.

Habitat Loss

During Project planning, specific mine footprints were redesigned to ensure the minimum possible impact on the surrounding environment would occur. During Construction, Project footprints will be kept to the minimum size required. At the end of mine life, during Decommissioning and Closure, habitat will be restored through reclamation and revegetation processes.

Impact avoidance and reduction mitigation proposed for the Project will be described in detail in the Wildlife/Vegetation Management Plan **(***Wildlife/Vegetation Monitoring Plan* Chapter 11.27), and will include:

- known RSEC occurrences will be used as inputs during the final design and Construction phase. Where feasible, project facilities will be placed so as to avoid direct impacts to these occurrences and habitats;
- a spatial database and maps of known RSEC locations in the vicinity of Project facilities should be maintained and consulted to avoid impacts during Operations and maintenance activities. The database should be actively updated as new information becomes available;
- exclusion areas will be created at all known RSEC occurrences located adjacent to Construction and Operation areas. These areas will be clearly flagged to discourage accidental encroachment with machines. Signage will be added where necessary to indicate the boundaries of the exclusion area (*Wildlife/Vegetation Monitoring Plan* Chapter 11.27);
- Construction personnel will attend a field-based orientation session where the exclusion areas will be explained, and the importance of avoiding disturbance within them will be stressed;
- roads and transmission lines will be designed to minimize the number of water crossings and to avoid running parallel to watercourses;
- erosion prevention and bank stabilization techniques will be used to minimize potential for secondary loss of trees after initial clearing efforts (*Erosion and Sedimentation Control Plan* Chapter 11.2); and
- avoid use of herbicide sprays within 200 m of known RSEC, and limit such use to direct application rather than broadcast sprays (except when required for invasive species control).

With the application of the above mitigation measures, residual effects will remain due to direct habitat loss. To further reduce residual effects, KAM will implement further mitigation in the form of a compensation program. The objective of the compensation program will be to achieve like-for-like offsetting of wetland function loss. Compensation efforts will initially focus on local wetlands,

including enhancement around the verges of Jacko Lake, and creation of wetland habitat in combination with fish habitat offsetting at Inks Lake. Further details of this plan are discussed in Appendix 11.21-A.

Habitat Alteration

Fugitive Dust Mitigation

Dust mitigation measures will be addressed under several management and monitoring plans. Mitigation measures to protect air quality are described in the *Air Quality Monitoring and Dust Control Plan* (Chapter 11.6). Reducing traffic by implementing the *Access Management Plan* and the *Transportation Management Plan* (Chapter 11.21, Chapter 11.20) will also reduce the potential for negative effects of dust. These measures will mitigate the potential effects of fugitive dust altering RSEC.

Invasive Species Mitigation

Development and implementation of the invasive plant species plan is integral to reducing the introduction and spread of invasive species. Avoiding introducing invasive species is central to circumventing costly measures required for their eradication to protect sensitive and Red- and Blue-listed ecological communities. Reducing traffic by implementing the *Access Management Plan* (Chapter 11.21) on site is also a key measure to help reduce the introduction of invasive plant species.

A site-specific invasive species management plan will be developed by the Project's Environmental Manager through discussion (as needed) with the Invasive Plant Council, environmental scientists, and local governing agencies. The plan will draw upon the *Invasive Alien Plant Program: Reference Guide* (BC MOFR 2010) and *Invasive Plant Pest Management Plan for the Southern Interior of British Columbia* (BC Ministry of Forests and Range 2010), which outline an Integrated Pest Management approach for invasive alien plants, under the authority of several partnering ministries.

Timely reclamation to restore affected areas after Project activities have ceased will reduce favourable conditions that could allow the establishment of invasive species. The progressive reclamation plan provides for the rapid re-vegetation of all temporarily disturbed areas and will use appropriate seed mixes that minimize the spread of invasive plants (*Wildlife/ Vegetation Monitoring Plan* Chapter 11.27). The *Wildlife/ Vegetation Monitoring Plan* (Chapter 11.27) will also include objectives for limiting invasive species, monitoring the presence and possible spread of invasive plants in temporarily disturbed areas, and monitoring the success of re-vegetation programs. Mitigation measures to reduce the spread of invasive species will include:

- prior to work commencing, surveys will be conducted to identify invasive species populations. Treatment will be initiated as required;
- all vehicles entering and leaving ground work sites will be cleaned thoroughly with special attention to wheel wells, tire treads, and tracks where mud and seeds of noxious weeds may be lodged;
- wash areas will be located away from any waterbody and riparian areas;

- used wash water will be recycled to prevent seed dispersal; and
- vehicle wash stations will be available for all vehicles entering the site.

In addition, Targeted Invasive Plant Solutions (TIPS) have been produced by the Invasive Plant Council of BC to recommend BMPs and Integrated Pest Management techniques for control of invasive plant introduction and spread (Invasive Plant Council of BC 2007, 2008). KGHM will incorporate BMP in invasive plant and noxious weed control programs developed for the Project site.

Hydrological Changes

Hydrological changes associated with Project Construction will be addressed under the *Water Management and Hydrometric Monitoring Plan* (Chapter 11.7). These measures will mitigate the potential effects of water quality on some wetlands. Wetlands along Peterson creek are expected to be substantially altered as Peterson Creek will be diverted for approximately three kilometres, altering the watercourse within the IDA. A large downstream pond is expected to be created which will alter the hydrology downstream of the pond. However, since several beaver dams are currently present along Peterson Creek inter-annual flow variation is already experienced in the downstream portion of the creek. Wetland function will be monitored along the creek outflow to determine if the diversion and the addition of the downstream pond alters the vegetation and wildlife that use the area.

Chemical Hazards

Water quality mitigation will be addressed under several management and monitoring plans: the *Surface Water Quality Management and Monitoring Plan* (Chapter 11.23), and the *Groundwater Quality Management and Monitoring Plan* (Chapter 11.24).

The BMP documents that are relevant to the Project include:

- *Best Management Practices for Amphibians and Reptiles in Urban and Rural Environments in British Columbia* (Ovaska et al. 2004);
- *Wetland Ways: Interim Guidelines for Wetland Protection and Conservation in British Columbia* (Cox & Cullington 2009);
- *Develop with Care: Environmental Guidelines for Urban and Rural Land Development in British Columbia* (BC Ministry of Environment 2012);
- Guidelines for Reduced Risk Instream Work Windows;
- *Standards and Best Practices for Instream Works* (BC Ministry of Water, Land and Air Protection 2004b); and
- Lakeshore stabilization (British Columbia Ministry of Environment 2006).

Wetland function will be monitored, and the concentration of dissolved metals will continue to be measured within Peterson Creek and Humphrey Creek. Vegetation along these wetlands will also be monitored to determine if any elements are accumulating.

6.9.5 Residual Effects and Their Significance

6.9.5.1 Summary of Residual Effects

Mitigation and reclamation to reduce the impact of the Project on RSEC cannot fully mitigate for the loss of habitat during Project Construction. Consequently, a residual effect of habitat loss is anticipated (Table 6.9-12).

Table 6.9-12. Summary of Residual Effects on RSEC

Valued Component	Project Phase (timing of effect)	Project Component/ Physical Activity	Description of Cause-Effect	Description of Mitigation Measure(s)	Description of Residual Effect
RSEC	Construction	Clearing and Grubbing, Earthworks, water divergence dams	Habitat Loss	Minimize loss; Reclamation / Revegetation	Reduction in the amount of RSEC

[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 VC.*

Implementation of management and monitoring plans associated with fugitive dust, invasive species, and hydrological changes is anticipated to mitigate for the adverse effects associated with habitat alteration. The area already experiences high levels of dust deposition, and invasive species are found throughout the LSA. The *Wildlife/Vegetation Monitoring Plan* (Chapter 11.27) includes an invasive species management plan. The *Air Quality Monitoring and Dust Control Plan* (Chapter 11.6) in combination with the *Access and Transportation and Management Plan* (Chapter 11.21 and 11.22) is expected to reduce the amount of fugitive dust outside of the IDA. Hydrological changes associated with Construction will be addressed under the *Water Management and Hydrometric Monitoring Plan* (Chapter 11.7).

No dissolved metals modelled in Jacko Lake, Peterson Creek and Humphrey Creek are expected to reach levels sufficient to cause toxicity effects to wetland associated plant species. As such, chemical hazards are not expected to have a residual effect on RSEC. Water quality mitigation will be addressed under several management and monitoring plans: the *Surface Water Quality Management and Monitoring Plan* (Chapter 11.23), and the *Groundwater Quality Management and Monitoring Plan* (Chapter 11.24).

6.9.5.2 Criteria for Characterization of Residual Effects

Specific criteria used to characterize residual effects are outlined in Section 5.2.5.2. Magnitude was assigned thresholds based on literature and professional knowledge. Negligible is a 0-5% change to available habitat in the LSA, Minor was a 5-30% change (Andren 1994), Medium was a 30-50% change and Major is a change greater than 50% (Table 6.9-13).

6.9.5.3 Characterization of Residual Effects

The overall magnitude of habitat loss is considered moderate for RSEC. Although the maximum potential effect for several Red- and Blue-listed ecological communities, wetlands and rock outcrops, is greater than 50 %. Mitigation will minimize loss of habitat to infrastructure footprints. Habitat loss will only occur sporadically, and will be restricted to the Local Study Area. The duration of this loss will depend upon reclamation activities. Reestablishment of Red- and Blue-listed communities could take more than 25 years depending on soil conditions, seed mixes and project activities, but may be reversible over the long-term. RSEC are rare on the landscape and sensitive to change so resiliency is expected to be low and ecological context is high.

6.9.5.4 Significance of Residual Effects

Excluding wetlands, 8 of 10 site series associated with at-risk ecological communities will be impacted by the clearing and grubbing, earthworks, and water management dams. Overall Construction will remove 23 to 43% (285 to 536 ha) of site series area associated with ECAR. In the IDFxh2 more than 50% of the site series associated with the Red-listed trembling aspen / common snowberry / Kentucky bluegrass community may be removed and 25 to 50 % of the site series associated with the Red-listed Douglas-fir - ponderosa pine/bluebunch wheatgrass, and western redcedar - Douglas-fir / red-osier dogwood may be lost. The remaining areas will be protected to mitigate for this loss. The duration of this effect will last beyond the life of the Project, and it is unknown if these at-risk ecological communities can be effectively recovered. The significance of the adverse residual effect of the Project on Rare and Sensitive Ecological Communities is anticipated to be not significant (moderate).

Project Construction will result in the removal of 28 to 50 % (35 to 62 ha) of wetlands (including several ha of Red and Blue-listed wetlands). It is unlikely that reclamation of the mine site will be able to fully restore wetlands on site. The effect of this loss will be far-future. A not significant (moderate) adverse residual effect is anticipated, and compensation is proposed to further mitigate this loss.

Project construction will affect 53 to 86 % (34 to 55 ha) of rock outcrops found within the LSA. This lost habitat consists entirely of the selaginella – clad lichen ecosystem. Reclamation of the mine site will include about 15 ha of outcrops to mitigate the loss of this ecosystem, and the effects of the loss could lead into the far future. Construction of the Project is anticipated to cause a not significant (moderate) adverse residual effect on rock outcrops.

Very little old-growth forest is found within the LSA (20 ha) and up to 17 % (3.2 ha) of old-growth forest may be removed during Project construction. This is considered a minor effect. Younger stands will also be earmarked as recruitment stands for future old growth.

The overall characterization of magnitude based on the indicators was moderate based on potential loss of 24 to 45% of the combined RSEC indicators (Table 6.9-13). This was primarily driven by ECAR as had the largest area potentially affected.

6.9.5.5 Characterization of Likelihood and Confidence

Characterization of residual effects is described in Table 6.9-14. Terrestrial Ecosystem Mapping is a method of mapping that uses both terrain and vegetation characteristics to classify a landscape into

map polygons. It has two components, bioterrain and ecosystems. Field studies were undertaken to confirm the accuracy of the ecosystem mapping and the presence of habitat features. Protocols for field truthing were based on the *Field Manual for Describing Ecosystems* (BC MELP and BC MOF 1998). Although TEM is a provincially standard map product it is not 100% accurate and some ecosystems are more difficult to identify and define then others.

Few occurrences of at-risk ecological communities were identified in the Project area during baseline surveys or by the BC CDC. Sites with the potential to support these listed communities within the LSA were identified using TEM. Most Red- and Blue-listed ecological communities are associated with specific site series; which have the potential to produce one or more ecosystems depending on the site specific characteristics. As such at-risk ecological communities are not necessarily present at all sites mapped as the associated site series. Due to this uncertainty confidence is low.

The likelihood of residual effects to wetlands due to habitat loss is high. The location of Project footprints is known, and while TEM is somewhat inaccurate in spatially defining wetlands due to the transitional nature of these ecosystems, residual effects are likely to occur.

Project Construction has a high likelihood of impacting rock outcrops. TEM accurately maps the location of rock outcrops. Consequently, the effects to rock outcrops are expected to occur as anticipated.

Likelihood of residual effects to old-growth is low. The locations of Project footprints are known and TEM accurately maps old-growth, so estimates of loss are accurate and the effect is expected to occur as predicted.

6.9.5.6 Summary of Residual Effects Assessment and Significance

RSEC are expected to experience a residual effect as a result of habitat loss (Table 6.9-15). Reclamation and revegetation will not be able to fully mitigate this adverse residual effect.

6.9.6 Cumulative Effects Assessment

6.9.6.1 Introduction

The cumulative effects assessment (CEA) considers the effects on RSEC that are likely to result from the residual environmental effects of the Project in combination with the effects of other projects and activities (past, present or future) within the RSA. The CEA methodology is based on the framework outlined in *Effects Assessment* Chapter 5.

Past land use has shaped much of the regions current ecosystem distribution. Many past, present and future projects have, and will continue to contribute to the amount and quality of RSECs in the RSA. Several projects have been identified as occurring in the region, and could potentially interact with the Project. Each of these projects will be considered in combination with the result of our residual effects assessment to determine if there is an interaction, and consequently, if there is the potential for a cumulative residual effect to occur. These interactions can include direct, indirect, additive and synergistic effects. To be included in the CEA projects must occur within the RSA, must

have a residual effect, and must have the potential to act cumulatively with the residual effects for RSEC described in Section 6.9.5.4.

Habitat loss was considered a residual effect for Red- and Blue-listed communities, wetlands and rock outcrops. All projects that could potentially occur in the region have been included in Table 6.9-15. Those projects that could have a residual effect associated with RSEC habitat loss will be included in the CEA.

6.9.6.2 Identification of Other Actions that May Affect RSEC

A list of past, present, and anticipated future projects and activities known to occur in the region were provided. Projects/activities were initially scoped out if there was no perceived spatial interaction (i.e., the project/activity occurs outside of the RSA). Other projects/activities were scoped into the CEA on a VC by VC basis. If a residual effect from the Project was determined, the likelihood of other projects/activities resulting in the same effect were assessed using reports generated from those projects/activities; in the absence of any data indicating specific effects, professional judgement was used. Other projects/activities considered for cumulative effects on RSEC are listed below (Table 6.9-16).

6.9.6.3 Interactions between Residual Project Effects and Other Project or Activity Effects

Habitat loss of RSEC is expected to interact with additional projects/activities in the region Figure 6.9-9). Habitat loss associated with past, present and future project activities cannot be quantified. In the majority of cases, no information is available on the historical locations of Red- and Blue-listed ecosystems, wetlands, old-growth forests and rock outcrops in the region. Consequently, a qualitative analysis was conducted to determine potential interactions based on professional judgement, location of these projects/activities, and the likelihood that RSEC will be impacted.

Agriculture and forestry has occurred in the region since the 1800s. Habitat loss associated with both of these activities is assumed to have occurred. Wetland drainage and filling associated with agriculture is responsible for 60-98% of wetland loss in southern regions of BC (Cox & Cullington 2009). Forestry is assumed to have removed areas of riparian habitat and other wetland areas, and old-growth forest. Continued active timber harvesting and agriculture expansion could remove additional wetlands from the landscape (Table 6.9-15). Due to a lack of knowledge of Red and Blue listed communities in the region, it is impossible to accurately rank the potential for these activities to

Future projects/activities, such as Kamloops city expansion or the Kinder Morgan pipeline, have not been finalized. The expansion of the city of Kamloops, specifically the growth of Aberdeen (neighbourhood adjacent to LSA), as well construction of Kinder Morgan's TransMountain pipeline, will likely result in additional loss of RSEC (Table 6.9-15). Aberdeen is expected to continue expanding, from an approximate population of 10,000 people in 2011 to over 16,000 by 2036 years (TRUE Consulting Group 2008; City of Kamloops 2012). If approved, construction of the TransMountain pipeline twinning is anticipated to commence as early as 2016.

Table 6.9-13. Definitions of Characterization Criteria for Residual Effects on RSEC

Magnitude	Duration	Frequency	Geographic Extent (Physical/Biophysical)	Reversibility	Resiliency	Ecological Context	Likelihood of Effects	
							Probability	Confidence Level
How severe will the effect be?	*How long will the effect last?*	*How often will the effect occur?*	*How far will the effect reach?*	*To what degree is the effect reversible?*	*How resilient is the receiving environment or population?*	*What is the current condition of the ecosystem and how commonly is it represented in the LSA?*	*How likely is the effect to occur?*	*How certain is this analysis?*
Negligible: No or very little detectable change from baseline conditions (>5% of available habitat in LSA).	**Short-term:** Effect lasts 1 to 5 years.	**Once:** Effect is confined to one discrete period in time during the life of the Project.	**Local:** Effect extends less than 500 m from infrastructure or activity.	**Reversible Short-term:** Effect can be reversed relatively quickly.	**Low:** The receiving environment or population has a low resilience to imposed stresses, and will not easily adapt to the effect.	**Low:** The receptor is considered to have little to no unique attributes or provision of functions is severely degraded.	**High:** It is highly likely that this effect will occur.	**High:** < 80% confidence. There is a good understanding of the cause-effect relationship and all necessary data are available for the Project area. There is a low degree of uncertainty and variation from the predicted effect is expected to be low.
Minor: Differs from the average value for baseline conditions to a small degree (5 to 30%).	**Medium-term:** Effect lasts 6 to 25 years.	**Sporadic:** Effect an effect that occurs at sporadic or intermittent intervals during any phase of the Project.	**Landscape:** Effect is limited to the LSA or one watershed (i.e., Sub-area).	**Reversible Long-term:** Effect can be reversed within 20 years of Post Closure.	**Neutral:** The receiving environment or population has a neutral resilience to imposed stresses and may be able to respond and adapt to the effect.	**Neutral:** The receiving environment considered to have some unique attributes and provides most functions that an undisturbed environment would provide.	**Medium:** This effect is likely, but may not occur.	**Medium:** 50 to 80% confidence. The cause-effect relationships are not fully understood, there are a number of unknown external variables, or data for the Project area are incomplete. There is a moderate degree of uncertainty; while results may vary, predictions are relatively confident.
Medium: Differs substantially from the average value for baseline conditions and approaches the limits of natural variation (30 to 50%).	**Long-term:** Effect lasts 26 to 50 years.	**Regular:** Effect occurs on a regular basis during the life span of the Project.	**Regional:** Effect extends across the broader region (e.g., RSA, multiple watersheds, etc.).	**Irreversible:** Effect cannot be reversed (i.e., is permanent).	**High:** The receiving environment or population has a high natural resilience to imposed stresses, and can respond and adapt to the effect.	**High:** The receiving environment or population is uncommon and occurs in a natural state and provides functions at a maximum capacity.	**Low:** This effect is unlikely but could occur.	**Low:** < 50% confidence. The cause-effect relationships are poorly understood, there are a number of unknown external variables, and data for the Project area are incomplete. High degree of uncertainty and final results may vary considerably.
Major: Differs substantially from baseline conditions, resulting in a detectable change beyond the range of natural variation (<50%).	**Far Future:** Effect lasts more than 50 years.	**Continuous:** Effect occurs constantly during the life of the Project.	**Beyond Regional:** Effect extends beyond the regional scale, and may extend across or beyond the province.					

Table 6.9-14. Characterization of Residual Effects, Significance, Likelihood and Confidence on RSEC

Valued Component	Residual Effects Characterization Criteria							Significance of Adverse Residual Effects	Likelihood and Confidence	
	Magnitude	Duration	Frequency	Geographic Extent	Reversibility	Resiliency	Context		Probability	Confidence
RSEC	Moderate	Far Future	Sporadic	Local	Reversible Long-term	Neutral	High	Not Significant (moderate)	High	Moderate

Table 6.9-15. Summary of Residual Effects, Mitigation, and Significance on RSEC

Residual Effects	Project Phase	Mitigation Measures	Significance
Habitat loss	Construction	Minimize, Reclamation, re-vegetation	Not Significant (Moderate)

Figure 6.9-9
Cumulative Effects Regional Study Area

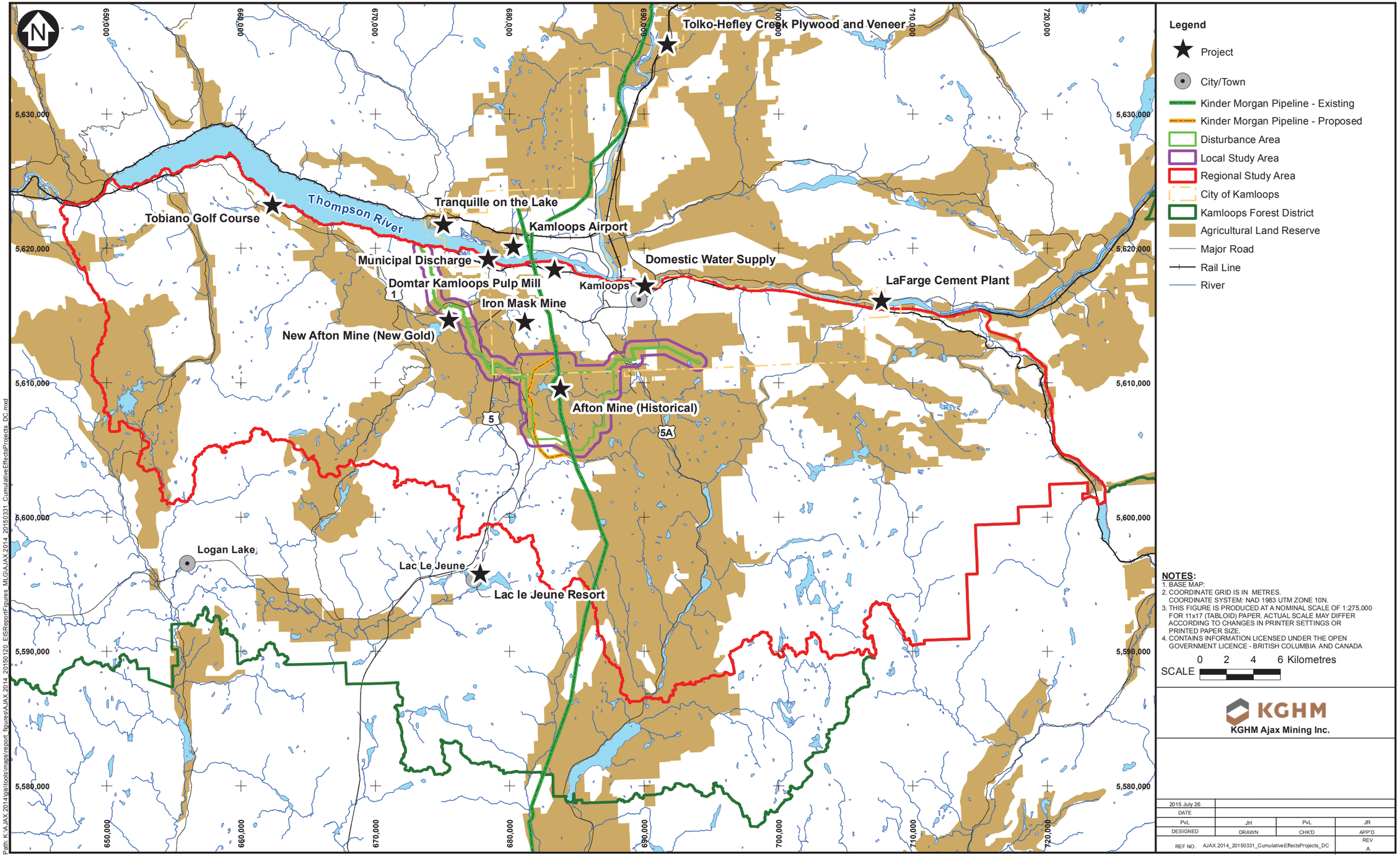


Table 6.9-16. Ranking Potential for Residual Effects to Interact Cumulatively with Effects of Other Human Activities on RSEC

	Industrial Projects/Activities													Natural Resources and Land Use			Tourism and Commercial Recreation Activities					Community Infra-structure			Transportation						
Residual Effect	Vidette Lake Mine	Afton Mine (Historical)	Iron Mask Mine	Bonaparte Mine	New Afton Mine (New Gold)	Highland Valley Copper Mine (Teck)	Domtar Kamloops Pulp Mill	Tolko-Hefley Creek Plywood and Veneer	LaFarge Cement Plant	Trans Mountain Pipeline System (Kinder Morgan)	Trans Mountain Pipeline System - Expansion (Kinder Morgan)	Harper Creek	Highland Valley Copper – Bethlehem Expansion	Kamloops Forest District	Agriculture	Ranching	Tranquille on the Lake	Lac Le Jeune Resort	Tobiano Golf Course	Recreational Hunting, Fishing, Foraging	Recreational Trails	City of Kamloops Wastewater Management	Water Treatment Centre	City Expansion and Growth	Lac le Jeune Road	Highway 1	Highway 5A	Highway 5 (Coquihalla Highway)	Kamloops Airport	Rail Yards and Lines (CP and CN)
Loss of RSEC	-	O	O	-	O	-	O	-	-	O	H	-	-	M	H	M	-	-	O	O	O	-	-	H	O	O	O	O	-	O

6.9.6.4 Proposed Mitigation Measures

It is assumed any present and future projects will take into consideration the goals and objectives outlined in the Kamloops LRMP (Kamloops Interagency Management Committee 1995) and the Nicola Thompson Fraser SFMP (SFMP Working Group 2015). 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 RSEC through planning;
- minimize all clearing dimensions during any construction activities;
- avoid the introduction and spread of invasive plants;
- avoid and/or minimize loss or alteration of ecosystem functions due to clearing activities, dust deposition, and altered hydrology; and
- ensure clearing activities are coordinated with other management plans.

Habitat Loss

Mitigation for the impacts of the Project on habitat loss includes minimizing disturbance area and mine site reclamation. The total loss of RSEC from past Projects and communities was assumed to be included in baseline. It is anticipated that this Project will contribute with other projects and activities in the RSA.

As KAM has limited authority to guide regional initiatives to support the diversity and persistence of habitat, this would be better guided by the provincial government. KAM is willing to work with organizations on higher level initiatives. Further habitat reclamation or enhancement activities including the fencing off of sensitive habitat and controlling the timing for livestock grazing in sensitive areas could return some damaged RSEC to "baseline conditions".

Habitat loss cannot fully be mitigated, and therefore will be carried forward and evaluated in Section 6.9.6.5.

6.9.6.5 Evaluation of Significance of Residual Cumulative Effects

ECAR

In the RSA approximately 293 ha (4%) of Red- and Blue-listed ecological communities within the IDFxh2 will be lost as a result of Project Construction (Table 6.9-6). Loss of ECARs from other projects within the RSA is expected to be negligible (<1%). Most of the historic loss of ECARs from conversion to agriculture is included in baseline. This is considered a minor magnitude effect. Additional surveys may be required to confirm the presence of these at-risk ecological communities in the study site, and additional mapping may be required to determine the distribution of these sites in the RSA.

Based on the estimated current distribution of Red- and Blue-listed ecological communities, the cumulative impact of the Project will be not significant (minor) (Table 6.9-17; Table 6.9-18).

Wetlands

Wetlands in the RSA have been reduced as a result of agriculture. The amount of habitat loss from Project construction is likely relatively small relative to other projects and activities. Relative to the total loss in the area, the amount of wetland lost resulting from the Project is minimal. Approximately <1 % of the wetlands in the RSA will be lost as a result of this Project. Awareness of wetland importance and stewardship are increasing offering some protection to remaining wetlands. The impact of the Project will be not significant (minor) (Table 6.9-17; Table 6.9-18).

Rock Outcrops

Less than 0.7 % of the rock outcrop habitat in the RSA will be lost as a result of Project construction. Other projects in the RSA are expected to have little to no impact on rock outcrops. The cumulative impact of the Project will be not significant (minor) (Table 6.9-17; Table 6.9-18).

6.9.7 Conclusion

RSEC were addressed as a VC to determine if an interaction with Project activities could result in an adverse residual effect. The potential effects of habitat loss, and habitat alteration were identified and evaluated in relation to anticipated Project activities. After the implementation of mitigation measures habitat loss was found to have a potential residual effect, and was assessed in combination with other projects and activities in the area to determine if a cumulative residual effect may occur as a result of Project. The summary of this assessment is presented in (Table 6.9-19).

6.9.7.1 ECAR

The primary effect of the Project on ECAR will be habitat loss. Regionally, forest removal has altered habitat that could support Red- and Blue-listed communities and has directly removed ecological communities at risk. Past activities have contributed to the current distribution of Red- and Blue-listed communities. Similarly, grazing within the RSA and trampling of wetland edge habitat by cattle directly impacts wetland Red- and Blue-listed communities and have likely played a part in the current quality of wetlands. It is difficult to determine the cumulative effect of this Project in combination with others. The greatest potential loss of Red- and Blue-listed communities as a result of the Project is in the IDFxh2 subzone, where 4 % of the at-risk communities found within the RSA will be lost as a result of Project Construction. This is considered a not significant (minor) effect.

6.9.7.2 Wetlands

Loss of wetlands is a concern to both provincial and federal governments. Environment Canada has identified the goal of maintaining wetland functions and values through a policy of no net loss of wetland function (Government of Canada 1991). Loss of wetlands within the LSA as a result of Project construction is considered a residual effect. Reclamation may reduce the total wetlands lost, but will not be able to mitigate habitat loss of wetlands completely and a compensation plan will be developed. Within the RSA less than 0.4 % of wetlands will be impacted as a result of Project Construction. This is considered a negligible effect.

6.9.7.3 Rock Outcrop

Rock outcrops are often limited in their distribution on the landscape. However, their rocky substrates have been shown to support high taxonomic richness, particularly for non-vascular plants (Vitt and Belland 1997; Sadler and Bradfield 2010), and provide specialized habitat for some wildlife species such as bats and snakes. Within the RSA 0.7 % (25 ha) of rock outcrop habitat will be lost as a result of Project Construction. This is considered a negligible effect.

6.9.7.4 Old-growth Forests

There is little (20 ha) of old-growth (structural stage 7) mapped in the LSA. There are large old veteran trees present in forests and grasslands but these isolated trees were not identified by the mapping. There is also 43 ha of OGMA delineated in the LSA. There is no overlap of the Project on these old-growth indicators and no residual effect. Regionally there is 8564 ha of OGMAs which will ensure retention of old-growth structure.

Table 6.9-17. Summary of Cumulative Effects Mitigation Measures and Residual Effects on RSEC

Ajax Project Activity	Other Human Action Activity	Description of Potential Cumulative Effect	Description of Mitigation Measure(s)	Description of Residual Cumulative Effect
Clearing and Grubbing/ Earthworks	Agriculture, Forestry, TM Pipeline, Ranching	Loss of listed communities, wetlands, old growth forest, rock outcrops	Minimize Reclamation and revegetation of mine site. compensation/ enhancement	Loss of RSEC

Table 6.9-18. Characterization of Cumulative Residual Effects, Significance, Likelihood and Confidence on RSEC

Cumulative Residual Effect	Residual Effects Characterization Criteria							Significance of Adverse Residual Effects	Likelihood and Confidence	
	Magnitude	Duration	Frequency	Geographic Extent	Reversibility	Resiliency	Context		Probability	Confidence
Loss of rare and sensitive ecological communities	Minor	Long-term	Sporadic	Regional	Reversible Long-term	Low	Neutral	Not Significant (minor)	High	Medium

Table 6.9-19. Summary of Project and Cumulative Residual Effects, Mitigation, and Significance for Rare and Sensitive Ecosystems

Residual Effects	Project Phase	Mitigation Measures	Residual Effect Significance	Residual Cumulative Effect Significance
Habitat Loss of rare and sensitive ecosystems	Construction	Avoidance through re-design where possible. Establish exclusion areas. Erosion and sediment control. Avoid use of herbicides. Invasive species management. Wetland compensation/enhancement	Not Significant (Moderate)	Not Significant (Minor)

6.10 GRASSLANDS

6.10.1 Rationale

This section includes a description of the scoping process used to identify Grasslands for inclusion in the assessment. Scoping is fundamental to focusing the Application/EIS on those issues where there is the greatest potential to cause significant adverse effects. Valued Components (VCs) are components of the natural and human environment that are considered to be of scientific, ecological, economic, social, cultural, or heritage importance. To be included in the EA, there must be a perceived likelihood that the VC will be affected by the proposed Project. Valued components are scoped into the environmental assessment based on issues raised during consultation with Aboriginal communities, government agencies, the public and stakeholders. Consideration of certain VCs may also be a legislated requirement, or known to be a concern because of previous project experience.

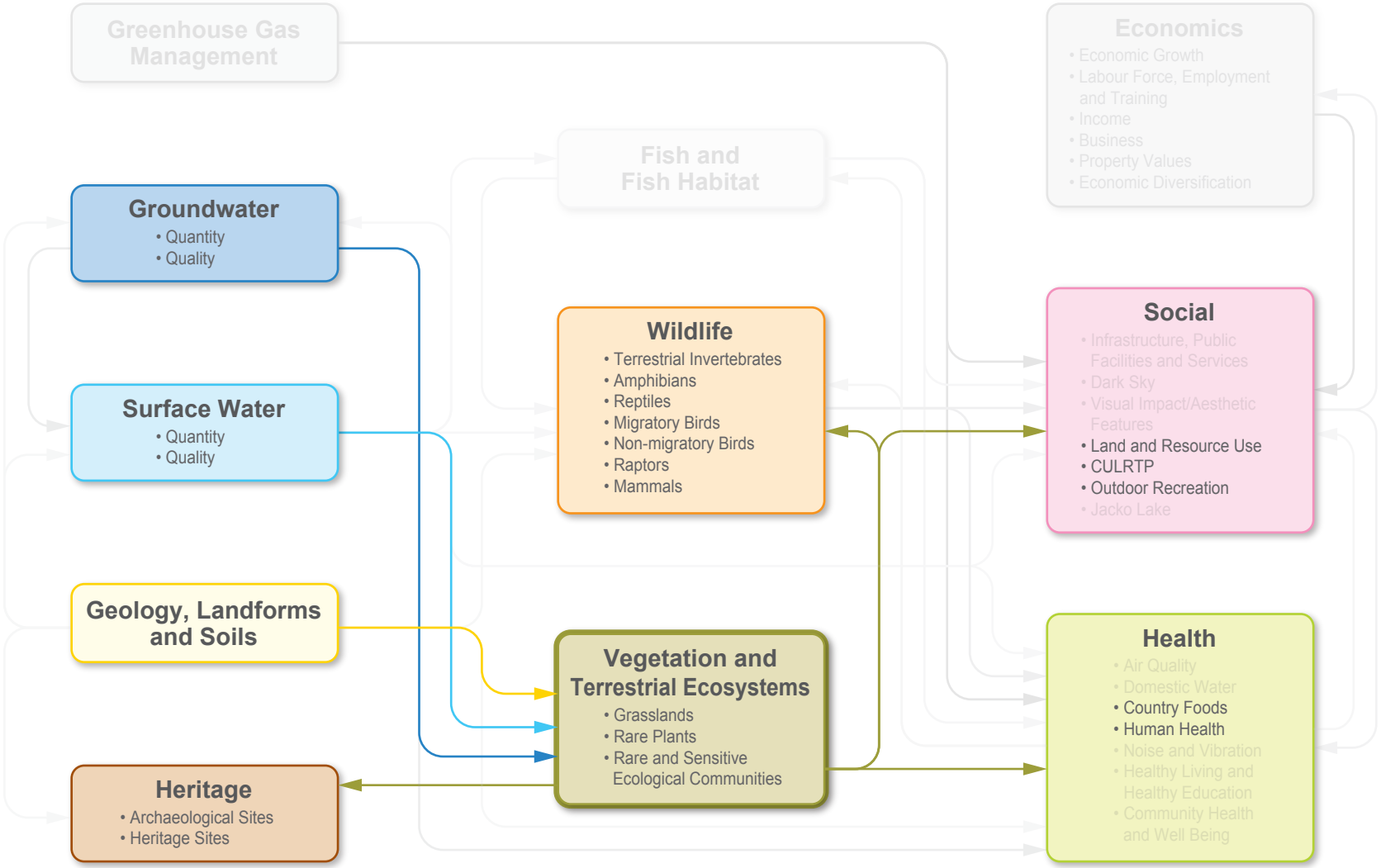
For grasslands the following was considered for inclusion as a valued component in the environmental assessment:

- Federal or provincial listing or regulation;
  - Information on actual known location records of Red or Blue-listed grassland ecological communities in or near the study area, as provided by the BC Conservation Data Centre (2010);
  - Communities of provincial concern.
- Aboriginal interest;
- Public or other stakeholder input;
- Municipal interest;
- Scientific/professional knowledge; and
- Relevant legislation or policy concerning the VC.

Grassland ecosystems are determined by surface and ground water, geology, landform and soils. The semi-arid climate and well-drained soils limit tree establishment. The assessment of effect to Grasslands is largely related to direct ground disturbance from Project activities (as described further in Section 6.10.4). The information developed to support the analysis of this VC also contributes to analyses for other VCs (Heritage (Section 9.2), Wildlife (Sections 6.11 – 6.17) and Social (Section 8.4 – 8.7) as summarized in Figure 6.10-1.

Grasslands are a very fragile ecosystem and make up less than 1% of the landmass within British Columbia. Due to the prevalence of Grasslands within the Project Area and the LSA the assessment of Grasslands is considered separately from Rare and Sensitive Ecosystems.

Figure 6.10-1
Vegetation and Terrestrial Ecology



6.10.1.1 Selection of Grasslands as a Valued Component

The VC "Grasslands" was selected as there is an expected interaction between grasslands and the Project. Specific justification for the selection of Grasslands as a VC includes:

1. Federal or provincial listing or regulation guidelines:
    a) Four grassland ecosystems that are Red or Blue-listed by the BC Conservation Data Centre (BC CDC) occur in the biogeoclimatic zones that overlap the Project;
2. Applicable government agencies (e.g., Environmental Assessment Office, Canadian Environmental Assessment Agency, Environment Canada, Ashcroft Indian Band);
3. Aboriginal interest (AIB, SSN)
4. Stakeholder input (including public):
    a) Public or other stakeholder input from the Grassland Conservation Council (GCC), Kamloops Naturalists Club, Kamloops Stockman's Association, and Kamloops and District Fish and Game Club.
        i Grasslands are able to support a diversity of plant and animal life, and they offer grazing opportunities for livestock and sites for recreational activities.
5. Information sources (baseline studies, professional judgement based on relevant best practices, *Kamloops LRMP* (1995), *Grasslands of British Columbia* (2004), and *Endangered Spaces Project: Land for Nature in the Kamloops Area* (1992);
6. Spatial scope (species range):
    a) In BC, grasslands are rare (< 1% of provincial land base), yet they provide habitat for a disproportionate amount of wildlife;
7. Temporal scope (VC exists during all stages of the Project);
8. Interaction with Project/Potential Effects (professional knowledge):
    a) Grasslands in BC are one of Canada's most endangered ecosystems (BC Ministry of Water, Land and Air Protection and Grasslands Conservation Council of BC 2004) and are vulnerable to loss or degradation as a result of Project activities.

6.10.1.2 Selection of Indicators

Grasslands were selected as an indicator based on the presence of grassland ecosystems in the Thompson Region, the availability of sufficient knowledge to produce a meaningful assessment, feedback from stakeholders and likely interactions with the Project (geographically and ecologically).

Four grassland ecosystems are Red or Blue-listed by the BC CDC (Table 6.10-1). These listed communities occur in one or more of the biogeoclimatic subzone variants present in the Project area. Since the alkali saltgrass herbaceous vegetation ecological community at risk (ECAR) is seasonally flooded, it was considered with other wetland communities under the VC "Rare and Sensitive Ecosystems" (Chapter 6.9). For the purpose of this assessment all grassland ecosystems present in the Project area will be considered together as a Valued Component.

Table 6.10-1. Red and Blue-listed Grassland Communities Potentially Occurring in the Project Area and Associated Site Series

Scientific Name	English Name	BC List	Associated Site Series		
			BGxw1	PPxh2	IDFxh2
Artemisia tridentata / Pseudoroegneria spicata	big sagebrush / bluebunch wheatgrass	Red	81ls	83ls	n/a
Festuca campestris - Pseudoroegneria spicata	rough fescue - bluebunch wheatgrass	Red	83ls/83	n/a	83
Pseudoroegneria spicata - Koeleria macrantha	bluebunch wheatgrass - junegrass	Blue	81	n/a	82
Leymus cinereus Herbaceous Vegetation	giant wildrye Herbaceous Vegetation	Red	84	n/a	n/a

Grasslands have been and continue to be a major supplier of many Aboriginal Groups cultural and other necessities for many generations (Ignace 2014). Aboriginal Groups have also used grasslands traditionally for hunting, plant gathering, travel, and settlement areas. Many plants found in grassland regions were used by Aboriginal Groups people for subsistence as well as for medicines, technology and for spiritual and ceremonial purposes (Blackstock & McAllister 2004).

Grasslands also provide habitat for species at risk including badger, Lewis' woodpecker, long-billed curlew, rubber boa, Townsend's big-eared bat, and sharp-tailed grouse.

6.10.2 Assessment Boundaries

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

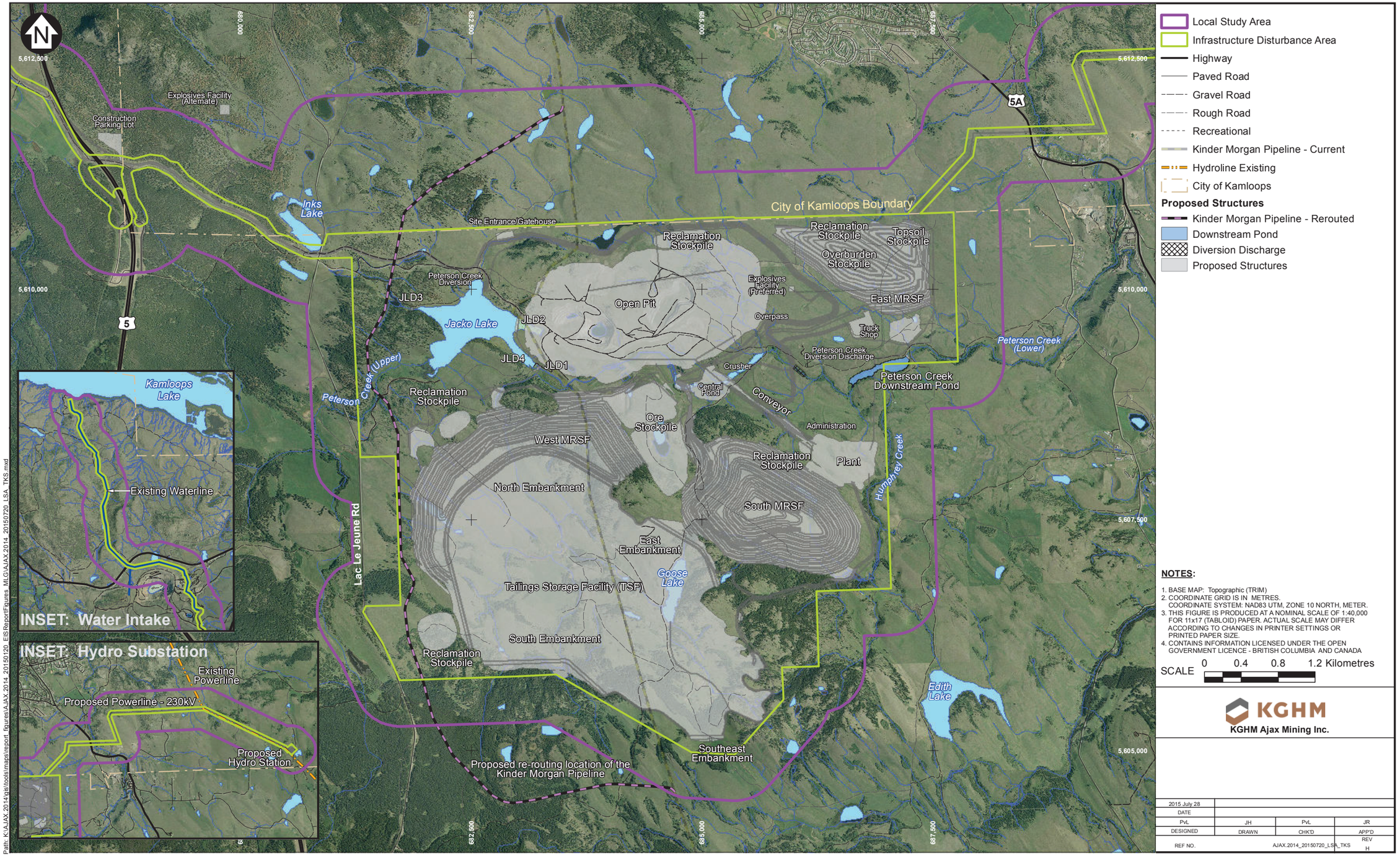
6.10.2.1 Spatial Boundaries

Infrastructure Footprints

Project infrastructure footprints (IF) include the Open Pit, ancillary buildings and facilities, roads, truck shop, Tailings Storage Facility (TSF), Water Management Ponds, Mine Rock Storage Facilities (MRSFs), and stockpiles (Figure 6.10-2). The Project infrastructure footprints are 1,705 ha in size.

The Project infrastructure footprints and linear features (transmission line and water line) were buffered by at least 50 m (Henderson 2011) to determine the Project Infrastructure Disturbance Area (IDA). The 3,185 ha IDA will be used to assess maximum direct Project effects (e.g., mortality, habitat loss, habitat alteration, etc.). The IDA includes the Project IF (1,705 ha) used to calculate direct loss of habitat, plus a 1,480 ha buffer around the Project IF that represents a zone of influence for potential disturbance associated with habitat alteration resulting from effects pathways such as contaminants, silt or dust, noxious weeds, and changes in drainage pattern (Figure 6.10-2).

Figure 6.10-2
Local Study Area, Infrastructure Disturbance Area and Project Infrastructure



NOTES:

1. BASE MAP: Topographic (TRIM)
2. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD83 UTM, ZONE 10 NORTH, METER.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:40,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
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The use of a buffered polygon area rather than individual infrastructure footprints will provide an overestimate of the direct effects of the Project for the assessment. The advantage of this approach is that it enables individual footprints to be moved and/or resized without changing the results of the effects assessment.

The IDA was modified from the General Arrangement Polygon to follow a section of the Kamloops city boundary to more accurately represent the current Project IF.

Habitat alteration by dust and water quantity is accounted for under potential habitat loss within the IDA. Areas outside of the IF that are not lost will be subject to potential alteration effects. However as plant species present in the area are adapted to the dry, dusty environmental conditions, these effects were considered mitigable.

Local Study Area

In accordance with the AIR the General Arrangement Polygon was buffered by 500 m to determine the Local Study Area (LSA). This is the expected area of potential disturbance associated with all Project facilities (BC Environmental Assessment Office 2015). The LSA is 7,167 ha and will be used to assess indirect Project effects (e.g., disturbance) and provide context on the amount of habitat available adjacent to the Project IF (Figure 6.10-2).

Regional Study Area

The Regional Study Area (RSA) is the area for which cumulative effects will be assessed. The RSA will include portions of the South Kamloops Landscape Unit and Campbell Landscape Unit, including areas south of the Thompson River and west of Highway 97 (Figure 6.10-3). Due to the proximity of the project to the City of Kamloops the RSA boundaries include the city and surrounding area within the Thompson Nicola Regional District. Landscape units were selected for the RSA as they are the geographical framework within which sustainable forest management regimes to maintain biodiversity are implemented. The RSA is 158,415 ha in size. The RSA includes Terrestrial Priority grasslands that could be affected.

Grassland mapping was completed for the province and Priority Grassland Areas were delineated in the Thompson Basin (Figure 6.10-3) (Grasslands Conservation Council (GCC) of BC 2004).

6.10.2.2 Temporal Boundaries

The temporal boundaries of the assessment will include the construction phase (short-term), operations (life of the mine), decommissioning and closure (short-term) and post-closure (short-term). The temporal phases of the Project are:

- **Construction**: 2 years (Year -2 to 1);
- **Operation**: 23 years (Year 1 to 23);
- **Decommissioning and Closure**: 5 years (Year 24 to 29, includes Project decommissioning, abandonment and reclamation activities, as well as temporary closure, and care and maintenance); and
- **Post Closure**: 5+ years (includes ongoing reclamation activities and post-closure monitoring).

6.10.2.3 Administrative Boundaries

The grasslands conservation council of British Columbia has identified ten relatively distinct ecological regions. The Project occurs in the Thompson-Pavilion region where terrestrial and riparian priority areas have been defined, with the goal to maintain these areas in a state that will allow ecosystems to function naturally (Grasslands Conservation Council of BC 2004).

6.10.2.4 Technical Boundaries

Technical limitations for the Grasslands VC include the fine scale of variation in grassland condition. Field assessments revealed that condition can vary markedly between the lower slopes, where cattle tend to congregate, and the upper slopes and crests where livestock use is lighter. A similar fine scale of variation was noted for the grassland site series, as the dominant species on grassland communities are rarely distinguishable from aerial photographs. Slope position, aspect, drainage and parent materials were the basis of grassland site series identification during the photo typing process. The differences in resolution between the field conditions and the grasslands condition assessment and TEM should be taken into account when considering the grassland VC assessment.

Terrestrial Ecosystem Mapping (TEM) was only completed within the IF since this is the area expected to directly interact with the Project and thus requires detailed mapping. Areas outside of the LSA were quantified using grassland mapping sources.

6.10.3 Background

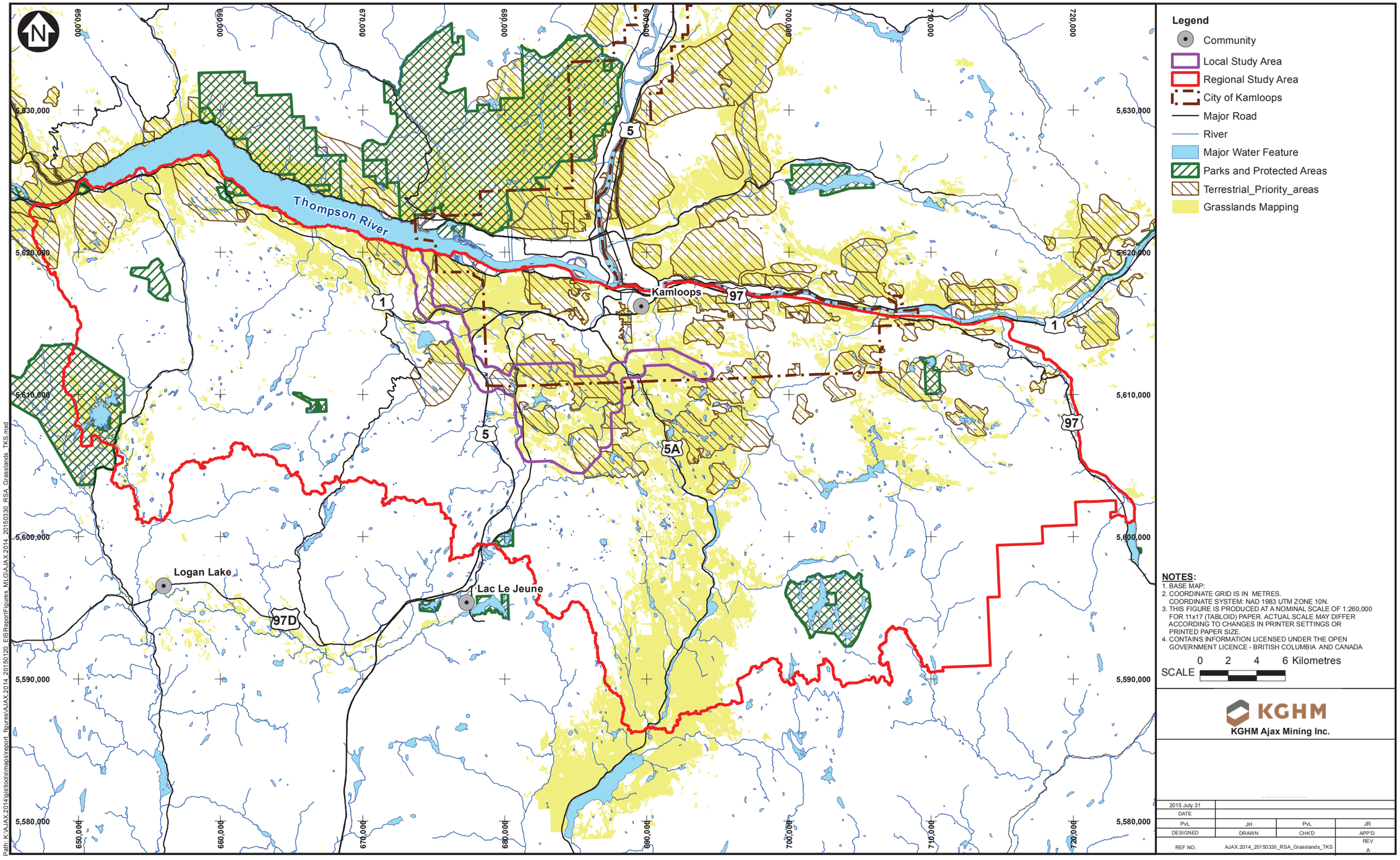
6.10.3.1 Regulatory and Policy Framework

The Kamloops Land and Resources Management Plan (LRMP) (1995) outlines that: special attention to Red and Blue-listed species should be considered; forests are to be managed to ensure diversity, as well as to ensure critical habitat is identified and managed appropriately through local level planning; and habitat improvement projects should be conducted where appropriate. Grassland management outlined in the Kamloops LRMP includes maintaining natural grassland ecosystem processes, including all grassland-dependent species.

The Grasslands Conservation Council (GCC) of British Columbia is dedicated to the stewardship and conservation of rare grasslands in BC. The three main program branches of the GCC are: education and outreach, grassland stewardship and sustainable ranching, and conservation of grasslands. This work has included the delineation of Priority Grassland areas (Grasslands Conservation Council of BC 2009; Section 6.10.3.2), and the development of several BMPs including:

- Best Management Practices for recreational activities on grasslands in the Thompson and Okanagan Basins (BC Ministry of Water, Land and Air Protection and Grasslands Conservation Council of BC 2004);
- Best Management Practices for motorized recreation on BC's grasslands (Grasslands Conservation Council of BC 2003).

Figure 6.10-3
Regional Study Area and Mapped Grasslands



6.10.3.2 Regional Overview

The Thompson Basin Ecosection area is a warm and exceptionally dry, broad low elevation basin. The vegetation in this ecosection reflects the warm, dry climate with the bunchgrass zone, mainly consisting of sagebrush-steppe and bunchgrass-steppe occupying the valley and lower slopes. Meadow-steppe and Ponderosa Pine forest are found at higher elevations, with Douglas-fir occurring on the cooler aspects and narrow draws. The pine stands have been adversely affected by the recent mountain pine beetle outbreak.

Grasslands are generally located in areas that are too dry and too hot for forests to establish (BC Ministry of Water, Land and Air Protection and Grasslands Conservation Council of BC 2004). Grasslands in the Thompson region are important for a variety of reasons. They make up 13% of all of BC's grasslands, supplying valuable grazing opportunities for livestock as well as foraging opportunities for wildlife. Grasslands provide habitat for over 30% of BC's species at risk, and they are used by Aboriginal groups for both food and medicinal plants (BC Ministry of Water, Land and Air Protection and Grasslands Conservation Council of BC 2004). The grassland type that is most prevalent in the Project area is bunchgrass, an aptly named perennial grass that grows in clumps or bunches. This grassland type is found from valley bottoms up to 1,000 m elevation (*ibid*.). Big sagebrush grassland (shrub-steppe) is also present throughout much of the study area.

Much of the LSA has been included in Priority Grasslands Conservation Areas delineated by the Grasslands Conservation Council of BC (2009). The objective of the BC Grasslands Mapping Project (Grasslands Conservation Council (GCC) of BC 2004) was to '*provide information and a clear provincial picture on the abundance, distribution and status of BC's grasslands*.' Priority ecological zone mapping was completed using a target based reserve selection method. Priority grasslands are identified grasslands of high value; values include species at risk, ranching and forage, and Aboriginal Groups heritage. The result of the Project was a Geographic Information System (GIS) layer identifying native grassland throughout the province, categorized into three priority areas: terrestrial, riparian and working landscape (See Section 6.10.3.4).

Aboriginal groups used agricultural techniques to stimulate and procure better crops on grasslands and these areas were a primary food source providing a dependable supply of roots, berries and medicines (Ignace 2014). The Secwépemc used low elevation grassland areas as a source of fresh protein and vitamins in the spring, while the Nlaka'pamux used the grasslands as a food source; hunting deer, elk, horse and sharp-tailed grouse (Ignace 2014).

6.10.3.3 Historical Activities

Historical activities considered in the section include mining, milling, pipelines, rail lines, agriculture, forestry, urban space, water treatment and recreation/tourism. Only those activities expected to interact with grasslands have been discussed here.

Several past and current projects and activities have occurred throughout the region over the past century. Mines, pipelines, rail lines, agriculture/ranching, forestry, and urban sprawl, are some of the activities that have likely reduced the quality and quantity of grasslands in the region. Reduction

of habitat function has likely occurred as a result of heavy grazing, introduction of invasive plant species and reduction of the amount of available habitat due to development.

Mining and subsequent revegetation activities has removed suitable habitats that could support grassland communities, and replaced it with unvarying habitat that focused on providing forage for wildlife and cattle as well as stabilizing disturbed areas. Given time, and colonization from neighbouring intact habitats, these areas return to native grasslands.

Construction and maintenance of pipelines and rail lines, agriculture, ranching, forestry and urban sprawl has removed grassland habitat. Furthermore, pipeline corridors and forestry roads are known to be vectors for invasive plants (BC Ministry of Forests and Range 2010), which degrade adjacent intact grasslands. Ranching and agricultural activities also physically alter grasslands through the introduction of agricultural species and soil compaction by livestock.

6.10.3.4 Baseline Studies

Baseline studies relevant to the Grasslands VC as described in the Project's AIR included the preparation of Terrestrial Ecosystem Mapping (TEM). The TEM was used to quantify and spatially locate grasslands across the LSA in order to measure the impacts of the Project on grassland habitat. The TEM was also used to map the amount of grassland site series associated with Red and Blue-listed ecosystems that are present in the LSA.

The Grasslands Council of BC has also mapped priority grassland habitat in the Thompson Region. The spatial files of the Grasslands Mapping Project were obtained from the GCC and overlain on the LSA and RSA to summarize the amount of grassland habitat within each area.

Field evaluation of grassland condition was also completed to evaluate the current condition of grassland habitat within the LSA for the purposes of the impact assessment and to guide reclamation activities. Grasslands condition assessment field surveys focused on the Project IF and took place July 15 to 18, 2010; June 4, 2011; and August 9 to 13, 2014. Grassland evaluation methodology followed that described in Delesalle et al. (2009).

Data Sources

Data sources used for this VC included:

- Terrestrial Ecosystem Mapping prepared for the Project;
- List of grassland ecosystem units described in the draft field guide for the Kamloops Forest Region;
- Spatial files from the BC Grasslands Mapping Project (Grasslands Conservation Council (GCC) of BC 2004); and
- Grassland ecosystems listed by the BC CDC as Ecological Communities at Risk (ECARs).

More details on the data sources used are provided in the Terrestrial Wildlife and Vegetation Baseline Report (Appendix 6.8-A).

Methods

Ecosystem Mapping Summaries

Quantification of grassland ecological communities was completed by theming the ecosystem map to identify polygons where any grasslands were mapped in any decile. Terrestrial Ecosystem Mapping (TEM) is a provincial method of classifying the landbase into ecosystems, which are mapped as polygons. TEM is based on standardized methodologies described in provincial standards (Resources Inventory Committee (RIC) 1996, 1998; BC Ministry of Environment 2007) and includes a terrain component (landforms and soils) as well as a vegetation component. TEM at 1:20,000 scale was completed for the LSA. The ecosystems mapped for the Project were those defined in the draft ecosystem field guide for the Southern Interior Forest Region at the time of mapping (Lloyd et al. 2005). More detailed information on TEM methodology can be found in the Terrestrial Wildlife and Vegetation Baseline Report (Appendix 6.8-A).

The spatial files of the Grasslands Mapping Project (Grasslands Conservation Council (GCC) of BC 2004) were obtained from the GCC and overlain on the Project boundaries to summarize the amount of grassland habitat within each area. Much of the Project area has been included in priority grasslands conservation areas, also delineated by the Grasslands Conservation Council of BC (2009). A grassland priority area was defined as terrestrial if most of the features used in the analysis are terrestrial. Riparian grasslands include areas with standing water (ponds, marshes and lakes) and major stream features. Working landscape grasslands include the remaining 60% of grassland areas outside of terrestrial grasslands, excluding a few grassland areas highly susceptible to degradation and destruction (e.g., within 100 m buffer of main roads) (Grasslands Conservation Council of BC 2009). Spatial boundaries of the proposed priority grasslands areas were obtained and used to quantify the amount of priority grasslands within the Project boundaries.

Grasslands Condition Assessment Surveys

An evaluation of grassland condition in Project footprint areas was carried out following methodology described by Delesalle et al. (2009). Grassland areas were given a score out of 100 based on the assessment of a variety of ecological attributes including: bunchgrass cover, cover of shrubs, cover of tall forbs, cover of medium forbs, cover of low forbs, soil crust, presence of erosion features, and presence of invasive species. Reference condition is the condition of a grassland when little or no disturbance has occurred, reflecting the influence of climate, soils, and topography. Scores higher than 75% indicate grasslands in reference condition, scores of 51-75% indicate grasslands that are “Slightly Altered,” “Moderately Altered” is indicated by 26-50%, and “Greatly Altered” by 0-25%.

Characterization of Grasslands Baseline Condition

The total amount of TEM mapped grassland and the amount of priority grassland areas have been considered separately. TEM mapped grasslands represent site series, some of which are associated with ecological communities at risk (ECAR). Priority grasslands were identified as areas with high value for multiple uses including species at risk, ranching and Aboriginal Groups. As such the objective of each map product was mutually exclusive.

Ecosystem Mapping Summaries

For the purpose of this assessment, all native grassland site series were treated as sensitive ecosystems under the broad VC category of "grasslands". Seven grassland site series are also associated with an at risk ecological community (ECAR). However, the presence of the site series does not guarantee that the site represents a current occurrence of an ECAR, merely that the site has the potential to contain the plant association. In total, 3,322 ha (55.9%) of the LSA was mapped as grassland habitat (Table 6.10-2, Figure 6.10-4). Cultivated Field and Reclaimed Mine were excluded from this analysis.

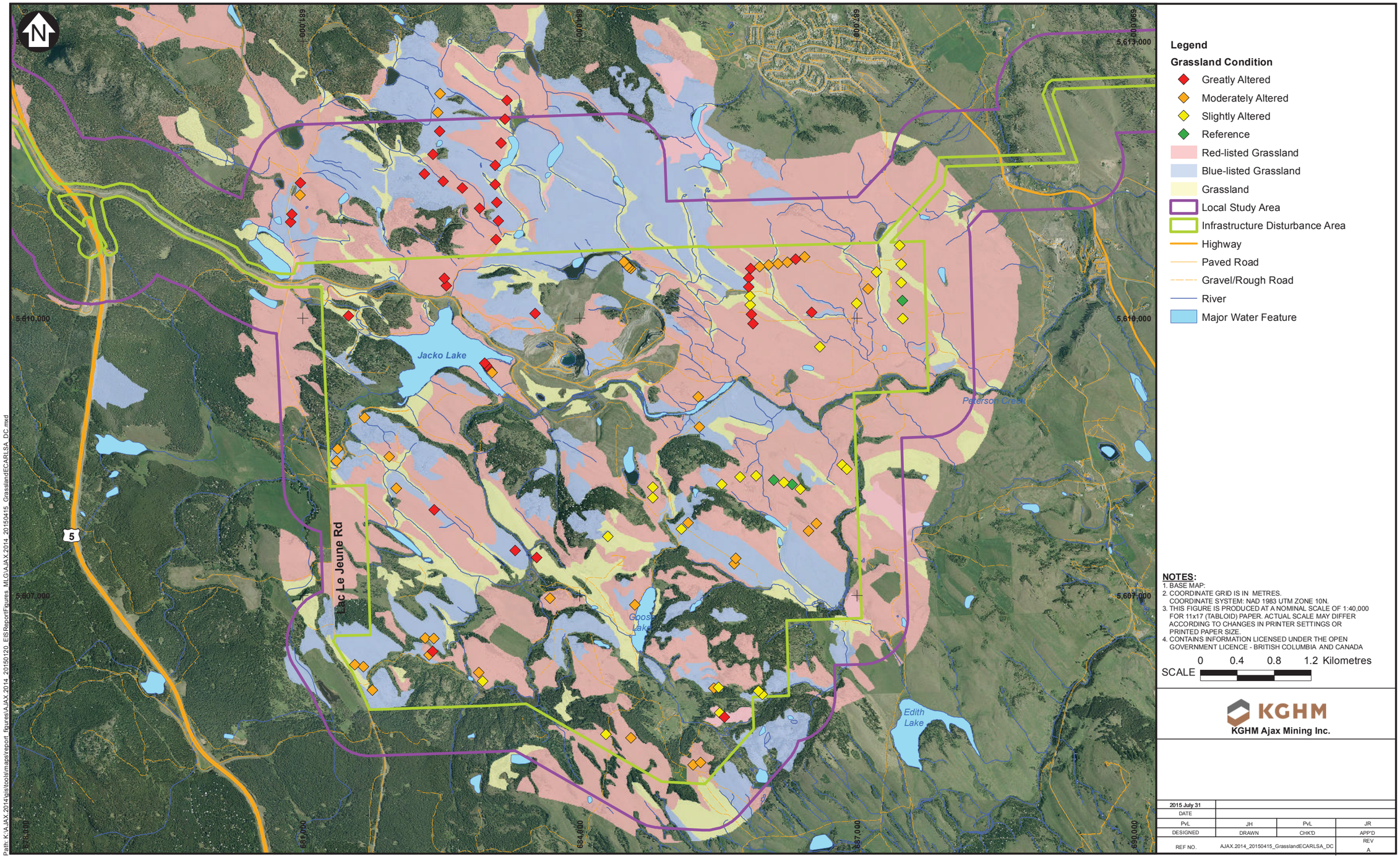
Table 6.10-2. Grasslands and Ecological Communities at Risk Mapped within the LSA

Biogeoclimatic Subzone Variant	Site Series	Name	Provincial Listing	Mapped Area (ha)	% of TEM
BGxw1	81	Bluebunch wheatgrass - Sandberg's bluegrass Big sagebrush /bluebunch wheatgrass Bluebunch wheatgrass-Junegrass	Red Blue	371.5	6.3
	82	Rabbitbrush-Bluebunch wheatgrass-Selaginella		1.6	<0.1
	83	Rough fescue Rough fescue - bluebunch wheatgrass	Red	40.4	0.7
	84	Giant wildrye - Kentucky bluegrass Giant wildrye - herbaceaous vegetation	Red	12.7	0.2
BGxw1 Total				**426.2**	**7.2**
IDFxh2	81	Rough fescue		445.3	7.5
	82	Bluebunch wheatgrass - Sandberg's bluegrass Bluebunch wheatgrass-Junegrass	Blue	845	14.2
	83	Rough fescue -Bluebunch wheatgrass	Red	1,494.5	25.1
IDFxh2 Total				**2,784.70**	**46.9**
PPxh2	82	Bluebunch wheatgrass - Sandberg's bluegrass		63.9	1.1
	83	Rough fescue -Bluebunch wheatgrass Big sagebrush /bluebunch wheatgrass	Red	42.3	0.7
	84	Rough fescue		5.2	0.1
PPxh2 Total				**111.5**	**1.9**
Total Grasslands				**3,322.40**	**55.9**

Grasslands Condition Assessment

Grassland condition assessment completed 109 plots and spot assessments in the LSA and immediate vicinity (Figure 6.10-4). For the LSA as a whole–across all 109 grassland condition plots–the average final score was 38 (Moderately Altered).

Figure 6.10-4
TEM Mapped Grasslands in the LSA



The highest average scores for grassland condition within Project IF were found in the plant site area. Six plots were completed in the plant site area, with an average score of 74 (Slightly Altered) and ranging from 51 to 94 (Table 6.10-3). The nearby ore stockpile area also averaged a Slightly Altered rating (final score average of 63); although only two plots were completed. The remaining facilities all averaged within the Moderately Altered category. The South Mine Rock Storage Facility (SWRSF) averaged a rating of 48, which was slightly higher than the East Mine Rock Storage Facility (EMRSF) at 44. The proposed pit footprint had the lowest average rating at 31.

Table 6.10-3. Summary of Grassland Condition Scores by Facility

Facility	N	Average Score*	Standard Deviation of Mean	Minimum Score	Maximum Score
Plant	6	74	13	51	94
Ore Stockpile	2	63	0	63	63
South MRSF	9	48	12	28	66
East MRSF	17	44	22	18	88
TSF	21	38	16	5	73
Pit	9	32	14	9	46
No Facility	45	28	22	2	90
Total	**109**	**38**	**22**	**2**	**94**

** Scores higher than 75% indicate grasslands in reference condition, scores of 51-75% indicate grasslands that are "Slightly Altered," "Moderately Altered" is indicated by 26-50%, and "Greatly Altered" by 0-25%.*

In general the grasslands were found to be in better condition toward the southeast portions of the Project area. The average grassland condition score for the 39 plots lying to the southeast of a diagonal line drawn through the middle of the disturbance area is 56 (Slightly Altered), while the average for the plots on the northwest side of that line is 27 (Moderately Altered).

GCC Grassland Mapping

BC Grasslands Mapping Project mapped BC's native grasslands and associated habitats. The project used existing information from around British Columbia to build a grassland Geographic Information System (GIS) and associated 1:20 000 scale maps for the whole province. Grasslands mapping filled a critical need and provided solid baseline information on a provincial scale that government, as well as wildlife, recreation and range management interests can have confidence in (Wikeem & Wikeem 2004).

Grasslands mapping delineated 38,405 ha of open grassland habitat within the RSA and 4,427 ha of habitat within the LSA (Figure 6.10-5).

Priority Grassland Mapping

In total, the Grasslands Mapping Initiative mapped 23,007 ha of terrestrial priority grasslands within the RSA, of which 2,528 ha were mapped within the LSA (Table 6.10-4, Figure 6.10-5). The mapping initiative identified both riparian priority areas and terrestrial priority areas within the LSA. Portions of nine Terrestrial Priority Grassland Areas are present within the LSA, and 57 are present in the RSA.

Table 6.10-4. Summary of Priority Grasslands Identified by the Grasslands Mapping Initiative in Relation to the Project

Classification	Ha in LSA	Ha in RSA	Ha in Thompson Basin
Riparian priority areas*	300	3,249	9,210.8
Terrestrial priority areas	2,528	23,007	110,151
Working landscape	4,202	35,604	112,040

** classifications overlap so areas are not additive.*

6.10.4 Potential Effects of the Project and Proposed Mitigation for Grasslands

6.10.4.1 Identifying Potential Effects on Grasslands

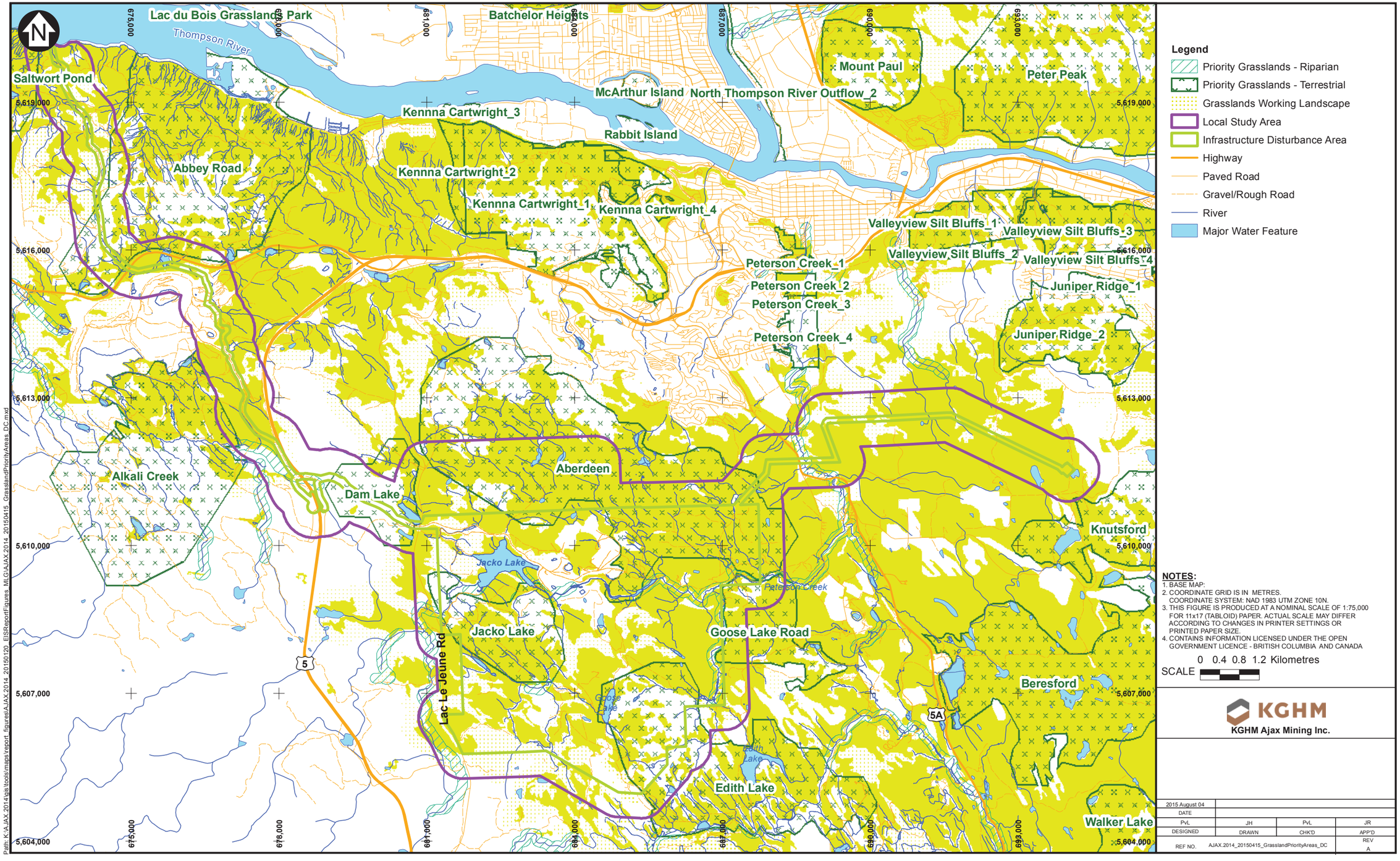
An interaction matrix (Table 6.10-5) was used to help scope potential effects by considering potential interactions with Project activities/components, consistent with the approach outlined in the assessment methodology (Section 5.2.4.1.). Further rationale for the scoping of potential effects is provided below.

Habitat Loss

For the purposes of this assessment habitat loss is defined as the process by which suitable habitat is rendered functionally unable to support vegetative structure or community. Habitat loss will occur during the construction phase of the Project, specifically during vegetation clearing, land excavation, dams for water management and any other changes to the physical landscape. Permanent loss results from the replacement of habitat by Project infrastructure footprints (IF) and is considered the minimum effect. All habitat occurring within the Project IF is assumed to be permanently lost. Habitat outside, but in close proximity to the Project IF, may not be permanently lost but is functionally compromised due to interactions with the Project IF. The IDA defines this area and is considered the maximum potential effect for habitat lost during Project construction and operation. Additional Project effects will not be considered for the Project IFs where habitat has been permanently removed (i.e., habitat cannot be altered that has already been permanently lost).

Although multiple Project activities will result in habitat loss, for the purpose of this assessment habitat loss will result from clearing and/or grubbing, earthworks and water management dams. It is assumed that all Project IFs will be cleared and/or grubbed prior to construction and all habitat overlapping Project IF will be permanently lost. Habitat reclamation during operations and closure phases is considered a habitat gain, and will not be considered under this potential effect. Several site series associated with grasslands have been mapped within the IDA and will be impacted by Project construction. A ranking of "High" was assigned for Project activities (Table 6.10-5) that will remove grasslands; and warrants analysis as described in Section 6.9.4.2.

Figure 6.10-5
Grasslands Mapping and Priority Areas



Path: K:\AJAX.2014\gis\tools\maps\report_figures\AJAX.2014_20150120_EISReportFigures_MLG\AJAX.2014_20150415_GrasslandPriorityAreas_DC.mxd

Legend

- Priority Grasslands - Riparian
- Priority Grasslands - Terrestrial
- Grasslands Working Landscape
- Local Study Area
- Infrastructure Disturbance Area
- Highway
- Paved Road
- Gravel/Rough Road
- River
- Major Water Feature

NOTES:

1. BASE MAP:
2. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD 1983 UTM ZONE 10N.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:75,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
4. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENCE - BRITISH COLUMBIA AND CANADA

0 0.4 0.8 1.2 Kilometres

SCALE

KGHM Ajax Mining Inc.

2015 August 04			
DATE			
PvL	JH	PvL	JR
DESIGNED	DRAWN	CHK'D	APP'D
REF NO.	AJAX.2014_20150415_GrasslandPriorityAreas_DC		REV A

Table 6.10-5. Identifying Potential Project Interactions and Effects on Grasslands

Project Activities		Potential Effects on Grasslands	
		Habitat Loss	Habitat Alteration
Construction	Clearing and Grubbing	H	O
	Earthworks	H	O
	Overburden/Topsoil Stockpile	O	O
	Laydown Areas and Storage Yards	O	O
	Project Lighting	O	O
	Site Security and Fencing	O	O
	Fuel Storage and Filling Area	O	O
	Hazardous Wastes Transport, Storage, and Disposal	O	L
	Construction Wastes Transport, Storage, and Disposal	O	L
	Sewage Infrastructure and Disposal	O	O
	Public Road Realignment, Use, and Maintenance	O	M
	Site Road Construction, Use and Maintenance	O	M
	Peterson Creek Overpass Construction, Use, and Maintenance	O	O
	Site Buildings and Process Plant	O	O
	Explosives Magazine and Storage Facilities	O	O
	Open Pit Development	O	O
	Drilling and Blasting	O	O
	Crushing Mine Rock	O	O
	Loading, Hauling, and Deposition of Mine Rock	O	O
	Temporary Ore Stockpile	O	O
	Tailing Storage Facility Development	O	O
	Power Transmission, Distribution	O	M
	Natural Gas Line	O	M
	Pipeline Utility Corridor (Potable Water, Sewage, and Site Water)	O	M
	Water Intake from Kamloops Lake	O	O
	Fire Suppression Infrastructure	O	O
	Contact Water	O	O
	Non-contact Water	O	O
	Peterson Creek Diversion	O	L
	Water Management Dams	M	O
	Mine Staffing (Direct Employment)	O	O
	Contracted Employment	O	O
	Taxation	O	O

	Project Activities	Potential Effects on Grasslands	
		Habitat Loss	Habitat Alteration
Operation	Open Pit Development	O	O
	Drilling and Blasting	O	O
	Hauling Mine Rock and Ore from Pit	O	O
	Crushing and Conveying Ore	O	O
	Temporary Ore Stockpile	O	O
	Development of Mine Rock Storage Facilities	O	O
	Stripping, Loading, Hauling, Deposition, and Contouring of Topsoil and Overburden	O	O
	Revegetation through Progressive Reclamation	O	O
	Process Plant Operation	O	O
	Deposition to Tailing Storage Facility	O	O
	Site Road Use and Maintenance (Materials, Personnel, Supplies)	O	M
	Concentrate Transport and Storage	O	O
	Explosives Magazine and Storage Facilities	O	O
	Fire Suppression Infrastructure	O	O
	Fuel Storage and Filling Area	O	O
	Hazardous Wastes Transport, Storage, and Disposal	O	O
	General Wastes Transport, Storage, and Disposal	O	O
	Sewage Infrastructure and Disposal	O	O
	Laydown Areas and Storage Yards	O	O
	Power Transmission, Distribution	O	M
	Project Lighting	O	O
	Site Access, Security and Fencing	O	O
	Water Intake from Kamloops Lake	O	O
	Contact Water	O	O
	Non-contact Water	O	O
	Potable Water Treatment and Use	O	O
	Peterson Creek Diversion	O	O
	Mine Staffing (Direct Employment)	O	O
	Contracted Employment	O	O
	Taxation	O	O

	Project Activities	Potential Effects on Grasslands	
		Habitat Loss	Habitat Alteration
Decommissioning and Closure	Dismantling of Ancillary Buildings	O	O
	Pit Lake Planning	O	O
	Site Road/Bridge Decommissioning	O	O
	Tailing Storage Facility Decommissioning and Reclamation	O	O
	Mine Rock Storage Facilities Reclamation	O	O
	Fuel Storage and Filling Area	O	O
	Hazardous Wastes Transport, Storage, and Disposal	O	O
	General Wastes Transport, Storage, and Disposal	O	O
	Sewage Infrastructure and Disposal	O	O
	Laydown Areas and Storage Yards	O	O
	Power Transmission, Distribution	O	M
	Project Lighting	O	O
	Site Access, Security and Fencing	O	O
	Contact Water	O	O
	Non-contact Water	O	O
	Potable Water Treatment and Use	O	O
	Peterson Creek Diversion	O	O
	Road use to the Project (Materials, Personnel, Supplies)	O	M
	Mine Staffing (Direct Employment)	O	O
	Contracted Employment	O	O
	Taxation	O	O
Post Closure	General Site Inspections and Maintenance	O	O
	Contact Water	O	O
	Non-contact Water	O	O
	Road use to the Project (Materials, Personnel, Supplies)	O	M
	Mine Staffing (Direct Employment)	O	O
	Contracted Employment	O	O

Notes:

O	*No interaction anticipated.*
L	*Negligible to minor interaction expected; implementation of best practices, standard mitigation and management measures; no monitoring required, no further consideration warranted.*
M	*Potential moderate interaction requiring unique active management/monitoring/mitigation; warrants further consideration.*
H	*Interaction; warrants further consideration.*

Habitat Alteration

Habitat alteration is defined as a reduction in habitat suitability. Activities that affect the physical characteristics of an ecosystem, either permanently or temporarily can result in a change in the vegetative structure or composition. Habitat alteration will occur throughout the construction and

operation phases of the Project, specifically as a result of drilling, blasting, crushing and road use (fugitive dust deposition), soil compaction, linear feature use and maintenance (invasive species introduction, vegetation maintenance) and changes in drainage and water quantity. Included within the IDA is a minimum 50 metre buffer between the edge of the Project IF and the IDA. This buffer incorporates habitat alteration resulting from edge effects into the maximum habitat loss effect (Gieselman et al. 2013). As all habitat within the IF will be permanently lost during initial Project construction activities (minimum effect), habitat alteration will be considered in the IDA and LSA. For the maximum habitat loss effect, habitat alteration will only be considered in the LSA.

Invasive species out-compete the native vegetation and may negatively impact grasslands. Construction and operation Project activities that may introduce invasive species include use and maintenance of site and public roads and linear corridors (power transmission, natural gas and pipeline corridors). Rankings of "High" and "Moderate" were given to road use, power transmission, pipeline utility corridor and natural gas line, warranting further analysis. The quantitative analysis of habitat alteration is described in Section 6.10.4.2.

Project activities that can result in soil compaction include earthworks; overburden stockpile; and laydown areas and storage yards. Project activities that could introduce contaminants include fuel storage and filling; hazardous waste transportation, storage and disposal; construction waste transportation, storage and disposal and contact water. Project activities that will physically alter ecosystems include vegetation maintenance along linear corridors and the Peterson creek diversion. A ranking of "low" to "moderate" was given to those Project activities (Table 6.10-5) that will physically or chemically alter a grassland, and further analysis is described in Section 6.10.4.2.

An interaction between grasslands and the Project is anticipated to lead to habitat alteration. Grasslands are particularly susceptible to invasive species.

6.10.4.2 Effects on Grasslands

For effects ranked M or H in Section 6.10.4.1 (Table 6.10-5) further analysis will be completed to quantify the impacts of Project activities on grasslands.

Habitat Loss

Methods to Predict Impacts of Project Activities on Grasslands in LSA

The amount of habitat lost for grasslands was calculated by determining the maximum and minimum potential effects. The maximum effect was calculated by overlaying the IDA footprint on the TEM grasslands, while the minimum effect was determined by overlying the Project IFs on the mapped grasslands. The potential exists for an adverse effect on the VC if grassland habitat is present within the IDA or IF. The amount of habitat lost within the IDA or IF was compared to the total amount of grasslands within the LSA to calculate the percent of grasslands lost within the LSA.

The amount of Priority Grassland lost was calculated by overlaying the IDA and IF on the grasslands map coverage produced by the BC Grasslands Mapping Initiative (Grasslands Conservation Council (GCC) of BC 2004). The mapping initiative identified both riparian priority areas and terrestrial

priority areas within the LSA. The area lost within the IDA and Project IF was then compared to the total area within the LSA to determine the percent of priority grasslands lost in the LSA.

Methods to Predict Relative Impacts of Project Activities on Grasslands in RSA

Spatial boundaries of the proposed priority grasslands areas (Grasslands Conservation Council (GCC) of BC 2004) were obtained from the GCC and used to assess the presence and distribution of priority grasslands within the RSA.

Predicted Impacts of Project Activities on Grasslands in LSA

Project activities during construction will result in the removal of up to 53% (1,002.3 to 1,777.4 ha) of grasslands within the LSA (Table 6.10-6, Figure 6.10-6). Of this area up to 1,475 ha were mapped as site series associated with an ECAR. However, the actual occurrence of ECAR in these mapped areas is likely less, since four of the six site series are associated with multiple plant communities.

Table 6.10-6. Summary of Grassland Ecosystems in the IF, IDA, and LSA

BGC Subzone Variant	Site Series	Name	BC List	Total Mapped LSA (ha)	Min Area Lost (IF) (ha)	Max Area Lost (IDA) (ha)	Range of Loss within the LSA
BGxw1	81	Bluebunch wheatgrass - Sandberg's bluegrass Big sagebrush /bluebunch wheatgrass Bluebunch wheatgrass-Junegrass	Red Blue	371.5	0.8	35.4	0 - 10%
	82	Rabbitbrush-Bluebunch wheatgrass-Selaginella		1.6	0.0	0.0	0%
	83	Rough fescue Rough fescue - bluebunch wheatgrass	Red	40.4	0.1	5.4	0 - 13%
	84	Giant wildrye - Kentucky bluegrass	Red	12.7	0.0	2.6	
BGxw1 Total				**426.2**	**0.8**	**43.5**	**0 – 10%**
IDFxh2	81	Rough fescue		445.3	183.7	294.3	41 - 66%
	82	Bluebunch wheatgrass - Sandberg's bluegrass Bluebunch wheatgrass-Junegrass	Blue	845.0	256.4	446.2	30 - 53%
	83	Rough fescue -Bluebunch wheatgrass	Red	1,494.5	561.4	986.1	38 - 66%
IDFxh2 Total				**2,784.7**	**1,001.5**	**1,726.6**	**36 – 62%**

BGC Subzone Variant	Site Series	Name	BC List	Total Mapped LSA (ha)	Min Area Lost (IF) (ha)	Max Area Lost (IDA) (ha)	Range of Loss within the LSA
PPxh2	82	Bluebunch wheatgrass - Sandberg's bluegrass		63.9	0.0	7.3	0 - 11%
	83	Rough fescue -Bluebunch wheatgrass Big sagebrush /bluebunch wheatgrass	Red	42.3	0.0	0.0	0%
	84	Rough fescue		5.2	0.0	0.0	0%
PPxh2 Total				**111.5**	**0.0**	**7.3**	**0.0**
Grand Total				**3,322.4**	**1,002.3**	**1,777.4**	**30 – 53%**

The BC Grasslands mapping initiative identified riparian priority areas, terrestrial priority areas, and working landscape areas within the LSA (Table 6.10-7, Figure 6.10-7). Terrestrial priority areas represent the full breadth and variety of grassland values. Riparian grasslands are higher order streams that contain riparian vegetation outside of terrestrial priority areas. In total up to 48% (32–143 ha) of riparian priority areas, up to 46% (671.3 to 1,150.9 ha) terrestrial priority areas, and up to 50% (1,015.5 to 2,092.8 ha) working landscape priority grasslands within the LSA will be lost as a result of Project construction. Portions of six Terrestrial Priority Grassland Areas are present within the IDA, and five within the IF (Table 6.10-8).

Table 6.10-7. List of Priority Grasslands within LSA, IDA, and IF

Classification	Area in LSA (ha)	Area in IF (ha)	Area in IDA (ha)	Range of Loss
Open Grasslands	4,427	1,095.8	1,974.9	25 – 45%
Terrestrial priority areas	2,528.2	671.3	1,150.9	27 – 46%
Riparian priority areas*	300.3	31.8	142.8	11 – 48%
Working landscape	4,202.2	1,015.5	2,092.8	24 – 50%

** classifications overlap so areas are not additive.*

Table 6.10-8. List of Terrestrial Priority Grassland Areas within the IDA and IF

Terrestrial Priority Areas	Area in LSA (ha)	Area in IF (ha)	Area in IDA (ha)	Range of Loss
Abbey Road	229.8	0	14.3	0 – 6%
Aberdeen	1,103.9	241.2	413.4	22 – 38%
Dam Lake	215.9	3.2	26.7	2 – 12%
Goose Lake Road	126.1	2.6	12.1	2 – 10%
Edith Lake	450.8	201.1	337.5	45 – 75%
Jacko Lake	361.8	223.1	346.9	62 – 96%
Total	**2,528.2**	**671.3**	**1,150.9**	**27 – 46%**

Figure 6.10-6
Loss of TEM Mapped Grasslands in the LSA

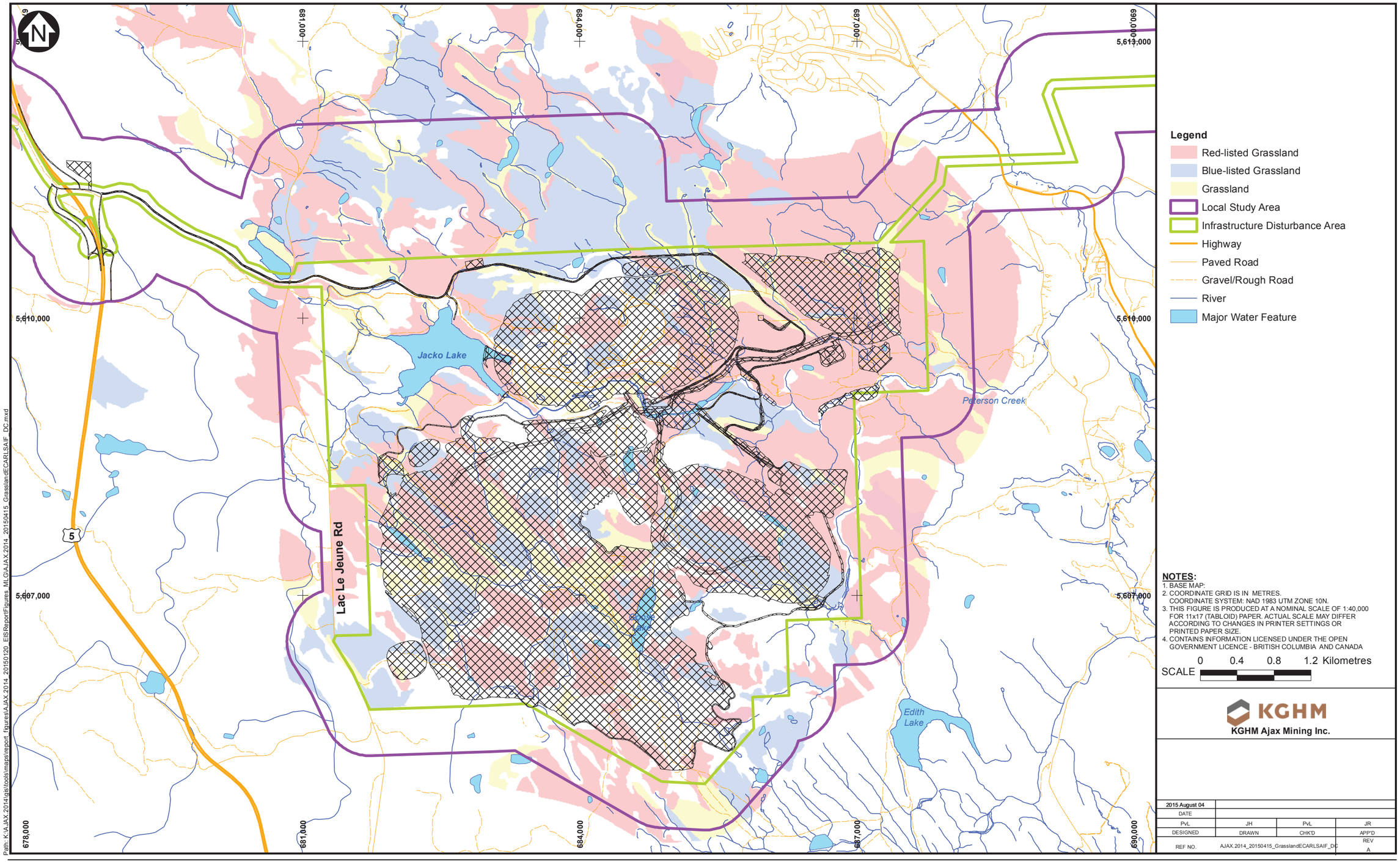
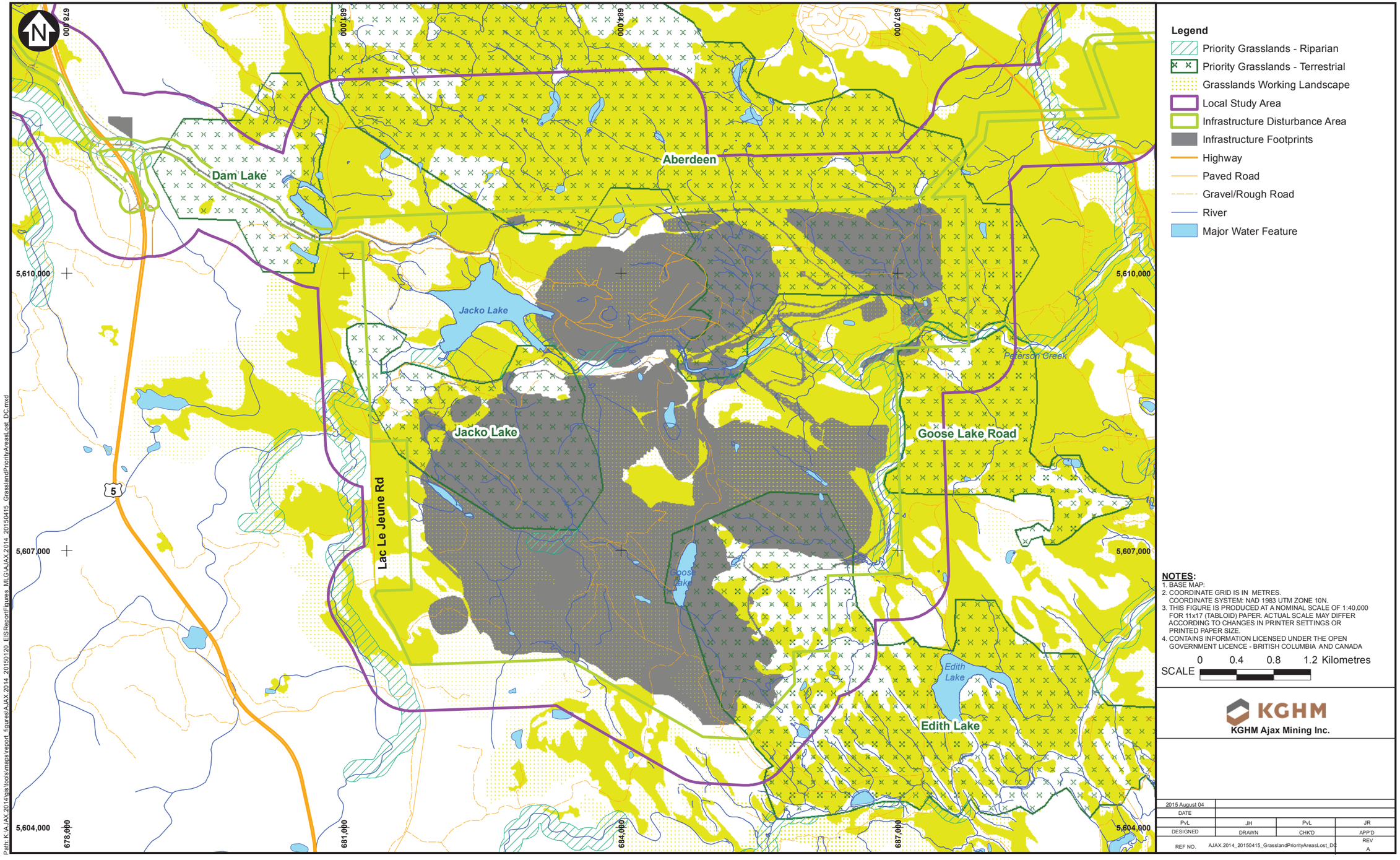


Figure 6.10-7
Loss of Grasslands Priority Areas in the LSA



The Project has the potential to affect a wide range of grasslands based on disturbance areas and grassland dominated landscape. Minor additional loss of grasslands is expected to occur during operations and closure phases. Reclamation of the project site has the potential to regain some lost habitat.

Predicted Impacts of Project Activities on Grasslands in RSA

Project construction is anticipated to remove up to 4.4% of riparian priority areas, up to 5.0% or terrestrial priority areas, and up to 5.0% of working landscape grasslands within the RSA (Table 6.10-9).

Table 6.10-9. List of Priority Grasslands within RSA, IDA and IF

Classification	Ha in RSA	Ha in IDA	Max % Lost	Ha in IF	Min % Lost
Open Grasslands	38,405	1,974.9	5.1	1,095.8	2.9
Terrestrial priority areas	23,006.7	1,150.9	5.0	671.3	2.9
Riparian priority areas	3,249.0	142.8	4.4	31.8	1.0
Working landscape	35,604.3	2,092.8	5.9	1,015.5	2.9

Habitat Alteration

Methods to Predict Impacts of Project Activities on Grasslands

Linear features (roads, pipelines, transmission lines) were buffered by 100 metres to determine the area where habitat alteration effects resulting from invasive plant species could occur. The 100 m buffer was determined based on literature review and the prominence of grassland habitat (Tyser & Worley 1992; Hansen & Clevenger 2005). This buffer was overlaid on the habitat mapping for grasslands to determine the amount of habitat affected. Habitat alteration cannot occur in areas where habitat has been lost, including the IF (minimum habitat loss effect) and the IDA (maximum habitat loss effect). The amount of suitable habitat altered is reported excluding the IF and the IDA.

Dust is not expected to alter grassland habitat. The area already experiences a high level of dust deposition, including dust storms. The additional fugitive dust created as a result of Project construction would not measurably alter or remove additional habitat outside of the Project footprints. The maximum dust fall (see Air Quality - section 10.1) is not expected to exceed the MoE guideline of 1.75 mg/dm^3/day (British Columbia Ministry of Environment 2014). As such, habitat alteration resulting from dust fall is not expected to occur.

Predicted Impacts of Project Activities on Grasslands

Road construction and maintenance operations are thought to provide conduits for the spread of exotic plants into natural areas, providing sites for seed germination and establishment (Gelbard & Belnap 2003). The power distribution and pipeline utility corridor Project activities also have the potential to damage or disturb grasslands in the LSA as well as spread invasive plant species. Construction and maintenance of pipelines and powerlines spread invasive plants (BC Ministry of Forests and Range 2010).

An additional up to 414.4 ha (up to 12.5%) of grasslands will be exposed to greater levels of invasive species and may experience habitat alteration (Table 6.10-10; Figures 6.10-8 and 6.10-9). This potential habitat alteration is limited to the BGxw1 and IDHxh2 subzone variants. This includes up to 353.3 ha of grassland habitat that could support Red and Blue-listed communities. The anticipated effect of habitat alteration to grasslands is expected to be low based on the limited amount of additional habitat affected.

6.10.4.3 Mitigation Measures for Grasslands

Mitigation measures proposed to address potential effects during all phases of the Project are discussed below.

Habitat Loss

During Project planning, specific mine footprints were designed to ensure the minimum possible impact on the surrounding environment would occur. During construction Project footprints will be kept to the minimum size required. In the short and medium-term, loss of grassland habitat can be partially compensated through enhancement of grasslands present in the LSA and RSA. KAM will partner with the City of Kamloops, the Grasslands Conservation Council of BC, local landowners, tenure holders and Aboriginal Groups to improve the function of grasslands.

Over the long-term, 1,125 ha of grassland habitat will be restored through reclamation and revegetation processes (*Landscape Restoration Plan* Chapter 11.26). Grassland habitats will be recreated to approximate the range of natural variation (i.e., slope, aspect) and species composition (bluebunch wheatgrass, rough fescue). Reclamation and revegetation will occur progressively throughout operations, closure, and post closure. Measures to mitigate the effect of habitat loss during construction, operation and closure include:

- exclusion areas will be created to preserve or enhance grassland areas outside of the Project IF (23% of mapped grasslands). These areas will be clearly flagged to discourage accidental encroachment with machines. Signage will be added where necessary to indicate the boundaries of the exclusion area;
- construction personnel will attend a field-based orientation session where the exclusion areas will be explained. Avoidance of these areas will be mandatory;
- progressive reclamation will occur to recreate grassland habitat during operation and closure;
- appropriate seed mixes will be used, as indicated in the *Landscape Restoration Plan* (Chapter 11.26). Reclamation experience at the nearby New Afton Mine indicates success with a custom-blended natural seed-mix;
- select recruitment areas from the working landscape to replace terrestrial priority grasslands effected by the Project, in consultation with the GCC;
- the *Grassland Monitoring Manual* (Delesalle et al. 2009) will be used to improve the function of grasslands outside the Project IF during operation. Measures to improve greatly altered sites include lighter stocking, longer and more effective rest periods, and improved rotational grazing. Monitoring will occur during operation and post-closure to determine the success of reclamation;
- Reclamation will target the creation of some reference condition grasslands in the LSA.

Table 6.10-10. Grasslands Potentially Impacted by Invasive Species

Biogeoclimatic Subzone Variant	Site Series	Name	BC List	Total Mapped LSA (ha)	Total Habitat in LSA Altered -Max	Max Habitat Altered (%)	Total Habitat in LSA Altered - Min	Min Habitat Altered (%)
BGxw1	81	Bluebunch wheatgrass - Sandberg's bluegrass Big sagebrush /bluebunch wheatgrass Bluebunch wheatgrass-Junegrass	 Red Blue	371.5	54.1	14.6	34.5	9.3
	82	Rabbitbrush-Bluebunch wheatgrass-Selaginella		1.6	0	0.0	0	0
	83	Rough fescue Rough fescue - bluebunch wheatgrass	 Red	40.4	8.0	19.8	6.8	16.8
	84	Giant wildrye - Kentucky bluegrass Giant wildrye - herbaceaous vegetation	 Red	12.7	0.6	4.7	0.6	4.7
BGxw1 Total				**426.2**	**62.8**	**14.7**	**41.8**	**9.8**
IDFxh2	81	Rough fescue		445.3	61.0	13.7	2.0	0.5
	82	Bluebunch wheatgrass - Sandberg's bluegrass Bluebunch wheatgrass-Junegrass	 Blue	845	76.6	9.1	2.7	0.3
	83	Rough fescue -Bluebunch wheatgrass	Red	1,494.5	214.1	14.3	12.4	0.8
IDFxh2 Total				**2,784.7**	**351.6**	**12.6**	**17.1**	**0.6**
PPxh2	82	Bluebunch wheatgrass - Sandberg's bluegrass		63.9	0	0.0	0	0.0
	83	Rough fescue -Bluebunch wheatgrass Big sagebrush /bluebunch wheatgrass	 Red	42.3	0	0.0	0	0.0
	84	Rough fescue		5.2	0	0.0	0	0.0
PPxh2 Total				**111.5**	**0**	**0.0**	**0**	**0.0**
Grand Total				**3,322.4**	414.4	12.5	58.9	1.8

A residual effect of habitat loss is expected to occur prior to reclamation.

Habitat Alteration

Fugitive Dust Mitigation

No potential effects of fugitive dust are expected to alter grasslands, nonetheless dust mitigation measures will be addressed under several management and monitoring plans. Mitigation measures to protect air quality are described in Section 10.1 and design changes to reduce dust deposition are described in the *Air Quality Technical Data Report* (Appendix 10.1-A) in the *Air Quality Monitoring and Dust Control Plan* (Chapter 11.6). Reducing traffic and speed limits by implementing the *Transportation Management Plan* and the *Access Management Plan* (Chapter 11.20, Chapter 11.21) will also reduce the potential for negative effects of dust.

Invasive Species Mitigation

Development and implementation of an *Invasive Plant Management Plan* (Chapter 11.17) are integral to reducing invasive species introduction. Avoiding the introduction of invasive species is central to circumventing costly measures required for their eradication. Reducing traffic by implementing the *Access Management Plan* (Chapter 11.21) on site is also a key measure to help reduce the introduction of invasive plant species. Grassland management that controls invasive species will improve cover of desirable plants, and result in more litter and less bare soil, these features will provide fewer opportunities for invasive plants to establish (Delesalle et al. 2009).

The invasive species management plan will manage for the priority species throughout the Project area. A site-specific plan based on the current existing plan will be developed by the Project's Environmental Manager through discussion (as needed) with the Invasive Plant Council, environmental scientists, and local governing agencies. The plan will draw upon the *Invasive Alien Plant Program: Reference Guide* (BC MOFR 2010) and *Invasive Plant Pest Management Plan for the Southern Interior of British Columbia* (BC Ministry of Forests and Range 2010), which outline an Integrated Pest Management approach for invasive alien plants, under the authority of several partnering ministries.

Immediate reclamation to restore affected areas after Project activities have ceased will reduce the establishment of invasive species, which prefer disturbed sites. The *Invasive Plant Management Plan* and the *Landscape Design and Restoration Plan* (Chapter 11.17, Chapter 26) will include objectives for limiting invasive species, monitoring the presence and possible spread of invasive plants in temporarily disturbed areas, and monitoring the success of re-vegetation programs. Mitigation measures to reduce the spread of invasive species could include:

- prior to work commencing, surveys will be conducted to identify invasive species populations. Treatment will be initiated as required;
- all vehicles entering and leaving work sites will be washed thoroughly with special attention to wheel wells, tire treads, and tracks where mud and seeds of noxious weeds may be lodged;
- wash areas will be located away from any waterbody and riparian areas;
- used wash water will be filtered to remove seeds and prevent dispersal;

Figure 6.10-8
Alteration of TEM Mapped Grasslands in the LSA

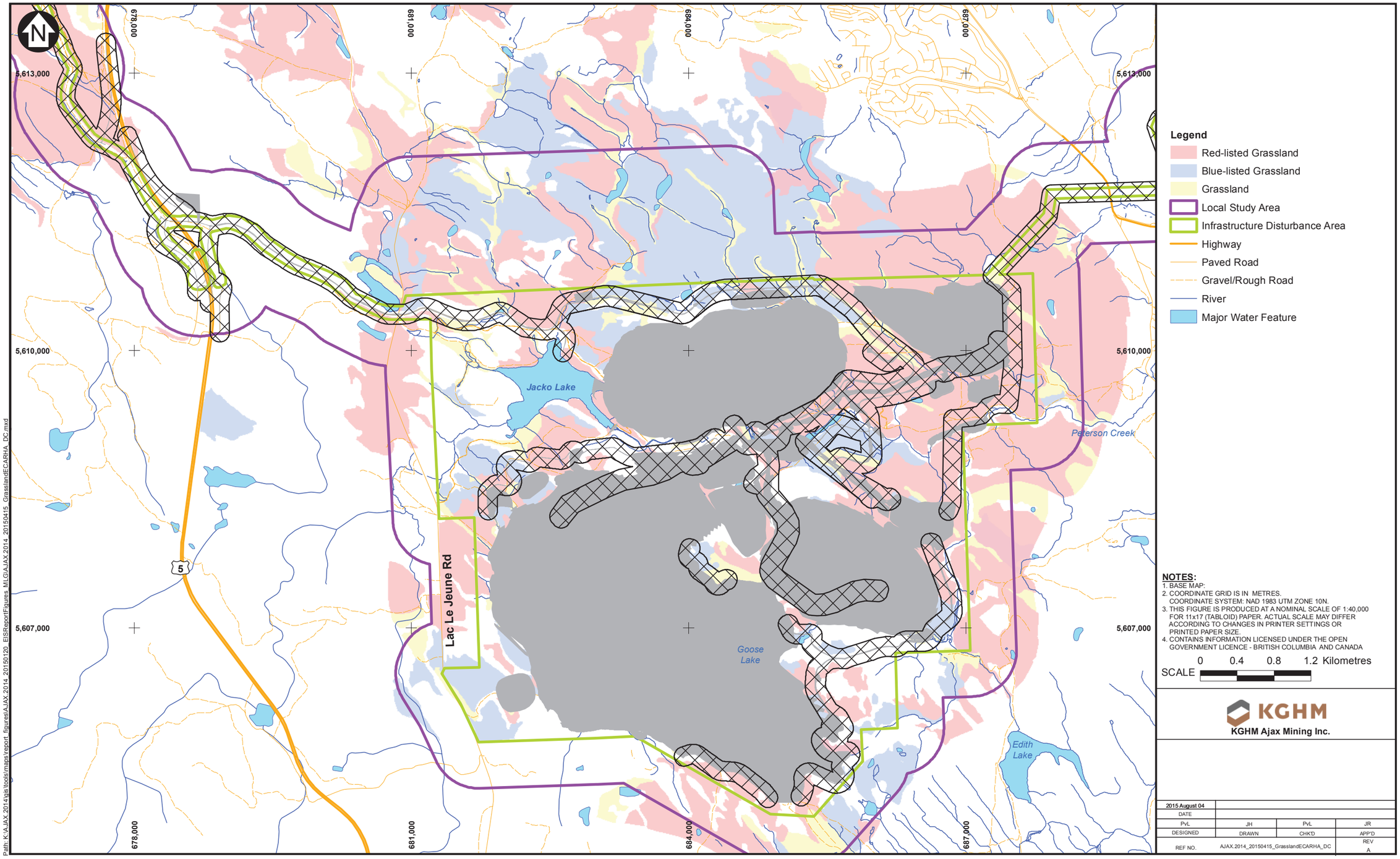
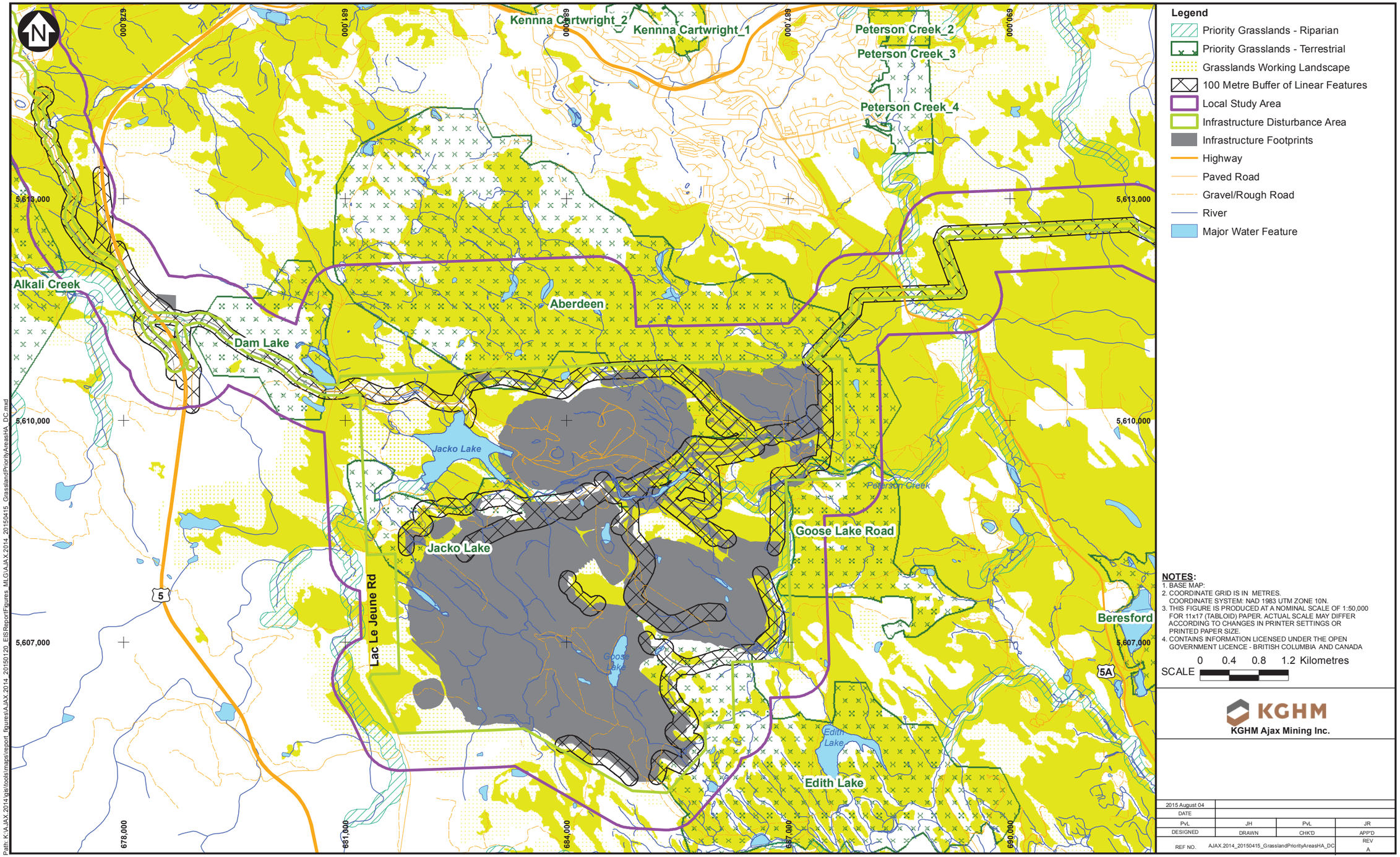


Figure 6.10-9
Alteration of Grasslands Priority Areas in the LSA



- vehicle wash station will be available for all vehicles entering the site;
- seed dispersal by grazing livestock will be prevented by limiting movement between infested and unaltered areas and allowing time for seeds to pass through the digestive system;
- rapid re-vegetation of all temporarily disturbed areas;
- use appropriate seed mixes that minimize the spread of invasive plants.

Once mitigation is in place, no adverse residual effects associated with habitat alteration is expected for grasslands.

6.10.5 Residual Effects and Their Significance

6.10.5.1 Summary of Residual Effects

Grassland habitat loss cannot be fully mitigated during Operatons from revegetation activities. Clearing and grubbing of the Project IDA is anticipated to remove grassland habitat, including Blue and red-listed grassland ecosystems, and Grassland Priority Areas defined by the Grassland Conservation Council of British Columbia. Post closure reclamation will replace 1,125 ha of grassland habitat, fully reclaiming the 1,002 ha lost during construction in the Project IF. Reclamation will focus on creating a stable landscape that will support a variety of ecosystems, ensuring equivalent capability for a variety of end land uses. Though reclamation is expected to reclaim grassland habitat, an adverse residual effect associated with habitat loss is anticipated.

Progressive revegetation and reclamation during operation cannot fully mitigate habitat loss in the medium term (25 years). Clearing and grubbing of the Project IDA is anticipated to remove up to 1,777 ha of grassland habitat, some of which will represent current occurrences of Red and Blue-listed ecological communities. Project construction will remove up to 1,150 ha defined as terrestrial priority areas by the Grassland Conservation Council of British Columbia. Loss of this habitat during construction and operations will have an adverse residual effect (Table 6.10-11).

Table 6.10-11. Summary of Residual Effects on Grasslands

Valued Component	Project Phase (timing of effect)	Project Component/ Physical Activity	Description of Cause-Effect[1]	Description of Mitigation Measure(s)	Description of Residual Effect
Grasslands	Construction	Clearing and Grubbing	Habitat Loss	Reclamation, Management	Loss of grasslands

[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 VC. Habitat alteration effects as a result of invasive species introduction can be mitigated through the implementation of an invasive species management plan. Implementation of this plan during construction and operation may help maintain existing occurrences of invasive species in the LSA and as such may have a net positive effect. No residual effects of habitat alteration are anticipated.*

6.10.5.2 Criteria for Characterization of Residual Effects

Criteria for characterization of residual effects are defined in Table 6.10-12. Specific criteria used to characterize residual effects are outlined below.

6.10.5.3 Characterization of Residual Effects

Characterization of residual effects is described in Table 6.10-13. The magnitude of habitat loss is considered moderate, as about 30% of grassland habitat within the LSA, including at-risk ecological communities, and 27% of terrestrial priority grasslands in the LSA, will be lost as a result of Project construction. Habitat loss will only occur sporadically as a result of clearing and grubbing activities during Project construction, and will be localized to the Project IDA. The duration of this loss will be long-term, as reclamation of grasslands will occur during the closure and post closure phases of the Project. The effect is considered reversible in the long-term since 1,125 ha of grasslands will be reclaimed. Reclamation will emulate the surrounding terrain and post-mine landscape features will be used to replicate pre-disturbance diversity. Grasslands should be able to "adapt" to this habitat loss with time, therefore the resiliency is neutral. With the exception of the Plant and Ore stockpile sites, the average grassland condition score of Project IF was determined to be moderately or greatly altered, as are the grasslands in much of the surrounding landscape. Although 818 ha were mapped as site series associated with an ECAR, the actual proportion of these areas that contain a current occurrence of a red- or blue-listed ecological community will be less, since each site series can produce more than one plant association. Since the overall ecological integrity of grasslands in the LSA is low, but ECAR may be present, the ecological context is neutral (Table 6.10-13).

6.10.5.4 Significance of Residual Effects

Habitat loss is anticipated to have a not significant (moderate) effect on grasslands within the LSA. Although the magnitude of the effect is expected to be medium, reclamation will restore 1,125 ha of grassland habitat in the long-term. In the short and medium term incorporating monitoring and management methods from the Grasslands Monitoring Manual (Delesalle et al. 2009) will improve grassland function in the LSA and RSA for multiple end uses, while progressive reclamation will provide grassland habitat within the IDA during operations.

The end land use and capability objective of the reclamation plan is based on the principle of ecological replacement, where landscapes are designed to have similar functional characteristics. Reclamation will include planned grazing systems which will exclude cattle from key wildlife areas. Reclamation of reference condition grasslands in the IDA will be an improvement from baseline conditions.

6.10.5.5 Characterization of Likelihood and Confidence

The probability that an adverse residual effect will occur on grasslands as a result of habitat loss is high. Clearing and grubbing of the IDA will remove grasslands present in the IF during construction.

Detailed TEM, consultation of Priority Grassland Areas combined with professional judgement results in a high degree of certainty from the predicted effects to grasslands. The effect of the Project on grassland ECARs has a lesser degree of certainty. ECAR are associated with mapped site series, but each site series can produce multiple plant associations, only one of which is an ECAR. Four of six grassland site series in the LSA are associated with two or more plant communities. Although the effect of the Project on ECAR is uncertain, the total area affected will be less than the total grassland habitat loss.

Table 6.10-12. Definitions of Characterization Criteria for Residual Effects on Grasslands

Magnitude	Duration	Frequency	Geographic Extent (Physical/Biophysical)	Reversibility	Resiliency	Ecological Context	Likelihood of Effects	
							Probability	Confidence Level
How severe will the effect be?	*How long will the effect last?*	*How often will the effect occur?*	*How far will the effect reach?*	*To what degree is the effect reversible?*	*How resilient is the receiving environment or population?*	*What is the current condition of the ecosystem and how commonly is it represented in the LSA?*	*How likely is the effect to occur?*	*How certain is this analysis?*
Negligible: No or very little detectable change from baseline conditions.	**Short-term:** Effect lasts 1 to 5 years.	**Once:** Effect is confined to one discrete period in time during the life of the Project.	**Local:** Effect extends less than 500 m from infrastructure or activity.	**Reversible Short-term:** Effect can be reversed relatively quickly.	**Low:** The receiving environment or population has a low resilience to imposed stresses, and will not easily adapt to the effect.	**Low:** The receptor is considered to have little to no unique attributes or provision of functions is severely degraded.	**High:** It is highly likely that this effect will occur.	**High:** < 80% confidence. There is a good understanding of the cause-effect relationship and all necessary data are available for the Project area. There is a low degree of uncertainty and variation from the predicted effect is expected to be low.
Minor: Differs from the average value for baseline conditions to a small degree.	**Medium-term:** Effect lasts 6 to 25 years.	**Sporadic:** Effect an effect that occurs at sporadic or intermittent intervals during any phase of the Project.	**Landscape:** Effect is limited to the LSA or one watershed (i.e., Sub-area).	**Reversible Long-term:** Effect can be reversed within 20 years of Post Closure.	**Neutral:** The receiving environment or population has a neutral resilience to imposed stresses and may be able to respond and adapt to the effect.	**Neutral:** The receiving environment considered to have some unique attributes and provides most functions that an undisturbed environment would provide.	**Medium:** This effect is likely, but may not occur.	**Medium:** 50 to 80% confidence. The cause-effect relationships are not fully understood, there are a number of unknown external variables, or data for the Project area are incomplete. There is a moderate degree of uncertainty; while results may vary, predictions are relatively confident.
Medium: Differs substantially from the average value for baseline conditions and approaches the limits of natural variation.	**Long-term:** Effect lasts between 26 and 50 years.	**Regular:** Effect occurs on a regular basis during the life span of the Project.	**Regional:** Effect extends across the broader region (e.g., RSA, multiple watersheds, etc.).	**Irreversible:** Effect cannot be reversed (i.e., is permanent).	**High:** The receiving environment or population has a high natural resilience to imposed stresses, and can respond and adapt to the effect.	**High:** The receiving environment or population is uncommon and occurs in a natural state and provides functions at a maximum capacity.	**Low:** This effect is unlikely but could occur.	**Low:** < 50% confidence. The cause-effect relationships are poorly understood, there are a number of unknown external variables, and data for the Project area are incomplete. High degree of uncertainty and final results may vary considerably.
Major: Differs substantially from baseline conditions, resulting in a detectable change beyond the range of natural variation.	**Far Future:** Effect lasts more than 50 years.	**Continuous:** Effect occurs constantly during the life of the Project.	**Beyond Regional:** Effect extends beyond the regional scale, and may extend across or beyond the province.					

Table 6.10-13. Characterization of Residual Effects, Significance, Likelihood and Confidence on Grasslands

Residual Effect	Residual Effects Characterization Criteria							Significance of Adverse Residual Effects	Likelihood and Confidence	
	Magnitude	Duration	Frequency	Geographic Extent	Reversibility	Resiliency	Context		Probability	Confidence
Habitat Loss	Medium	Long-term	Sporadic	Local	Reversible Long-term	Neutral	Neutral	Not Significant (Moderate)	High	Medium

The ability of reclamation efforts to restore grasslands is also uncertain. Studies indicate that grassland restoration projects are often unable to fully restore all aspects of species diversity (Martin et al. 2005). In particular, restoration efforts have been unable to reproduce the species richness and composition of native sites (Kindscher & Tieszen 1998). Although reclamation will target recreation of the baseline diversity in grassland sites the ability to replicate the diversity found in natural reference condition grasslands is unknown. Field assessment found few reference condition grasslands in the study area so attempts to recreate the grasslands currently present in the study area will likely be successful. Therefor representative grassland habitats in the LSA will be maintained.

Based on this information the confidence is medium, since the occurrence of ECAR and success of reclamation efforts are not fully understood.

6.10.5.6 Summary of Residual Effects Assessment and Significance

Habitat loss is anticipated to have a not significant (moderate) effect on grasslands (Table 6.10-14). Mitigation will not be able to fully reclaim the habitat lost during project construction.

Table 6.10-14. Summary of Residual Effects, Mitigation, and Significance on Grasslands

Residual Effects	Project Phase	Mitigation Measures	Significance
Habitat Loss of grasslands	Construction	Reclamation, Compensation	Not Significant (Moderate)

6.10.6 Cumulative Effects Assessment

6.10.6.1 Introduction

The cumulative effects assessment (CEA) considers the effects on grasslands that are likely to result from the residual environmental effects of the Project in combination with the effects of other projects and activities (past, present or future) within the RSA. The CEA methodology is based on the framework outlined by the *Canadian Environmental Assessment Act* (1992) guidelines (Hegmann, Cocklin, Creasy, et al. 1999) with additional guidance provided in the AIR.

Past land use has shaped much of the regions current grassland distribution, and, in turn, has shaped how grassland species makes use of the landscape. Many past, present and future projects have, and will continue to contribute to the amount and quality of grassland habitat in the RSA. Several projects have been identified as occurring in the region, and could potentially interact with the Project. Each of these projects will be considered in combination with the result of our residual effects assessment to determine if there is an interaction, and consequently, if there is the potential for a cumulative residual effect to occur. These interactions can include direct, indirect, additive and synergistic effects. To be included in the CEA projects must occur within the RSA, must have a residual effect, and must have the potential to act cumulatively with the residual effects for grasslands described in Section 6.10.5.

Habitat loss was considered a residual effect for grasslands. All projects that could potentially occur in the region have been included in Table 6.10-15. Those projects that could have a residual effect associated with grassland habitat loss should be included in the CEA.

Table 6.10-15. Ranking Potential for Residual Effects to Interact Cumulatively with Effects of Other Human Actions on Grassland

Residual Effect	Industrial Projects/Activities													Natural Resources and Land Use			Tourism and Commercial Recreation Activities					Community Infrastructure			Transportation						
	Vidette Lake Mine	Afton Mine (Historical)	Iron Mask Mine	Bonaparte Mine	New Afton Mine (New Gold)	Highland Valley Copper Mine (Teck)	Domtar Kamloops Pulp Mill	Tolko-Hefley Creek Plywood and Veneer	LaFarge Cement Plant	Trans Mountain Pipeline System (Kinder Morgan)	Trans Mountain Pipeline System - Expansion (Kinder Morgan)	Harper Creek	Highland Valley Copper – Bethlehem Expansion	Kamloops Forest District	Agriculture	Ranching	Tranquille on the Lake	Lac Le Jeune Resort	Tobiano Golf Course	Recreational Hunting, Fishing, Foraging	Recreational Trails	City of Kamloops Wastewater Management	Water Treatment Centre	City Expansion and Growth	Lac le Jeune Road	Highway 1	Highway 5A	Highway 5 (Coquihalla Highway)	Kamloops Airport	Rail Yards and Lines (CP and CN)
Habitat Loss	-	O	O	-	O	-	O	-	-	O	M	-	-	L	M	L	-	-	O	O	O	-	-	M	O	O	O	O	-	O

6.10.6.2 Identification of Other Actions that May Affect Grasslands

A list of past, present, and anticipated future projects and activities known to occur in the region were provided. Projects/activities were initially scoped out if there was no perceived spatial interaction (i.e., the project/activity occurs outside of the RSA). Other projects/activities were scoped into the CEA on a VC by VC basis. If a residual effect from the Project was determined, the likelihood of other projects/activities resulting in the same effect were assessed using reports generated from those projects/activities; in the absence of any data indicating specific effects, professional judgement was used. Other projects/activities considered for cumulative effects on grasslands are listed below (Table 6.10-15, Figure 6.10-10).

6.10.6.3 Interactions between Residual Project Effects and Other Project or Activity Effects

Habitat loss of grasslands is expected to interact with additional projects/activities in the region. Habitat loss associated with past, present and future project activities cannot be quantified in the RSA. In the majority of cases, no information is available on total habitat loss. Consequently, a qualitative analysis was conducted to determine potential interactions based on professional judgement, location of these projects/activities, and the likelihood that grasslands will be impacted.

Agriculture has occurred in the region since the 1800s. Agriculture has converted fertile grassland habitats into commercial crops, and lower quality rangeland, and would continue to do so if agriculture expands in the RSA. Approximately 11.8% (14,790 ha) of grasslands in the Thompson Basin has been lost to agricultural conversion (Grasslands Conservation Council (GCC) of BC 2004). Over 6.7% (9,000 ha) of native grassland have been lost to urban and industrial development in the Thompson Basin, with the majority of this loss occurring within the Municipal boundaries of the City of Kamloops. Due to a lack of knowledge of historical grassland locations in the region, it is impossible to accurately rank the potential for these activities to interact cumulatively with the project. A ranking of "High" was given due to this knowledge gap.

Future projects/activities, such as Kamloops city expansion or the Kinder Morgan pipeline, have not been finalized, and therefore, footprints are not available. The expansion of the city of Kamloops, specifically the growth of Aberdeen (neighbourhood adjacent to LSA), and the construction of Kinder Morgan's TransMountain pipeline, will likely result in the loss of grasslands in the RSA. Aberdeen is expected to continue expanding, from an approximate population of 10,000 people in 2011 to over 16,000 by 2036 (TRUE Consulting Group 2008; City of Kamloops 2012). If approved, construction of the TransMountain pipeline twinning is anticipated to commence as early as 2016. The amount of grassland habitat that will be lost as a result of this future development is unknown. A ranking of "High" was given to both these actions due to the knowledge gap.

6.10.6.4 Proposed Mitigation Measures

<u>Habitat Loss</u>

Mitigation for the impacts of the Project on habitat loss consisted of mine site reclamation. In the short and medium-term, loss of grassland habitat can be partially compensated through enhancement of grasslands present in the LSA and RSA. KAM will partner with the City of Kamloops, the Grasslands Conservation Council of BC, local landowners, tenure holders and Aboriginal Groups to improve the function of grasslands. Further habitat reclamation or

enhancement activities includes working with local ranchers to implement best management practices, providing incentives to fence off of grasslands and control the timing for livestock grazing in sensitive areas could return some damaged grasslands to "baseline conditions".

Habitat loss cannot fully be mitigated, and therefore will be carried forward and evaluated in Section 6.10.6.5.

6.10.6.5 Evaluation of Significance of Residual Cumulative Effects

After the implementation of mitigation measures, one residual effect is anticipated to occur. The loss of grasslands, including Red and Blue-listed communities, and Priority Grassland Areas, cannot be mitigated and may result in a cumulative effect (Table 6.10-16).

Table 6.10-16. Summary of Cumulative Effects Mitigation Measures and Residual Effects on Grasslands

Ajax Project Activity	Other Human Action Activity	Description of Potential Cumulative Effect	Description of Mitigation Measure(s)	Description of Residual Cumulative Effect
Clearing and Grubbing	Construction of other projects and activities	Loss of grasslands	Reclamation/ enhancement of suitable habitat	Reduction of the amount of grassland

Loss of grasslands has and will continue to occur in the region if anticipated projects and urban expansion continue as expected.

Loss of habitat has occurred as a result of agriculture. Additional habitat is expected to be lost as a result of Kamloops city expansion and growth, as well as the twinning of the Kinder Morgan Pipeline. The magnitude of grassland habitat loss in the RSA cannot be quantified, as limited information is available on historical grassland distribution. The magnitude of habitat loss for priority grassland area in the RSA as a result of the Project was considered Minor (<3%; Section 6.10.5). Habitat loss will only occur once as a result of vegetation clearing, but has occurred throughout the RSA. The duration of this loss will depend upon reclamation activities. Reestablishment of grasslands could take up to 25 years depending on soil conditions, seed mixes and project activities, but is reversible over the long-term. Grasslands may be able to "adapt" to this habitat loss, therefore the resiliency is neutral. The current condition of the grasslands in the LSA considered "Moderately Altered", and it is expected that grasslands in the RSA would be similar, therefore the context is neutral. The likelihood or probability that grassland habitat loss has occurred in the RSA is high. Approximately 18.5% of Grasslands in the Thompson Basin has been lost to agriculture and urbanization (Grasslands Conservation Council (GCC) of BC 2004). Confidence was ranked low for the characterization of cumulative residual effects (Table 6.10-17).

6.10.7 Conclusion

Grasslands were assessed as a VC to determine likely interactions with specific Project activities, and how these interactions could result in an adverse effect. All potential effects, habitat loss and habitat alteration, arising from each Project activity were identified and evaluated. After the implementation of mitigation measures, habitat loss was found to have a potential residual effect and was assessed for potential interactions with other projects/activities, past, present, and future, occurring within the region (Table 6.10-18).

Figure 6.10-10
Grassland Cumulative Effects

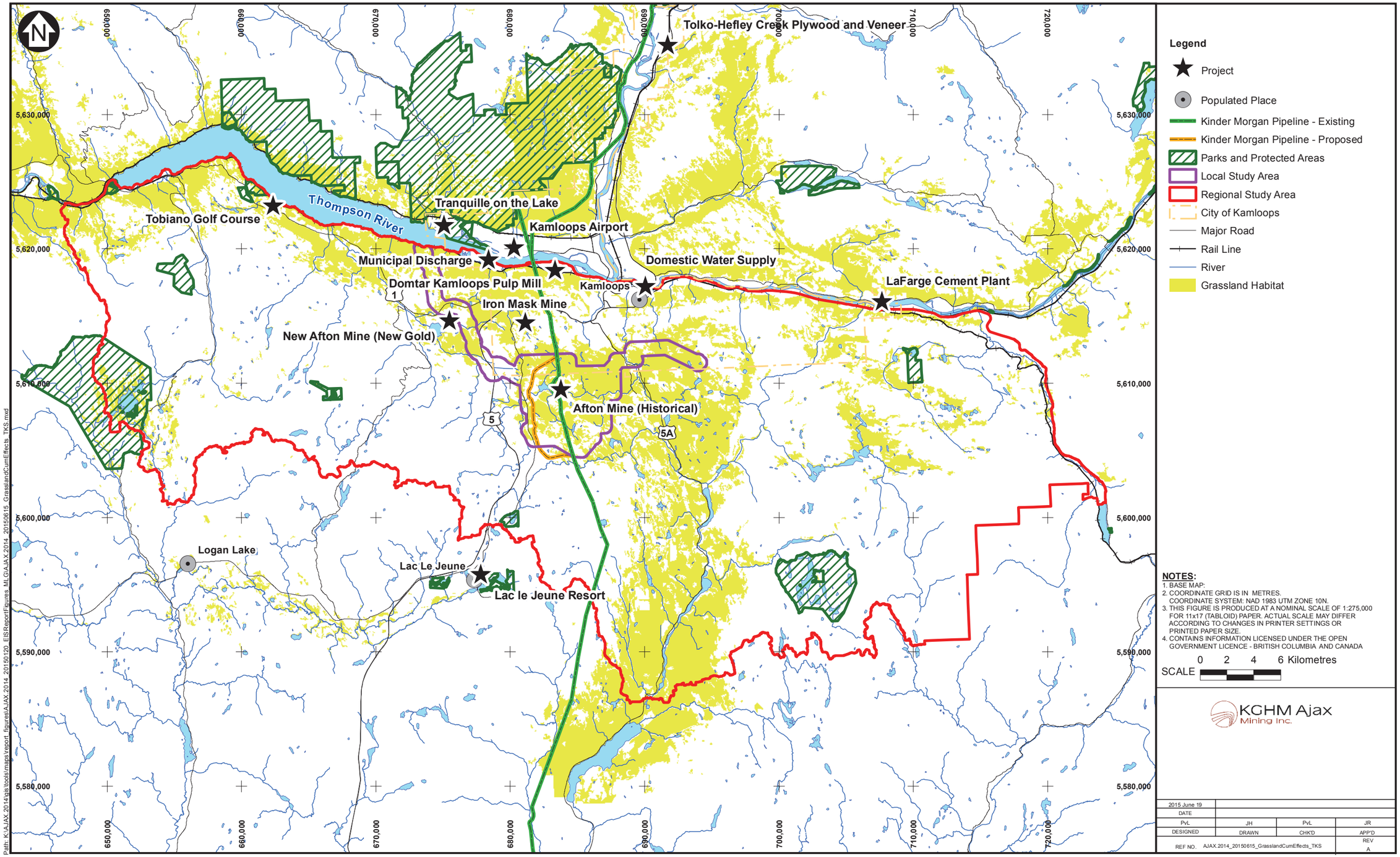


Table 6.10-17. Characterization of Cumulative Residual Effects, Significance, Likelihood and Confidence on Grasslands

Cumulative Residual Effect	Residual Effects Characterization Criteria							Significance of Adverse Residual Effects	Likelihood and Confidence	
	Magnitude	Duration	Frequency	Geographic Extent	Reversibility	Resiliency	Context		Probability	Confidence
Habitat Loss	Minor	Long-term	Sporadic	Regional	Reversible Long-term	Low	Neutral	Not Significant (Minor)	High	Low

Table 6.10-18. Summary of Project and Cumulative Residual Effects, Mitigation, and Significance for Grasslands

Residual Effects	Project Phase	Mitigation Measures	Residual Effect Significance	Residual Cumulative Effect Significance
Loss of grassland habitat	Construction	Limit construction footprint. Establish exclusion areas. Use appropriate reclamation seed mixes. Invasive species management. Progressive reclamation.	Not Significant (Moderate)	Not Significant (Minor)

Grasslands in the Thompson region are important for a variety of reasons. They make up 13% of all of BC's grasslands, supplying valuable grazing opportunities for livestock as well as foraging opportunities for wildlife. Grasslands provide habitat for over 30% of BC's species at risk, and they are used by Aboriginal groups for both food and medicinal plants (BC Ministry of Water, Land and Air Protection and Grasslands Conservation Council of BC 2004). Much of the LSA has been included in Priority Grasslands Conservation Areas delineated by the Grasslands Conservation Council of BC (2009), and are listed as ecological communities at risk.

Habitat loss is considered not significant (moderate) for Project-related residual effects. Regionally, habitat loss is considered not significant (minor) for cumulative residual effects as less than 3% of the priority grassland areas within the RSA will be lost, and suitable habitat still exists within the region.

6.11 TERRESTRIAL INVERTEBRATES

6.11.1 Rationale

This section includes a description of the scoping process used to identify terrestrial invertebrates for inclusion in the assessment. Scoping is fundamental to focusing the Application/EIS on those issues where there is the greatest potential to cause significant adverse effects. Valued components (VCs) are components of the natural and human environment that are considered to be of scientific, ecological, economic, social, cultural, or heritage importance (CEAA 2006; EAO 2013). To be included in the EA, there must be a perceived likelihood that the VC will be affected by the proposed Project.

For terrestrial invertebrates the following was considered for inclusion as a valued component in the environmental assessment:

- Federal or provincial listing or regulation;
  - Lists of Red- and Blue-listed species believed to occur within the Kamloops Forest District, and information on known locations of these species, according to the BC Conservation Data Centre (2010);
  - Information on SARA-listed species provided by the Government of Canada;
- Applicable Government Agencies;
- Aboriginal interest;
- Public or other stakeholder input;
- Scientific/professional knowledge; and
- Relevant legislation or policy concerning the VC.

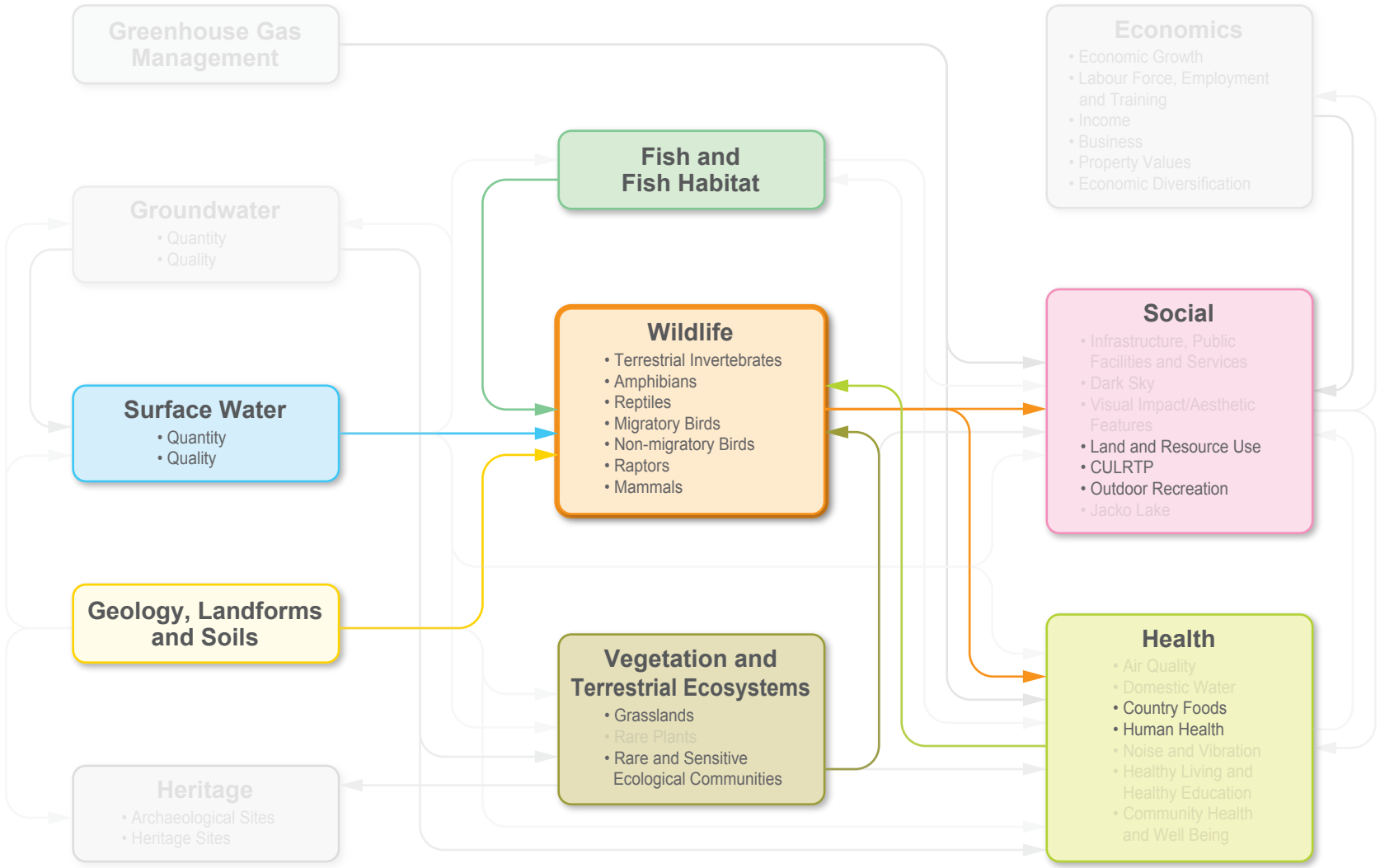
Terrestrial Invertebrates offer the potential for short and long term monitoring of the impact of increasing development, changing land use practices, and climate change for the region's aquatic and terrestrial ecosystems. Terrestrial invertebrates use grassland and wetland habitats which are determined by surface and ground water, geology, landform and soils. Nymphs may be a food source for fish and amphibians and adults are eaten by birds and bats. The assessment of effects to terrestrial invertebrates is largely related to disturbances from Project activities (as described further in Section 6.11.4). The information developed to support the analysis of this VC may also contribute to Outdoor Recreation (Figure 6.11-1).

6.11.1.1 Selection of Terrestrial Invertebrates as a Valued Component

Terrestrial invertebrate is a broad term that includes nematodes, annelids, molluscs and arthropods. Although a wide variety of terrestrial invertebrates are present in the project area, only butterflies (Lepidoptera) and dragonflies and damselflies (Odonta) are being considered in this EIS, as the biology of many of these other invertebrate taxa is poorly known.

Figure 6.11-1

VC Interactions for Wildlife (Terrestrial Invertebrates)



The VC "Terrestrial Invertebrates" was selected based on anticipated interactions with the Project. Specific justification for the selection of terrestrial invertebrates as a VC includes:

1. Federal or provincial listing or regulation guidelines;
   - Five Blue-listed species (Monarch, Hagen's Bluet, Nevada Skipper, Common Sootywing, and California Hairstreak) in the Region;
   - One Red-listed species (Olive Clubtail) in the Region;
   - One SARA schedule 1 species (Monarch) in the Region.
2. Applicable Government Agencies (MoE, CWS); terrestrial invertebrates identified as a concern;
3. Stakeholder interest: Kamloops Naturalist Club (BC MOE, 2013);
4. Information Sources (baseline studies, professional judgement);
5. Spatial scope: previous studies have confirmed the presence of the 4 listed butterfly species and the 1 listed dragonfly species in the region;
6. Temporal scope: The majority of butterfly and dragonfly species found in the region are year-round residents. Monarchs are migratory and are known to be present from June to late summer or fall; and
7. Interaction with Project/Potential Effects (professional knowledge).

6.11.1.2 Selection of Indicators

A preliminary list of indicator species was prepared based on at-risk taxa for the area, taxa of regional concern, and taxa likely to interact with the Project based upon their life history and geographical range in accordance with the AIR (BC Environmental Assessment Office, 2015).

Indicator species were selected from at-risk species as these populations are more likely to experience an adverse effect. Stakeholder input, spatial and temporal scope and potential interaction with Project (Section 6.11.1.1) were also considered when selecting the Indicator species. One dragonfly, one damselfly, and four butterfly species are potentially present in the project area and at risk (Table 6.11-1).

Table 6.11-1. Listed Invertebrate Species Potentially Present in the Area

English Name	Scientific Name	BC List	COSEWIC Status	SARA Schedule/ Status	Identified Wildlife	Selected as Indicator?
Monarch	*Danaus plexippus*	Blue	SC (Apr 2010)	1-SC (Jun 2003)	No	Yes
Hagen's Bluet	*Enallagma hageni*	Blue	--	--	No	No
Nevada Skipper	*Hesperia nevada*	Blue	--	--	No	Yes
Common Sootywing	*Pholisora Catullus*	Blue	--	--	No	Yes
California Hairstreak	*Satyrium californica*	Blue	--	--	No	Yes
Olive Clubtail	*Stylurus olivaceus*	Red	E (May 2011)	--	No	Yes

Pollinators such as bees and moths were not chosen as indicator species as there are no listed species and Project is not anticipated to have an effect.

Insufficient information is available for the other terrestrial invertebrate species to carry-out a meaningful assessment. No nematodes, annelids or molluscs were selected as indicator species.

Indicator species were selected based on the presence of suitable habitat, the availability of sufficient species knowledge to produce a meaningful assessment, federal or provincial listing, and likely geographic and ecological interactions with the project (Table 6.11-2). The Hagen's bluet was not selected as an indicator species as occurrence records (Cannings, Ramsay, Cannings, & Copley, 2008) are from the Cariboo and Prince George regions to the north and the bluet has similar habitat requirements as the Olive Clubtail.

Table 6.11-2. Indicator Specific and Issues Raised during Consultation Feedback

	Feedback by*					
Subject Area	AG	G	P/S	S/P	Issues Raised	Rationale
Butterflies						
Monarch		✓	✓		Loss and alteration of habitat, change in migration patterns	Species at risk; potentially suitable habitat present; potential for interaction with Project
Nevada Skipper		✓	✓		Loss and alteration of habitat	Species at risk; potentially suitable habitat present; potential for interaction with Project
Common Sootywing		✓	✓		Loss and alteration of habitat	Species at risk; potentially suitable habitat present; potential for interaction with Project
California Hairstreak		✓	✓		Loss and alteration of habitat	Species at risk; potentially suitable habitat present; potential for interaction with Project; known from Kamloops area
Dragonflies and Damselflies						
Olive Clubtail		✓	✓		Loss and alteration of habitat	Species at risk; potentially suitable habitat present; potential for interaction with Project

**AG = Aboriginal Group (Stk'emlupsemc Te Secwepemc Nation (SSN) and Nlaka'pamux Nation); G = Government; P/S = Public/Stakeholder (e.g., LRMP); S/P = Scientific/Professional Knowledge.*

Butterflies are strongly associated with specific vegetation and often have a restricted local distribution. Eggs are laid on host plants to be used as a food source when larvae (caterpillars) emerge. Some butterfly species require specific plant species as a host (e.g. monarch butterflies and the host plant showy milkweed), whereas others are generalists. This aspect of their life history makes them particularly vulnerable to disturbance. Four butterflies were selected as indicator species. All four butterfly indicator species are habitat specialists, with known or suspected food plants. Habitat generalists are not as selective as the above mentioned indicator species, but do have similar habitat needs. Monarchs, Nevada skippers, common sootywings and California hairstreaks were selected to represent all butterfly species that could potentially occur in the study area.

Dragonflies and damselflies reproduce in aquatic habitats including rivers, streams, lakes, ponds, wetlands and wet seepage areas. Females lay eggs in or near open water, which hatch into naiads, where the majority of a dragonfly's life is spent. Months to years later, depending on the species, these naiads emerge and metamorphosize into their adult flying form. Dragonfly and damselfly requirements for both terrestrial and aquatic habitats mean that they are vulnerable to loss or degradation of both habitat types. Furthermore, dragonflies and damselflies are upper level insectivores and have been identified as indicators of ecosystem health (BC Environmental Assessment Office, 2015). Olive clubtails were selected as an indicator species as it is Red-listed (BC Conservation Data Centre, 2014c). As all dragonflies and damselflies have similar life requisites and habitat requirements, olive clubtails were selected as indicator species, and represent other dragonflies and damselflies that could occur in the region.

6.11.2 Assessment Boundaries

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

6.11.2.1 Spatial Boundaries

Infrastructure Footprints

The Project infrastructure footprints (IF) include the Open Pit, ancillary buildings and facilities, roads, truck stop, Tailings Storage Facility (TSF), Water Management Ponds, Mine Rock Storage Facilities (MRSFs), and stockpiles (Figure 6.11-2). The Project infrastructure footprints are 1,705 ha in size.

Infrastructure Disturbance Area

The Project infrastructure footprints and linear features (transmission line and water line) were buffered by at least 50 m (Henderson, 2011) to determine the Project Infrastructure Disturbance Area (IDA). The 3,185 ha IDA will be used to assess maximum direct Project effects (e.g., mortality, habitat loss, habitat alteration, etc.). The IDA includes the Project IF (1,705 ha) used to calculate direct loss of habitat, plus a 1,480 ha buffer around the Project IF that represents a zone of influence for potential disturbance associated with habitat alteration resulting from effects pathways such as contaminants, silt or dust, noxious weeds, and changes in drainage pattern (Figure 6.11-2).

The use of a buffered polygon area rather than individual infrastructure footprints will provide an overestimate of the direct effects of the Project for the assessment. The advantage of this approach is that it enables individual footprints to be moved and/or resized without changing the results of the effects assessment.

The IDA was modified from the General Arrangement Polygon to follow a section of the Kamloops city boundary to more accurately represent the current Project IF.

Habitat alteration by dust and water quantity is accounted for under potential habitat loss within the IDA. Areas outside of the IF that are not lost will be subject to potential alteration effects. However as wildlife species present in the area are adapted to the dry, dusty environmental conditions, these effects were considered mitigable.

Local Study Area

In accordance with the AIR the General Arrangement Polygon was buffered by 500 m to determine the Local Study Area (LSA). This area is the maximum expected area of potential disturbance associated with all Project facilities (BC Environmental Assessment Office, 2015). The LSA is 7,167 ha and will be used to assess indirect Project effects (e.g., disturbance) and provide context on the amount of habitat available adjacent to the Project (Figure 6.11-2)**.**

Regional Study Area

The Regional Study Area (RSA) is the area for which cumulative effects will be assessed. The RSA will include portions of the South Kamloops Landscape Unit and Campbell Landscape Unit, including areas south of the Thompson River and west of Highway 97 (Figure 6.11-3**)**. Landscape units were selected for the RSA as they are the geographical framework within which sustainable forest management regimes to maintain biodiversity are implemented. The RSA also includes local watershed basins and is 158,415 ha in size.

6.11.2.2 Temporal Boundaries

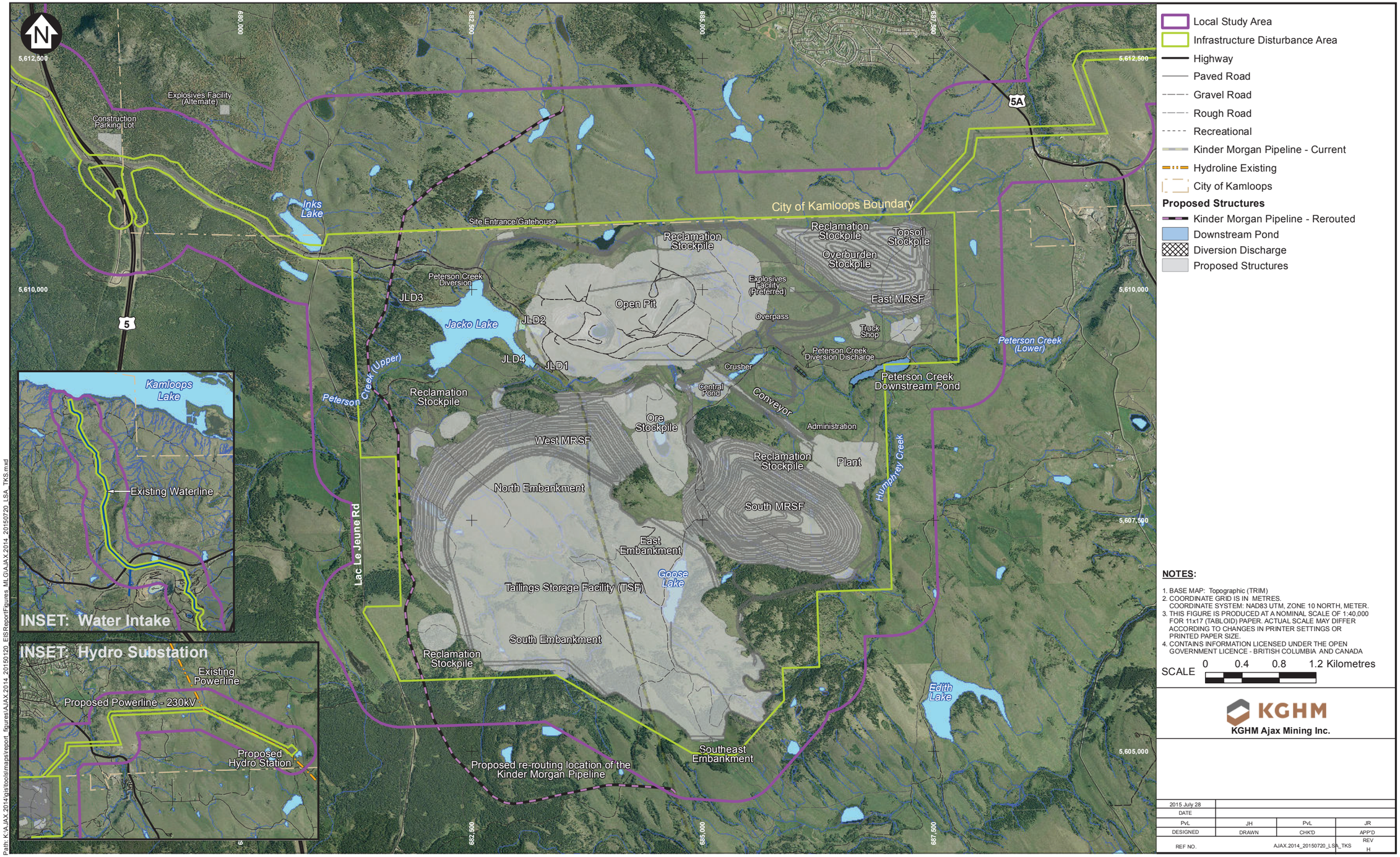
The temporal boundaries of the assessment will include the construction phase (short-term), operations (life of the mine), decommissioning and closure (short-term) and post-closure (short-term). The temporal phases of the Project are:

- **Construction**: 2 years (Year -2 to 1);
- **Operation**: 23 years (Year 1 to 23);
- **Decommissioning and Closure**: 5 years (Year 24 to 29, includes Project decommissioning, abandonment and reclamation activities, as well as temporary closure, and care and maintenance); and
- **Post Closure**: 5+ years (includes ongoing reclamation activities and post-closure monitoring).

6.11.2.3 Administrative Boundaries

No administrative boundaries have impacted, constrained or expanded the assessment of terrestrial invertebrates.

Figure 6.11-2
Local Study Area, Infrastructure Disturbance Area and Project Infrastructure



NOTES:

1. BASE MAP: Topographic (TRIM)
2. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD83 UTM, ZONE 10 NORTH, METER.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:40,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
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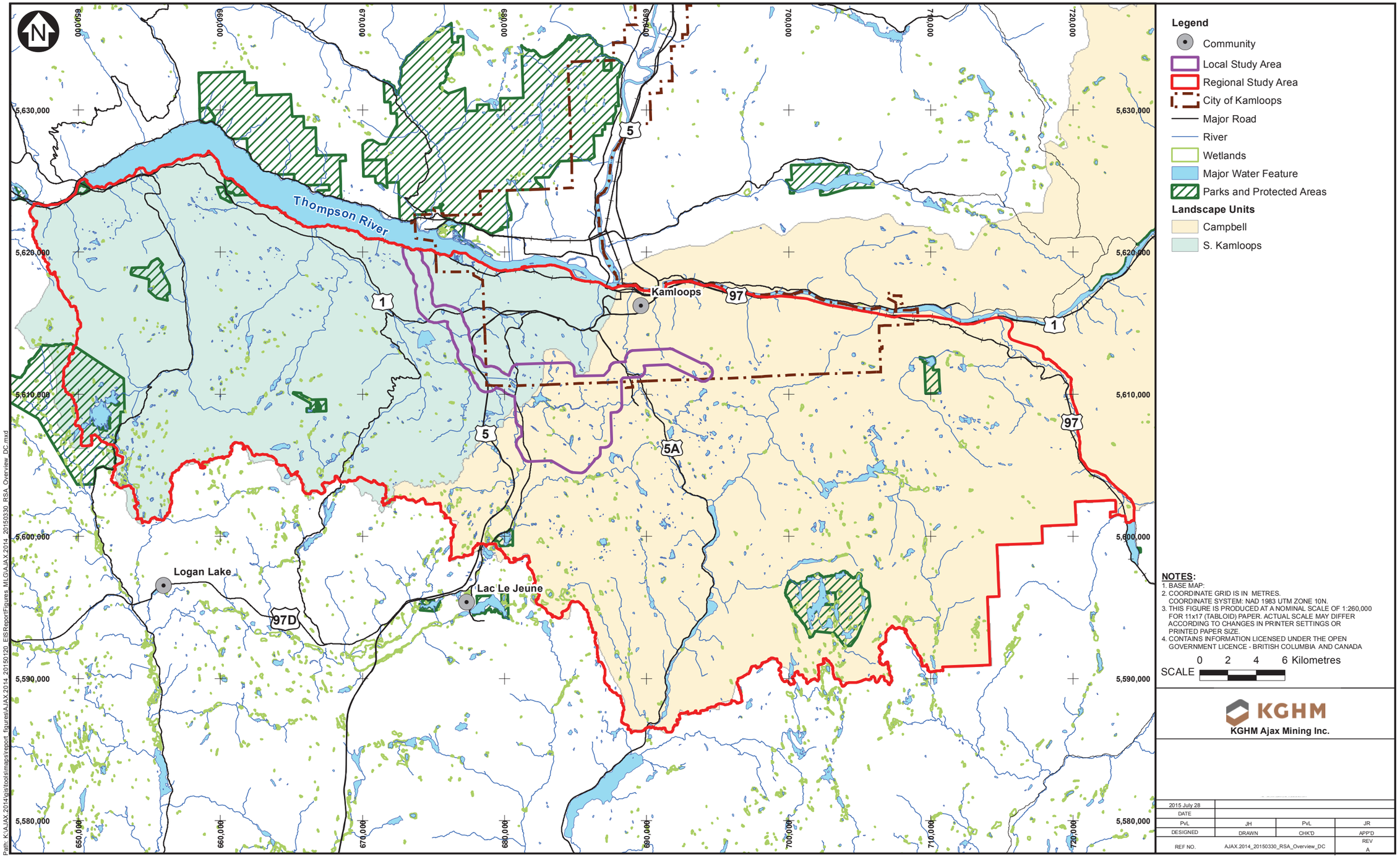
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Figure 6.11-3
Regional Study Area



6.11.2.4 Technical Boundaries

Technical boundaries have impacted the assessment of terrestrial invertebrates. Listed indicator species were not detected in the LSA during baseline studies, despite over 142 hours of sampling by a butterfly and dragonfly expert. No targeted food plant surveys were conducted. The presence/absence of food plants was determined through review of rare plant survey data; however, the distribution of these food plants was not defined. There are also gaps in the knowledge of these species relating to population habitat requirements; food plant density and the patch size required to support a breeding population are not known. The Nevada skipper and common sootywing food plants have not been recorded in BC, and the suspected food plants are based on observations of populations in Washington and Colorado (BC Conservation Data Centre, 2014a).

6.11.3 Background

6.11.3.1 Regulatory and Policy Framework

The Kamloops Land and Resources Management Plan (LRMP) (1995) outlines that: special attention to red- and blue-listed species should be considered; forests are to be managed to ensure diversity, as well as to ensure critical habitat is identified and managed appropriately through local level planning; and habitat improvement projects should be conducted where appropriate. The Nicola Thompson Fraser Sustainable Forest Management Plan (SFMP) (2015) aims to conserve species diversity by ensuring that habitats for a particular species are maintained, including habitats for known occurrences of species at risk.

The *Species at Risk Act* [SARA] prohibits the killing, harming, harassing, capturing, taking, possessing, collecting, buying, selling or trading of individuals (or its parts or derivatives) of endangered, threatened and extirpated species listed in Schedule 1 of the Act. It also prohibits damage or destruction of the residence of one or more individuals of a listed endangered or threatened species, or a listed species if a recovery strategy has recommended its reintroduction into the wild into Canada. The monarch is listed as Schedule 1, Special Concern, under SARA.

A proposed management plan for the monarch was published in 2014 and outlines management objectives and broad strategies for conservation measures (Environment Canada, 2014). Management objectives include:

- To mitigate threats to monarch and ensure that there is sufficient breeding, nectaring and staging habitat in Canada to maintain the current Canadian contribution to the overall North American monarch population.

In addition to the above-mentioned legislative and policy frameworks, documents containing Best Management Practices (BMPs) are available for certain activities and species groups, to provide guidance for maintaining environmental values during development. The BMP documents that are relevant to invertebrates include:

- Grasslands in British Columbia: a Primer for Local Governments (Wetland Stewardship Partnership, 2010)

- BC Grasslands Stewardship Guide (Chutter, 1997)
- Wetland Ways: Interim Guidelines for Wetland Protection and Conservation in British Columbia (Cox & Cullington, 2009);
- Develop with Care: Environmental Guidelines for Urban and Rural Land Development in British Columbia (BC Ministry of Environment, 2012);
- Guidelines for Reduced Risk Instream Work Windows, and
- Standards and Best Practices for Instream Works (BC Ministry of Water, Land and Air Protection, 2004).

Water Quality Guidelines are used to determine what levels of substances found in fresh and marine surface water are safe for the environment (BC Ministry of Environment, 2014a). These guidelines have been developed for different water uses including aquatic life, wildlife, drinking water, recreation and agriculture and irrigation. For the purpose of this assessment, aquatic life guidelines.

6.11.3.2 Regional Overview

The Bunchgrass Zone extends from river level up to about 900 m elevation. It is located in the Thompson River valley between Kamloops and Spences Bridge. This zone is characterized by very warm and dry summers, while most winters are moderately cold. Precipitation is very low. Evaporation rates are high in summer, and drought conditions are common in upland areas from June onwards.

Drought conditions limit tree growth; consequently, grasses form the dominant vegetation. Native grasses include bunchgrasses (particularly Bluebunch Wheatgrass), Needle-and-thread Grass, Junegrass, and Sandberg's Bluegrass. Sagebrush ecosystems (also called shrub-steppes) often dominate the lower elevations of the zone.

Although the Bunchgrass Zone is one of the smallest zones in British Columbia, its unique mosaic of grassland, shrub-steppe, moist and wet ecosystems, and dry, open forests supports a tremendous diversity of wildlife.

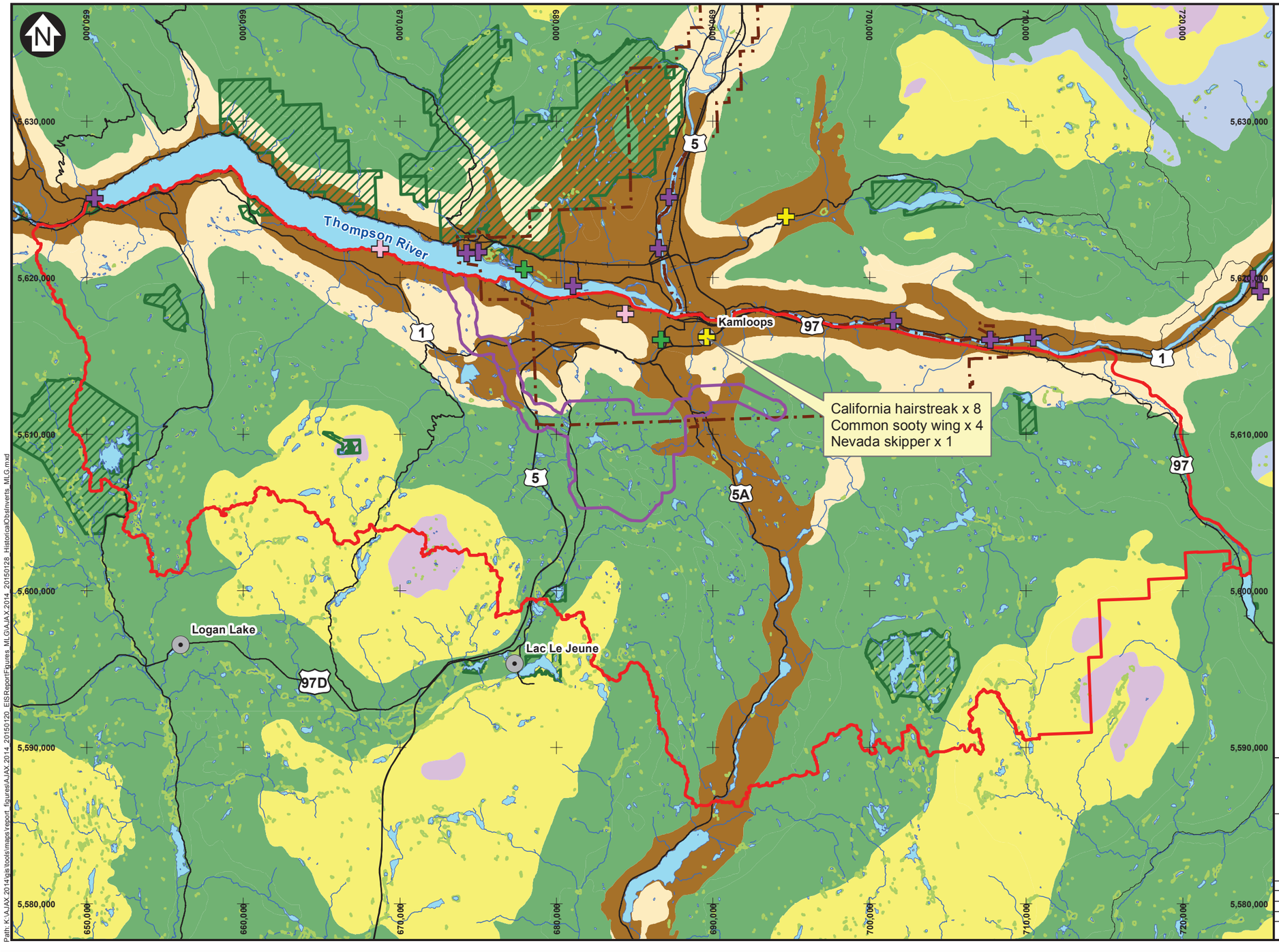
Butterfly surveys were conducted in the region in 1944 by J.K. cooper (Klinkenberg 2012a,b,c). The majority of the butterfly observations shown in Figure 6.11-4 are from this time. The majority of Olive clubtail locations are from the COSEWIC status report (COSEWIC, 2011).

<u>Indicator Species</u>

Monarch

The Blue-listed monarch butterfly has been recorded throughout southern British Columbia from June to late July, and is strongly associated with its larval food plant, showy milkweed (*Asclepias speciosa*; Table 6.11-3). The destruction of hibernation sites in California, the fragmentation of dry southern interior habitats as a result of urban/rural land development, and the removal of their food plant as a result of the implementation of weed control programs are all contributing to the decline of this species in British Columbia (COSEWIC, 2010; Klinkenberg, 2012a; BC Conservation Data Centre, 2014a). Monarchs have been previously recorded in the RSA (Figure 6.11-4).

Figure 6.11-4
Historical Observations of Listed Terrestrial Invertebrates



Legend

Species
- California hairstreak
- Common sooty wing
- Monarch
- Nevada skipper
- Olive clubtail
- Community
- Local Study Area
- Regional Study Area
- City of Kamloops
- Major Road
- River
- Wetlands
- Major Water Feature
- Parks and Protected Areas

BGC Zone
- BG
- ESSF
- ICH
- IDF
- MS
- PP

NOTES:
1. BASE MAP:
2. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD 1983 UTM ZONE 10N.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:260,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
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SCALE 0 2 4 6 Kilometres

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Nevada Skipper

The Blue-listed Nevada skipper ranges throughout the southern interior in the Okanagan Valley and the Thompson River Valley (Guppy & Shepard, 2001), inhabiting grasslands and xeric ridgetops (Klinkenberg, 2014a). This species flies from mid-May to mid-June, and probably overwinters as partially mature larva (Klinkenberg, 2014a). There are location records for this butterfly species from Vernon; Ashcroft; Osoyoos; Richter Pass; Kilpoola Lake; Riske Creek; Tranquille (BC Conservation Data Centre, 2014a). This species has been declining, likely due to increased development in the lowland bunchgrass areas where its larval food plants, sheep fescue (*Festuca ovina*) and western needlegrass (*Stipa occidentalis*) (Layberry, Hall, & Lafontaine, 1998), are found (BC Conservation Data Centre, 2014c)(Table 6.11-3). Nevada skippers have been previously recorded in the RSA (Figure 6.11-4).

Table 6.11-3. Habitat Associations for Indicator Species

English Name	Scientific Name	Food Plant(s)	BGC	Habitat Associations
Monarch	*Danaus plexippus*	Showy milkweed (*Asclepias speciosa*)	BG	Open areas and grasslands, including meadows, wetlands, fields and roadside areas
Nevada Skipper	*Hesperia nevada*	Unknown. Food plants in Washington include sheep fescue (*Festuca ovina*), and in Colorado include western needlegrass (*Stipa occidentalis*)	BG (IDF)	Xeric ridgetops
Common Sootywing	*Pholisora catullus*	Unknown. Food plants elsewhere include lamb's-quarters (*Chenopodium album*)	BG	Xeric areas
California Hairstreak	*Satyrium california*	*Ceanothus* cherry (*Prunus* sp.) saskatoon (*Amelanchier* sp.)	IDF (BG)	Dry Open Habitats
Olive Clubtail	*Stylurus olivaceus*	None - Insectivores	BG	Wetlands

Common Sootywing

The Blue-listed common sootywing is a dark butterfly whose range in British Columbia is restricted to the southern interior. Its flight period is late May to mid-June, and from mid-July to late August (Klinkenberg, 2012b). The species is experiencing a decline in habitat due to agricultural and urban development (BC Conservation Data Centre, 2014c). This species has been known to occur in the Kamloops Forest District (BC Conservation Data Centre, 2014a) (Figure 6.11-4). No larval food plant has been recorded in BC, but elsewhere it is lamb's-quarters (*Chenopodium album*) (Guppy & Shepard, 2001). Lamb's quarters is a weedy species, and common sootywings are often found in weedy areas where this plant is abundant (Klinkenberg, 2012b) (Table 6.11-3).

California Hairstreak

The Blue-listed California hairstreak occurs in the southern interior and has been recorded around the south Thompson River east of Kamloops (BC Conservation Data Centre, 2014a) (Figure 6.11-4). It flies in dry, open habitats from June through August (Jones 1951 in Layberry et al., 1998). The larvae of this butterfly feed on *Ceanothus* shrubs as well as cherry (*Prunus* sp.) and saskatoon (*Amelanchier*

sp.) (Layberry et al., 1998) (Table 6.11-3). The species is threatened from habitat conversion and habitat fragmentation from urban development and agricultural practices (BC Conservation Data Centre, 2014b).

Olive Clubtail

The Red-listed olive clubtail has been found along the south Thompson River near Kamloops (COSEWIC, 2011) (Figure 6.11-4). In BC it flies from mid-July until October (COSEWIC, 2011). This dragonfly inhabits sandy or muddy streams and lakeshores; aquatic larvae live in the bottom sediments and emerge as adults after approximately two years (COSEWIC, 2011) (Table 6.11-3). The distribution of the olive clubtail in the province is restricted and only a few occurrences are known (BC Conservation Data Centre, 2014c).

6.11.3.3 Historical Activities

Historical activities considered in the section include mining, mills, pipelines, rail lines, agriculture, forestry, urban space, water treatment and recreation/tourism as presented in Sections 6.9.3.3 and 6.10.3.3. Historical activities and previous development has likely reduced the availability of several species specific food plants from grasslands and the amount of dragonfly habitat (wetlands) in the region. Conversely, several weedy food plants (i.e. lamb's quarters and showy milkweed), have probably increased in the region as a result of historical activities.

Revegetation programs at the former Afton Mine began at a large scale in 1987. Reclamation programs focused primarily on returning disturbed sites back to land use conditions that are suitable for grazing by cattle and wildlife. Vegetation species planted as part of wetland development included cattails, rushes and sedges (Golder Associates, 2003). Revegetation efforts did not appear to include butterfly specific food plants. Several of these food plants, including showy milkweed, are considered nuisance weeds and may have been actively removed.

The development of the rail line has likely removed some habitat for dragonflies and butterflies as well as provided habitat for common sootywing and monarch butterflies as their weedy food plants prefer to grow along roadsides and other transportation corridors.

Agriculture has likely removed butterfly habitat throughout the region by reducing the number of food plants and nectar sources. Agriculture has also likely reduced dragonfly habitat. Historically wetlands in the low valleys of the Thompson-Okanagan region were drained for agricultural purposes (Government of Canada, 1991). Dragonflies are particularly sensitive to wetland habitat loss as they are dependent on this habitat for reproduction and the larval stage of their life.

Food plants for the California hairstreak are known to occur in some open forested areas. Removal of forests and their associated vegetation may have removed habitat for these two species.

Urban sprawl in the Okanagan Region has removed grassland and wetland areas which has reduced butterfly and dragonfly habitat (Cannings, Durance, & Scott, 1999). Urban development in the Kamloops Region has likely also contributed to loss of invertebrate habitats.

6.11.3.4 Baseline Studies

Baseline studies were conducted for terrestrial invertebrates in 2010, 2011 and 2014 (Appendix 6.8-A). Surveys were completed in an effort to determine indicator species presence, and to confirm habitat associations of target species. Baseline surveys for invertebrates were carried out in accordance with provincial standards (Resources Inventory Committee, 1998)

Data Sources

General information on species status and distribution was drawn from on-line sources such as the BC Ministry of Environment's Species Explorer and NatureServe (BC Conservation Data Centre, 2014a; NatureServe, 2014). Occurrence records of terrestrial invertebrates in the RSA were obtained from the BC Conservation Data Centre (BC Conservation Data Centre, 2014d) and from the provincial Species Inventory Database (BC Ministry of Environment, 2014b).

Information was also taken from:

- COSEWIC Assessment and Status Report on the Monarch *Danaus plexippus* in Canada;
- Management Plan for the Monarch (*Danaus plexippus*) in Canada (Environment Canada, 2014); and
- COSEWIC Assessment and Status Report on the Olive Clubtail *Stylurus olivaceus* in Canada.

Methods

Surveys for terrestrial invertebrates were undertaken to:

- establish presence of indicator species within the LSA;
- identify and characterize important sites (e.g. food plants) that may be affected by the Project;
- collect data on the location and timing of use of the LSA by indicator species;
- provide information to KAM to use during the Project design phase to avoid or minimize impacts to target species; and
- provide guidance on potential mitigation strategies

Wildlife survey methods were consistent with provincial Resources Information Standards Committee (RISC) standards. Detections of wildlife that occurred during other fieldwork were recorded as incidental observations.

Dragonflies, damselflies and butterflies were surveyed using hand-netting techniques (Resources Inventory Committee, 1998). These surveys are the recommended inventory method for collecting baseline data on the presence and/or relative abundance of terrestrial invertebrates in BC (Resources Inventory Committee, 1998). Surveys were conducted by a two-person crew consisting of two biologists, one of whom was an expert in dragonfly and butterfly identification. Both vehicle and foot transects were used, concentrating on potential species preferred habitat within Project footprint areas. Captured individuals were identified in the hand by the expert and then released. Dragonflies are particularly difficult to net, so the majority of dragonfly species were identified

visually through binoculars. As the flight periods for each indicator species varies, surveys were scheduled to target times of the year when indicator species were most likely to be present.

Invertebrate surveys were carried out from June 19 to 23, 2010, June 25 to 26, 2011, July 25 to 28, 2011, June 18-20, 2014, and August 7-10, 2014 (Figure 6.11-5). No surveys were conducted during the Nevada skipper's predicted flight period of mid-May to mid-June (Klinkenberg 2012b). However, sources on the flight period of Nevada skipper are not consistent, and the flight period may extend into August (Opler & Wright, 1999), when several surveys were completed. However, there is evidence that the Nevada skipper's flight period is longer than that proposed (Opler and Wright 1999, Klinkenberg 2012b). Nevada skippers have been observed in the Thompson-Nicola region as late as September in 1989 (Klinkenberg, 2014a). Surveys during this time were completed on May 26 to 28 in 2015.

Characterization of Terrestrial Invertebrate Baseline Conditions

Seventy-seven invertebrate species (order of Odonata and Lepidoptera) were identified in the Project area, including 21 dragonfly/damselfly taxa, and 56 butterfly taxa (Appendix 6.8-A). Total survey effort was 142 hours and 48 minutes (Table 6.11-4).

Table 6.11-4. Summary of Invertebrate Survey Effort

Month - Year	Number of Locations Surveyed (including repeat surveys)	Total Time Surveyed (person-hours)	Additional ButterflySpecies Observed	Additional Dragonfly Species Observed
June - 2010	11	39h58	32	5
June - 2011	15	26h50	7	6
July - 2011	5	30h22	9	7
June – 2014	15	19h42	5	0
August - 2014	17	25h56	3	3
Grand Total	**63**	**142h48**	**56**	**21**

Species accumulation curves data show that about 72% of dragonfly species and 82% of butterfly species were observed although differences in survey timing and habitat confound the issue (Figure 6.11-6). All 77 of the observed species are Yellow-listed and considered secure and widespread.

None of the listed indicator species were observed during baseline studies, despite being known to occur in the region (B.C. Conservation Data Center, 2014). Monarchs have been observed as close as Kamloops (Klinkenberg, 2012a). Nevada skippers and common sootywings were also observed in Kamloops during surveys in 1944 (Klinkenberg, 2012b, 2014a). California hairstreaks have also been observed in the Kamloops region, and were recorded in 1936 (Klinkenberg, 2014a). The olive clubtail was observed to the north, west and east of Kamloops (COSEWIC, 2011; Klinkenberg, 2014b). All of the known locations for indicator species were in the Bunchgrass biogeoclimatic zone which only comprises a small portion (18%) of the LSA (Figure 6.11-4).

Figure 6.11-5
Locations of Invertebrate Surveys

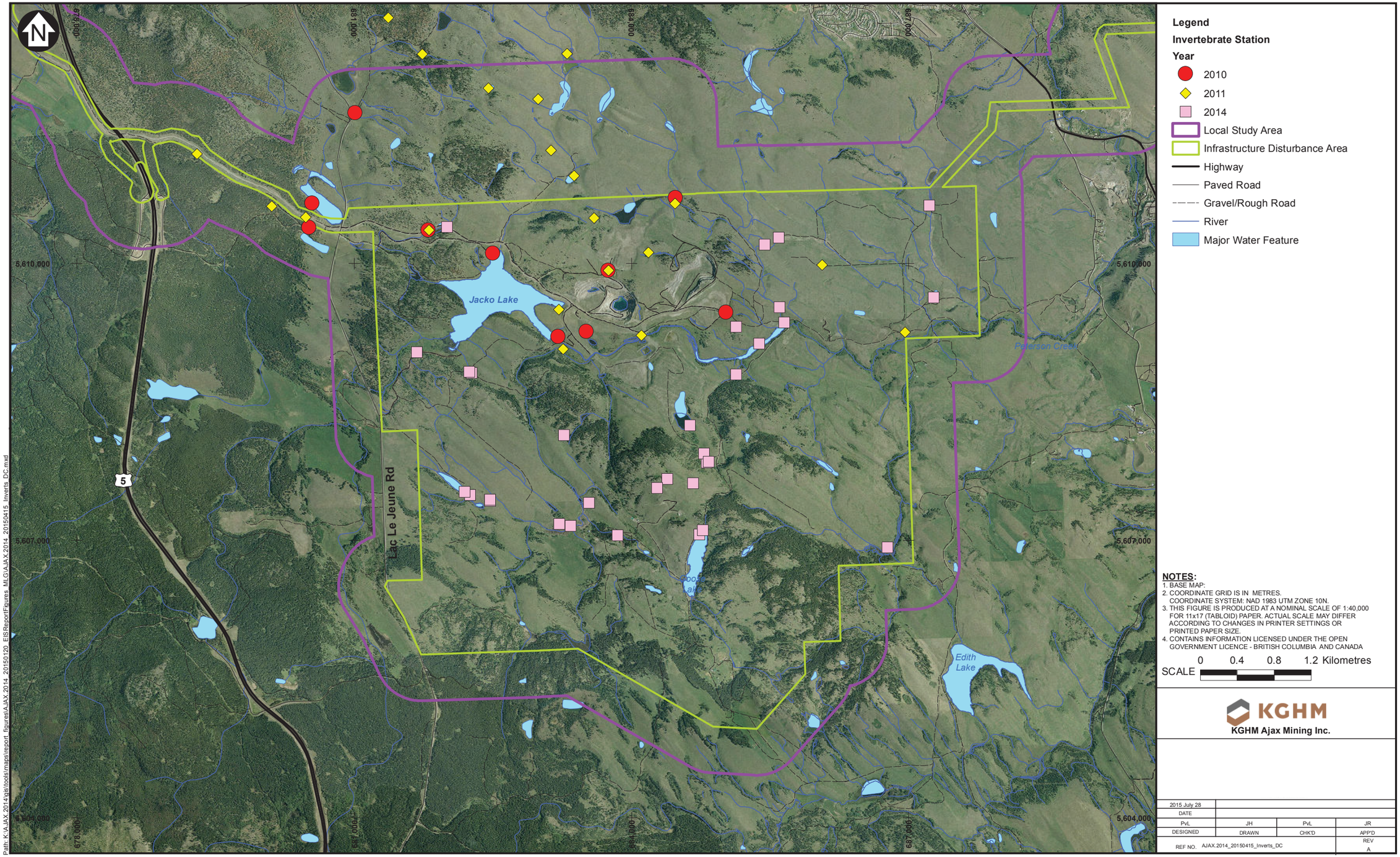
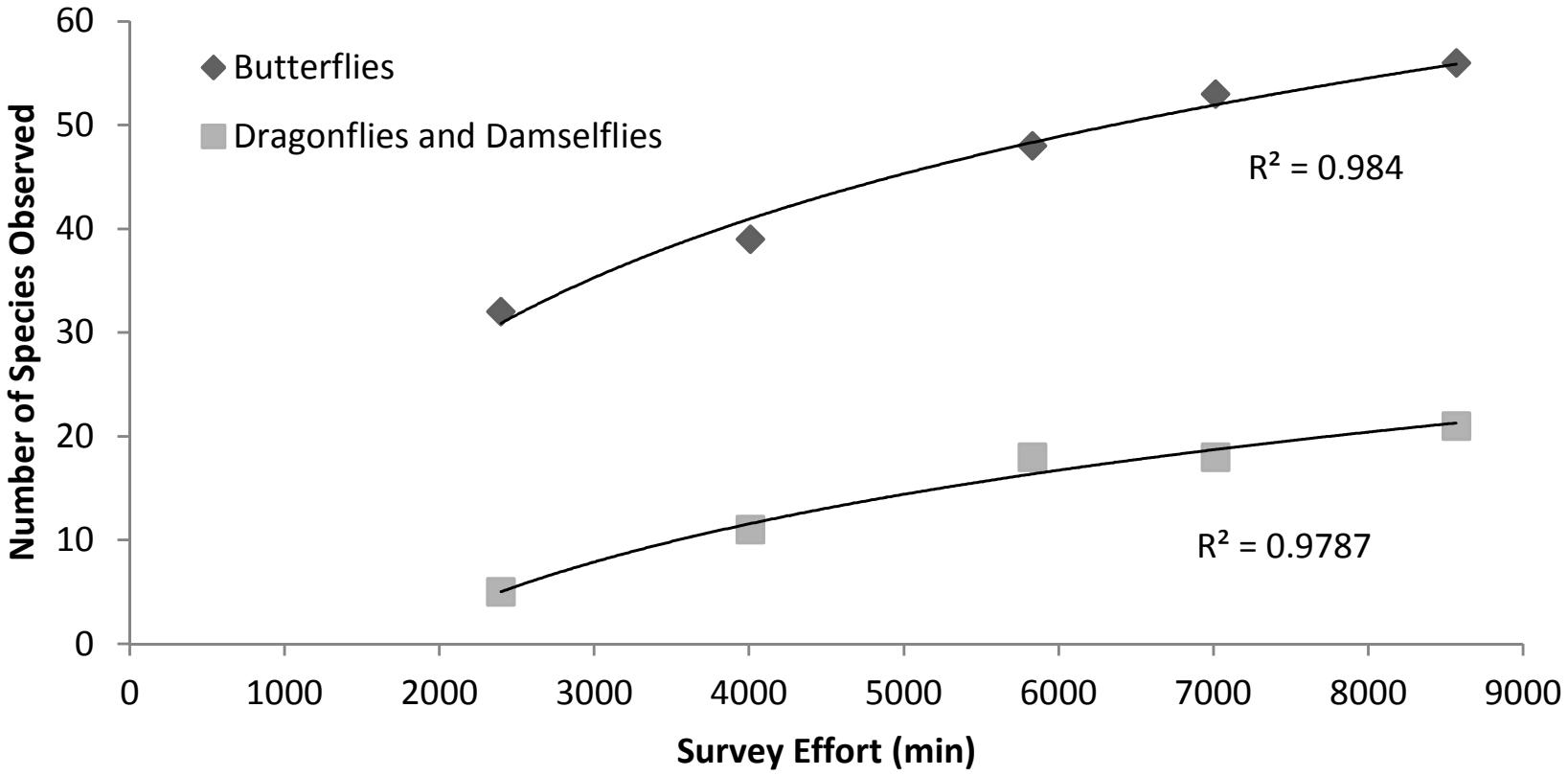


Figure 6.11-6
Species Accumulation Curves



Although no targeted food plant surveys were conducted, the presence and absence of these species was recorded during rare plant surveys (Table 6.11-5). The specific food plants for common sootywing in BC are unknown, though they may depend on lamb's quarters, *Chenopodium*, and/or *Amaranthus* (Guppy & Shepard, 2001) which were observed throughout the project area. Lamb's quarters is a weedy plant that colonize disturbed areas, and is traditionally harvested (Section 12). California hairstreak food plants are known to be Saskatoon, cherry, and ceanothus shrubs (Layberry et al., 1998). These plants have also been found throughout the Project area, and are traditional food plants (Section 12). Nevada skipper food plants include sheep fescue, hairgrass, needlegrass and bluegrass. Needlegrass was found in several patches within the Project site, likely planted during previous reclamation. Monarchs depend on showy milkweed, which were observed occasionally along roadsides in the project area. The patch size and distribution of food plants required to support a breeding population of each of the butterfly indicator species is unknown.

Table 6.11-5. Associated Food plants and Habitats of Indicator Species

Indicator Species	Potential and Confirmed Food plant	Habitat Association
Monarch	Showy Milkweed (*Asclepias speciosa*)	Roadsides, streamsides
Nevada Skipper	Sheep Fescue (*Festua ovina*) Western Needlegrass (*Stipa* sp.), Bluegrass *(Poa pratensis, poa agazzizensis*) Hairgrass (*Deschampsia elongata*)	Grasslands, xeric ridgetops
Common Sootywing	Lamb's Quarters (*Chenopodium album*) *Chenopodium* *Amaranthus* spp	Weedy areas, dry xeric habitats
California Hairstreak	*Ceanothus* shrubs cherry (*Prunus* sp.) saskatoon (*Amelanchier* sp.)	Dry open habitats
Olive Clubtail	None - Insectivores	Sandy Lakeshores

6.11.4 Potential Effects of the Project and Proposed Mitigation for Terrestrial Invertebrates

6.11.4.1 Identifying Potential Effects on Terrestrial Invertebrates

The AIR identified potential effects as habitat alteration and loss, disturbance and displacement and mortality. For Terrestrial Invertebrates these effects were further subdivided into: habitat loss; habitat alteration; sensory disturbance; direct mortality; and chemical attractants. An interaction matrix (Table 6.11-6) was used to help scope potential effects by considering potential interactions with Project activities/components, consistent with the approach outlined in the assessment methodology (Section 5.2.4.1). Further rationale for the scoping of potential effects is provided below. Other potential effects such as disruption of movement, wildlife attractants, and indirect mortality were not evaluated as effects would be negligible.

Table 6.11-6. Identifying Potential Project Interactions and Effects on Terrestrial Invertebrates

	Project Activities	Potential Effects on Terrestrial Invertebrates				
		Habitat Loss	Habitat Alteration	Sensory Disturbance	Direct Mortality	Chemical Hazards
Construction	Clearing and Grubbing	L	O	O	L	O
	Earthworks	O	L	O	O	O
	Overburden/Topsoil Stockpile	O	O	O	O	O
	Laydown Areas and Storage Yards	O	O	O	O	O
	Project Lighting	O	O	L	O	O
	Site Security and Fencing	O	O	O	O	O
	Fuel Storage and Filling Area	O	O	O	O	L
	Hazardous Wastes Transport, Storage, and Disposal	O	O	O	O	L
	Construction Wastes Transport, Storage, and Disposal	O	O	O	O	L
	Sewage Infrastructure and Disposal	O	O	O	O	L
	Public Road Realignment, Use, and Maintenance	O	L	O	L	L
	Site Road Construction, Use and Maintenance	O	L	O	O	O
	Haul Road Overpass Construction, Use, and Maintenance	O	O	O	L	O
	Site Buildings and Process Plant	O	O	O	O	O
	Explosives Magazine and Storage Facilities	O	O	O	O	O
	Open Pit Development	O	O	O	O	O
	Drilling and Blasting	O	L	O	O	O
	Crushing Mine Rock	O	L	O	O	O
	Loading, Hauling, and Deposition of Mine Rock	O	O	O	O	O
	Temporary Ore Stockpile	O	O	O	O	O
	Tailing Storage Facility Development	O	O	O	O	O
	Power Transmission, Distribution	O	L	O	O	O
	Natural Gas Line	O	L	O	O	O
	Pipeline Utility Corridor (Potable Water, Sewage, and Site Water)	O	L	O	O	L
	Water Intake from Kamloops Lake	O	O	O	O	O
	Fire Suppression Infrastructure	O	O	O	O	L
	Contact Water	O	O	O	O	L
	Non-contact Water	O	O	O	L	O
	Haul Road Overpass	O	O	O	L	O
	Mine Staffing (Direct Employment)	O	O	O	O	O
	Contracted Employment	O	O	O	O	O
	Taxation	O	O	O	O	O

	Project Activities	Potential Effects on Terrestrial Invertebrates				
		Habitat Loss	Habitat Alteration	Sensory Disturbance	Direct Mortality	Chemical Hazards
Operation	Open Pit Development	O	O	O	O	O
	Drilling and Blasting	O	L	O	O	O
	Hauling Mine Rock and Ore from Pit	O	O	O	O	O
	Crushing and Conveying Ore	O	L	O	O	O
	Temporary Ore Stockpile	O	O	O	O	O
	Development of Waste Rock Management Facilities	O	O	O	O	O
	Stripping, Loading, Hauling, Deposition, and Contouring of Topsoil and Overburden	O	O	O	O	O
	Revegetation through Progressive Reclamation	O	O	O	O	O
	Process Plant Operation	O	O	O	O	O
	Deposition to Tailing Storage Facility	O	O	O	O	O
	Site Road Use and Maintenance (Materials, Personnel, Supplies)	O	L	O	O	L
	Concentrate Transport and Storage	O	O	O	O	O
	Explosives Magazine and Storage Facilities	O	O	O	O	O
	Fire Suppression Infrastructure	O	O	O	O	L
	Fuel Storage and Filling Area	O	O	O	O	L
	Hazardous Wastes Transport, Storage, and Disposal	O	O	O	O	L
	General Wastes Transport, Strorage, and Disposal	O	O	O	O	L
	Sewage Infrastructure and Disposal	O	O	O	O	L
	Laydown Areas and Storage Yards	O	O	O	O	O
	Power Transmission, Distribution	O	L	O	O	O
	Project Lighting	O	O	L	L	O
	Site Access, Security and Fencing	O	O	O	O	O
	Water Intake from Kamloops Lake	O	O	O	O	O
	Contact Water	O	O	O	O	L
	Non-contact Water	O	O	O	O	O
	Haul Road Overpass	O	O	O	O	O
	Mine Staffing (Direct Employment)	O	O	O	O	O
	Contracted Employment	O	O	O	O	O
	Taxation	O	O	O	O	O

	Project Activities	Potential Effects on Terrestrial Invertebrates				
		Habitat Loss	Habitat Alteration	Sensory Disturbance	Direct Mortality	Chemical Hazards
Decommissioning and Closure	Dismantling of Ancillary Buildings	O	O	O	O	O
	Pit Lake Planning	O	O	O	O	O
	Site Road Decommissioning	O	O	O	O	O
	Tailing Storage Facility Decommissioning and Reclamation	O	O	O	O	O
	Mine Rock Management Facilities Reclamation	O	O	O	O	O
	Fuel Storage and Filling Area	O	O	O	O	L
	Hazardous Wastes Transport, Storage, and Disposal	O	O	O	O	L
	General Wastes Transport, Storage, and Disposal	O	O	O	O	L
	Sewage Infrastructure and Disposal	O	O	O	O	L
	Laydown Areas and Storage Yards	O	O	O	O	O
	Power Transmission, Distribution	O	L	O	O	O
	Project Lighting	O	O	L	O	O
	Site Access, Security and Fencing	O	O	O	O	O
	Contact Water	O	O	O	O	L
	Non-contact Water	O	O	O	O	O
	Potable Water Treatment and Use	O	O	O	O	O
	Haul Road Overpass	O	O	O	O	O
	Road use to the Project (Materials, Personnel, Supplies)	O	O	O	L	L
	Mine Staffing (Direct Employment)	O	O	O	O	O
	Contracted Employment	O	O	O	O	O
	Taxation	O	O	O	O	O
Post Closure	General Site Inspections and Maintenance	O	O	O	O	O
	Contact Water	O	O	O	O	L
	Non-contact Water	O	O	O	O	O
	Road use to the Project (Materials, Personnel, Supplies)	O	O	O	L	L
	Mine Staffing (Direct Employment)	O	O	O	O	O
	Contracted Employment	O	O	O	O	O

Notes:
O No interaction anticipated.
L Negligible to minor interaction expected; implementation of best practices, standard mitigation and management measures; no monitoring required, no further consideration warranted.
M Potential moderate interaction requiring unique active management/monitoring/mitigation; warrants further consideration.
H Key interaction; warrants further consideration.

Habitat Loss

For the purposes of this assessment habitat loss (or loss of food plants for butterflies) is defined as the process by which suitable habitat is rendered functionally unable to support the indicator species. Habitat loss will occur during the construction phase of the Project, specifically during vegetation clearing, land excavation, dams for water management and any other changes to the physical landscape. Permanent loss results from the replacement of habitat by Project infrastructure footprints (IF) and is considered the minimum effect. All habitat occurring within the Project IF is assumed to be permanently lost. Habitat outside, but in close proximity to the Project IF, may not be permanently lost but may be functionally compromised due to interactions with the Project IF. The IDA defines this area and is considered the maximum effect for habitat lost during Project construction and operation. Additional Project effects will not be considered for the Project IFs where habitat has been permanently removed (ie a species cannot be displaced from habitat that has already been permanently lost).

Habitat Alteration

Habitat alteration is defined as a reduction in habitat suitability. Activities that affect the physical characteristics or accessibility of an area, either permanently or temporarily can result in a change in habitat suitability. Habitat alteration will occur throughout the construction and operation phases of the Project, specifically as a result of drilling, blasting and crushing (fugitive dust deposition), and linear feature use and maintenance (invasive species introduction, vegetation maintenance). Included within the IDA is a minimum 50 metre buffer between the edge of the Project IF and the IDA. This buffer incorporates habitat alteration resulting from edge effects into the maximum habitat loss effect (Gieselman, Hodges, & Vellend, 2013). As all suitable habitat within the IF will be permanently lost, habitat alteration will be considered in the IDA and LSA. For the maximum habitat loss effect, habitat alteration will only be considered in the LSA.

Sensory Disturbance

Sensory disturbance refers to a Project related activity (e.g., noise, light, human presence) that causes individuals to change their behaviour or avoid certain habitats that would otherwise be suitable. Disturbance can interrupt normal activity and cause an animal to move away from the source of disturbance, resulting in use of sub-optimal habitats and energetic costs to the individual (Gill and Sutherland 2000; Blanc et al. 2006; Ward et al. 1999; Gibeau et al. 2002; Bautista et al. 2004). Disturbance during critical periods (e.g., breeding) may be more detrimental to some species than others. Some species will tolerate a considerable amount of human presence, providing there is no perceived risk. Invertebrates, specifically butterflies and dragonflies, are not particularly sensitive to noise disturbance (Munguira & Thomas, 1992).

Artificial light during evening construction and operations activities can also disturb a variety of species, depending on the season. The attraction of many insect species to artificial light is well-known (Rich & Longcore, 2006). Many of the attracted insects will die or become injured, or fall prey to predators such as bats (Bruce-White & Shardlow, 2011), though actual population effects are unknown.

Direct Mortality

Direct mortality is defined as the death of an individual resulting directly from a Project-related activity. Direct mortality can result from any number of Project activities, but are typically associated with collisions with vehicle/machinery on roads, removal of a habitat feature while they are occupied, and interactions with anthropogenic structures. The risk of mortality on terrestrial invertebrates is dependent on the activity, season, time of day and habitat type. Roadside attractants can also increase the risk of vehicular collisions. Mortality may be caused directly from Project activities such as vegetation clearing, land excavation, and vehicular collisions.

Chemical Hazards

Chemical hazards are defined as chemicals that result from Project related activities that have the potential to cause an adverse health effect on wildlife. Wildlife may ingest, inhale, or absorb chemicals (e.g., metals, dust, organic anthropogenic substances, etc.) from improperly stored substances, dust on soil or vegetation, or bioaccumulation from prey.

6.11.4.2 Effects on Terrestrial Invertebrates

Minor effects to terrestrial invertebrates are expected due to habitat loss (wetlands and food plants).

Habitat Loss

An interaction between butterfly indicator species and the Project (Section 6.9) is anticipated to lead to habitat loss. Food plants for various butterfly indicator species have been found in the LSA, and are some are expected to be lost as a result of clearing and grubbing activities. As no targeted butterfly foodplant surveys were conducted, this loss cannot be quantified. An interaction between wetlands and the Project (Section 6.10) is anticipated to lead to olive clubtail habitat loss. Several wetlands and waterbodies occur within the IDA (See Section 6.10 for map of wetlands). Earthworks and the Peterson Creek diversion is expected to remove these wetlands, which will remove potential olive clubtail breeding habitat. However, no indicator species were observed during baseline study, habitat loss effects to these species is expected to be low.

Although several occurrences of indicator species food plants will be removed during clearing and grubbing, and a large proportion of wetlands found in the LSA will be lost during earthworks activities, habitat loss is not anticipated to have an adverse residual effect on indicator species. No listed butterfly species were observed in the LSA, and none have been recorded in over 70 years. All historical records of listed butterflies and dragonflies in the RSA were observed in the bunchgrass ecosection. Less than 1% of the BGxw biogeoclimatic subzone occurs within the IF and is expected to be lost as a result of project construction. Consequently, no interaction between indicator species and habitat loss is anticipated. The indicator species foodplants are often associated with grasslands that make up a substantial part of the IDA. Habitat loss associated with grasslands is covered under the Grassland VC (Chapter 6.10), and will not be discussed further in this section.

Several wetlands and waterbodies occur within the IDA (See Section 6.9 for map of wetlands). Earthworks and the Peterson Creek diversion is expected to remove these wetlands, which will remove potential olive clubtail breeding habitat. Although any wetland could potentially support

olive clubtail, all observations of this species in the region occur along the shores of the Thompson River, and it is unlikely that a breeding population would occur in the LSA. No olive clubtails were observed in the LSA. No interaction between the olive clubtail and habitat loss is anticipated. Loss of wetlands will be covered under Rare and Sensitive Ecosystem VC (Chapter 6.9) and will not be discussed further in this section.

Habitat Alteration

The maximum dust fall (see Air Quality - section 10.1) is not expected to exceed the MoE guideline of 1.75 mg/dm^3/day (British Columbia Ministry of Environment, 2014). As such, habitat alteration resulting from dust fall is not expected to occur.

The impacts of invasive species on the distribution of food plants within the LSA cannot be characterized. Certain weedy food plant species, such as the showy milkweed and lamb's quarters, may increase as a result of invasive spread. Conversely, some species may be outcompeted by other invasive and noxious weeds. However, as no indicator species were observed in the LSA, it is unlikely a change in the distribution of their food plants will impact their population.

An interaction between terrestrial invertebrates and the Project, is anticipated to lead to habitat alteration. As no indicator species were observed during baseline study, habitat alteration effects to terrestrial invertebrates is expected to be low.

Sensory Disturbance

Dragonflies are not expected to be attracted to the light, but the dragonflies may be indirectly attracted to the light source to hunt the insect swarms. As no olive clubtail were observed during surveys, the artificial light sources within the IF are not expected to cause a sensory disturbance to this indicator species.

Artificial lighting may impact migrating monarch butterflies. The extended day-length provided by artificial light could disrupt the behaviour and flight navigation of monarchs (Froy, Gotter, Casselman, & Reppert, 2003). The majority of project lighting is expected to occur within project footprints, where suitable habitat has been removed. There is the potential that neighbouring habitat will be illuminated during different project phases; however, project lighting is more likely to be required in the winter months when daylight hours are short and monarchs are not present. Monarchs were also not confirmed in the study area, so the potential to affect this indicator species is low. Artificial light is unlikely to impact migrating monarchs.

Direct Mortality

As no indicator species were observed within the LSA, it is unlikely that these species will experience direct mortality as a result of the project, including lethal control of problem wildlife. Direct mortality effects are anticipated to be low.

Chemical Hazards

Contact water, which is any water that may have come into contact with potentially toxic materials, may have a negative effect on dragonfly habitat. Heavy metals such as copper, cadmium, lead, chromium and mercury are known to be persistent and mobile in the environment, and to be potentially toxic to many forms of life. Potential sources of metal contamination within the LSA include terrestrial (e.g., Mine Rock Storage Facilities) and aquatic (pit lake, Tailings Storage Facilities) components. The water quality in the pit depends on the interaction of the water with the rock in the pit walls and with the pH of the water.

As no indicator species were observed within the LSA, it is unlikely that these species will be exposed to chemical hazards as a result of the project. Similarly, the majority of food plants occur in grassland habitat, or along road sides, and are not anticipated to be exposed to contact water. All chemical hazard effects are anticipated to be low.

As no olive clubtails were observed during baseline surveys, they are not anticipated to experience and adverse effect as a result of chemical hazards. Chemical hazard effects to olive clubtail habitat (wetlands), is covered under Section 6.9.

6.11.4.3 Mitigation Measures for Terrestrial Invertebrates

The Monarch Management Plan outlines several broad strategies to achieve the objectives that could be implemented including: Continue to promote and support citizen engagement in the conservation and monitoring of monarch and its habitat.

Habitat Loss

During Project planning, specific mine footprints were designed to ensure the minimum possible impact on the surrounding environment would occur. During construction Project footprints will be kept to the minimum size required. Suitable habitat (grasslands and wetlands) will be maintained in the LSA. At the end of mine life, during decommissioning and closure, habitat will be restored through reclamation and revegetation processes.

Habitat Alteration

Fugitive Dust Mitigation

No potential effects of fugitive dust are expected to impact terrestrial invertebrates. Dust mitigation measures will be addressed under several management and monitoring plans. Mitigation measures to protect air quality are described in Section 10.1 and in the *Air Quality Monitoring and Dust Control Plan* (Chapter 11.6).

Invasive Species Mitigation

Invasive plant species are expected to have a neutral impact on terrestrial invertebrates. A *Soil Salvage and Handling Plan* and a *Landscape Design and Restoration Plan* (Sections 11.3 and 11.260, respectively) as well as the Invasive Species Management Section in the *Wildlife and Vegetation Monitoring Plan* (Section 11.27) will help to reduce the impact of invasive plants. Development and

implementation of an *Invasive Plant Management Plan* (Chapter 11.17) are integral to reducing invasive species introduction. Avoiding the introduction of invasive species is central to circumventing costly measures required for their eradication. Reducing traffic by implementing the *Access Management Plan* (Chapter 11.21) on site is also a key measure to help reduce the introduction of invasive plant species.

Direct Mortality

Vehicular mortalities of terrestrial invertebrates may occur during butterfly and dragonfly flight periods. Although this effect is anticipated to be low, it could occur throughout all phases of the Project, especially during construction and operations when road use will be higher than in later stages. The frequency of collisions will be reduced through the implementation of speed limits and minimizing the number of vehicles using sites roads (Transportation Management Plan Section 11.20). To reduce mortality from potential lethal control, integrated pest management will be practiced which selects effective (natural) control methods.

As indicator species are unlikely to be present on food plants, direct mortality associated with clearing and grubbing is will not result in a residual effect. Limiting clearing to the non-breeding season (winter months) will remove any possibility of direct mortality on monarchs.

Chemical Hazards

Chemical hazards from various Project activities (e.g., fuel storage and filling area, deposition to the TSF, contact water, vehicle/machinery leaks) are expected to be low in all phases of the Project. Mitigation Plans that will be in place to further reduce these effects include:

- a *Construction Waste Management Plan* (Chapter 11.4);
- a *Metal Leaching and Acid Rock Drainage Management and Monitoring Plan* (Chapter 11.5);
- a *Water Management and Hydrometric Monitoring Plan* (Chapter 11.7);
- a *Contaminated Sites Management Plan* (Chapter 11.8);
- a *Solid Waste Management Plan* (Chapter 11.9).
- a *Hazardous Waste Management Plan* (Chapter 11.10);
- a *Risk Management Plan (Accidents and Malfunctions)* (Chapter 11.12);
- a *Natural Hazards Management Plan* (Chapter 11.13);
- an *Emergency Response Plan* (Chapter 11.14).
- a *Surface Water Quality Management and Monitoring Plan* (Chapter 11.23); and
- a *Groundwater Quality Management and Monitoring Plan* (Chapter 11.24).

The *Surface Water Quality Management and Monitoring Plan* (Chapter 11.23) will be the most significant plan to reduce the interaction with potentially toxic water. Exposure to any contaminants will be reduced by ensuring that any hazardous materials are stored safely and securely. As

chemical hazards are expected to have a negligible to low impact on terrestrial invertebrates, no residual effects are expected for terrestrial invertebrates.

6.11.5 Residual Effects and their Significance

6.11.5.1 Summary of Residual Effects

Residual habitat loss effects to butterflies are not anticipated to remain after implementation of mitigation measures. As no indicator species were observed, habitat loss will not have an adverse residual effect on the regional population.

Residual habitat alteration effects as a result of invasive species is not expected to occur once the *Invasive Species Management Plan* (Section 11.17) and the *Air Quality and Dust Control Management Plan* (11.6) is initiated. Showy milkweed and lambs quarters will not be adversely impacted by additional invasive species in the area, as they are considered weedy species themselves, and should be able to compete effectively. As habitat alteration is expected to have a negligible to low impact on terrestrial invertebrates, no residual effects are expected for terrestrial invertebrates.

Sensory disturbance, specifically project lighting, has the potential to impact migrating monarchs, if the project site is lit during migration periods, and if monarchs are present on the site. As monarchs have not been observed on site, and lighting is expected to be greatest during winter months (when daylight hours are shorter), and monarchs are using wintering habitat it is unlikely that project lighting will interact sufficiently to cause an adverse residual effect.

Direct mortality can occur through vehicular collision, or through clearing and grubbing of food plants. Direct mortality of indicator species is not expected to occur, because there is no evidence of breeding by indicator species within the LSA. No adverse residual effect of direct mortality is expected to occur.

Terrestrial invertebrates are not expected to experience and adverse residual effect associated with chemical hazards. The majority of food plants are associated with dry grassland areas, and therefore will not be exposed to contact water. Olive clubtail may experience chemical hazards if they were found to breed or forage in or near contact water, but at present there is no evidence of a breeding population within the LSA. No adverse residual effects of chemical hazards are expected.

No residual effects are anticipated for any of the terrestrial invertebrate indicator species (Table 6.11-7). No additional analysis or characterization is required. As no residual effects are anticipated, no cumulative effects will be addressed.

Table 6.11-7. Summary of Residual Effects on Terrestrial Invertebrates

Valued Component	Project Phase (timing of effect)	Project Component/ Physical Activity	Description of Cause-Effect[1]	Description of Mitigation Measure(s)	Description of Residual Effect
Terrestrial invertebrates	Construction	Vegetation clearing/grubbing; earthworks	Loss of potential habitat	Minimize loss, Reclamation, Habitat compensation	None expected

[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 VC.*

6.11.6 Conclusion

The terrestrial invertebrates VC was assessed to determine potential interactions between Project activities and indicator species. No residual adverse effects are anticipated as a result of the Project. No observations of the listed indicator species were recorded in the Local Study Area, despite extensive survey effort by a species expert. No population level effects to California hairstreak, common sootywing, monarch, Nevada skipper and olive clubtail populations are anticipated. Seventy-seven terrestrial invertebrate species were identified over 3 years of surveys within the LSA, including 21 dragonfly/damselfly taxa, and 56 butterfly taxa. However, as these yellow-listed species are considered secure and widespread throughout the Province and effects of the Project to these species are not anticipated to have an adverse residual effect on the VC.

6.12 AMPHIBIANS

6.12.1 Rationale

This section includes a description of the scoping process used to identify Amphibians for inclusion in the assessment. Scoping is fundamental to focusing the Application/EIS on those issues where there is the greatest potential to cause significant adverse effects. Valued components (VCs) are components of the natural and human environment that are considered to be of scientific, ecological, economic, social, cultural, or heritage importance (CEAA 2006; EAO 2015). To be included in the EA, there must be a perceived likelihood that the VC will be affected by the proposed Ajax Project (the Project). Valued components are scoped into the environmental assessment based on issues raised during consultation with Aboriginal communities, government agencies, the public and stakeholders. Consideration of certain VCs may also be a legislated requirement, or known to be a concern because of previous project experience.

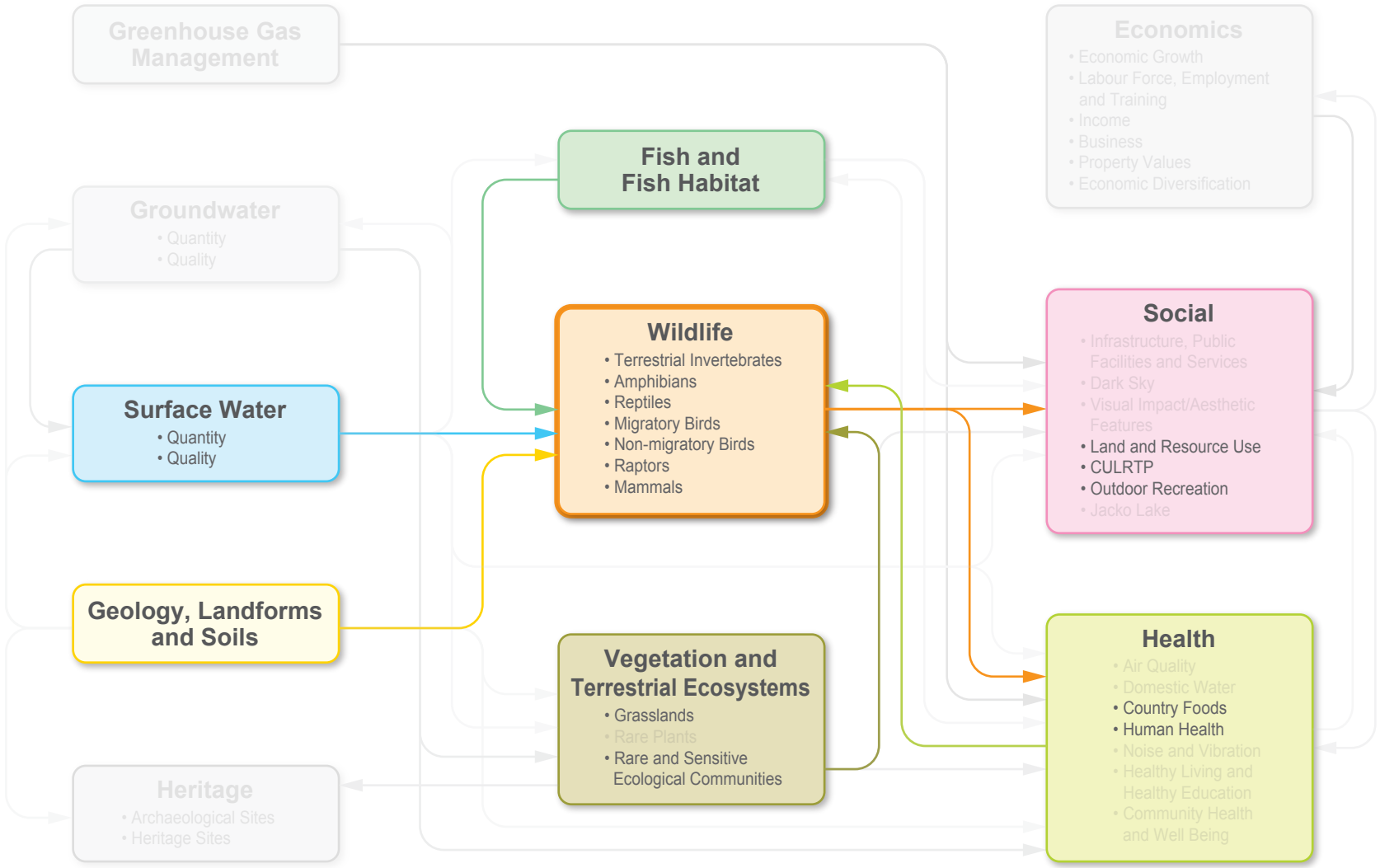
For amphibians to be considered for inclusion as a valued component in the environmental assessment, the following were considered:

- Federal or provincial listing or regulation (including relevant legislation or policy concerning the VC);
  - Lists of Red and Blue-listed species thought to occur within the Kamloops Forest District (BC Conservation Data Centre 2014a);
  - Information on actual known location records of Red or Blue-listed amphibians in or near the Project area (provided by the BC Conservation Data Centre (2014a);
  - Information on SARA and COSEWIC-listed amphibians available from the Government of Canada;
  - Amphibians listed as part of the Identified Wildlife Management Strategy (IWMS);
  - Taxa of regional concern; and
  - Data from targeted wildlife surveys and from incidental observations.
- Aboriginal interest;
- Public or other stakeholder input;
- Scientific/professional knowledge; and
- Relevant legislation or policy concerning the VC.

Amphibians occupy habitats based soil moisture and soil nutrient regimes. The assessment of effects to amphibians is largely related to disturbances from Project activities (as described further in Section 6.9.4). The information developed to support the analysis of this VC also contributes to Wildlife, Land and Resource Use, Outdoor Recreation, Country Foods, and Heritage (Figure 6.12-1).

Figure 6.12-1

VC Interactions for Wildlife (Amphibians)



6.12.1.1 Selection of Amphibians as a VC

Amphibians include frogs, toads, caecilians, salamanders and newts. Amphibians may spend a large portion of their lives on dry land, but many species must return to water in order to breed. Their eggs are laid in water and hatch into aquatic larvae. The larvae continue to grow and eventually develop legs, begin to breathe air and finally complete their metamorphosis into their adult form. Their requirement for both terrestrial and aquatic habitats means that amphibians are vulnerable to loss or degradation of both habitat types. They are susceptible to water-borne contaminants and are at risk from road-kill as they travel to and from breeding areas (Glista et al. 2007). In general amphibians are experiencing world-wide population declines, with habitat loss, environmental changes, disease, contaminants, and invasive species believed to be the leading causes (Wake and Vredenburg 2008; Gibbons et al. 2000; Hayes et al. 2010; Blaustein and Kiesecker 2002; Gallant et al. 2007). Amphibians are considered to be reliable indicators of environmental quality (Boyer and Grue 1995).

The VC "Amphibians" was selected as there is an expected interaction between amphibians and the Project. Specific justification for the selection of amphibians as a VC includes:

1. Federal or Provincial listing or regulation guidelines;
    a) Two Blue-listed species (Great Basin spadefoot and western toad) may be present in the Project area (Table 6.12-1);
    b) Two SARA schedule 1 species (Great Basin spadefoot and western toad) may be present in the Project area (Table 6.12-1).
2. Applicable government agencies (e.g., Environmental Assessment Office, Canadian Environmental Assessment Agency, Environment Canada, Forests, Lands, Natural Resource Operations, and First Nations) identified amphibians as a concern;
    a) frogs and toads are used for story and as ecological indicators for Aboriginal peoples (Ignace 2014).
3. Stakeholder input (Public, Kamloops Naturalist Club) identified amphibians as a concern;
4. Information sources (baseline studies (Appendix 6.8-A) and professional judgement based on relevant best practices);
5. Spatial scope (species range) – species range overlaps Project area;
6. Temporal scope (e.g., resident, rare visitant, uncommon) – resident species potentially occur in the Project area; and
7. Interaction with Project/potential effects (areas of disturbance associated with the Project components and activities including the Ajax pit, processing plant, tailings storage facilities, mine rock storage facilities, and transmission line) – a potential interaction is anticipated.

Table 6.12-1. Amphibian Species Present in the Region

English Name	Scientific Name	Provincial List	COSEWIC Status	SARA Schedule/ Status[1]	Identified Wildlife	Selected as Indicator?
Long-toed Salamander	*Ambystoma macrodactylum*	Yellow	Not At Risk	--	No	No
Columbia Spotted Frog	*Rana luteiventris*	Yellow	Not At Risk	--	No	Yes
Great Basin Spadefoot	*Spea intermontana*	Blue	Threatened	Schedule 1/T	Yes	Yes
Northern Pacific Treefrog	*Pseudacris regilla*	Yellow	--	--	No	Yes
Western Toad	*Anaxyrus boreas*	Blue	Special Concern	Schedule 1/SC	No	Yes

[1] *T = Threatened, SC = Special Concern*

6.12.1.2 Selection of Indicators

A preliminary list of indicator species was prepared (Table 6.12-1) based on the presence of suitable/capable habitat, the availability of sufficient species knowledge to produce a meaningful assessment, feedback from stakeholders and likely interactions with the Project (geographically and ecologically; Table 6.12-2). Wildlife surveys for particular indicators were planned when significant data gaps existed.

Table 6.12-2. Indicator Species Selection Rationale and Issues Raised

Indicator Species	Feedback by*				Issues Raised	Rationale
	AG	G	P/S	S/P		
Columbia Spotted Frog	✓	✓		✓	Loss of habitat, increased disturbance, displacement and mortality of Columbia spotted frog	Suitable habitat present within Project area, feedback from MoE
Great Basin Spadefoot	✓	✓		✓	Loss of habitat, increased disturbance, displacement and mortality of Great Basin spadefoot	Species at risk, suitable habitat present within Project area
Northern Pacific Treefrog	✓	✓		✓	Loss of habitat, increased disturbance, displacement and mortality of Northern Pacific treefrog	Suitable habitat present within Project area, feedback from MoE
Western Toad	✓	✓		✓	Loss of habitat, increased disturbance, displacement and mortality of western toad	Species at risk, suitable habitat present within Project area

**AG = Aboriginal Group (Stk'emlupsemc Te Secwepemc Nation (SSN) and Nlaka'pamux Nation); G = Government; P/S = Public/Stakeholder (e.g., LRMP); S/P = Scientific/Professional Knowledge.*

Amphibian species known to be present in the region include long-toed salamander (*Ambystoma macrodactylum*), Columbia spotted frog (*Rana luteiventris*), Great Basin spadefoot (*Spea intermontana*), Northern Pacific treefrog (also known as Pacific chorus frog; *Pseudacris regilla*), and western toad (*Anaxyrus boreas*; Table 6.12-1).

Columbia spotted frog, Great Basin spadefoot, Northern Pacific treefrog, and western toad were selected as indicators for the amphibian VC based on recorded observations of the species in the Project area during baseline studies, Aboriginal significance, incidental observations or reported historical presence, or on the presence of suitable habitat. All four of these species have been traditionally used by local Aboriginal Groups as ecological indicators, as well as for story (Ignace 2014). The Great Basin spadefoot and western toad are both provincially Blue-listed, and the spadefoot is also SARA-listed as Threatened. The western toad is listed under SARA's Schedule 1 as Special Concern. The Columbia spotted frog and Northern Pacific treefrog are not listed provincially or federally but were added as indicators based on feedback from the Ministry of Environment (MoE).

Long-toed salamander is provincially ranked as S4S5 (apparently secure or demonstrably widespread, abundant, and secure) and was not selected as an indicator because the Project is not anticipated to have an adverse effect on the population.

6.12.2 Assessment Boundaries

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

6.12.2.1 Spatial Boundaries

Infrastructure Footprints

The Project infrastructure footprints (IF) include the Open Pit, ancillary buildings and facilities, roads, truck stop, Tailings Storage Facility (TSF), Water Management Ponds, Mine Rock Storage Facilities (MRSFs), and stockpiles (Figure 6.12-2). The Project infrastructure footprints are 1,705 ha in size.

Infrastructure Disturbance Area

The Project infrastructure footprints and linear features (transmission line and water line) were buffered by at least 50 m (Henderson, 2011) to determine the Project Infrastructure Disturbance Area (IDA). The 3,185 ha IDA will be used to assess maximum direct Project effects (e.g., mortality, habitat loss, habitat alteration, etc.). The IDA includes the Project IF (1,705 ha) used to calculate direct loss of habitat, plus a 1,480 ha buffer around the Project IF that represents a zone of influence for potential disturbance associated with habitat alteration resulting from effects pathways such as contaminants, silt or dust, noxious weeds, and changes in drainage pattern (Figure 6.12-2).

The use of a buffered polygon area rather than individual infrastructure footprints will provide an overestimate of the direct effects of the Project for the assessment. The advantage of this approach is that it enables individual footprints to be moved and/or resized without changing the results of the effects assessment.

The IDA was modified from the General Arrangement Polygon to follow a section of the Kamloops city boundary to more accurately represent the current Project IF.

Habitat alteration by dust and water quantity is accounted for under potential habitat loss within the IDA. Areas outside of the IF that are not lost will be subject to potential alteration effects. However as wildlife species present in the area are adapted to the dry, dusty environmental conditions, these effects were considered mitigable.

Local Study Area

In accordance with the AIR the General Arrangement Polygon was buffered by 500 m to determine the Local Study Area (LSA). This area is the expected area of potential disturbance associated with all Project facilities (BC Environmental Assessment Office 2015). The LSA is 7,167 ha and will be used to assess indirect Project effects (e.g., disturbance) and provide context on the amount of habitat available adjacent to the Project IF (Figure 6.12-2).

Regional Study Area

The Regional Study Area (RSA) is the area for which cumulative effects will be assessed. The RSA will include portions of the South Kamloops Landscape Unit and Campbell Landscape Unit, including areas south of the Thompson River and west of Highway 97 (Figure 6.12-3). Landscape units were selected for the RSA as they are the geographical framework within which sustainable forest management regimes to maintain biodiversity are implemented. The RSA also includes local watershed basins and is 158,415 ha in size.

6.12.2.2 Temporal Boundaries

The temporal boundaries of the assessment will include the construction phase (short-term), operations (life of mine), de-commissioning and closure (short-term) and post-closure (short-term) activities.

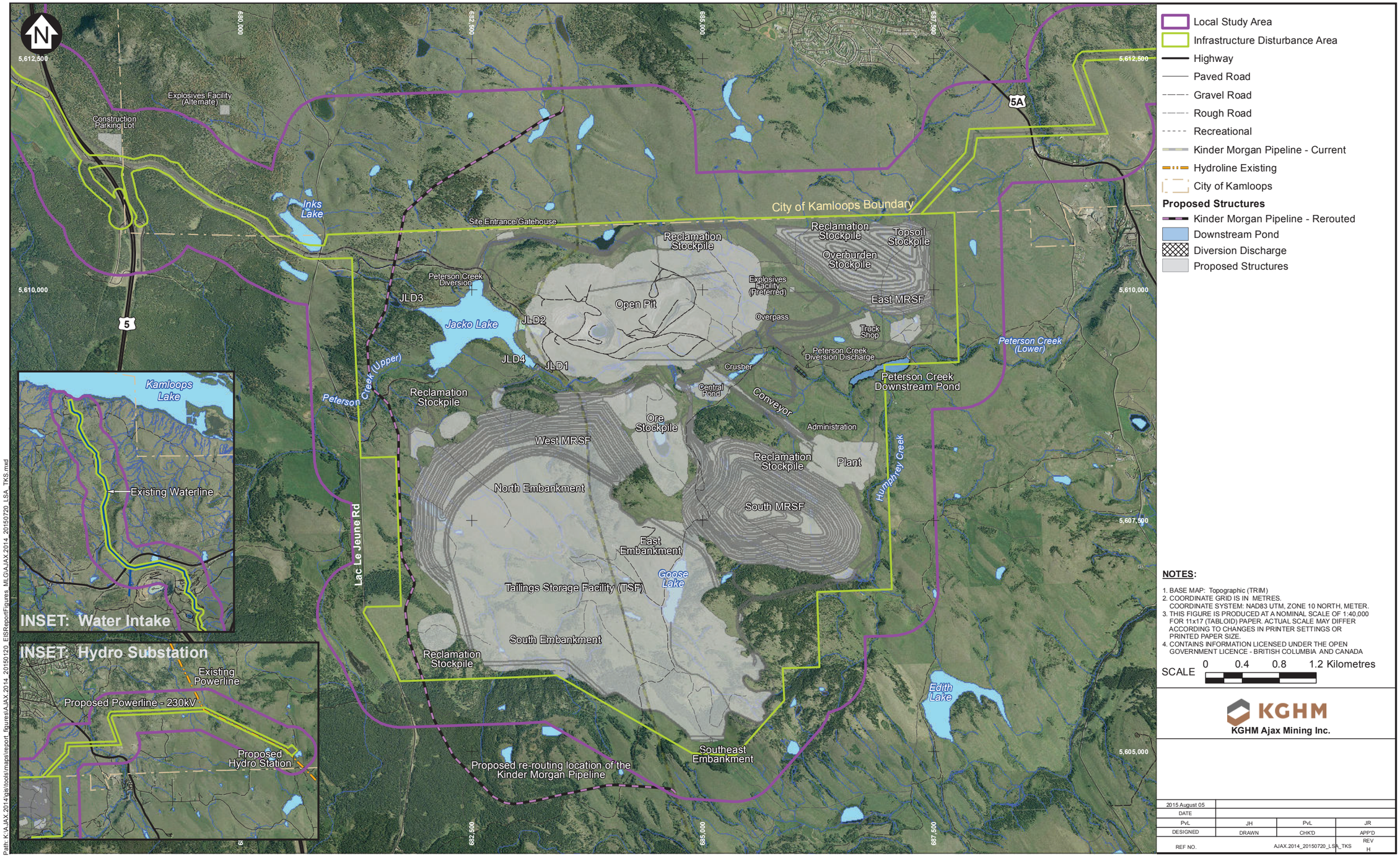
The temporal phases of the Project are:

- **Construction**: 2 years (Year -2 to 1);
- **Operation**: 23 years (Year 1 to 23);
- **Decommissioning and Closure**: 5 years (Year 24 to 29, includes Project decommissioning, abandonment and reclamation activities, as well as temporary closure, and care and maintenance); and
- **Post Closure**: 5+ years (includes ongoing reclamation activities and post-closure monitoring).

6.12.2.3 Administrative Boundaries

No administrative boundaries have impacted, constrained or expanded the assessment of amphibians.

Figure 6.12-2
Local Study Area, Infrastructure Disturbance Area and Project Infrastructure



NOTES:

1. BASE MAP: Topographic (TRIM)
2. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD83 UTM, ZONE 10 NORTH, METER.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:40,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
4. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENCE - BRITISH COLUMBIA AND CANADA

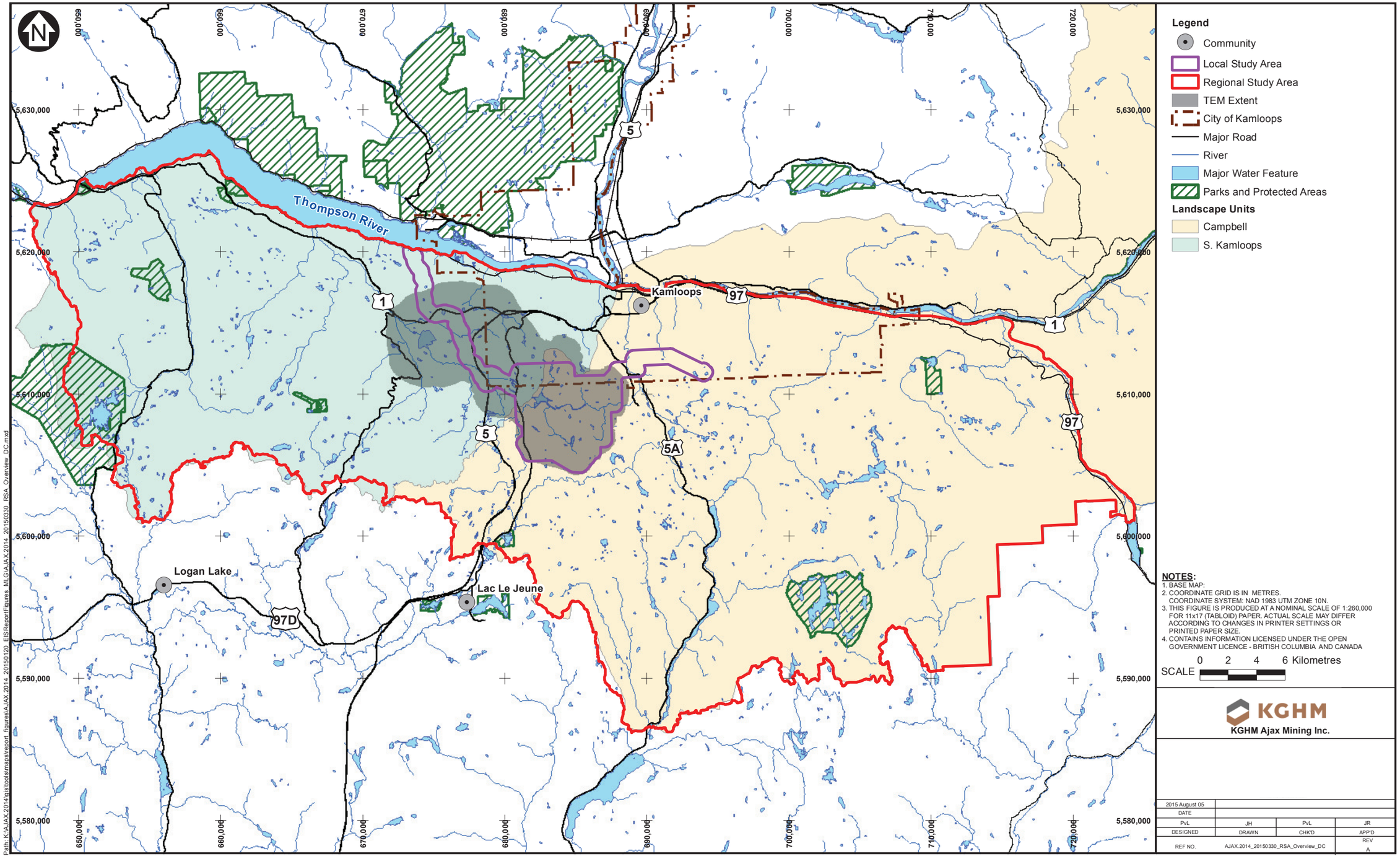
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KGHM Ajax Mining Inc.

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Figure 6.12-3
Regional Study Area



6.12.2.4 Technical Boundaries

Terrestrial Ecosystem Mapping (TEM) was only completed within the LSA as this is the area expected to interact with the Project, and thus requires detailed mapping. Areas outside of the LSA were quantified using VRI and other broad mapping sources.

The western toad, Great Basin spadefoot and Northern Pacific treefrog often breed in temporary waterbodies as these are generally free of aquatic predators that consume eggs and larvae. The presence, size and duration of temporary waterbodies is dependent on the amount of precipitation during the late winter and early spring. These intermittent waterbodies are not represented in the TEM mapping because they are not permanent features on the landscape. As such, only permanent waterbodies were considered in the quantification of breeding habitat completed for this assessment. Since additional breeding sites are likely to be present in a given year, particularly if there has been heavy rainfall, the amount of available breeding habitat reported in this assessment is an underestimate.

6.12.3 Background

6.12.3.1 Regulatory and Policy Framework

The Kamloops Land and Resources Management Plan (LRMP; Kamloops Interagency Management Committee 1995) outlines that: special attention to Red- and Blue-listed species should be considered; forests are to be managed to ensure diversity, as well as to ensure critical habitat is identified and managed appropriately through local level planning; and habitat improvement projects should be conducted where appropriate. Spadefoot habitat is identified as a resource value in the Skull Habitat Resources Management Zone.

The Nicola Thompson Fraser Sustainable Forest Management Plan (SFMP; SFMP Working Group 2015) aims to conserve species diversity by ensuring that habitats for a particular species are maintained, including habitats for known occurrences of species at risk. The SFMP (2015) identifies the need to maintain structural features of forest ecosystems including the provision of large course woody debris (CWD) for amphibian habitat. The CWD management strategy specifies levels of CWD that should be maintained, creation of stubs, and guidelines for enhancing CWD levels.

The Great Basin spadefoot is Identified Wildlife under the *Forest and Range Practices Act* (FRPA; Government of British Columbia 2002). General wildlife goals for the spadefoot include minimizing road mortality and soil disturbance, maintaining water quality and levels, minimizing disturbance during the breeding season (April through July), and maintaining riparian and aquatic habitat and important habitat features (Sarell 2004).

Amphibians are protected from being killed, collected, or held in captivity without a permit under the BC *Wildlife Act* (Government of British Columbia 1996). The *Species at Risk Act* (Government of Canada 2002) requires a recovery strategy or management plan for listed species within a specific timeframe depending on the species status and schedule. A provincial recovery strategy is in place for Great Basin spadefoot (British Columbia Southern Interior Reptile and Amphibian Recovery Team 2008) and a provincial management plan has been prepared for western toad (Provincial Western Toad Working Group 2014; Table 6.12-3). A federal management plan for the western toad

is currently being prepared, and should be available in 2015 or early 2016 (Environment Canada 2015). A federal recovery strategy is being prepared for the Great Basin spadefoot, and should be available in 2016 or early 2017 (Environment Canada 2015).

Table 6.12-3. Amphibian Recovery Planning Documents

English Name	SARA Schedule/ Status[1]	BC[2]	SARA[3]
Great Basin Spadefoot	1-T	RS – 2008	RS – anticipated 2016/2017
Western Toad	1-SC	MP – 2014	MP – anticipated 2015/2016

[1] *T = Threatened, SC = Special Concern*
[2] *RS = Recovery Strategy, MP = Management Plan*
[3] Species at Risk Act *Three-year Recovery Document Posting Plan (Environment Canada 2015)*

Guidelines for Amphibian and Reptile Conservation during Urban and Rural Land Development in British Columbia (BC Ministry of Forests, Lands, and Natural Resources 2014) provides practices to help maintain a viable native amphibian population in areas subject to rural and urban developments. Recommendations in this plan for amphibians include identifying and protecting aquatic breeding sites, avoiding development adjacent to potential breeding sites, and installation of crossing structures at known movement corridors.

The BC conservation framework ranks the Columbia spotted frog and western toad as priority 2 under goal 2 (prevent species and ecosystem from becoming at risk). The Great Basin spadefoot is priority 1 under goal 2. Northern Pacific treefrog are ranked as priority 6 (lowest) for all conservation framework goals.

6.12.3.2 Regional Overview

Lakes, wetlands, creeks and intermittent waterbodies (both natural and anthropogenic) occur across the landscape and provide breeding habitat for amphibians in the region. All amphibian species may be found in or adjacent to wetlands, riparian areas, or in coarse woody debris. Development throughout the region has removed aquatic habitat, diminishing the availability of suitable breeding sites. Loss and degradation of aquatic habitat is a significant threat to amphibians.

Indicator Species

Columbia spotted frogs are highly aquatic and do not venture more than a few metres from water. They are widely distributed in the province and are expected to be present in the region at most lake shores, ponds, and slow-moving creeks where there is sufficient cover in the form of riparian vegetation (Matsuda et al. 2006; BC Conservation Data Centre 2014a). Provincially, Columbia spotted frogs are ranked S4 (apparently secure).

Great Basin spadefoots, Northern Pacific treefrogs, and western toads may be found in a variety of habitats far from water during the non-breeding season and often shelter in rodent burrows, under tree roots, logs or rocks to prevent desiccation. Northern Pacific treefrogs are common across the southern half of the province (BC Conservation Data Centre 2014a), with a ranking of S5 (demonstrably widespread, abundant, and secure) and, despite their name, may also inhabit non-treed areas.

The Great Basin spadefoot and western toad have been recorded throughout the region (BC Ministry of Environment 2014a; Leupin et al. 1994; Hobbs and Werden 2012; BC Conservation Data Centre 2014a; Garner 2012) and targeted surveys have been conducted for both species in the Thompson region (Iredale and Ferguson 2007; Hobbs and Werden 2012; Biolinx Environmental Research Ltd and Nicola Naturalist Society 2012). In BC, Great Basin spadefoots are ranked S3 (special concern, vulnerable to extirpation or extinction) and western toads are ranked S3S4 (special concern, vulnerable to extirpation or extinction or apparently secure).

6.12.3.3 Historical Activities

Several past and current projects and activities have occurred throughout the region over the past century. Habitat loss and degradation, as well as mortality resulting from these projects and activities, are the greatest threats to amphibians. Mines, mills, pipelines, rail lines, agriculture/ranching, forestry, urban sprawl, and commercial recreation are some of the activities that occur within the vicinity of the Ajax Project that have the greatest potential to interact with amphibians.

Agriculture, ranching and forestry practices often degrade breeding/wetland habitat through clearing, introduction of invasive species, and trampling by cattle. Urban sprawl removes wetland habitat as wetlands are filled in for developments.

6.12.3.4 Baseline Studies

Baseline studies were conducted according to Resource Inventory Standards Committee (RISC) standards for amphibians in 2008, 2010 and 2014. Nocturnal auditory, road, and larval surveys were completed in an effort to determine species presence and abundance within the LSA. Any amphibian species observed incidentally at any time during the course of field work were recorded. Baseline surveys for amphibians were carried out as described in the AIR (BC Environmental Assessment Office 2015).

Auditory, road encounter, and larval surveys for amphibians were undertaken throughout the LSA and areas of the RSA within 500 m of the LSA to: a) identify and characterize amphibian breeding sites that may be affected by the Project, b) establish presence of target species and key habitat areas within the LSA, c) collect data on the location and timing of use of the LSA by target species, and d) provide information to KGHM Ajax Mining Inc. (KAM) to use during the Project design phase to avoid or minimize impacts to target species.

Data Sources

General information on species status and distribution was drawn from on-line sources such as the BC Ministry of Environment's Species Explorer and NatureServe (BC Conservation Data Centre 2014a; NatureServe 2014). Occurrence records of amphibians in the region were obtained from the BC Conservation Data Centre (BC Conservation Data Centre 2014b) and from the provincial Species Inventory Database (BC Ministry of Environment 2014c). Other reports providing local amphibian data include:

- Auditory and Larval Surveys for the Great Basin Spadefoot Toad in the Thompson Region, British Columbia (Iredale and Ferguson 2007);
  - Detections of individual spadefoots as well as spadefoot breeding was confirmed in the vicinity of the Project;
- Census and Life History Observations of the Great Basin Spadefoot Toad (*Scaphiopus intermontanus*) Breeding Populations in the Thompson Nicola Regions (Leupin et al. 1994);
  - A permanent pond with spadefoots was located in the LSA;
- Movement and habitat-use of the Great Basin spadefoot (*Spea Intermontana*) at its northern range limit (Garner 2012);
- Western toad monitoring study in Kentucky Alleyne Provincial Park, July - August 2012 (Biolinx Environmental Research Ltd and Nicola Naturalist Society 2012);
- COSEWIC Assessment and Status Report on the Western Toad *Anaxyrus boreas* in Canada (COSEWIC 2012); and
- COSEWIC Assessment and Status Report on the Great Basin Spadefoot *Spea intermontana* in Canada (COSEWIC 2007).

Traditional Aboriginal use of various amphibian species was taken from the report SSN Cultural Heritage Study - Final Report (Ignace 2014). All four indicator species were identified as having significance for story and as ecological indicators (ibid.).

Methods

Habitat Associations

Suitable breeding habitat for amphibians was defined for all BGC zones (IDF, BG, PP) as alkaline ponds, open water, ponds, alkali meadows, swamps, marshes, and lakes (Appendix 6.8-A). The presence of sport/game fish in lakes may result in the predation of amphibian eggs or individuals (BC Ministry of Environment 2015; Zevit and Wind 2010; Sarell 2004). Some frogs and toads may have success breeding in fish bearing waterbodies, provided they are in shallow water with vegetative cover (Zevit and Wind 2010). Anecdotal evidence exists for western toad breeding in Jacko Lake (P. LeGresley, Google Earth photo, 2011), as well as for frog migrations between Jacko Lake and Inks Lake.

While Jacko Lake may have suitable amphibian breeding habitat along the edges of the lake, the lake it its entirety was not considered suitable breeding habitat due to the presence of fish (predator) and the absence of suitable vegetation (eggs attachment) throughout the majority of the lake.

Field Surveys

Field surveys for amphibians followed methods described in *Inventory Methods for Pond-breeding Amphibians and Painted Turtle* (Resources Inventory Committee (RIC) 1998). Amphibian surveys were carried out between 2008 and 2014 and consisted of nocturnal road surveys, nocturnal auditory surveys, and time-constrained pond/larval surveys. For a more detailed account of survey methods, see Appendix 6.8-A. Any amphibians observed incidentally during targeted surveys for other taxa were also recorded.

Road Surveys

Road surveys involved slowly driving roads in the LSA at night (any time after sunset) while watching for amphibians on or alongside the road (Figure 6.12-4).

Auditory Surveys

Nocturnal auditory surveys were completed by listening for calling amphibians during the breeding season (April through July; Figure 6.12-4). Auditory surveys targeted Great Basin spadefoot and Northern Pacific treefrogs as neither western toads nor Columbia spotted frogs call loudly enough to be detected during surveys.

Time-constrained Search Surveys

During (diurnal) time-constrained surveys, surveyors actively searched for adult amphibians, tadpoles, and egg masses near the shores of waterbodies (Figure 6.12-4). All amphibians detected were recorded.

Water Quality

Baseline water quality was measured throughout the LSA (Surface Water Quality - Chapter 6.3). Waterbodies such as Jacko Lake, Peterson Creek, and Humphrey Creek were examined. The results of the baseline water quality analysis were compared to the modeled predicted water quality levels to determine any potential changes to areas of suitable amphibian habitat.

Characterization of Amphibian Baseline Condition

Habitat Associations

Over 173 ha of suitable amphibian breeding habitat was mapped in the LSA (Table 6.12-4, Figure 6.12-5). This included all mapped aquatic habitat, with the exception of Jacko Lake.

Road Surveys

Four nocturnal road surveys were completed from June 8 to 11, 2010 with a total survey effort 9 hours 33 minutes and 49.1 km. Five Great Basin spadefoots and seven western toads were detected (Figure 6.12-5). One road killed western toad was observed incidentally on Goose Lake Road, approximately 100 metres east of the east entrance, and an adult western toad was seen in a puddle at Inks Lake. Western toad tadpoles were seen at the junction of Peterson Creek and Jacko Lake, just downstream of the Peterson Creek outflow from the lake; this area does not have any fish present.

Auditory Surveys

In total, 65 survey stations and over 9 hours of nocturnal auditory surveys were completed during baseline studies. Survey timing windows were later in 2008 (mid-June) and 2010 (mid-May and mid-June) than in 2014 (late April). Detections were made at 56 of the survey stations.

Auditory detections of Northern Pacific treefrogs and Great Basin spadefoots had large inter-annual variation (Table 6.12-5). Surveys in 2014 in April indicate that spadefoots are more vocal in the LSA earlier in the season. The largest detection of Northern Pacific treefrogs occurred in 2010 with 149 individuals recorded in one evening (Figure 6.12-5). The most detections of Great Basin spadefoots in one evening occurred in 2014, with 221 individuals observed.

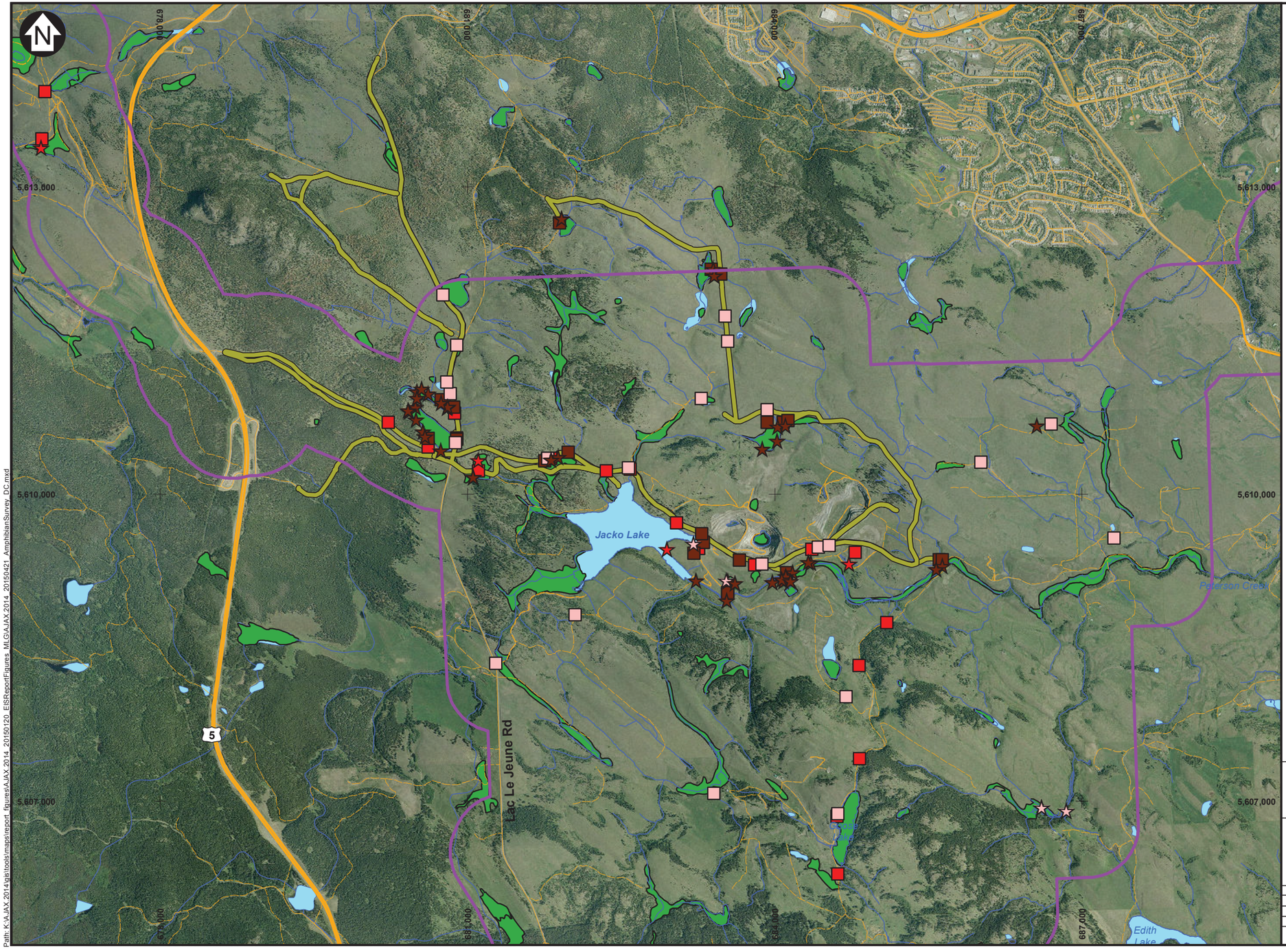
Table 6.12-4. Suitable Amphibian Breeding Habitat in LSA

Biogeoclimatic Subzone Variant	Wetland Name	TEM Code	Total (ha) in LSA
BGxw1	Alkaline Pond	AK	3.7
	Open water	OW	5.3
	Pond	PD	10.2
	Alkali Saltgrass herbaceous meadow	Gs01	5.6
	Beaked sedge -Water sedge	Wm01	0.9
	Common Cattail marsh	Wm05	8
BGxw1 Total			**33.7**
IDFxh2	Alkaline Pond	AK	7.7
	Lake (excluding Jacko Lake)	LA	25.5
	Open water	OW	15.1
	Pond	PD	13.8
	Alkali Saltgrass herbaceous meadow	Gs01	2.6
	Nuttall's alkaligrass-Foxtail barley	Gs02	9.9
	Beaked sedge -Water sedge	Wm01	7.4
	Common Cattail marsh	Wm05	12.2
	Great bulrush marsh	Wm06	10.9
	Baltic rush saline marsh	Wm07	7.7
	Bebb's willow-Bluejoint	Ws03	16
	Drummond's willow-Beaked sedge	Ws04	2.5
IDFxh2 Total			**131.2**
PPxh2	Alkaline Pond	AK	5.2
	Alkali Saltgrass herbaceous meadow	Gs01	3.1
PPxh2 Total			**8.3**
Grand Total			**173.2**

Table 6.12-5. Summary of Amphibian Auditory Surveys

			Individual Observations			
Year	Total Survey Time (hr min)	Number of Stations Surveyed	Western toad (visual)	Northern Pacific treefrog	Great Basin spadefoot	Total Estimated
2008 (June)	02h10	21	1	49	3	53
2010 (May & June)	04h21	22	-	281	11	292
2014 (April)	02h34	22	-	60	419	479
Total	**09h05**	**65**	**1**	**390**	**433**	**824**

Figure 6.12-4
Road Survey, Auditory Survey Locations, and Time-constrained Search Survey Locations



Legend

Auditory Survey

Date

- 2008
- 2010
- 2014

Time-constrained Search Survey

Date

- 2008
- 2010
- 2014
- Road Survey Track
- Potential Amphibian Breeding Habitat
- Local Study Area
- Highway
- Paved Road
- Gravel/Rough Road
- River
- Major Water Feature

NOTES:

1. BASE MAP:
2. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD 1983 UTM ZONE 10N.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:40,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
4. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENCE - BRITISH COLUMBIA AND CANADA

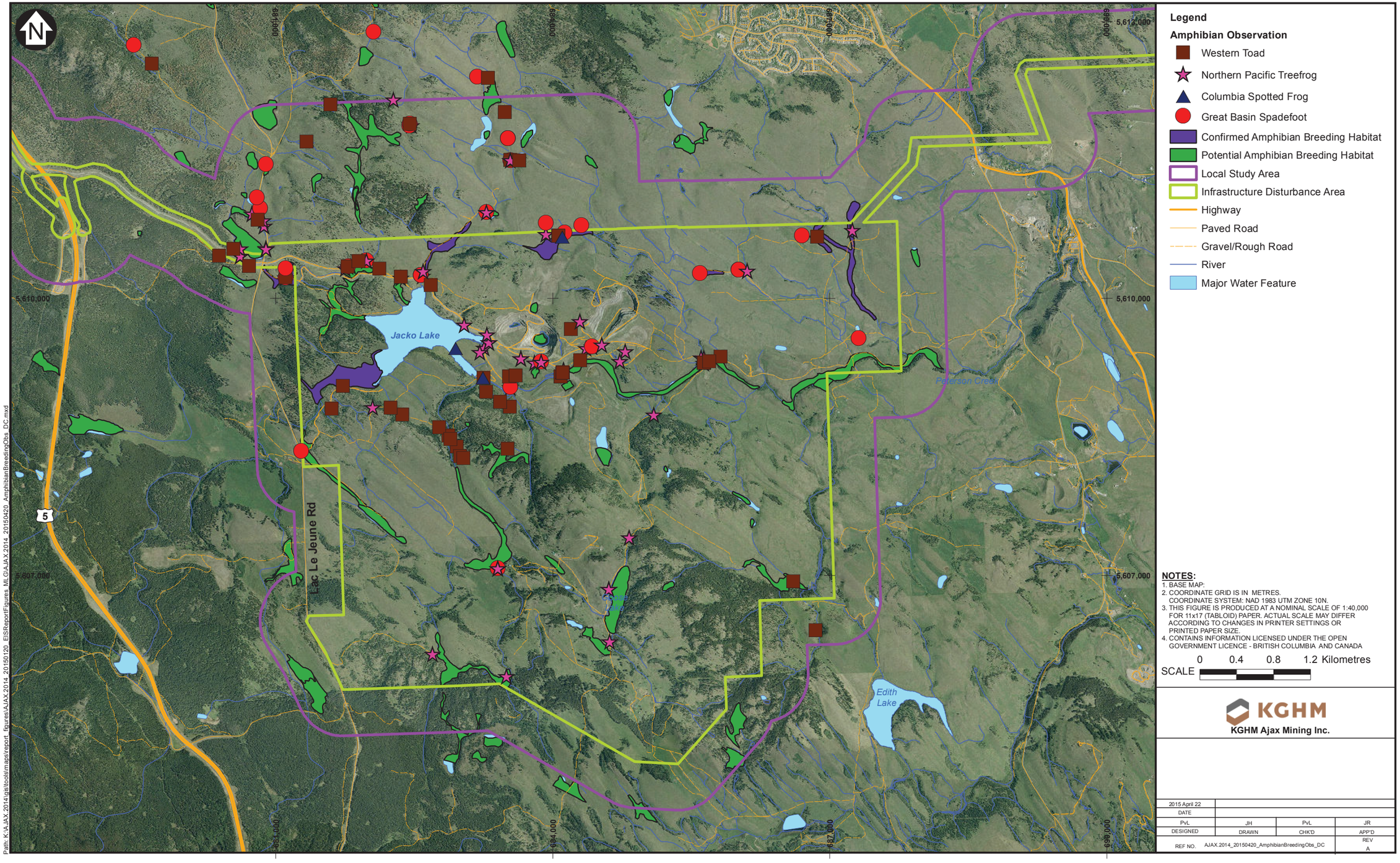
0 0.4 0.8 1.2 Kilometres

SCALE

KGHM Ajax Mining Inc.

2015 April 22			
DATE			
PvL	JH	PvL	JR
DESIGNED	DRAWN	CHK'D	APP'D
REF NO.	AJAX.2014_20150421_AmphibianSurvey_DC		REV A

Figure 6.12-5
Amphibian Breeding Habitat and Observations in the LSA



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Time-constrained Search Surveys

Larval surveys were completed at 31 sites for a total survey effort of 29 hours and 54 minutes (Table 6.12-6).

Table 6.12-6. Summary of Amphibian Time-constrained Search Survey Effort

Year	Number of Search Points	Sum of Total Search Time (hr min)
2008 (June)	5	05h00
2010 (April – June)	22	21h52
2014 (Apr & May)	4	03h02
Total	**31**	**29h54**

Both Great Basin spadefoot and Northern Pacific treefrog tadpoles were observed during field surveys in ephemeral wetlands, not represented by the TEM. Spadefoots were observed just east of Inks Lake and treefrogs were observed east of the existing pits. Mating adult western toads and their eggs were observed at a pond north of the pits. Adult frogs and western toads were observed at several other terrestrial locations (Table 6.12-7, Figure 6.12-5).

Table 6.12-7. Results of Amphibian Time-constrained Search Surveys

		Development Stage				
Year	Species	Adult	Egg Mass	Tadpole	Juvenile	Total
2008	Columbia spotted frog	1	0	0	0	1
	Great Basin spadefoot	0	0	30	0	1
	Northern Pacific treefrog	0	0	4	0	4
2010	Columbia spotted frog	3	0	0	0	3
	Northern Pacific treefrog	1	0	0	0	1
	Western toad	16	6	0	9	31
2014	Western toad	19	0	0	3	22
Total		**40**	**6**	**34**	**12**	**63**

Incidental Observations

Incidental amphibian observations were made in 2008, 2010, and 2014. Western toad and Great Basin spadefoot tadpoles were noted in an intermittent pond north of the existing pits, and adult Great Basin spadefoots and western toads were seen on site roads during nocturnal surveys for other species. One intermittent/seasonal pond northwest of the existing pits was drying up and the Great Basin spadefoot tadpoles there would have perished from lack of water a few days after the observation was recorded. Several juvenile western toads were found dispersing from their natal ponds at the confirmed breeding site near the southern arms of Jacko Lake, but no confirmed breeding of any amphibian occurred in Jacko Lake itself. Northern Pacific treefrogs were observed in the grasslands associated with the west mine rock storage facility footprint and in the rocky outcrops of the proposed pit footprint. Egg masses of Columbia spotted frogs were observed in Peterson Creek in the spring of 2014 at the bridge at the creek outlet from Jacko Lake. Great Basin

spadefoot tadpoles were recorded during invertebrate surveys in an ephemeral waterbody at the eastern edge of the proposed pit. Two incidental observations of long-toed salamander were also recorded, one near the open pit footprint in 2008 and a dead individual on an alkaline pond in 2010.

Water Quality

Chromium, Selenium, Manganese, and Molybdenum were found to exceed aquatic and/or wildlife water quality guidelines in several sites throughout the LSA (Surface Water Quality - Chapter 6.3). This included portions of Peterson Creek and Humphrey Creek as well as several other areas such as the historic waste rock seepage ponds and south catchment.

Summary

Field surveys confirmed the presence of all indicator species within the LSA (Figure 6.12-5) and confirmed breeding populations of Blue-listed Great Basin spadefoots and western toads in the LSA. Columbia spotted frogs were only detected breeding in Peterson Creek, but adults were also present in Jacko Lake, as well as a pond north of the existing pits. Nine mapped wetlands (42.6 ha) were confirmed as amphibian breeding habitat in the LSA, including alkaline ponds, open water, ponds, alkali meadows, swamps, marshes, and lakes. A number of unmapped, ephemeral wetlands were also observed as amphibian breeding habitat. Great Basin spadefoots can breed in small, temporary wetlands in the grassland and were observed travelling in grassland habitats during nocturnal surveys. Several aquatic breeding sites were noted for western toad, and individual toads were found in a variety of habitats throughout the LSA. Treefrogs were also detected throughout the LSA, in both grassland and forested habitats.

6.12.4 Potential Effects of the Project and Proposed Mitigation for Amphibians

6.12.4.1 Identifying Potential Effects on Amphibians

The AIR identified potential effects as habitat alteration and loss, disturbance and displacement, and mortality. These effects were further subdivided into: habitat loss; habitat alteration; sensory disturbance; disruption of movement; direct mortality; indirect mortality; wildlife attractants; and chemical attractants. An interaction matrix (Table 6.12-8) is used to help scope potential effects by considering potential interactions with Project activities/components, consistent with approach outlined in the assessment methodology (Section 5.2.4.1.). Further rationale for the scoping of potential effects is provided below.

A complete list of Project activities and what effect each activity may have on amphibians is provided below (Table 6.12-8).

Table 6.12-8. Identifying Potential Project Interactions and Effects on Amphibians

Project Activities		Potential Effects on Amphibians							
		Habitat Loss	Habitat Alteration	Sensory Disturbance	Disruption of Movement	Direct Mortality	Indirect Mortality	Wildlife Attractants	Chemical Hazards
Construction	Clearing and Grubbing	H	O	O	O	H	O	O	O
	Earthworks	H	O	O	O	H	O	O	O
	Overburden/Topsoil Stockpile	O	L	O	O	O	O	O	O
	Laydown Areas and Storage Yards	O	L	O	O	O	O	O	O
	Project Lighting	O	O	L	O	O	O	O	O
	Site Security and Fencing	O	O	O	O	O	O	O	O
	Fuel Storage and Filling Area	O	O	O	O	O	O	O	L
	Hazardous Wastes Transport, Storage, and Disposal	O	O	O	O	O	O	O	L
	Construction Wastes Transport, Storage, and Disposal	O	O	O	O	O	O	O	O
	Sewage Infrastructure and Disposal	O	O	O	O	O	O	L	L
	Public Road Realignment, Use, and Maintenance	O	L	L	L	H	O	O	O
	Site Road Construction, Use and Maintenance	O	L	M	M	M	O	L	O
	Haul Road Overpass Construction, Use, and Maintenance	O	O	O	O	O	O	O	O
	Site Buildings and Process Plant	O	O	O	O	O	O	O	O
	Explosives Magazine and Storage Facilities	O	O	O	O	O	O	O	O
	Open Pit Development	O	O	O	O	O	O	O	O
	Drilling and Blasting	O	L	M	O	O	O	O	O
	Crushing Mine Rock	O	L	M	O	O	O	O	O
	Loading, Hauling, and Deposition of Mine Rock	O	O	M	O	O	O	O	L

(continued)

Table 6.12-8. Identifying Potential Project Interactions and Effects on Amphibians (continued)

Project Activities		Potential Effects on Amphibians							
		Habitat Loss	Habitat Alteration	Sensory Disturbance	Disruption of Movement	Direct Mortality	Indirect Mortality	Wildlife Attractants	Chemical Hazards
Construction (*cont'd*)	Temporary Ore Stockpile	O	O	O	O	O	O	O	O
	Tailing Storage Facility Development	O	O	O	O	O	L	O	O
	Power Transmission, Distribution	O	L	O	O	O	O	O	O
	Natural Gas Line	O	L	O	O	O	O	O	O
	Pipeline Utility Corridor (Potable Water, Sewage, and Site Water)	O	L	O	O	O	O	O	L
	Water Intake from Kamloops Lake	O	O	O	O	O	O	O	O
	Fire Suppression Infrastructure	O	O	O	O	O	O	O	L
	Contact Water	O	O	O	O	O	O	L	M
	Non-contact Water	O	O	O	O	O	O	L	O
	Haul Road Overpass	O	M	O	O	O	L	O	O
	Water Management Dams	L	O	O	O	O	O	O	O
	Mine Staffing (Direct Employment)	O	O	O	O	O	O	O	O
	Contracted Employment	O	O	O	O	O	O	O	O
	Taxation	O	O	O	O	O	O	O	O
Operation	Open Pit Development	O	O	O	O	O	O	O	O
	Drilling and Blasting	O	O	M	O	O	O	O	O
	Hauling Mine Rock and Ore from Pit	O	O	L	O	O	O	O	L
	Crushing and Conveying Ore	O	O	M	O	O	O	O	O
	Temporary Ore Stockpile	O	O	O	O	O	O	O	O
	Development of Mine Rock Management Facilities	O	O	O	O	O	O	O	O
	Stripping, Loading, Hauling, Deposition, and Contouring of Topsoil and Overburden	O	O	L	O	O	O	O	O
	Revegetation through Progressive Reclamation	O	O	O	O	O	O	O	O

(continued)

Table 6.12-8. Identifying Potential Project Interactions and Effects on Amphibians (continued)

Project Activities		Potential Effects on Amphibians							
		Habitat Loss	Habitat Alteration	Sensory Disturbance	Disruption of Movement	Direct Mortality	Indirect Mortality	Wildlife Attractants	Chemical Hazards
Operation (*cont'd*)	Process Plant Operation	O	O	L	O	O	O	O	O
	Deposition to Tailing Storage Facility	O	O	O	O	O	O	O	L
	Site Road Use and Maintenance (Materials, Personnel, Supplies)	O	L	L	L	M	O	L	L
	Concentrate Transport and Storage	O	O	O	O	L	O	O	L
	Explosives Magazine and Storage Facilities	O	O	O	O	O	O	O	O
	Fire Suppression Infrastructure	O	O	O	O	O	O	O	L
	Fuel Storage and Filling Area	O	O	O	O	O	O	O	L
	Hazardous Wastes Transport, Storage, and Disposal	O	O	O	O	O	O	O	L
	General Wastes Transport, Storage, and Disposal	O	O	O	O	O	O	O	O
	Sewage Infrastructure and Disposal	O	O	O	O	O	O	L	L
	Laydown Areas and Storage Yards	O	O	O	O	O	O	O	O
	Power Transmission, Distribution	O	L	O	O	O	O	O	O
	Project Lighting	O	O	L	O	O	O	O	O
	Site Access, Security and Fencing	O	O	O	O	O	O	O	O
	Water Intake from Kamloops Lake	O	O	O	O	O	O	O	O
	Contact Water	O	O	O	O	O	O	L	M
	Non-contact Water	O	O	O	O	O	O	L	O
	Potable Water Treatment and Use	O	O	O	O	O	O	L	O
	Haul Road Overpass	O	M	O	O	O	L	O	O
	Mine Staffing (Direct Employment)	O	O	O	O	O	O	O	O
	Contracted Employment	O	O	O	O	O	O	O	O
	Taxation	O	O	O	O	O	O	O	O

(continued)

Table 6.12-8. Identifying Potential Project Interactions and Effects on Amphibians (continued)

Project Activities		Potential Effects on Amphibians							
		Habitat Loss	Habitat Alteration	Sensory Disturbance	Disruption of Movement	Direct Mortality	Indirect Mortality	Wildlife Attractants	Chemical Hazards
Decommissioning and Closure	Dismantling of Ancillary Buildings	O	O	O	O	O	O	O	O
	Pit Lake Planning	O	O	O	O	O	O	O	O
	Site Road Decommissioning	O	O	O	O	O	O	L	O
	Tailing Storage Facility Decommissioning and Reclamation	O	O	O	O	O	O	O	L
	Mine Rock Management Facilities Reclamation	O	O	O	O	O	O	O	L
	Fuel Storage and Filling Area	O	O	O	O	O	O	O	L
	Hazardous Wastes Transport, Storage, and Disposal	O	O	O	O	O	O	O	L
	General Wastes Transport, Storage, and Disposal	O	O	O	O	O	O	O	O
	Sewage Infrastructure and Disposal	O	O	O	O	O	O	O	L
	Laydown Areas and Storage Yards	O	O	O	O	O	O	O	O
	Power Transmission, Distribution	O	L	O	O	O	O	O	O
	Project Lighting	O	O	L	O	O	O	O	O
	Site Access, Security and Fencing	O	O	O	O	O	O	O	O
	Contact Water	O	O	O	O	O	O	L	M
	Non-contact Water	O	O	O	O	O	O	L	O
	Potable Water Treatment and Use	O	O	O	O	O	O	L	O
	Haul Road Overpass	O	M	O	O	O	O	O	O
	Road use to the Project (Materials, Personnel, Supplies)	O	O	L	L	M	O	O	L
	Mine Staffing (Direct Employment)	O	O	O	O	O	O	O	O
	Contracted Employment	O	O	O	O	O	O	O	O
	Taxation	O	O	O	O	O	O	O	O

(continued)

Table 6.12-8. Identifying Potential Project Interactions and Effects on Amphibians (completed)

Project Activities		Potential Effects on Amphibians							
		Habitat Loss	Habitat Alteration	Sensory Disturbance	Disruption of Movement	Direct Mortality	Indirect Mortality	Wildlife Attractants	Chemical Hazards
Post Closure	General Site Inspections and Maintenance	O	O	O	O	O	O	O	O
	Contact Water	O	O	O	O	O	O	L	M
	Non-contact Water	O	O	O	O	O	O	L	O
	Road use to the Project (Materials, Personnel, Supplies)	O	L	L	L	L	O	O	L
	Mine Staffing (Direct Employment)	O	O	O	O	O	O	O	O
	Contracted Employment	O	O	O	O	O	O	O	O

Notes:

O *No interaction anticipated.*

L *Negligible to minor interaction expected; implementation of best practices, standard mitigation and management measures; no monitoring required, no further consideration warranted.*

M *Potential moderate interaction requiring unique active management/monitoring/mitigation; warrants further consideration.*

H *Key interaction; warrants further consideration.*

Habitat Loss

For the purposes of this assessment habitat loss is defined as the process by which suitable habitat is rendered functionally unable to support the indicator species. Habitat loss will occur during the Construction phase of the Project, specifically during vegetation clearing, land excavation, dam construction for water management and any other changes to the physical landscape. Permanent loss results from the replacement of habitat by Project infrastructure footprints (IF) and is considered the minimum spatial extent of anticipated habitat loss. All habitat occurring within the Project IF is assumed to be permanently lost. Habitat outside, but in close proximity to the Project IF, may not be permanently lost but may be functionally compromised due to interactions with the Project IF. The IDA defines this area and is considered the maximum spatial extent of anticipated habitat loss during Project Construction and Operation. Additional Project effects will not be considered for the Project IF where habitat has been permanently removed (i.e., a species cannot be displaced from habitat that has already been permanently lost).

Although multiple Project activities will result in habitat loss, for the purpose of this assessment habitat loss will result from clearing and/or grubbing (terrestrial habitat), earthworks (wetlands and waterbodies) and water management dams during Construction. It is assumed that all Project IF will be cleared and/or grubbed prior to Construction and all habitat overlapping Project IF will be permanently lost. Habitat reclamation during Operation and Decommissioning and Closure phases is considered a habitat gain, and will be considered under mitigation. Suitable habitat is present in the LSA for western toad, Northern Pacific treefrog, Great Basin spadefoot, and Columbia spotted frog and an interaction with the Project is anticipated. A ranking of "high" was assigned for these activities, and warrants further analysis as described in Section 6.12.4.2.

Habitat Alteration

Habitat alteration is defined as a reduction in habitat suitability. Activities that affect the physical characteristics or accessibility of an area, either permanently or temporarily can result in a change in habitat suitability. Habitat alteration will occur throughout the construction and operation phases of the Project, specifically as a result of drilling, blasting, crushing and road use (fugitive dust deposition), soil compaction, linear feature use and maintenance (invasive species introduction, vegetation maintenance) and changes in drainage and water quantity. Included within the IDA is a minimum 50 metre buffer between the edge of the Project IF and the IDA. This buffer incorporates habitat alteration resulting from edge effects into the maximum habitat loss effect (Gieselman et al. 2013). As all suitable habitat within the Project IF will be permanently lost during initial Project Construction activities (minimum anticipated loss effect), habitat alteration will only be considered in the IDA and LSA. For the maximum habitat loss effect, habitat alteration will only be considered in the LSA.

Construction and Operation Project activities that will lead to habitat alteration include public and site road realignment, use and maintenance; drilling and blasting; crushing mine rock; Peterson Creek diversion; overburden/topsoil stockpile; laydown areas and storage yards; and linear features (power transmission, natural gas and pipeline corridor). These activities can degrade the habitat through the creation of fugitive dust, introduction and distribution of invasive species, changes to hydrology patterns in wetlands, and soil compaction. Suitable habitat is present for amphibians in the LSA and an interaction with the Project is anticipated. A ranking of "low" to "moderate" was

assigned for Project activities (Table 6.12-8) that will alter breeding and terrestrial amphibian habitat, and warrants further analysis as described in Section 6.12.4.2.

Habitat fragmentation can be associated with corridors of unsuitable habitat (e.g., open roads) that may function as filters or barriers for some wildlife populations (Jalkotzy et al. 1997). The loss of vegetative cover can restrict road crossings to a few individuals (filter) or no individuals (barrier). The degree of loss of connectivity will vary with the width of the corridor, the frequency of vehicular traffic, the habitat on either side of the corridor and the species being considered. The resulting fragmentation and obstruction can limit the ability of species to disperse, breed and survive if it cannot access critical habitats or travel corridors. Project activities that can lead to habitat fragmentation have been ranked as "M" and will be considered under disruption of movement and direct mortality in Section 6.12.4.2.

Sensory Disturbance

Sensory disturbance refers to a Project related activity (e.g., noise, light, human presence) that cause individuals to change their behaviour or avoid certain habitats that would otherwise be suitable. Little is known about the impacts of sensory disturbance for most amphibian species. Disturbance can interrupt normal activity and cause an animal to move away from the source of disturbance, resulting in increased energy expenditures or utilization of sub-optimal habitats (Ward et al. 1999; Gill and Sutherland 2000; Gibeau et al. 2002; Bautista et al. 2004; Blanc et al. 2006). Disturbance during critical periods (e.g., breeding season) may be more detrimental to some species than others. Masking can reduce fitness (breeding success), especially for species that are highly reliant on their acoustic environment. In some cases, habituation and adaptation can allow wildlife to accommodate the presence of noise in their environment. Some species will tolerate a considerable amount of human presence, providing there is no perceived risk.

Project activities expected to cause noise-sensory disturbance to amphibians during Construction and operation include public and site road construction, use and maintenance; drilling and blasting; crushing mine rock; crushing and conveying ore; loading, hauling and deposition of mine rock and ore; stripping, loading, hauling, deposition, and contouring of topsoil and overburden; and process plant operation. Noise disturbance may have a detrimental effect on those amphibian species that rely on auditory calls to attract a mate (Parris et al. 2009; Sun and Narins 2005; Bee and Swanson 2007; Lengagne 2008; Schwartz and Bee 2013; Eigenbrod et al. 2009). Project related noise may result in decreased reproductive success of Great Basin spadefoots and Northern Pacific treefrogs, if Project activities occur during sensitive breeding times. Predation risk may also increase as a result of Project related noise by disguising the sound of approaching predators (Barber et al. 2010). Noise can also cause stress levels to rise by increasing the perception of predation risk. Based on preliminary noise modeling, Project related noise is anticipated to have a range of potential interactions on this VC. A ranking of "low" to "moderate" was assigned for Project activities causing sensory disturbance and further analysis is included in Section 6.12.4.2.

Project lighting during Construction, Operation, and Decommissioning and Closure activities may disturb amphibians. Potential effects of increased light levels include increased predation risk, and disruption of circadian rhythms governing behaviours such as foraging, hibernation and reproduction (Buchanan 2006; Perry et al. 2008). Individuals in areas where artificial lighting is

constant do not have the option of concentrating their activities during darker periods, and must either suffer increased risk of predation or abandon the habitat. As many amphibians are nocturnal or partly nocturnal (Buchanan 2006) the potential for these species to be affected by artificial light exists. As the majority of artificial light is expected to be focused in the Project footprints where suitable habitat has been removed, the expected interaction of this activity on amphibians was assigned a ranking of "low" and will not be discussed further.

Disruption of Movement

A wildlife movement corridor is a linear habitat that connects two significant habitat areas (Beier and Loe 1992). Disruption of movement refers to Project related activities that may cause an interruption to animal movements or migration, or may cause complete avoidance of certain habitats that would otherwise be suitable. Displaced or disturbed individuals may choose to temporarily vacate habitats, resulting in increased energy expenditures. Amphibian movement may be affected directly as a result of Project related activities, such as excavation of the mine (movement barrier) or road construction (corridors).

Roads are often cited as having the greatest effects of disturbance on wildlife (Jalkotzy et al. 1997) and Project use of public and site roads during Construction and Operation may have an effect on amphibian movement. Repeated disturbances from traffic may cause some species to avoid the area around active roads, resulting in a net decrease in available habitat, as well as changes in daily and seasonal movement patterns. A ranking of "low" to "moderate" was assigned for disruption of movement and further discussion is included in Section 6.12.4.2.

Direct Mortality

Direct mortality is defined as the death of an individual resulting directly from a Project related activity. Direct mortality can result from any number of project activities, but are typically associated with vehicle/machinery use on roads and removal of habitat features while they are occupied.

Project activities expected to cause mortality include clearing/grubbing; earthworks, and public and site road use. Road mortality is anticipated to have the greatest effect on spadefoots and western toads as they both undergo mass dispersal events (Cannings 1999; Bull 2009). A ranking of "moderate" to "high" was assigned for direct mortality and further analysis is included in Section 6.12.4.2. Direct mortality may also occur during transport of concentrate from the Project to the Port of Vancouver. This activity was ranked as "low", as the incremental effect of those vehicles to existing highway traffic is very small.

Indirect Mortality

Indirect mortality is defined as the death of an individual resulting indirectly from a Project related activity. Indirect mortality resulting from the Project could result from a home range shift leading to an increase in resource competition between individual amphibians. Since all amphibian indicator species have relatively small home ranges the primary effects on amphibian populations are associated with habitat loss and direct mortality rather than range shift. Indirect mortality for amphibians is considered to have a low potential effect.

Wildlife mortality may be caused indirectly from range shifts leading to increased resource competition between individuals or from increased hunting pressure by natural predators. A ranking of "low" was assigned for indirect mortality.

Wildlife Attractants

Wildlife attractants are defined as features or materials that may attract wildlife away from their natural environments, to areas that are superficially superior. Odours, food waste, sewage, garbage, and stored chemicals from construction crews are examples of types of attractants that may entice individuals, but that ultimately will have a detrimental effect on the species.

During Construction and Operation the presence of sewage infrastructure and disposal, non-contact, contact and treated potable water (potential sources of drinking water) throughout the LSA may attract amphibians away from otherwise superior habitat. Regenerating vegetation on road sides and artificial ditches associated with site roads may be used by amphibians during the Operation, Decommissioning and Closure, and Post-Closure phases of the Project. Contact water, for the purpose of this assessment, will be assessed under chemical hazards. As the occurrence of non-contact water will be limited to Project IF, the anticipated interaction between wildlife attractants was ranked as "low".

Chemical Hazards

Chemical hazards are defined as chemicals that result from Project related activities that have the potential to cause an adverse health effect on wildlife. Wildlife may ingest, inhale, or absorb chemicals (e.g., metals, organic anthropogenic substances, etc.) from improperly stored substances or bioaccumulation from prey. Contamination of the environment may affect amphibians more than other vertebrate groups as amphibians have moist, permeable skin and unshelled eggs, and spend part of their lives in both terrestrial and aquatic habitats, exposing them to a range of possible pollutants (Blaustein and Kiesecker 2002).

Evaluation of potential toxic effects of metals on wildlife and ecosystems is hampered by a wide array of environmental factors operating both independently and synergistically, which are known to affect toxicity and bioaccumulation (Blaustein and Kiesecker 2002). Metals bioavailability varies greatly with environmental factors such as temperature, pH, water velocity, season, and salinity. The potential effects of metal contamination may be complicated due to interactions between different metals. Amphibians feeding on invertebrates will likely ingest more metals than other wildlife species feeding on vegetation.

Project activities that have the potential to result in a chemical hazard during Construction, Operation and Decommissioning include: fuel storage and filling area; hazardous waste transport, storage and disposal; sewage infrastructure and disposal; loading, hauling and deposition of mine rock; pipeline utility corridor; fire suppression; contact water; hauling mine rock and ore from pit; deposition to tailing storage facility; site road use; concentrate transport and storage; and general waste transport, storage and disposal.

Oil, fuel, and other petroleum-based fluids and antifreeze from machinery can cause direct mortality and habitat contamination if they are allowed to escape into the environment. Petroleum compounds can affect amphibians physically (smothering, reduced light), via habitat modification (alterations in pH or diminished food availability) or via toxic action (Albers 2003). Since all chemical hazards would result from an accident or malfunction (Chapter 11.13), the expected interaction of these activities on amphibians was given a ranking of "low".

Contact water, which is any water that may have come in contact with potentially toxic materials, may have a negative effect on amphibians. Heavy metals and contaminants such as arsenic, copper, cadmium, lead, chromium, molybdenum, and mercury are known to be persistent and mobile in the environment, and to be potentially toxic to many forms of life. Potential sources of metal contamination within the LSA include terrestrial (e.g., Mine Rock Storage Facilities (MRSF)) and aquatic (pit lake, Tailings Storage Facilities (TSF)) components. The water quality in the pit depends on the interaction of the water with the rock in the pit walls, and with the pH of the water. Acidified water will have increased metal loading (Miller 2002). Amphibians born into the same contaminated environments as their parents will be exposed, both maternally as well as environmentally, to potential toxins (Bergeron et al. 2011).

The specific effects that contaminants may have on amphibians are not well understood. Amphibians are attracted to water, especially during the breeding season. Foraging amphibians may be exposed to metal ingestion through consumption of insects that have fed on plants in mining areas or of insects that have developed in contaminated water. For these reasons, the potential for an interaction from the presence of contact water on the landscape was ranked "moderate," and warrants further discussion in Section 6.12.4.2.

A complete list of Project activities and what effect each activity may have on amphibians is provided below (Table 6.12-8).

6.12.4.2 Effects on Amphibians

For effects ranked "M" or "H" in Section 6.12.4.1, further analysis was undertaken, and is described below to quantify the potential effects of Project activities on amphibians.

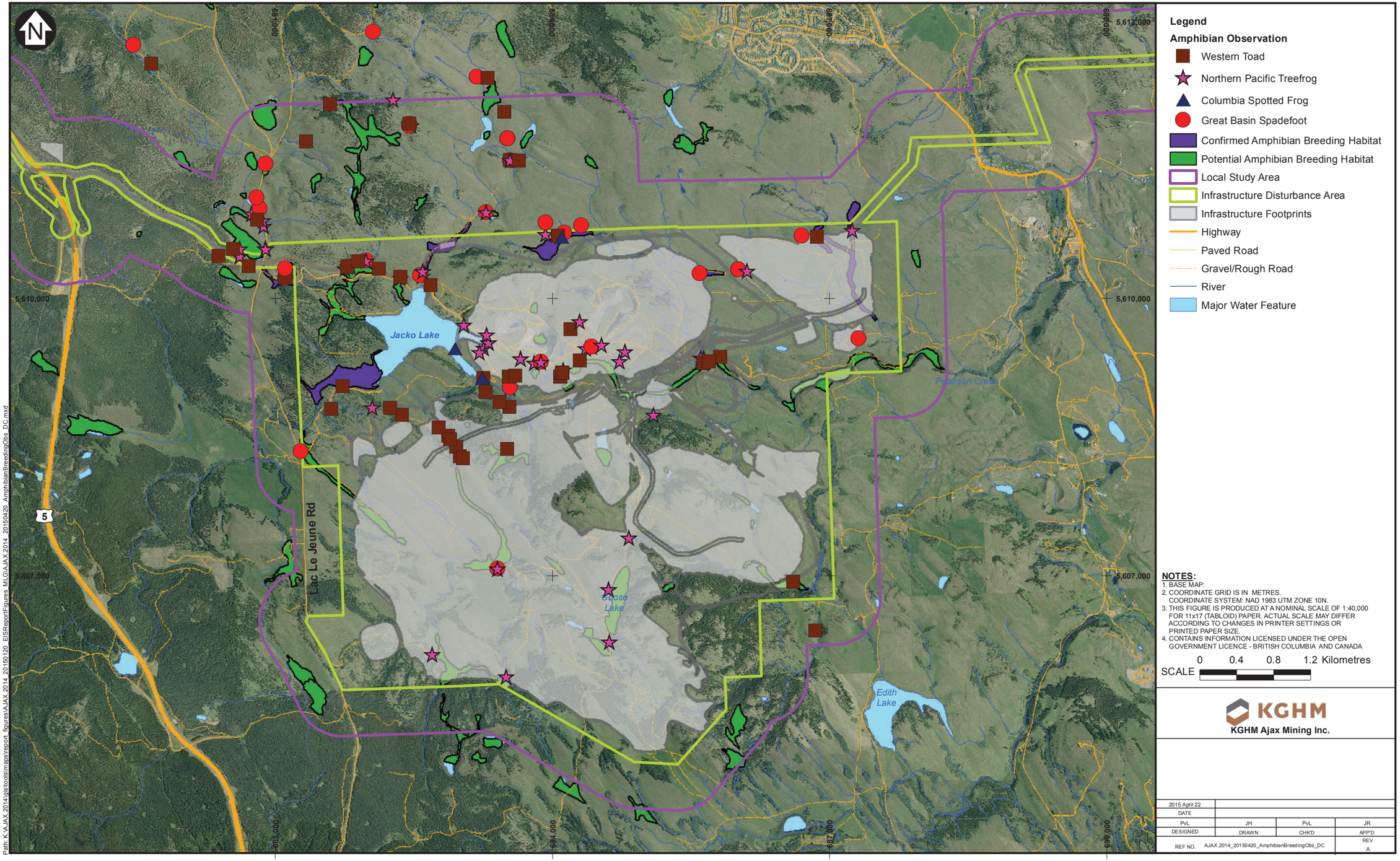
Habitat Loss

Methods to Predict Impacts of Project Activities on Amphibians in the LSA

The potential exists for an adverse effect on amphibians if suitable habitat is present within the IF or IDA. Due to the specificity of breeding habitat, it is considered to be limiting for amphibians and was the focus of this assessment, although loss of suitable terrestrial habitat can reduce the survival of dispersing juveniles (Cushman 2006). Breeding habitat was defined in the TEM as ponds, marshes, and alkaline wetlands (Langton et al. 2001; Stebbins 2003; Wells 2007).

The amount of suitable habitat lost for amphibians was calculated by determining the maximum and minimum potential spatial extent of habitat loss. The maximum effect was calculated by overlaying the IDA footprint on the habitat suitability mapping, while the minimum effect was determined by overlying the Project IF (Figure 6.12-6). The amount of suitable habitat lost within the IDA or IF was compared to the total amount of suitable habitat within the LSA to calculate the percent of suitable habitat lost within the LSA.

Figure 6.12-6
Amphibian Breeding Habitat and Observations in the LSA



Methods to Predict Impacts of Project Activities on Amphibians in the RSA

To determine the amount of amphibian breeding habitat available in the RSA, the VRI was used to assess the presence and distribution of wetlands in the RSA. The Project RSA was overlaid on the VRI (2012) to determine the proportion of wetlands in the RSA that will be affected by the Project. Wetlands were identified as non-vegetated water wetlands in the VRI. VRI is not as accurate as TEM mapping, and wetlands identified by these two mapping sources cannot be directly compared.

Predicted Impacts of Project Activities on Amphibians in the LSA

Habitat loss ranged from a minimum effect of 26% to a maximum effect of 48% for all indicator species. (Table 6.12-9, Figure 6.12-6). The total maximum effect to amphibians in the BGxw1 and the PPxh2 was 28% and 5%, respectively. The effect to amphibians in the IDFxh2 ranged from 31% to 59% and the Project will have the greatest effect on amphibians in this subzone variant. Confirmed amphibian breeding sites within the IDA are primarily located outside the IF and these sites are not anticipated to be removed.

Table 6.12-9. Summary of Breeding Habitat Loss

Biogeoclimatic Subzone Variant	Wetland Name	TEM Code	Total (ha) in LSA	Total (ha) in IDA	Max % loss	Total (ha) in IF	Min % loss
BGxw1	Alkaline Pond	AK	3.7	0.3	8.1	0.0	0.0
	Open water	OW	5.3	1.4	28.3	0.0	0.0
	Pond	PD	10.2	1.2	11.8	0.0	0.0
	Alkali Saltgrass herbaceous meadow	Gs01	5.6	0.8	12.5	0.0	0.0
	Beaked sedge -Water sedge	Wm01	0.9	0.7	77.8	0.1	10.5
	Common Cattail marsh	Wm05	8.0	4.9	61.3	3.4	42.4
BGxw1 Total			**33.7**	**9.3**	**27.7**	**3.5**	**10.4**
IDFxh2	Alkaline Pond	AK	7.7	0.5	6.1	0.3	4.3
	Lake (excluding Jacko Lake)	LA	25.5	16.4	64.3	2.5	9.8
	Open water	OW	15.1	10.8	71.8	8.0	55.5
	Pond	PD	13.8	8.5	61.6	7.0	51.0
	Alkali Saltgrass herbaceous meadow	Gs01	2.6	1.6	60.1	1.4	54.9
	Nuttall's alkaligrass-Foxtail barley	Gs02	9.9	1.0	9.5	0.9	9.6
	Beaked sedge -Water sedge	Wm01	7.4	4.7	63.1	3.6	52.2
	Common Cattail marsh	Wm05	12.2	11.0	90.6	5.3	58.0
	Great bulrush marsh	Wm06	10.9	9.6	87.7	8.0	73.6
	Baltic rush saline marsh	Wm07	7.7	2.3	30.5	1.9	24.5
	Bebb's willow-Bluejoint	Ws03	16.0	9.0	56.5	0.0	0.0
	Drummond's willow-Beaked sedge	Ws04	2.5	2.5	100.0	2.1	83.5
IDFxh2 Total			**131.2**	**77.8**	**59.3**	**41.2**	**31.4**
PPxh2	Alkaline Pond	AK	5.2	0.0	0.0	0.0	0.0
	Alkali Saltgrass herbaceous meadow	Gs01	3.1	0.4	11.7	0.0	0.0
PPxh2 Total			**8.3**	**0.4**	**4.4**	**0.0**	**0.0**
Grand Total			**173.2**	**87.5**	**48.1**	**44.7**	**25.8**

Habitat loss can lead to a decrease in amphibian species richness, as wetlands may become more isolated, reducing connectivity between suitable areas (Lehtinen et al. 1999). The potential effect of loss of amphibian breeding habitat due to the Project is anticipated to be moderate based on the maximum effect in the IDFxh2 and the presence of confirmed amphibian breeding sites in the IDA.

Predicted Impacts of Project Activities on Amphibians in the RSA

Analysis of the VRI indicates that Project activities will affect up to 2.1% of wetlands in the RSA (Table 6.12-10).

Table 6.12-10. Estimation of Wetlands within the RSA

Habitat	Area IF (ha)	Area LSA (ha)	Area RSA (ha)	% loss in RSA
Wetlands	2.8	13.4	640.9	0.4 – 2.1

Habitat Alteration

The introduction of invasive plant species may have an interaction with amphibians. Aquatic invasive plants, such as Eurasian purple loosestrife (*Lythrum salicaria*), may lead to reductions in important native species, such as cattails (*Typha latifolia*; Brown et al. 2006; Voller and McNay 2007). Terrestrial invasive species may change the soil composition (Gordon 1998; Wolfe and Klironomos 2005; Batten et al. 2006; Jordan et al. 2008), potentially reducing the ability of amphibians to efficiently burrow. Invasion of non-native plants may also affect the available invertebrate species composition (BC Ministry of Water, Land and Air Protection 2004a). Since aquatic invasive species are typically transported by boats or on fishing gear, it is unlikely that the Project will influence the spread of aquatic invasive species in the area and the potential effect of the Project on habitat alteration due to invasive species is anticipated to be low.

The maximum dust fall (see Air Quality - Section 10.1) is not expected to exceed 1.12 mg/dm^3/day, which is well below the MoE Ambient Air Quality Objectives lower range (applying to sensitive environmental situations) of 1.7 mg/dm^3/day (British Columbia Ministry of Environment 2014). As such, habitat alteration resulting from dust fall is not expected to occur.

Sensory Disturbance

Methods to Predict Impacts of Project Activities on Amphibians

Sensory disturbance was determined for amphibians using noise contours modelled for the Noise Effects Assessment (Section 10.5). Noise modelling produced noise contours for continuous noise resulting from roads and associated Project activities and regular blasting noise expected to occur once a day during operation. The 40 dB level was the maximum that was modelled. Thresholds for blasting noise were determined to be 120 dB, which is the noise level expected to result in avoidance of habitats (Dooling and Popper 2007) and 108 dB, which is expected to induce energetic costs. Sensory disturbance cannot occur in areas were habitat has been lost, including the Project IF (minimum habitat loss effect) and the IDA (maximum habitat loss effect). The amount of suitable habitat disturbed is reported excluding the IF but including the IDA.

Suitable habitat within the LSA (excluding the IF) and the noise disturbance area was quantified. Since amphibians are typically more active at night, vehicle and machine use at night will likely have a greater effect on some species (Eigenbrod et al. 2009). Continuous Project noise from roads and associated Project activities was the only noise evaluated (blasting not scheduled to occur at night).

Predicted Impacts of Project Activities on Amphibians

A total of 50.6 ha (29%) of suitable amphibian breeding habitat may be subject to continuous Project noise (Figure 6.12-7). Bee and Swanson (2007) found that female Cope's grey treefrogs (*Hyla chrysoscelis*) respond to males calling at 43 dB but not at 37 dB. Studies of a Neotropical frog, *Hyla ebraccata,* suggest that females can detect a calling conspecific male in the presence of breeding chorus noise, provided the call is at least 3 dB more intense than background chorus noise (Wollerman 1999; Wollerman and Wiley 2002). Sun and Narins (2005) reported overall anuran noise at breeding ponds to be 80 to 86 dB sound pressure level (SPL) peak, with sound level decreasing to 68 to 76 dB SPL peak following an anthropogenic disturbance. Kaiser et al. (2011) documented nighttime ambient noise at breeding ponds to be above 60 dB SPL, and found anuran species did not respond to anthropogenic noise at 70 or 90 dB SPL. This information indicates that baseline noise levels for breeding amphibians exceed 40 dB and breeding habitat found outside this noise contour are unlikely to be affected by the Project.

Several breeding sites occur within the Project IDA and 40 dB noise contour, including a confirmed breeding site for the Blue-listed Great Basin spadefoot. The maximum noise level due to continuous project noise will exceed 40 dB, but the specific level of noise disturbance at a specific time and location within the IDA is unknown. The anticipated effect of noise disturbance on breeding amphibians is moderate within the 40 dB noise contour due to the uncertainty of this effect and the proportion of breeding habitat potentially affected. Project related noise within this area may mask calling males or reduce calling rates.

Blasting noise is expected to occur on average once per day, around noon. Since amphibians are nocturnal and most species are expected to resume their pre-stimulus calling rates once the sound has diminished (Sun and Narins 2005) no effect is anticipated from blasting noise disturbance on amphibians.

Disruption of Movement

Disruption of movement for amphibians is not anticipated to have a large impact on amphibians as the Project will remove habitat at a scale greater than an individual amphibians home range so barriers between breeding and terrestrial habitat are unlikely. No mass dispersal events were observed during field work, but anecdotal evidence suggests that amphibians may move from areas around Jacko Lake to areas around Inks Lake. The Project access road may restrict movement between these two areas, either acting as a physical barrier or resulting in increased road mortality (discussed in Direct Mortality section).

Direct Mortality

Methods to Predict Impacts of Project Activities on Amphibians in the LSA

Since the population size and density of each indicator species in the LSA is unknown a proportional analysis was conducted to determine the potential effect of direct mortality associated with habitat removal. This analysis was based on the assumption that the proportion of terrestrial habitat lost is equivalent to the proportion of the population that could be lost. Terrestrial habitat was identified by determining the dispersal distance for each species and buffering suitable breeding habitat by this distance. The resulting dispersal buffer represents that maximum distance that a dispersing juvenile will travel from breeding habitat and thus identifies the maximum area occupied by terrestrial amphibians. The amount of terrestrial habitat lost within the IF was compared to the total amount of terrestrial habitat within the LSA to calculate the percent of terrestrial habitat lost within the LSA. As Columbia spotted frogs do not travel away from aquatic habitats, the proportion of wetlands removed in the IDA relative to the amount of wetlands present in the LSA was calculated.

For Northern Pacific treefrog, a buffered distance of 300 metres was used based on the knowledge that this species may travel several hundred metres from breeding sites (BC Conservation Data Centre 2014a). Spadefoots can disperse 500 to 1,000 metres from breeding sites (British Columbia Southern Interior Reptile and Amphibian Recovery Team 2008). In the Thompson-Nicola Region, Great Basin spadefoots were observed to use habitats within an average of 750 metres (Oaten 2012; Crosby 2014) so this distance was selected as a buffer. Western toads have been observed to have a wide range of dispersal patterns, depending on geographic location (BC Conservation Data Centre 2014a). Specific information for BC is lacking, so a 1,000 meter buffer was used based on average distances from Colorado (Muths 2003; BC Conservation Data Centre 2014a), Idaho (Bartelt et al. 2004; BC Conservation Data Centre 2014a), and Utah (Thompson 2004; BC Conservation Data Centre 2014a).

High mortality for Great Basin spadefoots occur at migration areas in the south Okanagan where traffic averages 2 to 14 cars per minute in the summer (BC Ministry of Water, Land and Air Protection 2004a). To determine the potential effect of vehicular mortality on amphibians a qualitative approach based on the number of roads present, number of vehicles expected to use these roads and timing of road use was considered.

Methods to Predict Impacts of Project Activities on Amphibians in the RSA

To determine the amount of terrestrial habitat available in the RSA the VRI was used to assess the presence and distribution of wetlands in the RSA. TEM mapping was not completed for this area. VRI (2012) mapping was overlaid with a spatial file of the RSA. Wetlands were identified as non-vegetated water wetlands in the VRI. Wetlands were buffered by 1,000 m and the amount of terrestrial habitat affected by the Project was compare to the amount of terrestrial habitat available in the region.

Predicted Impacts of Project Activities on Amphibians in the LSA

Estimated mortality rates for amphibians based on the amount of terrestrial habitat lost vary from 26% to 29% amongst indicator species (Table 6.12-11 and Figures 6.12-8, 6.12-9, and 6.12-10). Based on the proportion of terrestrial habitat affected by the project, and the potential for direct mortality of indicator species inhabiting that habitat, the anticipated effect of direct mortality resulting from clearing/grubbing activities is expected to be moderate.

Figure 6.12-7
Amphibian Breeding Habitat and Observations in the LSA

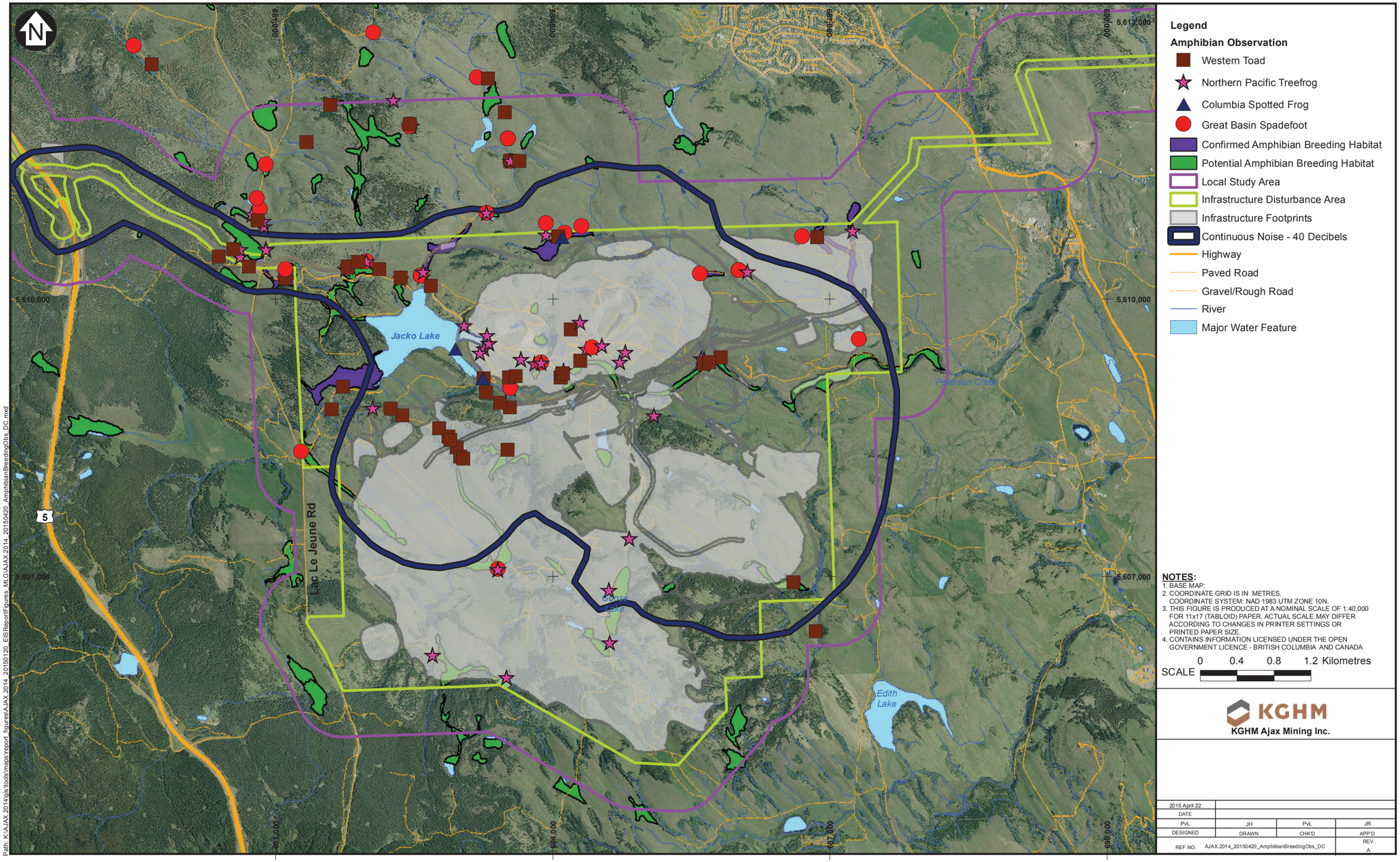


Figure 6.12-8
Potential Mortality for Northern Pacific Treefrog

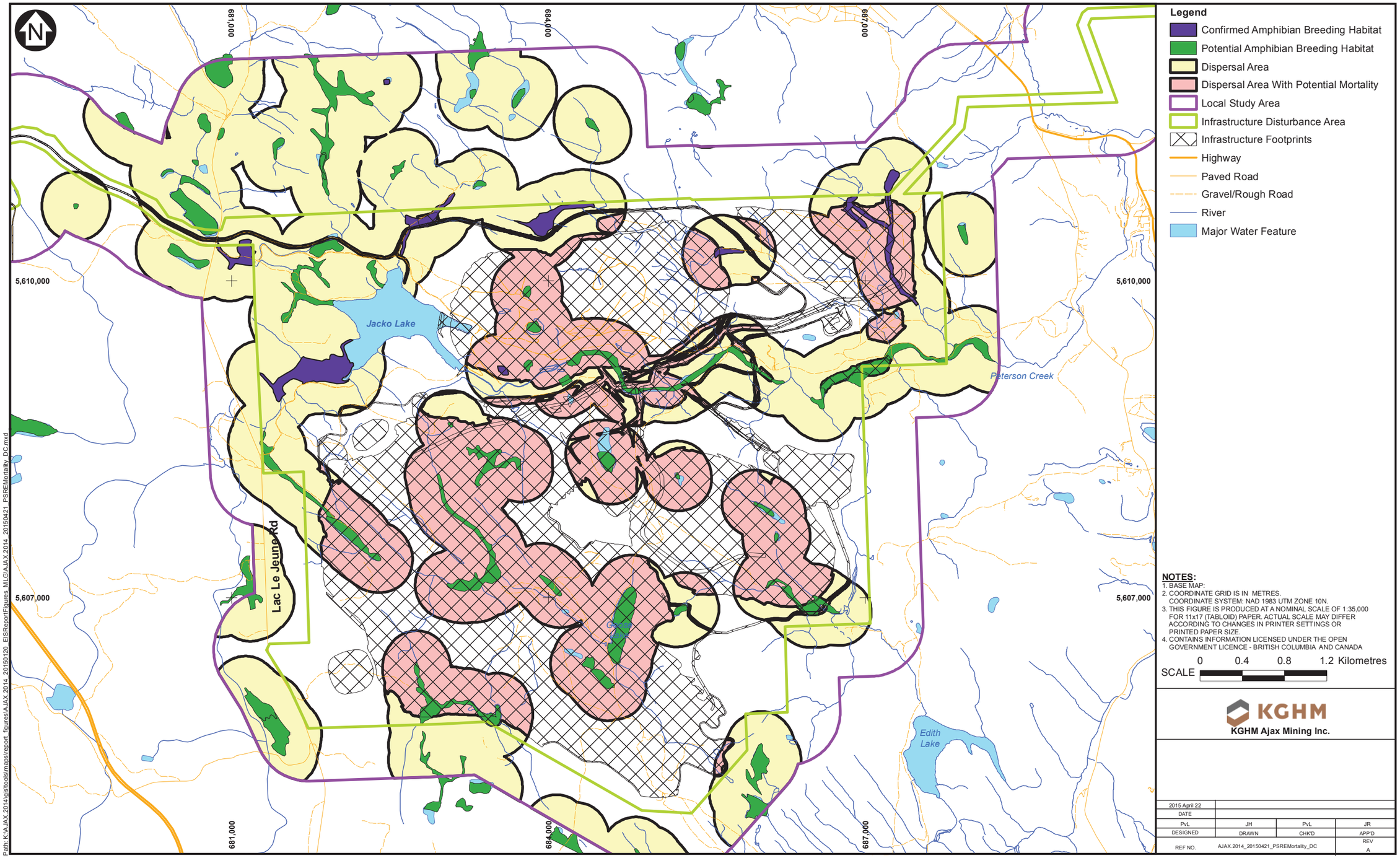


Figure 6.12-9
Direct Mortality for Great Basin Spadefoot

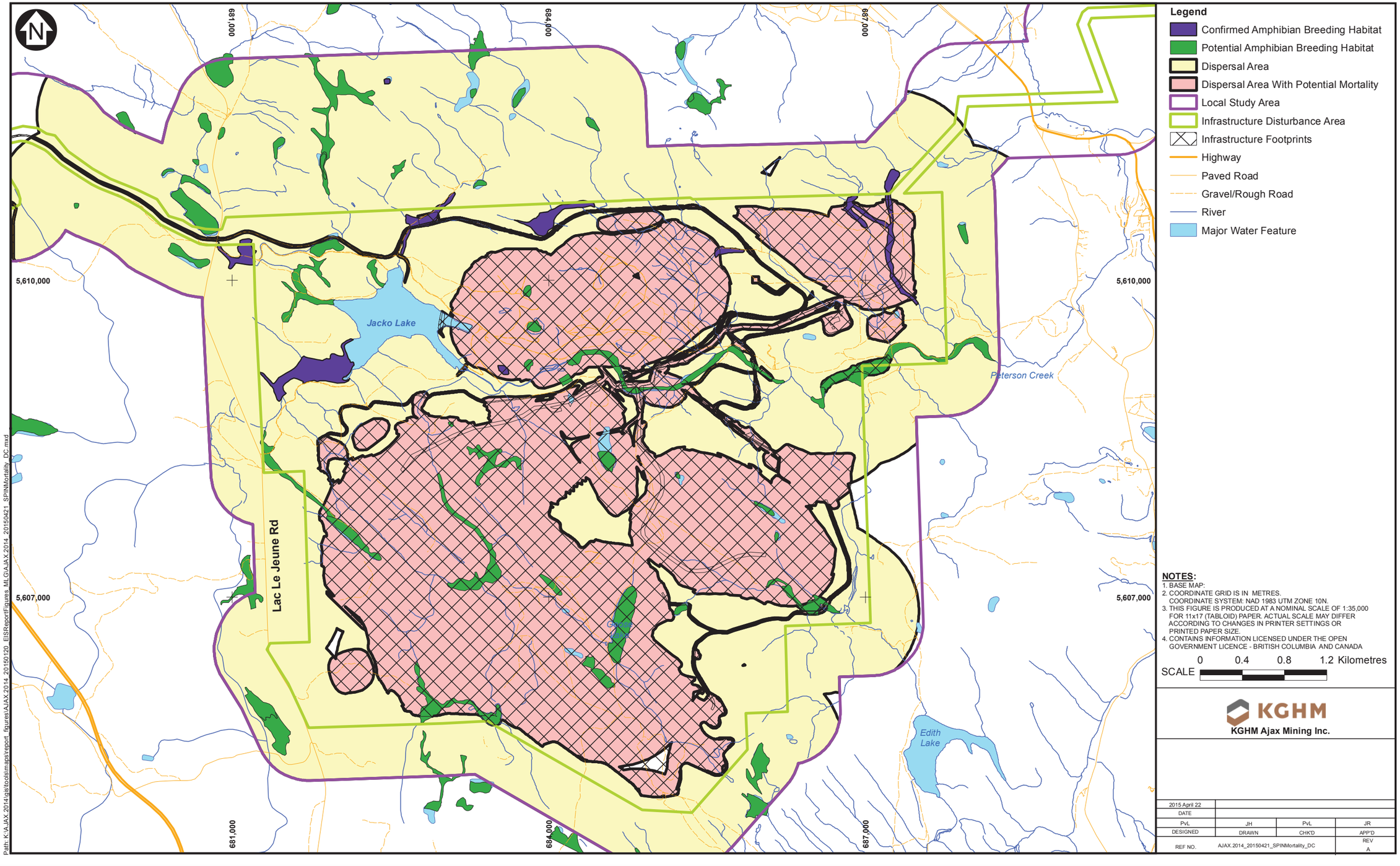


Figure 6.12-10
Direct Mortality for Western Toad

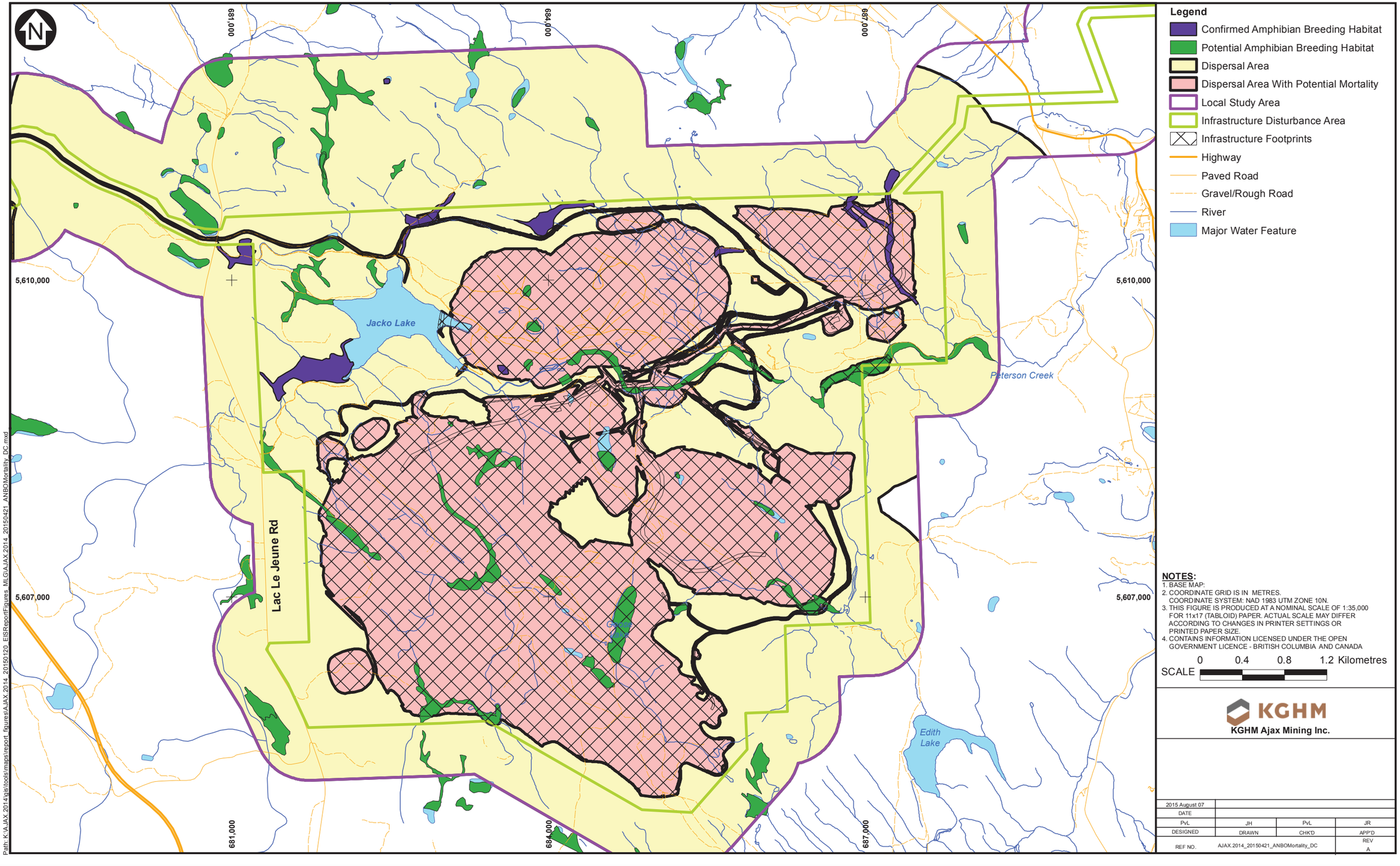


Table 6.12-11. Summary of Terrestrial Amphibian Habitat Loss in the LSA

Indicator Species	Total (ha) in LSA	Total (ha) in IF	Potential % Loss
Columbia Spotted Frog	173	45	26%
Northern Pacific treefrog	3,315	969	29%
Great Basin Spadefoot	5,796	1,697	29%
Western Toad	6,041	1,705	28%

The movement of vehicles and construction machinery on Project roads may cause amphibian mortality as a result of wildlife-vehicle collisions. Traffic on Project roads during operation has been estimated at 15 to 23 trucks per day and 467 passenger cars per day. During Construction traffic has been estimated at 300 passenger cars per day.

Terrestrial habitat surrounds the Project IF and interactions between vehicles and amphibians is anticipated (Figures 6.12-8, 6.12-9, and 6.12-10). Vehicular mortality is a known threat to all indicator species and spadefoots and western toads undertake mass migration to and from breeding sites making them particularly susceptible to becoming road kill. High mortality for spadefoots has been documented to occur at 120 cars/hour (BC Ministry of Water, Land and Air Protection 2004a). Passenger traffic associated with the Project has the potential to exceed this threshold. Confirmed breeding sites in the IDA also occur adjacent to the main Project access roads increasing the potential for interaction. Based on the proximity of terrestrial habitat and the risk of vehicular collisions the potential effect of direct mortality on amphibians is anticipated to be high.

Predicted Impacts of Project Activities on Amphibians in the RSA

Analysis of the VRI indicates that Project activities may result in loss of 5% of terrestrial amphibian habitat available in the RSA.

Chemical Hazards

Methods to Predict Impacts of Project Activities on Amphibians

To determine potential impacts of the Project on water quality within the LSA, five sites within the IDA and LSA were modelled. This included Jacko Lake, three sites along Peterson Creek (Peterson Creek Downstream Pond, Peterson Creek node 2.3 and 2.0) and Humphrey Creek; the nodes in Peterson Creek were within the LSA while the other three sites were within IF. Seven Project infrastructure sites were also modelled, including three sites on Tailing Storage Facility (TSF, TSF S WMP, and TSF SE WMP) and four sites on the Mine Rock Storage Facility (WMRSF 1, WMRSF 2, SMRSF, and EMRSF). Modelling was completed from start of Construction to year 124 (100 years Post Closure). Major ions, nutrients and dissolved metals were modelled for each month. Only those elements that exceed aquatic guidelines will be discussed (BC Ministry of Environment 2014b). Aquatic guidelines take into account the chronic effects of exposure to potentially harmful elements, as well as consider the bioaccumulation and the sensitivity of species along the food chain. These guidelines determine what levels of substances found in surface water are safe for the environment. Exceeding water quality guidelines does not imply that unacceptable risks exist, but rather that the potential for adverse effects may be increased and additional investigation may be required. Details of the modelling are provided in Chapter 6.3.

Predicted Impacts of Project Activities on Amphibians

Water quality within Jacko Lake and in the Peterson Creek Downstream Pond is not expected to exceed aquatic water quality guidelines for any dissolved metals (Chapter 6.3).

Less than a kilometre downstream of the Peterson Creek Downstream Pond, at Peterson Creek node 2.3, sulphate and dissolved iron levels are anticipated to exceed aquatic guidelines (Table 6.12-12). Dissolved iron will be greater than 0.35 mg/L in 14 months between January of year 80 and December of year 82. Sulphate will be above 429 mg/L in March of year one of Operations.

Table 6.12-12. Modelled Median Water Quality for Peterson Creek Node 2.3

Dissolved Metals	Aquatic Guideline (mg/L)	No. of Months Guidelines Exceeded	Max Modelled Value (mg/L)
Iron (Fe)	0.35	14	0.542
Sulphate (SO_4^{2-})	429	1	667

Further downstream at Peterson Creek node 2.0, chloride, selenium, and sulphate will exceed aquatic water quality guidelines (Table 6.12-13). Chloride will exceed 150 mg/L in January and February of year 1 of Construction, and every September between year 2 and year 29 of Operations. Selenium levels at this node exceeded the aquatic water quality guideline of 0.002 mg/L in April of 2011 and 2013, with a maximum level of 0.0029 mg/L. Selenium levels at this node are expected to be above this baseline maximum starting in April and May of year 1 of Operations and every April and May thereafter until year 124. Sulphate will be above 429 mg/L in the majority of months of the Project, from year 1 of Construction until the end of year 124.

Table 6.12-13. Modelled Median Water Quality for Peterson Creek Node 2.0

Dissolved Metals	Aquatic Guideline (mg/L)	No. of Months Guidelines Exceeded	Max Modelled Value (mg/L)
Chloride (Cl^-)	150	30	183
Selenium (Se)	0.002	249	0.0034
Sulphate (SO_4^{2-})	429	1,098	989

Aluminum (Al), copper (Cu), mercury (Hg), selenium, and sulphate are anticipated to exceed aquatic water quality guidelines along Humphrey Creek (Table 6.12-14). Aluminum is anticipated to exceed 0.05 mg/L in May of year 25. Copper is anticipated to exceed aquatic guidelines in every August from year 1 to year 29 and every November from year 3 to year 25. Mercury levels will exceed 0.00002 mg/L in various months starting in Construction and continuing until the end of year 29. Baseline Selenium levels along Humphrey Creek were found to be above aquatic guidelines from March to June in 2014 with a maximum value of 0.00618 mg/L. Selenium levels along Humphrey Creek are expected to be above aquatic guidelines starting in year 1 and continuing through to year 124. However, selenium levels are only expected to be greater than baseline maximums between December to February of years 41 to 46 and 87 to 102.

Table 6.12-14. Modelled Median Water Quality for Humphrey Creek

Dissolved Metals	Aquatic Guideline (mg/L)	No. of Months Guidelines Exceeded	Max Predicted Value (mg/L)
Aluminum (Al)	0.05	1	0.0815
Copper (Cu)	0.01	52	0.0108
Mercury (Hg)	0.00002	120	0.000082
Selenium (Se)	0.002	775	0.0065
Sulphate (SO_4^{2-})	429	104	493

Ammonia (NH_3), antimony (Sb), arsenic (As), chloride (Cl^-), copper, mercury, molybdenum (Mo), nitrate (NO_3), nitrite (NO_2), selenium, sulphate, uranium (U), and zinc (Zn) are all expected to exceed aquatic water quality guidelines in the TSF (Table 6.12-15). Ammonia is expected to exceed water quality guidelines from January or year 2 until the end of year 24. Antimony is expected to exceed water quality guidelines in the TSF during the first three months of Construction, and from August of year 2 of until year 24. Arsenic is expected to exceed water quality guidelines in every month of construction and from February of year 2 until the end of modeling (December of year 24). Chloride will exceed water quality guidelines May of year 2 until the end of modeling. Copper is anticipated to exceed aquatic water quality guidelines in all months of Construction and all years of Operation after February of year 2. Mercury levels will exceed 0.00002 mg/L starting in February of year 2 until the end of year 24. Molybdenum will exceed aquatic water quality guidelines during the first two months of Construction and from July of year 12 until the end of year 24. Nitrate and Nitrite will both exceed guidelines in each month of Construction; nitrate will exceed water quality guidelines from January of year 2 to October of year 24 while nitrite will exceed water quality guidelines in January and February in year 1 of Operation, and from January or year 2 until the end of year 24. Selenium will exceed aquatic water quality guidelines throughout Construction and again in year 2 through year 24. Sulphate will exceed water quality guidelines of 427 mg/L in all months of Construction and all years of Operation excluding year 1. Uranium and zinc are expected to exceed water quality guidelines during the first two months of Construction and again in March of year 2 through year 24 of Operation.

Table 6.12-15. Modelled Median Water Quality for the TSF

Dissolved Metals	Aquatic Guideline (mg/L)	No. of Months Guidelines Exceeded	Max Modelled Value (mg/L)
Ammonia (NH_3)	0.66	276	48
Antimony (Sb)*	0.009	271	0.0208
Arsenic (As)	0.005	286	0.022
Chloride (Cl^-)	150	272	502
Copper (Cu)	0.003	287	0.030
Mercury (Hg)	0.00002	275	0.000049
Molybdenum (Mo)	1	152	2.2
Nitrate (NO_3)	3	286	21
Nitrite (NO_2)	0.04	279	2.8
Selenium (Se)	0.002	285	0.0174

Dissolved Metals	Aquatic Guideline (mg/L)	No. of Months Guidelines Exceeded	Max Modelled Value (mg/L)
Sulphate (SO_4^{2-})	429	288	7,250
Uranium (U)*	0.0085	275	0.0406
Zinc (Zn)	0.0075	275	0.0684

** Working water quality guidelines*

The TSF South and Southeast WMPs will exceed aquatic guidelines for arsenic, cadmium, chloride, copper, mercury, nitrite, selenium, sulphate, and zinc (Tables 6.12-16 and 6.12-17).

Table 6.12-16. Modelled Median Water Quality for the TSF South Embankment WMP

Dissolved Metals	Aquatic Guideline (mg/L)	No. of Months Guidelines Exceeded	Max Modelled Value (mg/L)
Arsenic (As)	0.005	1,217	0.022
Cadmium (Cd)	0.000018	1,205	0.000035
Chloride (Cl^-)	150	284	167
Copper (Cu)	0.002	1,400	0.020
Mercury (Hg)	0.00002	1,049	0.000052
Nitrite (NO_2)	0.02	353	0.038
Selenium (Se)	0.002	1,338	0.014
Sulphate (SO_4^{2-})	429	993	920
Zinc (Zn)	0.008	780	0.015

Table 6.12-17. Modelled Median Water Quality - TSF Southeast Embankment WMP

Dissolved Metals	Aquatic Guideline (mg/L)	No. of Months Guidelines Exceeded	Max Modelled Value (mg/L)
Arsenic (As)	0.005	1,254	0.0038
Cadmium (Cd)	0.000018	1,253	0.000035
Chloride (Cl^-)	150	1,148	714
Copper (Cu)	0.002	1,352	0.027
Mercury (Hg)	0.00002	1,061	0.000068
Nitrite (NO_2)	0.02	1,305	0.077
Selenium (Se)	0.002	1,303	0.010
Sulphate (SO_4^{2-})	429	565	718
Uranium (U)*	0.0085	675	0.017
Zinc (Zn)	0.008	879	0.020

** Working water quality guidelines*

Arsenic will exceed aquatic guidelines beginning in August of year 23 in the south embankment and in June of year 20 in the southeast embankment. Cadmium will exceed aquatic water quality guidelines from July of year 24 in the south embankment and July of year 20 in the southeast embankment until the end of year 124 (both sites). Chloride will exceed guidelines in years 100 and 101 in the south embankment and will remain above guidelines from year 102 until the end of

modeling (year 124); chloride will exceed guidelines in the southeast embankment in years 28 and 29 and will remain above guidelines from June of year 30 until the end of modeling. Copper will exceed water quality guidelines beginning in April of year 8 in the south embankment and April of year 12 in the southeast embankment, with exceedance at both locations lasting until the end of year 124. Mercury will exceed water quality guidelines from 37 in the south embankment and year 35 in the southeast to the end of modeling. Nitrite will exceed water quality guidelines in the south embankment beginning in year 15 and ending in year 44; in the southeast embankment, nitrite will exceed guidelines beginning in beginning in year 16 and remaining there until the end of year 124. Selenium will exceed aquatic guidelines starting in June of year 10 in the south embankment and June of year 14 in the southeast embankment. Both sites will continue to exceed selenium guidelines until year 124. Sulphate will first exceed water quality guidelines in the south embankment in December of year 31 and will remain above guidelines from August of year 42 until the end of modeling; sulphate will first exceed water quality guidelines in the southeast embankment in September of year 76 and will remain above guidelines from August of year 77 until the end of modeling. Zinc will exceed guidelines in the south embankment starting in year 59 and will continue to exceed through to year 124, whereas the southeast embankment will exceed in September of year 21 to year 124.

Uranium is anticipated to exceed aquatic guidelines for the TSF southeast embankment, starting in September of year 67 and continuing until the end of the Closure, with the exception of April, to June in years 68, 69, and 70.

The West Mine Rock Storage Facility (WMRSF) WMP1 will exceed aquatic guidelines for ammonia, antimony, arsenic, mercury, nitrate, nitrite, selenium, and sulphate (Table 6.12-18). Ammonia is expected to exceed water quality guidelines from May of year 10 to March of year 25. Antimony will exceed aquatic guidelines in the WMP1 beginning in July of year 4 of Operation and ending in February of year 24. Arsenic will exceed water quality guidelines from April of year 3 until the end of modeling (year 124). Mercury will exceed water quality guidelines from June of year 4 to February of year 27. Nitrate will be above guidelines from May of year 8 to February of year 25. Nitrite will exceed guidelines beginning in September of year 13 until May of year 24. Selenium will exceed aquatic guidelines starting in April of year 3 through until year 124. Sulphate will exceed water quality guidelines from August of year 5 to April of year 25.

Table 6.12-18. Modelled Median Water Quality - West Mine Rock Storage Facility North WMP 1

Dissolved Metals	Aquatic Guideline (mg/L)	No. of Months Guidelines Exceeded	Max Modelled Value (mg/L)
Ammonia (NH_3)	0.66	179	2.29
Antimony (Sb)*	0.009	232	0.021
Arsenic (As)	0.005	1,461	0.022
Mercury (Hg)	0.00002	272	0.00005
Nitrate (NO_3)	3	213	18
Nitrite (NO_2)	0.2	123	0.42
Selenium (Se)	0.002	1,461	0.035
Sulphate (SO_4^{2-})	429	236	784

** Working water quality guidelines*

The West Mine Rock Storage Facility (WMRSF) WMP2 will exceed aquatic guidelines for ammonia, antimony, arsenic, mercury, nitrate, nitrite, selenium, and sulphate (Table 6.12-19). Ammonia is expected to exceed water quality guidelines from April of year 10 to April of year 26. Antimony will exceed aquatic guidelines in October of year 4 to March of year 25. Arsenic will exceed guidelines starting in April of year 3 and continuing until the end of modeling (year 124). Mercury will exceed water quality guideline from August of year 4 to April of year 31 and again from April of year 77 until the end of year 124; between year 31 and year 77, levels will fluctuate between just above and just below the exceedance level. Nitrate will exceed guidelines between May of year 8 and March of year 28. Nitrite will exceed guidelines between April of year 13 and March of year 25. Selenium will exceed aquatic guidelines starting in April of year 3 through until year 124. Sulphate will exceed water quality guidelines from August of year 5 to March of year 28.

Table 6.12-19. Modelled Median Water Quality - West Mine Rock Storage Facility North WMP 2

Dissolved Metals	Aquatic Guideline (mg/L)	No. of Months Guidelines Exceeded	Max Modelled Value (mg/L)
Ammonia (NH_3)	0.66	193	2.78
Antimony (Sb)*	0.009	246	0.021
Arsenic (As)	0.005	1,461	0.0022
Mercury (Hg)	0.00002	896	0.00006
Nitrate (NO_3)	3	239	20.7
Nitrite (NO_2)	0.2	144	0.504
Selenium (Se)	0.002	1,461	0.044
Sulphate (SO_4^{2-})	429	270	963

** Working water quality guidelines*

The South Mine Rock Storage Facility (SMRSF) will exceed aquatic guidelines for ammonia, antimony, arsenic, boron, chromium, cobalt, copper, mercury, molybdenum, nitrate, nitrite, selenium, sulphate, and uranium (Table 6.12-20). Ammonia is expected to exceed water quality guidelines between July of year 5 and February of year 27. Antimony will exceed guidelines during Construction through to March of year 25. Arsenic will exceed water quality guidelines during Construction through to the end of modeling (year 124). Boron will rise above and below aquatic guidelines between September of year 9 and February of year 18. Between August of year 5 and May of year 25, chromium levels will fluctuate, exceeding water quality guidelines for the majority of this time. Cobalt will exceed water quality guidelines from June of year 3 until February of year 25. Copper will exceed water quality guidelines beginning in August of year 2 and remaining there until April of year 25. Mercury will exceed water quality guideline beginning in May of Construction until the end of year 124; for 20 months of the Project, levels will drop to just below the exceedance level. Molybdenum will first exceed aquatic guidelines starting in July of year 4 and returning below aquatic guidelines in March of year 25. Nitrate will exceed guidelines between August of year 4 and April of year 26, and again from August of year 26 to April of year 27. Nitrite will exceed guidelines between July of year 6 and April of year 25, and again from August of year 25 to February of year 26. Selenium will exceed water quality guidelines during Construction through to the end of modeling. Sulphate will exceed water quality guidelines beginning in August during Construction and will continue through to February of year 28. Uranium will first exceed guidelines in October of year 2 and will continue to through to April of year 25.

Table 6.12-20. Modelled Median Water Quality - South Mine Rock Storage Facility WMP

Dissolved Metals	Aquatic Guideline (mg/L)	No. of Months Guidelines Exceeded	Max Modelled Value (mg/L)
Ammonia (NH_3)	0.66	257	15.4
Antimony (Sb)*	0.009	299	0.021
Arsenic (As)	0.005	1,497	0.022
Boron (B)	1.2	62	1.405
Chromium (Cr)	0.0089	220	0.017
Cobalt (Co)	0.004	259	0.0135
Copper (Cu)	0.01	273	0.041
Mercury (Hg)	0.00002	1,476	2.535
Molybdenum (Mo)	1	240	2.535
Nitrate (NO_3)	3	268	20.7
Nitrite (NO_2)	0.2	233	2.77
Selenium (Se)	0.002	1,497	0.1107
Sulphate (SO_4^{2-})	429	326	5,606
Uranium (U)*	0.0085	268	0.039

** Working water quality guidelines*

The East Mine Rock Storage Facility (EMRSF) will exceed aquatic guidelines for antimony, arsenic, mercury, nitrate, selenium, and sulphate (Table 6.12-21). Antimony will exceed aquatic guidelines starting in July of year 5 and continuing through to March of year 21. Arsenic will exceed water quality guidelines from July of year 2 until the end of monitoring (year 124). Mercury will exceed water quality guideline beginning in May of year 6 and ending in March of year 25. Nitrate will exceed guidelines from April of year 7 until February of year 19 (excluding 3 months in year 18). Selenium will exceed aquatic guidelines starting in April of year 2 though to April of year 25. Sulphate will exceed water quality guidelines from July of year 11 to February of year 25.

Table 6.12-21. Modelled Median Water Quality - East Mine Rock Storage Facility WMP

Dissolved Metals	Aquatic Guideline (mg/L)	No. of Months Guidelines Exceeded	Max Modelled Value (mg/L)
Antimony (Sb)*	0.009	189	0.021
Arsenic (As)	0.005	1,470	0.0022
Mercury (Hg)	0.00002	227	0.00005
Nitrate (NO_3)	3	140	4.3
Selenium (Se)	0.002	277	0.024
Sulphate (SO_4^{2-})	429	164	634

** Working water quality guidelines*

Aluminum has been found to have a negative effect on amphibians, especially in highly acidic (low pH) environments (Freda 1991; Bradford et al. 1994; Clark and LaZerte 1985). Freda (1991) found that northern leopard frogs (*Rana pipiens*) had a 96 h LC_{50} (pH level of 4-8) of: 0.25 mg/L for newly hatched

tadpoles; 0.403 mg/L for embryos; and >1.0 mg/L for 3-week old tadpoles. Acid levels that will result in a negative interaction for amphibians varies from species to species, but generally a pH of < 5.25 may begin to cause mortality of amphibian embryos and tadpoles (Bradford et al. 1994; Clark and LaZerte 1985). In high concentrations (20 – 30 mg/L), iron can be to western toads (Freda 1991).

Antimony may adversely affect amphibians populations (Blaustein et al. 2003; Hussain and Pandit 2012), but aside from increased mortality, specific effects on amphibians are not well understood. Adlassnig et al. (2013) found that increasing concentrations of antimony from 0.020 mg/L to 0.027 mg/L did not have any measureable effects on amphibians.

Wetlands with chloride concentrations that exceed 200 mg/L have been found to correlate with decreased amphibian abundance and diversity (Sadowski 2002). Chloride concentrations of 450 mg/L have been identified as the threshold at which half of amphibian eggs become viable in the lab (Wintson et al. 2012). Ammonia has been observed to decrease survivorship, increase deformities, and slow growth and development in green frogs (*Rana clamitans*) at 0.6 mg/L, in leopard frogs at 1.5 mg/L, and not at all in American toads (*Bufo americanus*) at 0.9 mg/L (Jofre and Karasov 1999).

Effects of molybdenum and cadmium on developing Eurasian marsh frogs (*Pelophylax ridibundus*) were studied (Stepanyan et al. 2011). In small concentrations, molybdenum is a necessary microelement; however, in high doses, it can become toxic (*ibid*.). High concentrations cadmium (2.4 mg/L) in aquatic habitats were found to be dangerous for amphibians, particularity those in the early stages of metamorphosis (Natale et al. 2000; Stepanyan et al. 2011). James and Semlitsch (2011) found that exposure to cadmium may have a positive or a negative effect, depending on specific environmental parameters. Chromium (III) levels of 1.5 mM may have lethal implications for amphibians (Calevro et al. 1998).

Loposata and Dunson (1998) found that high boron concentrations (100 mg/L) reduced the hatching success of American toads and resulted in increased deformities in the offspring of wood frogs (*Rana sylvatica*). The same study found that increased nitrate concentrations (up to 40 mg/L) resulted in no change to hatching success or proportion of deformed larvae (Loposata and Dunson 1998). Meredith and Whitemann found that even at very high concentrations (500 mg/L), nitrate doesn't appear to have an effect on amphibian embryos (Meredith and Whiteman 2008). Prolonged exposure to nitrate and nitrite can delay development, reduce feeding activity and mobility, and eventually cause problems such as paralysis and edema that lead to mortality (Marco et al. 1999; Marco and Blaustein 1999); levels of nitrite > 1 mg/L and levels of nitrate > 10 mg/L were found to be toxic with chronic exposure (Marco et al. 1999). Nitrite may also cause amphibians to hatch before they have completely developed, leading to an increase in mortality from predators and environmental conditions (Griffis-Kyle 2007).

Adlassnig et al. (2013) found areas of mine rock and mine tailings to be generally devoid of amphibians. In moist habitats (i.e., streams, puddles, and ponds fed by drainage water), however, a variety of amphibian species were observed in the presences of moderately increased concentrations of copper and arsenic (0.5 mg/L for each; Adlassnig et al. 2013). A study completed by Dorchin and Shanas (2010) suggest that copper does not have a negative effect on survival of European green toad (*Bufo viridis*) embryos and tadpoles, but that it may affect development rate. Increased copper concentrations have been observed to lead to a decline in amphibian embryo survivorship, with a

significant effect occurring at 0.1 mg/L (Lance et al. 2012). An additional study by Chen et al. (2009) found that northern leopard frog larval exposure to arsenic (up to 1 mg/L) resulted in decreased tadpole swimming speed, but not a decrease in survival, growth, or percent metamorphosis.

Mercury concentrations in the blood (2,250 ± 489.8 ng/g dry weight) of maternal American toads does not appear to affect amphibian larval development, but may delay individual growth after metamorphosis (Todd et al. 2011). Northern two-lined salamanders (*Eurycea bislineata*) have been observed to be negatively affected by mercury contamination, showing signs of reduced feeding activity and behavioural changes (Burke et al. 2010). Bergeron et al. (2011) found increased American toad larvae mortality when individuals were exposed to a combination of maternal mercury and high dietary mercury intake.

Studies on the effects of selenium on amphibians have shown that amphibian embryos and tadpoles are sensitive to this element (Ohlendorf 2003). The South African clawed frog (*Xenopus laevis*) has been observed to have an LC_{50} value of 1.5 mg/L at an exposure of 3 days and 0.456 mg/L at an exposure of 7 days (Ohlendorf 2003). The narrow-mouthed toad (*Gastrophryne caroliensis*) has been observed to have an LC_{50} value of 0.09 mg/L, and may maternally transfer selenium to their eggs (Ohlendorf 2003; Janz et al. 2010; Bergeron et al. 2010). Relatively low selenium concentrations (0.003 to 0.010 mg/L) may lead to reproductive impairment, while low concentrations (<0.002 mg/L) will result in no significant accumulation in the food web the majority of the time (Beatty and Russo 2014). A study of Columbia spotted frog located below coal mining activities in the Elk Valley, BC found that increased selenium concentrations may have contributed to increased mortality and deformity in tadpoles (Beatty and Russo 2014).

Birge (1978) found that the narrow-mouthed toad had a 7-day LC_{50} of 0.05 mg/L for cobalt for developing embryos, while another study found that clawed frogs had a lowest-observed-effect concentration (LOEC) for growth of 2.48 mg/L (Nagpal 2004).

Iberian green frogs (*Rana perezi* Seoane) exposed to uranium were observed to have a decrease in body length of larvae, a decrease in stimulus reactions, and an increase in pigmentation along with tail deformities (Marques et al. 2008). African clawed frogs and have been observed to have a delay in metamorphosis in 64-d tests when exposed to 13.1 – 54.3 mg/L of uranium (Hinck et al. 2010). Iberian green frogs were found to have reduced survival and growth at 96 h exposure to 1.75 mg/L (in 100% uranium mine effluent; *ibid*.).

Zinc may negatively interact with amphibians (Blaustein et al. 2003; Hussain and Pandit 2012). Some South African clawed frogs (*Xenopus laevis*) experienced mid-gut malformations at 96 h and a concentration of 1.5 mg/L (US Department of the Interior 1998). Some newts were observed to become lethargic and experienced poor eating habits and darkening skin before eventual mortality at a range of 0.2 – 3.0 mg/L (*ibid*.). Narrow-mouthed toad embryos experienced a 7-day LC_{50} of 0.01 mg/L, while South African clawed frogs had a higher tolerance, with some embryonic malformations beginning at 1.5 mg/L, and 50% of individual embryos experiencing malformations at 2.7 mg/L (Eisler 1998b).

As amphibians disperse from breeding areas, adults and juveniles may interact with contact water. Amphibians are especially susceptible to environmental contaminants and any interaction with contact water is likely to be detrimental. Ammonia, aluminum, antimony, arsenic, boron, cadmium,

cobalt, chloride, chromium, copper, iron, mercury, molybdenum, nitrate, nitrite, nickel, selenium, sulphate, uranium, and zinc have been shown to have deleterious effects on amphibians. Only those areas modelled in proximity to suitable breeding habitat will be considered to have a potential interaction with amphibians. As the TSF will have no suitable habitat remaining after clearing and grubbing, this IF is not anticipated to interact with amphibians; all other modelled areas where elements will exceed aquatic guidelines will be considered.

6.12.4.3 Mitigation Measures for Amphibians

Mitigation measures proposed to address potential effects during all phases of the Project are discussed below. The document *Guidelines for Amphibian and Reptile Conservation during Urban and Rural Land Development in British Columbia* (BC Ministry of Forests, Lands, and Natural Resources 2014) will be reviewed before any Project activities commence.

The *Recovery Strategy for the Great Basin Spadefoot (Spea intermontana) in British Columbia* (British Columbia Southern Interior Reptile and Amphibian Recovery Team 2008) identifies general steps to ensure that there is sufficient, secure habitat distributed throughout the historic range to maintain a self-sustaining population. These include:

- Monitor selected sites to assess long term habitat use, population persistence and to identify high priority sites for securement;
- Improve inventory standards and continue species and habitat inventory to clarify geographic distribution and identify sites for securement;
- Develop and implement a strategy to reduce or eliminate illegal introductions of non-native fish species;
- Continue to work toward eliminating introduced bullfrogs;
- Develop best management practices for the application of magnesium chloride on gravel road surfaces in proximity to Spadefoot breeding habitat;
- Develop and implement a strategy to reduce impacts from road mortality at priority sites;
- Clarify threats from road mortality at priority sites;
- Use radio-telemetry and mark-recapture to clarify movement and dispersal patterns, habitat use and quality in natural and modified habitats, population demography, and metapopulation dynamics to help identify critical habitat;
- Develop and implement a program to create and monitor artificial breeding sites;
- Work with Aboriginal Groups to identify traditional ecological knowledge;
- Develop research partnerships to assist with disease identification and containment options;
- Clarify potential impacts from livestock activities at priority sites;
- Clarify threats from urban and agriculture development at priority sites; and

- Develop and implement an outreach strategy to increase awareness of threats, stewardship options, and best management practices; and encourage involvement in and support for recovery actions.

The *Management Plan for the Western Toad (Anaxyrus boreas) in British Columbia* (Provincial Western Toad Working Group 2014) identifies general steps to maintain self-sustaining populations of the Western Toad distributed throughout the species' present range in B.C. These include:

- implementing a Western Toad monitoring strategy at strategic sites throughout B.C.;
- identifying and protecting regionally important breeding sites through analysis of existing distribution data and new surveys, habitat mapping, protected areas, and high impact zones;
- clarifying movement and dispersal patterns, terrestrial and hibernation habitat use, metapopulation structure and function, and population viability parameters to inform habitat protection priorities and improve best management practices;
- integrating consideration of the species' needs into land use plans, best management practices, and other documents;
- protecting regionally important breeding sites in mainland B.C. from disturbance by cattle when necessary through altering range practices, fencing, or other effective techniques;
- controlling bullfrogs and other invasive or introduced species where they cause important threats and prevent new introductions where possible through outreach and enforcement of regulations; and
- identifying problem areas for road mortality at regionally important sites, with a priority on Vancouver Island and the Lower Mainland, mitigate impacts, monitor effectiveness and improve best management practices.

General wildlife measures for the Great Basin Spadefoot include (BC Ministry of Water, Land and Air Protection 2004a):

- minimizing disturbance during the breeding season;
- minimizing road mortality;
- maintaining water quality;
- maintaining water levels;
- minimizing soil disturbance and trampling of burrows;
- maintaining important habitat features (i.e., small mammal burrows, riparian and emergent vegetation, and non-compacted soils); and
- maintaining or remediate riparian and aquatic habitats to a properly functioning condition.

Habitat Loss

Habitat loss will occur in the Project IF. Amphibian breeding sites (i.e., wetlands) will be avoided if at all possible and whenever practical. Over the long-term, habitat may be restored through

reclamation and revegetation processes, though this will not occur until the Decommissioning and Closure phase. Impact avoidance and reduction mitigation proposed for the Project will be described in detail in the *Wildlife and Vegetation Monitoring Plan* (Chapter 11.27), and will include:

- known amphibian breeding sites will be used as inputs during the final design and Construction phase. Where feasible, Project facilities will be placed so as to avoid direct impacts to these habitats;
- a spatial database and maps of known breeding sites in the vicinity of Project facilities will be maintained and consulted to avoid impacts during Operations and maintenance activities. The database will be actively updated as new information becomes available;
- exclusion areas will be created at all known breeding sites and temporary diversion ponds located adjacent to Construction and Operation areas. These areas will be clearly flagged to discourage accidental encroachment with machines. Signage will be added where necessary to indicate the boundaries of the exclusion area (Chapter 11.27);
- Construction personnel will attend a field-based orientation session where the exclusion areas will be explained, and the importance of avoiding disturbance within them will be stressed;
- roads and transmission lines will be designed to minimize the number of water crossings and to avoid running parallel to watercourses;
- erosion prevention and bank stabilization techniques will be used to minimize potential for secondary loss of trees after initial clearing efforts (Chapter 11.2).
- avoid use of herbicide sprays within 200 m of amphibian breeding sites, and limit such use to direct application rather than broadcast sprays (except when required for invasive species control).

Reclamation planning includes amphibian breeding habitat (e.g., ponds and marshes), rock piles for cover, and riparian vegetation (Aspen Park Consulting 2013). A wetland habitat compensation plan will be initiated during project Construction with the aim to conserve and enhance wetland function within the RSA. This plan will target traditional and KAM owned lands. Details of this plan will be discussed in the *Wildlife and Vegetation Monitoring Plan* (Chapter 27). Some key considerations include:

- creation of ponds with and without vegetation that is attractive to waterfowl to decrease the incidence of egg or tadpole predation;
- enhancing existing wetlands, providing habitat features for breeding amphibians;
- using small woody debris to provide initial egg attachment sites until proper aquatic vegetation develops.
- including non-breeding habitat areas with bunchgrasses or relatively open grass sites, with minimum soil depths of 15 cm for burrowing.
- installation of exclusion fencing in some reclaimed areas to avoid soil disturbance and trampling of burrows by livestock (BC Ministry of Water, Land and Air Protection 2004a).
- monitoring breeding sites to (Provincial Western Toad Working Group 2014; British Columbia Southern Interior Reptile and Amphibian Recovery Team 2008):

- ensure habitat use and population persistence; and
- control introduced invasive species (bullfrogs, non-native fish species) and prevent new introductions.

As wetland reclamation will not occur during Construction and Operation phases, 'diversion pools' will be created to attract amphibians away from mining activity. Artificial 'diversion pools,' are locations where amphibians can breed during Operation (Merrow 2007). Water levels will be maintained in these pools during the amphibian breeding season and fencing will be installed to exclude livestock (VAST Resources Solutions Inc. 2015). Ongoing monitoring to determine the effectiveness of artificial ponds as breeding sites will be required.

Habitat loss will be unavoidable for amphibians. Columbia spotted frog, Great Basin spadefoot, Northern Pacific treefrog, and western toad will lose suitable breeding habitat as a result of Project Construction activities. A residual effect is anticipated to occur for all four of the indicator species.

Habitat Alteration

Fugitive Dust Mitigation

Dust mitigation measures will be addressed under several management and monitoring plans. Mitigation measures to protect air quality are described in the *Air Quality Monitoring and Dust Control Plan* (Chapter 11.6). Reducing traffic by implementing the *Transportation Management Plan* and the *Access Management Plan* (Chapter 11.20 and Chapter 11.21) will also reduce the potential for negative effects of dust. These measures will mitigate the potential effects of fugitive dust on amphibian habitat.

Invasive Species Mitigation

Development and implementation of the invasive plant species plan and other measures identified in the *Wildlife and Vegetation Monitoring Plan* (Chapter 11.27) is integral to reducing the introduction and spread of invasive species. Avoiding introducing invasive species is central to circumventing costly measures required for their eradication. Reducing traffic by implementing the *Access Management Plan* (Chapter 11.21) on site is also a key measure to help reduce the introduction of invasive plant species.

A site-specific invasive species management plan will be developed by the Project's Environmental Manager through discussion (as needed) with the Invasive Plant Council, environmental scientists, and local governing agencies. The plan will draw upon the *Invasive Alien Plant Program: Reference Guide* (Ministry of Forests and Range 2010) and *Invasive Plant Pest Management Plan for the Southern Interior of British Columbia* (BC Ministry of Forests and Range 2010), which outline an Integrated Pest Management approach for invasive alien plants, under the authority of several partnering ministries.

Timely reclamation to restore affected areas after Project activities have ceased will reduce favourable conditions that could allow the establishment of invasive species. The *Landscape Design and Restoration Plan* (Chapter 11.26) provides for the rapid re-vegetation of all temporarily disturbed areas and will use appropriate seed mixes that minimize the spread of invasive plants. *The Invasive Plant Management Plan* (Chapter 11.17) will also include objectives for limiting invasive species,

monitoring the presence and possible spread of invasive plants in temporarily disturbed areas, and monitoring the success of re-vegetation programs. Mitigation measures to reduce the spread of invasive species will include:

- prior to work commencing, surveys will be conducted to identify invasive species populations. Treatment will be initiated as required;
- all vehicles entering and leaving work sites will be washed thoroughly with special attention to wheel wells, tire treads, and tracks where mud and seeds of noxious weeds may be lodged;
- wash areas will be located away from any waterbody and riparian areas;
- used wash water will be treated to prevent seed dispersal; and
- a vehicle bay associated with the truck shop will be available for all vehicles entering the site.

In addition, Targeted Invasive Plant Solutions (TIPS) have been produced by the Invasive Plant Council of BC to recommend BMPs and Integrated Pest Management techniques for control of invasive plant introduction and spread (Invasive Plant Council of BC 2007; Invasive Plant Council of BC 2008).

The introduction of bullfrogs is also a known threat to amphibians. If bullfrogs are discovered in the Project area immediate steps should be taken to eradicate this invasive species.

As habitat alteration is expected to have a negligible to low impact on amphibians, no residual effects are expected for any indicator species.

Hydrological Changes

Hydrological changes associated with Project Construction will be addressed under the *Water Management and Hydrometric Monitoring Plan* (Chapter 11.7). These measures will mitigate the potential effects of water quality on amphibian breeding habitat.

Wetlands along the Peterson creek diversion are expected to be substantially altered as Peterson Creek will be diverted via pipeline for approximately three kilometres, altering the watercourse within the IDA. A large diversion pond will be created which will alter the hydrology downstream of the diversion. Wetland function will be monitored along the creek outflow to determine if the diversion and the addition of the diversion pools alter the vegetation and wildlife that use the area. Measures will be taken to maintain these aquatic habitats in properly functioning conditions. These measures include:

- maintaining water levels, particularly during the breeding season;
- maintaining water quality;
- maintaining important habitat features (i.e., riparian and emergent vegetation, and non-compacted soils); and
- continued monitoring to determine the effectiveness of the mitigation measures and the status of the amphibian breeding population.

With the implementation of theses mitigation measures, a residual effect is not anticipated for amphibians as a result of habitat alteration.

Sensory Disturbance

Noise is anticipated to have a negative effect on the two calling amphibian species, Great Basin spadefoots and Northern Pacific treefrogs. Disturbance from continuous Project noise and blasting noise will occur in the LSA. A *Noise Management Plan* (Chapter 11.22) will be developed with the objective to ensure that noise levels during all phases of the Project are acceptably low for human and wildlife receptors, as per human health guidelines (Health Canada 2011).

Noise mitigation measures relevant to Great Basin spadefoots and Northern Pacific treefrogs include:

- monitoring noise levels at breeding sites within the IDA;
- minimizing loud, continuous noise at dawn, dusk and overnight during breeding season;
- considering noise ratings when selecting equipment;
- optimizing the operation of equipment to minimize noise (e.g., reduced speed limits);
- optimizing the site layout to minimize noise impact (e.g., through use of natural screens such as buildings, facing away from relevant receptors, minimizing the need for mobile equipment to use their backup alarms); and
- applying noise dampening measures where possible, including conducting loud procedures indoors, where practical.

Project related noise (e.g., drilling, crushing) can be avoided during critical times of day (sunrise/sunset), however, it may be difficult to limit traffic noise at that time. Traffic noise may be mitigated by minimizing traffic along roads by providing a vehicle parking lot for staff, and shuttling mine personnel from this site to the mine.

As calling/singing amphibians are most active at night, especially the crepuscular periods (sunset/sunrise), Project activities will be limited during this time during the amphibian breeding season (April through July), if practical and whenever possible. Project noise levels will be monitored at breeding sites. Since effects of anthropogenic noise on amphibian behaviour is poorly understood, Project noise that exceeds 45 dB (maximum level modelled for continuous Project noise and considered in this assessment) will be monitored to determine if calling amphibians are being affected. With implementation of these mitigation measures, a residual effect from sensory disturbance is not anticipated for amphibians.

Disruption of Movement

Disruption of movement for amphibians as a result of Construction related activities is anticipated to be low, but may occur between Jacko Lake and Inks Lake. Amphibian movement within the IDA will be minimal since most suitable habitat within the IF will be removed. Diversion pools will be situated in areas near suitable habitat, and arranged to allow movement between suitable areas, while avoiding unsuitable areas within the Project IF. Culverts (crossing structures) will be installed to facilitate movement between these two areas. Ongoing monitoring to determine if exclusion fencing (measure to keep individuals off roads) is necessary and surveys to determine if mass dispersal events are occurring, will also take place. Appropriate measures will be taken if a mass

dispersal is observed. With mitigation, a residual effect is not anticipated for disruption of movement of amphibians.

Direct Mortality

Direct mortality is anticipated for all species of amphibians during Construction and Operation of the Project. Activities that involve the removal of soil/aquatic vegetation and installation of infrastructure will result in the mortality of any amphibian species present. Egg masses, tadpoles, and recently metamorphosed juveniles, will suffer mortality if aquatic vegetation is removed. Dispersing juveniles and adults will likely suffer mortality during clearing, grubbing, and earthworks activities.

Egg, tadpole, and recently metamorphosed juvenile mortality can be avoided by limiting clearing during the critical time when they will be present (April through August; Ovaska et al. 2004). As amphibians require water to reproduce, the breeding window does not begin until after the spring thaw.

Before activities that will remove large areas of habitat commence, pre-clearing surveys, conducted by a Registered Professional Biologist with knowledge of amphibian biology will occur. If any amphibians are present, they will be translocated to closest area of suitable habitat outside of the IDA (RECON Environmental, Inc 2010). Translocation of amphibians appears to be successful the majority of the time (65%; Smith and Sutherland 2014). Translocation cannot occur in the winter as individuals will be hibernating under the soil, so pre-clearing surveys will not need to be completed during this time. To maximize the likelihood of success translocations should be conducted in the late summer, in preparation for clearing in the fall after juveniles have dispersed.

Vehicular mortalities may occur throughout all phases of the Project, especially during Construction and Operation when road use will be highest. These collisions may be reduced through the implementation of speed limits and minimizing the number of vehicles using sites roads (*Transportation Management Plan*; Chapter 11.20). The potential for road mortality exists since confirmed amphibian breeding habitat is present in the IDA adjacent to Project roads.

Measures to mitigate mortality of amphibians will include:

- avoiding vegetation clearing during breeding/dispersal (April through August) and working within timing windows as required when possible (Government of British Columbia 1996);
- yielding to wildlife observed along Project roads and communicating these observations;
- minimizing traffic along roads by providing a vehicle parking lot for staff, and mine personnel will be shuttled from this site to the mine;
- implementing speed limits and wildlife signage to alert drivers of potential collisions;
- developing an action plan to manage and mitigate effects of mass dispersal events on Project roads;
    - if closing or detouring roads is not practical, then fencing will be installed to funnel/direct the frogs and toads to specific locations. Workers and volunteers could

then transport the toads ('bucket brigade') from these locations to areas of suitable habitat outside of the IDA.

- installing drift fences and culverts in locations where road mortality is excessive (BC Ministry of Water, Land and Air Protection 2004a).
- following best management practices for the application of magnesium chloride on gravel road surfaces in the LSA (British Columbia Southern Interior Reptile and Amphibian Recovery Team 2008).

Implementation of these measures is expected to mitigate the effect of road mortality on amphibians. Mortality resulting from clearing and grubbing cannot be fully mitigated and a residual effect for is anticipated.

Indirect Mortality

Indirect mortality as a result of increased hunting pressure by natural predators as well as increased competition for resources due to range shifts will be difficult to avoid. However, as all of the indicator species have relatively small home ranges, a noticeable change in the population across the LSA is not expected. As there is a low risk of occurrence, a residual effect for indirect mortality is not expected for amphibians.

Wildlife Attractants

The attraction of amphibians to sub-optimal habitat is expected to be low in all phases of the Project. Non-contact water may attract amphibians to them for breeding habitat.

The BMP documents that are relevant to the Project include:

- *Best Management Practices for Amphibians and Reptiles in Urban and Rural Environments in British Columbia* (Ovaska et al. 2004);
- *Wetland Ways: Interim Guidelines for Wetland Protection and Conservation in British Columbia* (Cox and Cullington 2009);
- *Develop with Care: Environmental Guidelines for Urban and Rural Land Development in British Columbia* (BC Ministry of Environment 2012);
- Guidelines for Reduced Risk Instream Work Windows;
- *Standards and Best Practices for Instream Works* (BC Ministry of Water, Land and Air Protection 2004b); and
- Lakeshore stabilization (British Columbia Ministry of Environment 2006).

With mitigation in place, a residual effect for wildlife attractants on amphibians is not expected.

Chemical Hazards

Chemical hazards from various Project activities (e.g., fuel storage and filling area, deposition to the TSF, vehicle/machinery leaks) are expected to be low in all phases of the Project. Management Plans that will be in place to further reduce these effects include:

- an *Air Quality and Dust Management Plan* (Chapter 11.6);
- a *Solid Waste Management Plan* (Chapter 11.9);
- a *Hazardous Waste Management Plan* (Chapter 11.10);
- a *Risk Management Plan (Accidents and Malfunctions) (*Chapter 11.12);
- an *Emergency Response Plan* (Chapter 11.14);
- a *Surface Water Quality Management and Monitoring Plan* (Chapter 11.23); and
- a *Groundwater Quality Management and Monitoring Plan* (Section 11.24).

Any areas where contact water is present will be monitored for the presence of emergent vegetation. As vegetation plays a role in habitat selection by amphibians (Monello and Wright 1999; Strijbosch 1979) removing emergent vegetation will make the habitat unattractive for amphibians (BC Ministry of Forests, Lands, and Natural Resources 2014).

To further reduce the interaction between amphibians and contact water, artificial 'diversion pools' can be created (Merrow 2007). These pools will be placed in areas adjacent to the TSF, SMRSF, EMRSF, and WMRSFs to provide suitable habitat that amphibians will preferentially select, thus keeping them away from contaminated water sources. Water levels in these pools will be maintained during the breeding season and habitat features will be added to increase the suitability. Keeping amphibians out of areas that may come into contact with water from Peterson Creek or Humphrey Creek will not be able to be fully mitigated for.

An amphibian monitoring program will help to determine if certain elements are bio accumulating in the various frog and toad species in the LSA. This could help to provide further insight into the effects that these elements have on amphibians.

With the implementation of these mitigation measures, a residual effect for chemical hazards on amphibians is expected.

6.12.5 Residual Effects and Their Significance

6.12.5.1 Summary of Residual Effects

After the implementation of mitigation measures, residual effects on amphibians are anticipated to result from habitat loss, direct mortality, and chemical hazards (Table 6.12-22). The loss of suitable amphibian breeding habitat will not be avoidable, and will have an effect on amphibian species present in the LSA. Wetland creation outlined in the reclamation plan, will reduce the effect in the long-term but an effect will be present for the life of the Project. Clearing and grubbing and earthworks cause direct mortality of amphibian inhabiting the area. Translocating individuals will reduce the effect but some amphibians will be lost.

Table 6.12-22. Summary of Residual Effects on Amphibians

Valued Component*	Project Phase (timing of effect)	Project Component/ Physical Activity	Description of Cause-Effect[1]	Description of Mitigation Measure(s)	Description of Residual Effect
Amphibians	Construction	Clearing/ Grubbing/ Earthworks	Removal of vegetation and wetlands – habitat loss	Reclamation/ revegetation/ artificial diversion pools/enhancement, wetland habitat compensation plan	Reduction in available habitat, living and reproducing
Amphibians	Construction, Operations	Clearing/ Grubbing/ Earthworks	Removal of vegetation and wetlands – direct mortality	Translocation of individuals to areas of suitable habitat/ avoid critical windows (April through August)	Reduction in overall population numbers
Amphibians	Construction, Operations	Contact Water	Presence of contact water in breeding habitat – chemical hazard	Installation of artificial 'diversion pools', clearing of emergent vegetation, amphibian monitoring program	Reduction in reproductive success, delayed development, mortality

[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 VC.*
*** Bold** indicates species anticipated to experience greatest impact.*

6.12.5.2 Criteria for Characterization of Residual Effects

Specific criteria used to characterize residual effects are outline below (Table 6.12-23). For habitat loss/alteration effects, magnitude was assigned thresholds based on literature and professional knowledge (Andren 1994). Negligible is a 0-5% change to available habitat in the LSA, Minor was a 5-30% change, Medium was a 30-50% change and Major is a change greater than 50%.

6.12.5.3 Characterization of Residual Effects

Residual effects on amphibians are anticipated as a result of the Project (Table 6.12-24). Habitat loss will have a medium magnitude of effect, with 26 to 48% of suitable breeding habitat being removed. The duration of these effects will last beyond the life of the Project (long-term), as revegetion and recolonization of these areas will not occur instantaneously, and amount of off-site habitat creation is unknown. The effect will occur once, during the Construction phase when the Project IF is cleared. The geographic extent is landscape since amphibians have small home ranges but disperse > 500 m from breeding sites. This effect may be reversible in the long-term with the reclamation of wetlands. All amphibians species are susceptible to continued loss of breeding habitat, particularly in low elevation areas where urbanization and agriculture encroachment is widespread (COSEWIC 2012; British Columbia Southern Interior Reptile and Amphibian Recovery Team 2008). Great Basin spadefoots and western toads are both provincially blue-listed species and federally SARA schedule 1

species, resulting in a low resilience, due to the limited availability of breeding sites, and a high ecological context.

Direct mortality resulting from Project site preparation and clearing was estimated at 26 to 29% of the population. Assuming translocation is effective at preventing some mortality the magnitude of this effect will be reduced to minor. The duration of direct mortality will be long-term since the population cannot recover until habitat is reclaimed. Direct mortality from clearing/grubbing and earthworks activities will occur once, during Construction, with sporadic occurrences during operation as laydown areas are used. The geographic extent is landscape since amphibians have small home ranges but disperse > 500 metres from breeding sites. The effect of mortality is reversible in the long-term if the population is allowed to recover post-reclamation. The Great Basin spadefoots and western toads are both provincially blue-listed species and federally SARA schedule 1 species, meaning the resilience is low and the ecological context is high.

Chemical hazards resulting from increased Al, As, B, Cd, Cl^-, Co, Cr, Cu, Fe, Hg, Mo, NO_2, NO_3, NH_3, Sb, Se, SO_4^{2-}, U, and Zn will have the a negative effects on amphibians in their aquatic life stages (e.g., embryos, tadpoles) as these are the elements that will be above aquatic habitat guidelines for Peterson and Humphrey Creeks. Decreased reproductive success, decreased tadpole swimming speed, delayed larval development, and increased mortality rates are all possible side effects resulting from the increase in these various elements in their aquatic environment. Flowing creek have lower breeding suitability and the magnitude was minor. The landscape level extent as effect will be confined to the two creeks. Duration will be into the far future based on modelling results. Water quality in the creeks will be continuously poor and likely irreversible. The Great Basin spadefoots and western toads are both provincially blue-listed species and federally SARA schedule 1 species, meaning the resilience is low and the ecological context is high.

6.12.5.4 Significance of Residual Effects

Habitat loss is anticipated to have a not significant (moderate) effect on amphibians within the LSA. Project infrastructure will remove 173.2 ha of wetlands of which 42.6 ha has confirmed amphibian breeding. Nearby ponds and wetlands can provide breeding opportunities during the life of the project and reclamation can provide quality breeding sites post-reclamation. Existing wetlands in the LSA can also be enhanced by managing cattle and providing suitable habitat features such as coarse woody debris for amphibians. The creation/enhancement of wetland habitat during Construction/Operation and reclamation of 14 ha wetlands and 10 ha of open water Post-Closure will reduce the significance of this effect as will wetland compensation.

Direct mortality is anticipated to have a not significant (minor) effect on amphibians. While a number of individuals are anticipated to be lost as a result of Construction activities, the significance can be reduced by translocating individuals from disturbance areas within the IDA to areas of suitable breeding habitat around the LSA. Despite these measures individuals will be lost. Although the population will recover to some degree, the population supported in the LSA will be reduced below baseline levels for the life of the Project due to habitat loss. Since suitable breeding habitat will be maintained in the LSA and in the RSA, wetlands recreated in the Project IF during reclamation can be recolonized from these source populations.

Table 6.12-23. Definitions of Characterization Criteria for Residual Effects on Amphibians

Magnitude	Duration	Frequency	Geographic Extent (Physical/Biophysical)	Reversibility	Resiliency	Ecological Context	Likelihood of Effects	
							Probability	Confidence Level
How severe will the effect be?	*How long will the effect last?*	*How often will the effect occur?*	*How far will the effect reach?*	*To what degree is the effect reversible?*	*How resilient is the receiving environment or population?*	*What is the current condition of the ecosystem and how commonly is it represented in the LSA?*	*How likely is the effect to occur?*	*How certain is this analysis?*
Negligible: No or very little detectable change from baseline conditions. (< 5% of available habitat in LSA)	**Short-term:** Effect lasts 1 to 5 years.	**Once:** Effect is confined to one discrete period in time during the life of the Project.	**Local:** Effect extends less than 500 m from infrastructure or activity.	**Reversible Short-term:** Effect can be reversed relatively quickly.	**Low:** The receiving environment or population has a low resilience to imposed stresses, and will not easily adapt to the effect.	**Low:** The receptor is considered to have little to no unique attributes or provision of functions is severely degraded.	**High:** It is highly likely that this effect will occur.	**High:** < 80% confidence. There is a good understanding of the cause-effect relationship and all necessary data are available for the Project area. There is a low degree of uncertainty and variation from the predicted effect is expected to be low.
Minor: Differs from the average value for baseline conditions to a small degree. (5-30%)	**Medium-term:** Effect lasts 6 to 25 years.	**Sporadic:** Effect that occurs at sporadic or intermittent intervals during any phase of the Project.	**Landscape:** Effect is limited to the LSA or one watershed (i.e., Sub-area).	**Reversible Long-term:** Effect can be reversed within 20 years of Post Closure.	**Neutral:** The receiving environment or population has a neutral resilience to imposed stresses and may be able to respond and adapt to the effect.	**Neutral:** The receiving environment considered to have some unique attributes and provides most functions that an undisturbed environment would provide.	**Medium:** This effect is likely, but may not occur.	**Medium:** 50 to 80% confidence. The cause-effect relationships are not fully understood, there are a number of unknown external variables, or data for the Project area are incomplete. There is a moderate degree of uncertainty; while results may vary, predictions are relatively confident.
Medium: Differs substantially from the average value for baseline conditions and approaches the limits of natural variation. (30-50%)	**Long-term:** Effect lasts between 26 and 50 years.	**Regular:** Effect occurs on a regular basis during the life span of the Project.	**Regional:** Effect extends across the broader region (e.g., RSA, multiple watersheds, etc.).	**Irreversible:** Effect cannot be reversed (i.e., is permanent).	**High:** The receiving environment or population has a high natural resilience to imposed stresses, and can respond and adapt to the effect.	**High:** The receiving environment or population is uncommon and occurs in a natural state and provides functions at a maximum capacity.	**Low:** This effect is unlikely but could occur.	**Low:** < 50% confidence. The cause-effect relationships are poorly understood, there are a number of unknown external variables, and data for the Project area are incomplete. High degree of uncertainty and final results may vary considerably.
Major: Differs substantially from baseline conditions, resulting in a detectable change beyond the range of natural variation. (> 50%)	**Far Future:** Effect lasts more than 50 years.	**Continuous:** Effect occurs constantly during the life of the Project.	**Beyond Regional:** Effect extends beyond the regional scale, and may extend across or beyond the province.					

Table 6.12-24. Characterization of Residual Effects, Significance, Likelihood and Confidence on Amphibians

Residual Effect	Residual Effects Characterization Criteria							Significance of Adverse Residual Effects	Likelihood and Confidence	
	Magnitude	Duration	Frequency	Geographic Extent	Reversibility	Resiliency	Context		Probability	Confidence
Habitat Loss	Medium	Long-term	Sporadic	Landscape	Reversible Long-term	Low	High	Not Significant (moderate)	High	Medium
Direct Mortality	Minor	Long-term	Sporadic	Landscape	Reversible Long-term	Low	High	Not Significant (minor)	High	Low
Chemical Hazard	Minor	Far Future	Continuous	Landscape	Irreversible	Low	High	Not Significant (minor)	Medium	Medium

Suitable breeding habitat will continue to exist throughout the LSA and RSA and reclamation will replace the 24 ha lost during Project Construction. The maintenance and habitat enhancement should provide breeding opportunities within the IDA. Once the habitat has been reclaimed the amphibian population should recover to pre-project levels. The effect of the Project on local amphibian populations is not anticipated to be significant.

Chemical hazards are anticipated to have a not significant (minor) effect on amphibians within the LSA. While increased levels of several elements will occur at various locations, mitigation measures to reduce interactions at any source of contact water within any IF will be in place. Humphreys Creek and Peterson Creek will have increased levels of some elements that exceed aquatic water quality guidelines, but these water bodies are not conducive to breeding habitat (i.e., amphibians prefer still water, not flowing creeks). The potential does exist, however, for an interaction to occur.

6.12.5.5 Characterization of Likelihood and Confidence

The probability and confidence of habitat loss on amphibians were ranked high and medium, respectively. All indicator species were documented in the LSA and breeding was confirmed at wetlands present in the LSA. Since Project infrastructure footprints overlap confirmed breeding habitat there is high confidence and likelihood of this effect. Most potential breeding sites in the LSA were mapped and surveyed. However, due to the temporary nature of ephemeral wetlands, not all wetlands associated with breeding sites could be mapped; these potential breeding sites were not accounted for in the analysis resulting in a confidence level of medium.

The probability and confidence of direct mortality on amphibians were ranked high and low, respectively. All indicator species were documented in the LSA and are known to inhabit the Project infrastructure footprints, however the proportion of the population affected in the LSA was based on a crude estimate. Therefore the probability that individuals will be lost is high but there is low confidence in the estimated number of potentially affected individuals.

The probability and confidence of chemical hazards on amphibians were both ranked medium. Probability was given this ranking as potentially toxic water will be present in the IDA, but the extent of which these areas will be used after the implementation of mitigation is not well understood. Confidence was also ranked medium as there is uncertainty regarding the implications of amphibian exposure to these elements, but extensive literature exists suggesting a heightened sensitivity for this taxa to contact with various chemicals.

6.12.5.6 Summary of Residual Effects Assessment and Significance

Residual effects are anticipated to occur on the VC "Amphibians" as a result of various Project activities after the implementation of mitigation measures (Table 6.12-25). Habitat loss is anticipated to have a not significant (moderate) effect on amphibians within the LSA. Direct mortality is anticipated to have a not significant (minor) effect on amphibians in the IDA during Construction activities. Chemical hazards are anticipated to have a not significant (minor) effect on amphibians in the IDA throughout the life of the Project and beyond.

These residual effects will be carried forward into the cumulative effects assessment section, and discussed in relation to other projects within the RSA (Section 6.12.6).

Table 6.12-25. Summary of Residual Effects, Mitigation, and Significance on Amphibians

Residual Effects	Project Phase	Mitigation Measures	Significance
Habitat Loss	Construction	Reclamation/ revegetation/ artificial diversion pools/ enhancement	Not Significant (moderate)
Direct Mortality	Construction, Operations	Translocation of individuals to areas of suitable habitat/ avoid critical windows	Not Significant (minor)
Chemical Hazards	Construction, Operations, Closure, Post-closure	Clearing of emergent vegetation, amphibian monitoring program	Not Significant (minor)

6.12.6 Cumulative Effects Assessment

6.12.6.1 Introduction

The cumulative effects assessment (CEA) considers the effects on wildlife and wildlife habitat that are likely to result from the residual environmental effects of the Project in combination with the effects of other projects and activities (past, present, or future) within the RSA. The CEA methodology is based on the framework outlined by the *Canadian Environmental Assessment Act* (1992) guidelines (Hegmann et al. 1999) with additional guidance provided in the AIR.

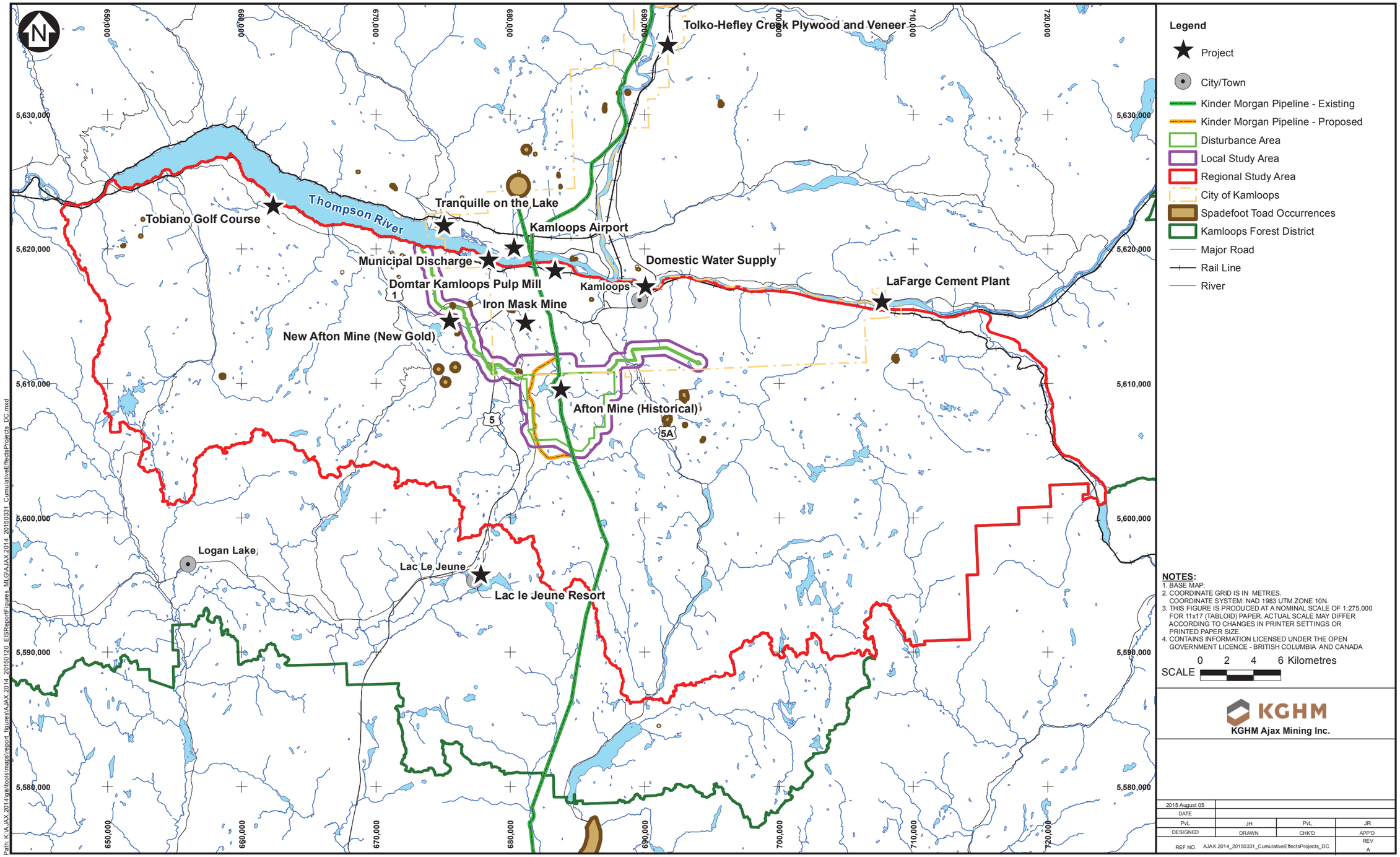
Past land use has shaped much of the regions current wildlife habitat abundance and distribution, and, in turn, has shaped how wildlife uses the landscape. Many past, present and future projects have, and will continue to contribute to the amount of various amphibian habitat types in the RSA (Figure 6.12-11). Several projects have been identified as occurring in the region, and could potentially interact with the Project. Each of these projects will be considered in combination with the result of our residual effects assessment to determine if there is an interaction, and consequently, if there is the potential for a residual cumulative effect to occur. These interactions can include direct, indirect, additive and synergistic effects. To be included in the CEA projects must occur within the RSA, must have a residual effect, and must have the potential to act cumulatively with the residual effects for amphibians described in Section 6.12.5.

Habitat loss, direct mortality, and chemical hazards were considered residual effects for amphibians. All projects that could potentially occur in the region have been included in Table 6.12-26. Those projects that could have a residual effect associated with amphibian habitat loss, direct mortality, and chemical hazards will be included in the CEA.

6.12.6.2 Identification of Other Actions that May Affect Amphibians

A list of past, present, and anticipated future projects and activities known to occur in the region were provided by KAM. Projects/activities were initially scoped out if there was no perceived spatial interaction (i.e., the project/activity occurs outside of the RSA). Other projects/activities were scoped into the CEA on a VC by VC basis. If a residual effect from the Project was determined, the likelihood of other projects/activities resulting in the same effect were assessed using reports generated from those projects/activities; in the absence of any data indicating specific effects, professional judgement was used. Projects/activities considered for cumulative effects on amphibians are listed below (Table 6.12-26).

Figure 6.12-11
Cumulative Effects Regional Study Area



NOTES:
1. BASE MAP:
2. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD 1983 UTM ZONE 10N.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:275,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
4. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENCE - BRITISH COLUMBIA AND CANADA

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KGHM Ajax Mining Inc.

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Table 6.12-26. Ranking Potential for Residual Effects to Interact Cumulatively with Effects of Other Human Actions on Amphibians

	Industrial Projects/Activities													Natural Resources and Land Use			Tourism and Commercial Recreation Activities					Community Infra-structure			Transportation						
Residual Effect	Vidette Lake Mine	Afton Mine (Historical)	Iron Mask Mine	Bonaparte Mine	New Afton Mine (New Gold)	Highland Valley Copper Mine (Teck)	Domtar Kamloops Pulp Mill	Tolko-Hefley Creek Plywood and Veneer	LaFarge Cement Plant	Trans Mountain Pipeline System (Kinder Morgan)	Trans Mountain Pipeline System - Expansion (Kinder Morgan)	Harper Creek	Highland Valley Copper – Bethlehem Expansion	Kamloops Forest District	Agriculture	Ranching	Tranquille on the Lake	Lac Le Jeune Resort	Tobiano Golf Course	Recreational Hunting, Fishing, Foraging	Recreational Trails	City of Kamloops Wastewater Management	Water Treatment Centre	City Expansion and Growth	Lac le Jeune Road	Highway 1	Highway 5A	Highway 5 (Coquihalla Highway)	Kamloops Airport	Rail Yards and Lines (CP and CN)
Habitat Loss	-	O	O	-	O	-	O	-	-	O	L	-	-	L	M	L	-	-	O	O	O	-	-	M	O	O	O	O	-	O
Direct Mortality	-	O	O	-	O	-	O	-	-	O	L	-	-	M	L	L	-	-	O	L	O	-	-	M	L	L	L	L	-	O
Chemical Hazards	-	O	O	-	L	-	L	-	-	O	O	-	-	O	O	O	-	-	O	O	O	-	-	O	O	O	O	O	-	O

Notes:

(-) *No spatial or temporal overlap.*

O *Spatial or temporal overlap, but no interaction anticipated OR No change from current condition anticipated, and already captured as part of baseline characterization. No further consideration warranted.*

L *Negligible to minor interaction expected; implementation of best practices, standard mitigation and management measures; no monitoring required, no further consideration warranted.*

M *Potential moderate interaction requiring unique active management/monitoring/mitigation; warrants further consideration.*

H *Key interaction; warrants further consideration.*

6.12.6.3 Interactions between Residual Project Effects and Other Project or Activity Effects

Habitat loss, direct mortality, and chemical hazards are potential effects that may be compounded by other projects/activities in the region. Habitat loss associated with past, present and future project activities cannot be quantified. In the majority of cases, no information is available on total habitat loss. Consequently, a qualitative analysis was conducted to determine potential interactions based on professional judgement, location of these projects/activities, and the sensitivity of amphibians to habitat loss.

Existing mine pits in the area (e.g., Afton, Crescent-Afton, Pothook, Ajax, and Iron Mask) would have likely removed suitable habitat for frogs and toads, as the landscape is quite similar to that of the Ajax Project. These projects were considered as baseline conditions for the purpose of this assessment. Construction of Lac le Jeune Road, Highway 5A, and the TransCanada Highway occurred previous to 1950, while the Coquihalla Highway was built in the early 1980's. The construction of these roadways, as well as other exiting projects (e.g., Domtar), were also considered as part of baseline conditions.

The New Afton Mine, an underground copper-gold mine on the site at the former Afton open pit mine, may be a risk of a chemical hazard for amphibians. The tailings facility for this project may attract frogs and toads to use the area as a potential breeding site. Potential mitigation measures taken by this mine to avoid this interaction are unknown, so the potential for an interaction was assumed to occur.

Agriculture, forestry, and ranching have occurred in the region since the 1800s. Habitat loss associated with all of these activities is assumed to have occurred, although it cannot be quantified. All three of these activities are assumed to have removed areas of suitable breeding habitat for amphibians, and also likely result in mortality of individuals. Continued active timber harvesting and cattle grazing also has the potential to have a mortality effect on amphibians (Table 6.12-26).

Construction of roadways results in an increased risk of vehicular mortality. As all of the roads and highways bisect areas of known suitable habitat, it is anticipated that all species of amphibian may be at risk of increased road mortality (Table 6.12-26). Quantification of this loss, however, is not possible based on the information available.

Future projects/activities, such as the expansion of the City of Kamloops, specifically the growth of Aberdeen (neighbourhood adjacent to LSA) and the Southwest Industrial Area, as well construction of Kinder Morgan's TransMountain pipeline, will likely result in additional habitat loss and mortality of all amphibian species (Table 6.12-26). Aberdeen is expected to continue expanding, from an approximate population of 10,000 people in 2011, to over 16,000 by 2036 years (TRUE Consulting Group 2008; City of Kamloops 2012). Construction of Kinder Morgan's TransMountain pipeline, if approved, is anticipated to commence as early as 2016. Construction of this project would likely result in some amphibian habitat loss, as well as direct mortality. The amount of habitat lost as a result of this project will likely be relatively small within the region.

Mortality effects from recreational use of the region (hunting, foraging, ATV use) are also unable to be quantified. While these activities are anticipated to be lower in duration and frequency than other activities, the possibility of mortality effects on amphibians are unknown. A cumulative effect may occur as a result of these activities (Table 6.12-26).

6.12.6.4 Proposed Mitigation Measures

As KAM has limited authority to guide regional initiatives to support the diversity and persistence of habitat, this would be better guided by the provincial government.

Habitat Loss

Mitigation for the impacts of the Project on habitat loss consists of avoiding sensitive breeding sites (wetlands), mine site reclamation (including amphibian breeding habitat, riparian vegetation), and wetland creation/enhancement. These measures, however, were not sufficient to reduce the total loss of habitat. Additional habitat loss mitigation will be required to compensate for the cumulative loss of habitat in the RSA. KAM will seek partnerships to enhance existing wetlands within the RSA (Section 6.9.6.4). Discussions with the provincial government will be initiated in an effort to develop Wildlife Habitat Areas (WHAs) on KAM owned land.

The provincial *Recovery Strategy for the Great Basin Spadefoot, (Spea intermontana) in British Columbia* (British Columbia Southern Interior Reptile and Amphibian Recovery Team 2008) as well as the provincial *Management Plan for the Western Toad (Anaxyrus boreas) in British Columbia* (Provincial Western Toad Working Group 2014) provide a list of existing and recommended approaches to habitat protection that will be followed. Further habitat reclamation, creation, or enhancement activities including the fencing off of wetlands and controlling the timing for livestock grazing on KAM owned lands in sensitive areas could return some damaged habitat to "baseline conditions." KAM will foster stewardship agreements with landowners and support best management practices to contribute to the conservation of amphibians in the region. KAM will also develop research partnerships with TRU to clarify movement and dispersal patterns, habitat use and quality in natural and modified habitats will help identify critical habitats.

Habitat loss cannot fully be mitigated, and will be carried forward and evaluated in Section 6.12.6.5

Direct Mortality

Mitigation for the impacts of the Project on direct mortality includes limiting clearing activities to avoid spring and summer, and translocating individuals away from the Project IF prior to clearing. These measures may reduce the number of individuals killed as a result of the Project, but are not sufficient to mitigate the effects of the Project. Additional mitigation will be required to compensate for the cumulative mortality of amphibians throughout the RSA. KAM will work with the BC Frogwatch Program to increase education regarding amphibian conservation in the region. Volunteers/KAM staff will be deployed to any mass dispersal events detected in proximity to the Project. Direct mortality cannot fully be mitigated, and therefore will be carried forward and evaluated in Section 6.12.6.5.

KAM will contribute to existing programs (e.g., New Gold) on spadefoot ecology and use of artificial breeding sites. Advantages of this contribution are that the framework and partnerships for the project have already been established. The geographic study area will need to be expanded to include the Ajax Project LSA. The effectiveness of artificial ponds as breeding sites will be the continued focus of this study.

Chemical Hazards

Mitigation to reduce the effects of chemical hazards to amphibians consisted of continued monitoring of water quality within the LSA and ensuring water bodies are unattractive to breeding amphibians. The tailings storage of the New Afton Mine may increase the likelihood of amphibians coming in contact with contaminated water in the region. Contaminant levels from these projects are unknown. Similar mitigation measures could be implemented for the other tailings areas in the RSA. Partnering with existing programs (e.g, New Gold) and the work on spadefoot ecology and use of artificial breeding sites will also help to reduce the effects of chemical hazards on amphibians in the region. Chemical hazards cannot fully be mitigated, and therefore will be carried forward and evaluated in Section 6.12.6.5.

6.12.6.5 Evaluation of Significance of Residual Cumulative Effects

After the implementation of mitigation measures, residual cumulative effects are anticipated to occur. The loss of amphibian breeding habitat cannot be mitigated and may result in a residual cumulative effect (Table 6.12-27). As wetlands are being degraded and lost globally (Millennium Ecosystems Assessment 2005), the preservation and creation of as much of this habitat, and the retention of minimum wetland densities on anthropogenically dominated landscapes, is of great importance (Gibbs 2000).

Table 6.12-27. Summary of Cumulative Effects Mitigation Measures and Residual Effects on Amphibians

Ajax Project Activity	Other Human Action Activity	Description of Potential Cumulative Effect	Description of Mitigation Measure(s)	Description of Residual Cumulative Effect
Clearing/ Grubbing, Earthworks	Construction of other project infrastructure	Loss of suitable breeding habitat	Reclamation/ revegetation, breeding site avoidance. Partnering with WSP to enhance existing wetlands. Discuss creation of WHAs on KAM owned land with provincial government.	Reduction in available habitat
Clearing/ Grubbing, Earthworks	Construction of other project infrastructure/ Traffic on project and public roads	Mortality of individuals	Translocation of individuals to areas of suitable habitat/ avoid critical windows. Work with BC Frogwatch Program to increase education of regional amphibian conservation. Contribute to existing programs on spadefoots.	Reduction in regional population
Contact Water	Presence of contaminants from other projects	Habitat degradation and mortality/ mutations to amphibians	Communicating water quality results with other projects in the RSA. Contribute to existing programs on spadefoots.	Reduction in available habitat, reduction in reproductive success, mortality or mutations of individuals

Direct mortality is anticipated to occur for amphibians within the RSA. As more development encroaches into suitable habitat, the likelihood of mortality increases. Road mortalities during mass migration and/or dispersal events may result in hundreds or even thousands of individuals crossing roadways. The Coquihalla Highway, Highway 5A, the TransCanada Highway (#1), and Lac le Jeune Road have been causing mortality to amphibians for decades, and the Ajax Project may further compound this issue, potentially resulting in a residual cumulative effect (Table 6.12-27).

Chemical hazards may be present across the RSA, and the potential for increased exposure increases with any new development. The New Gold mine site and Domtar mill may have increased the amount of potential contaminated areas across the RSA. As amphibians are especially susceptible to environmental contaminants, any polluted habitat has the potential to negatively affect this VC. A residual cumulative effect resulting from the Project and other projects/activities in the region may occur (Table 6.12-27).

Characterization of the residual cumulative effects is presented in Table 6.12-28. Habitat loss has, and will continue to occur for various species of amphibians. The Project will result in loss of 0.4 to 2.1% of wetlands in the RSA. Habitat loss for Great Basin spadefoots and western toads ranked not significant (minor) since the regional effect of habitat loss is considered a minor effect.

Direct mortality is anticipated for amphibians. The Project will result in loss of 5% of terrestrial amphibian habitat available in the RSA. The construction of motorways (Coquihalla, Highway 1, Highway 5A, and Lac le Jeune Road) in the past would have fragmented amphibian habitat in the region. Dispersing individuals may suffer mortality as a result of these projects/activities. Additional project construction in the area may also add to amphibian mortality. Direct mortality for amphibians was ranked not significant (minor).

Chemical hazards may present throughout the RSA as a result of other projects and activities. Amphibians throughout the region may have an increased level of mortality or mutations resulting from increased contaminants in areas of suitable breeding habitat, but this information cannot be quantified. As few projects in the RSA are anticipated to release significant amounts of deleterious substances into the environment, the effect of chemical hazards on amphibians was ranked not significant (minor).

KAM will support research initiatives outlined in the R*ecover Strategy for the Great Basin Spadefoot* (BC Ministry of Forests, Lands, and Natural Resources 2014) and the *Management Plan for the Western Toad* (Provincial Western Toad Working Group 2014) to help reduce cumulative effects to these species in the region.

Table 6.12 28. Characterization of Residual Cumulative Effects, Significance, Likelihood and Confidence on Amphibians

Residual Cumulative Effect	Residual Effects Characterization Criteria							Significance of Adverse Residual Effects	Likelihood and Confidence	
	Magnitude	Duration	Frequency	Geographic Extent	Reversibility	Resiliency	Context		Probability	Confidence
Habitat Loss	Minor	Long-term	Sporadic	Regional	Reversible Long-term	Low	High	Not Significant (minor)	High	Medium
Direct Mortality	Minor	Long-term	Sporadic	Regional	Reversible Long-term	Low	High	Not Significant (minor)	High	Medium
Chemical Hazards	Minor	Far Future	Continuous	Regional	Irreversible	Low	High	Not Significant (minor)	Medium	Low

6.12.7 Conclusion

Amphibians were assessed as a VC to determine likely interactions with specific Project activities and how these interactions would affect this species group. All potential effects (habitat loss, habitat alteration, sensory disturbance, disruption of movement, direct mortality, indirect mortality, wildlife attractants and chemical hazards) arising from each Project activity were identified and evaluated. After the implementation of mitigation measures, three Project-related residual effects and three residual cumulative effects were determined for amphibians as a result of this Project in combination with other projects/activities, past, present, and future, occurring within the region (Table 6.12-29).

Table 6.12-29. Summary of Project and Residual Cumulative Effects, Mitigation, and Significance for Amphibians

Residual Effects	Project Phase	Mitigation Measures	Residual Effect Significance	Residual Cumulative Effect Significance
Habitat Loss	Construction	Avoidance of breeding sites through re-design where possible. Establish exclusion areas. Erosion and sediment control. Avoid use of herbicides. Integration of amphibian habitat with wetland compensation efforts. Artificial diversion pools to attract amphibians away from the mine site infrastructure. Discuss creation of Wildlife Habitat Areas on KAM owned land with provincial government. Contribute to existing programs on spadefoots.	Not Significant (moderate)	Not Significant (minor)
Direct Mortality	Construction, Operations	Translocation of individuals to areas of suitable habitat/ avoid critical windows. Work with BC Frogwatch Program to increase education of regional amphibian conservation.	Not Significant (minor)	Not Significant (minor)
Chemical Hazards	Construction, Operations, Decommissioning and Closure, Post-closure	Installation of artificial "diversion pools" to attract amphibians away from mine site infrastructure. Communicating water quality results with other projects in the RSA. Contribute to existing programs on spadefoots.	Not Significant (minor)	Not Significant (minor)

Habitat loss, direct mortality, and chemical hazards were considered Project-related and residual cumulative effects. The magnitude and geographic extent of these effects differs as the scale at which they were assessed was much smaller for the Project-related residual effects than for residual

cumulative effects (i.e., LSA vs. RSA). The frequencies also differ as the timeline for future projects is not well understood. Duration, reversibility, and resilience do not differ between assessments.

The loss of suitable breeding habitat may result in a negative impact to various species. Two Blue-listed amphibians, Great Basin spadefoot and western toad, are known to reside in the area, and a reduction in habitat may impact these species locally and regionally. Habitat loss is considered not significant (moderate) for this species group for Project-related residual effects as 48% of potentially suitable breeding habitat will be removed. Habitat loss is considered not significant (minor) for residual cumulative effects as 2% of potentially suitable habitat available in the region will be removed.

Direct mortality of amphibians may result in decreased gene flow amongst populations, and possible decreased reproductive success for this species group. Direct mortality is considered not significant (moderate) for Project-related residual effects, as 29% of terrestrial habitat may be lost due to the Project. Direct mortality is considered not significant (minor) for this species group for residual cumulative effects as 5% of terrestrial habitat may be lost due to the Project.

Chemical hazards have the potential to negatively affect amphibian populations, both in increasing mortality, as well as decreasing reproductive success of adults and development of tadpoles. With proper mitigation procedures, chemical hazards are considered not significant (minor) for both Project-related effects as well as residual cumulative effects on amphibians.

6.13 REPTILES

6.13.1 Rationale

This section includes a description of the scoping process used to identify Reptiles for inclusion in the assessment. Scoping is fundamental to focusing the Application/EIS on those issues where there is the greatest potential to cause significant adverse effects. Valued components (VCs) are components of the natural and human environment that are considered to be of scientific, ecological, economic, social, cultural, or heritage importance (CEAA 2006; EAO 2013). To be included in the EA, there must be a perceived likelihood that the VC will be affected by the proposed Ajax Project (the Project).

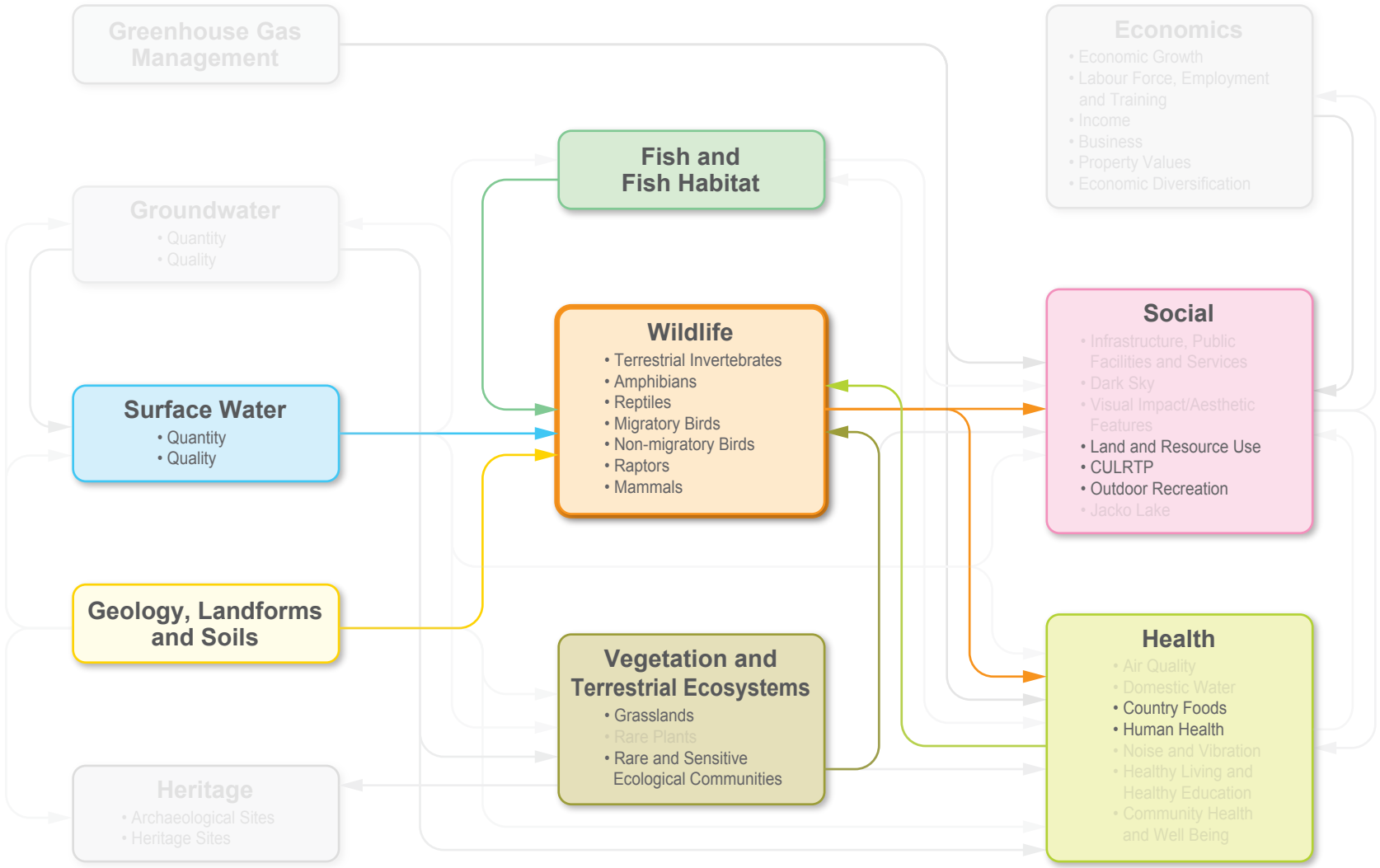
For Reptiles the following was considered for inclusion as a valued component in the environmental assessment:

- Federal or provincial listing or regulation;
  - Lists of Red- and Blue-listed species believed to occur within the Kamloops Forest District, and information on known locations of these species, according to the BC Conservation Data Centre (2010);
  - Information on SARA- or COSEWIC-listed taxa available from the Government of Canada
  - Taxa listed as part of the Identified Wildlife Management Strategy (IWMS);
  - Taxa of regional concern; and data from targeted wildlife surveys and from incidental observations;
- Regional significance;
- Aboriginal interest;
- Public or other stakeholder input;
- Scientific/professional knowledge; and
- Relevant legislation or policy concerning the VC.

Reptiles are ectothermic and less dependent upon moisture and water because of their protective scales and their reproductive strategies of laying shelled eggs (BC Ministry of Forests, Lands, and Natural Resources 2014). Key habitat needs for reptiles are warmth, habitat complexity, and habitat connectivity. Reptiles use rock outcrops or loose rocky slopes as dens to hibernate through the winter. Grassland, open forests and riparian areas are used for hunting. Reptiles feed on small mammals, amphibians and insects. The assessment of effects to reptiles is largely related to disturbances from Project activities (as described further in Section 6.13.4). The information developed to support the analysis of this VC may also contribute to Outdoor Recreation (Figure 6.13-1).

Figure 6.13-1

VC Interactions for Wildlife (Reptiles)



6.13.1.1 Selection of Reptiles as a VC

Reptiles in British Columbia include lizards, snakes, and turtles. The VC "Reptiles" was selected as there is an expected interaction between reptiles and the Project. Specific justification for the selection of reptiles as a VC includes:

1. Federal or Provincial listing or regulation guidelines;
    a) three Blue-listed species (Great Basin gopher snake, Western Yellow-bellied racer, and Northern Pacific rattlesnake) may be present in the Project area;
    b) four SARA schedule 1 species may be present in the Project area (Great Basin gopher snake, Western Yellow-bellied racer, Northern Pacific rattlesnake and rubber boa);
2. Applicable government agencies (e.g. MoE, CWS) - identified snakes as a concern;
3. Stakeholder input (Public, Kamloops Naturalist Club) - identified snakes as a concern;
4. Spatial scope (species range) – species range overlaps Project area;
5. Temporal scope (e.g., resident, rare visitant, uncommon) – resident species potentially occur in the Project area; and
6. Interaction with Project/potential effects (professional knowledge) – a potential interaction is anticipated.

Loss of a den feature can be catastrophic for the local snake population, especially if den destruction occurs in the winter when the den is occupied (Hobbs 2001). Snakes return annually to particular subterranean features used as dens (hibernacula) in order to survive winter weather. Deep rock crevices or talus on warm aspects are favoured sites and may be used for many years. Dens are usually communal and may be used by more than one species. Snakes are also particularly vulnerable to road mortality due to their need to cross roads that lie between their thermoregulation sites or hibernaculum and their summer foraging habitat (COSEWIC 2013; Bonnet et al. 1999). Their requirement for specific terrestrial and sub-terrestrial habitat means that reptiles are vulnerable to loss or degradation of important habitat types.

6.13.1.2 Selection of Indicators

A preliminary list of indicator species was prepared based on the presence of suitable/capable habitat, the availability of sufficient species knowledge to produce a meaningful assessment, feedback from stakeholders and likely interactions with the Project (geographically and ecologically). Reptiles known to be present in the region include six snake species, four of which are provincially or federally listed (Table 6.13-1).

Yellow-listed species are considered secure and widespread and the Project is not anticipated to have an adverse residual effect on these species. The common and terrestrial gartersnakes (*Thamnophis sirtalis* and *T. elegans*) were not selected as indicators due to their widespread distribution and secure status in the province. Both gartersnake species are ranked S5 (demonstrably widespread, abundant, and secure).

Table 6.13-1. Reptile Species Present in the Thompson Region

English Name	Scientific Name	Provincial List	COSEWIC Status	SARA Schedule/ Status1	BC Identified Wildlife	Selected as Indicator?
Common Gartersnake	Thamnophis sirtalis	Yellow	--	--	--	No
Great Basin Gopher snake	Pituophis catenifer deserticola	Blue	Threatened	Schedule 1/T	Yes	Yes
Western Yellow-bellied Racer	Coluber constrictor mormon	Blue	Special Concern	Schedule 1/SC	Yes	Yes
Northern Rubber Boa	Charina bottae	Yellow	Special Concern	Schedule 1/SC	--	Yes
Terrestrial Gartersnake	Thamnophis elegans	Yellow	--	--	--	No
Northern Pacific Rattlesnake	Crotalus oreganus	Blue	Threatened	Schedule 1/T	Yes	Yes

[1] *T = Threatened, SC = Special Concern*

Gopher snake (*Pituophis catenifer*), western yellow-bellied racer (*Coluber constrictor mormon*), northern rubber boa (*Charina bottae*), and Northern Pacific rattlesnake (*Crotalus oreganus oreganus*) were selected as indicator species for the reptile VC based on recorded observations of the species in the Project area (baseline studies, incidental observations or reported historical presence) and the presence of suitable habitat. For these four species, stakeholder consultation identified specific concerns related to habitat loss, disturbance, displacement and mortality (Table 6.13-2).

Table 6.13-2. Indicator Species Selection Rationale and Issues Raised

Indicator Species	Feedback by*				Issues Raised	Rationale
	AG	G	P/S	S/P		
Great Basin Gopher snake		✓		✓	Loss of habitat, increased disturbance, displacement and mortality of Great Basin gopher snake	Species at risk; Potentially suitable habitat present; historical anecdotal records from landowners; high potential for effects due to Project
Western Yellow-bellied Racer		✓		✓	Loss of habitat, increased disturbance, displacement and mortality of North American racer	Species at risk; Potentially suitable habitat present; high potential for effects due to Project
Northern Rubber Boa		✓		✓	Loss of habitat, increased disturbance, displacement and mortality of northern rubber boa	Species at risk; known present; high potential for effects due to Project
Northern Pacific Rattlesnake		✓		✓	Loss of habitat, increased disturbance, displacement and mortality of rattlesnake	Species at risk; Potentially suitable habitat present; high potential for effects due to Project

**AG = Aboriginal Group (Stk'emlupsemc Te Secwepemc Nation (SSN) and Nlaka'pamux Nation); G = Government; P/S = Public/Stakeholder (e.g., LRMP); S/P = Scientific/Professional Knowledge.*

Throughout this assessment the shortened names gopher snake, racer, rubber boa and rattlesnake refer to the appropriate subspecies.

6.13.2 Assessment Boundaries

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

6.13.2.1 Spatial Boundaries

Infrastructure Footprints

The Project infrastructure footprints (IF) include the Open Pit, ancillary buildings and facilities, roads, truck stop, Tailings Storage Facility (TSF), Water Management Ponds, Mine Rock Storage Facilities (MRSFs), and stockpiles (Figure 6.13-2). The Project infrastructure footprints are 1,705 ha in size.

Infrastructure Disturbance Area

The Project infrastructure footprints and linear features (transmission line and water line) were buffered by at least 50 m (Henderson, 2011) to determine the Project Infrastructure Disturbance Area (IDA). The 3,185 ha IDA will be used to assess maximum direct Project effects (e.g., mortality, habitat loss, habitat alteration, etc.). The IDA includes the Project IF (1,705 ha) used to calculate direct loss of habitat, plus a 1, 480 ha buffer around the Project IF that represents a zone of influence for potential disturbance associated with habitat alteration resulting from effects pathways such as contaminants, silt or dust, noxious weeds, and changes in drainage pattern (Figure 6.13-2).

The use of a buffered polygon area rather than individual infrastructure footprints will provide an overestimate of the direct effects of the Project for the assessment. The advantage of this approach is that it enables individual footprints to be moved and/or resized without changing the results of the effects assessment.

The IDA was modified from the General Arrangement Polygon to follow a section of the Kamloops city boundary to more accurately represent the current Project IF.

Habitat alteration by dust and water quantity is accounted for under potential habitat loss within the IDA. Areas outside of the IF that are not lost will be subject to potential alteration effects. However as wildlife species present in the area are adapted to the dry, dusty environmental conditions, these effects were considered mitigable.

Local Study Area

In accordance with the AIR the General Arrangement Polygon was buffered by 500 m to determine the Local Study Area (LSA). This area is the maximum expected area of potential disturbance associated with all Project facilities (BC Environmental Assessment Office 2015). The LSA is 7,167 ha and will be used to assess indirect Project effects (e.g., disturbance) and provide context on the amount of habitat available adjacent to the Project (Figure 6.13-2).

Regional Study Area

The Regional Study Area (RSA) is the area for which cumulative effects will be assessed. The RSA includes portions of the South Kamloops Landscape Unit and Campbell Landscape Unit, including areas south of the Thompson River and west of Highway 97 (Figure 6.13-3**)**. Landscape units were selected for the RSA as they are the geographical framework within which sustainable forest management regimes to maintain biodiversity are implemented. The RSA also includes local watershed basins and is 158,415 ha in size.

6.13.2.2 Temporal Boundaries

The temporal boundaries of the assessment will include the construction phase (short-term), operations (life of the mine), decommissioning and closure (short-term) and post-closure (short-term). The temporal phases of the Project are:

- **Construction**: 2 years (Year -2 to 1);
- **Operation**: 23 years (Year 1 to 23);
- **Decommissioning and Closure**: 5 years (Year 24 to 29, includes Project decommissioning, abandonment and reclamation activities, as well as temporary closure, and care and maintenance); and
- **Post Closure**: 5+ years (includes ongoing reclamation activities and post-closure monitoring).

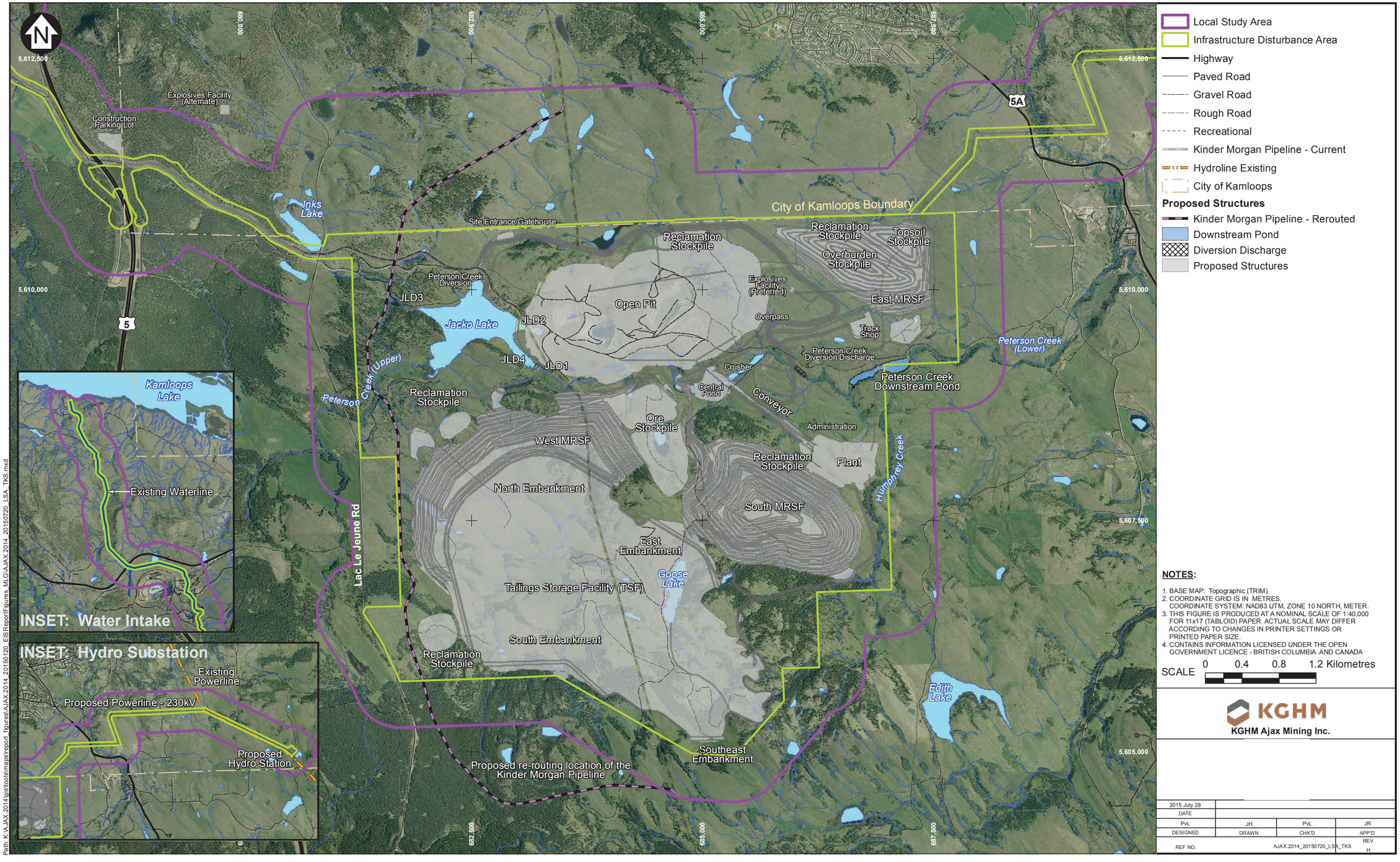
6.13.2.3 Administrative Boundaries

No administrative boundaries have impacted, constrained or expanded the assessment of reptiles.

6.13.2.4 Technical Boundaries

Locating specific dens or hibernacula is difficult and time consuming, as all four snake species are rare, small, and cryptic. Even experienced professionals, provided with sufficient resources, are often unable to locate snake dens. Snake hibernacula are considered sensitive sites and actual locations cannot be presented in a public document.

Figure 6.13-2
Local Study Area, Infrastructure Disturbance Area and Project Infrastructure



NOTES:

1. BASE MAP: Topographic (TRIM)
2. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD83 UTM, ZONE 10 NORTH, METER.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:40,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
4. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENCE - BRITISH COLUMBIA AND CANADA

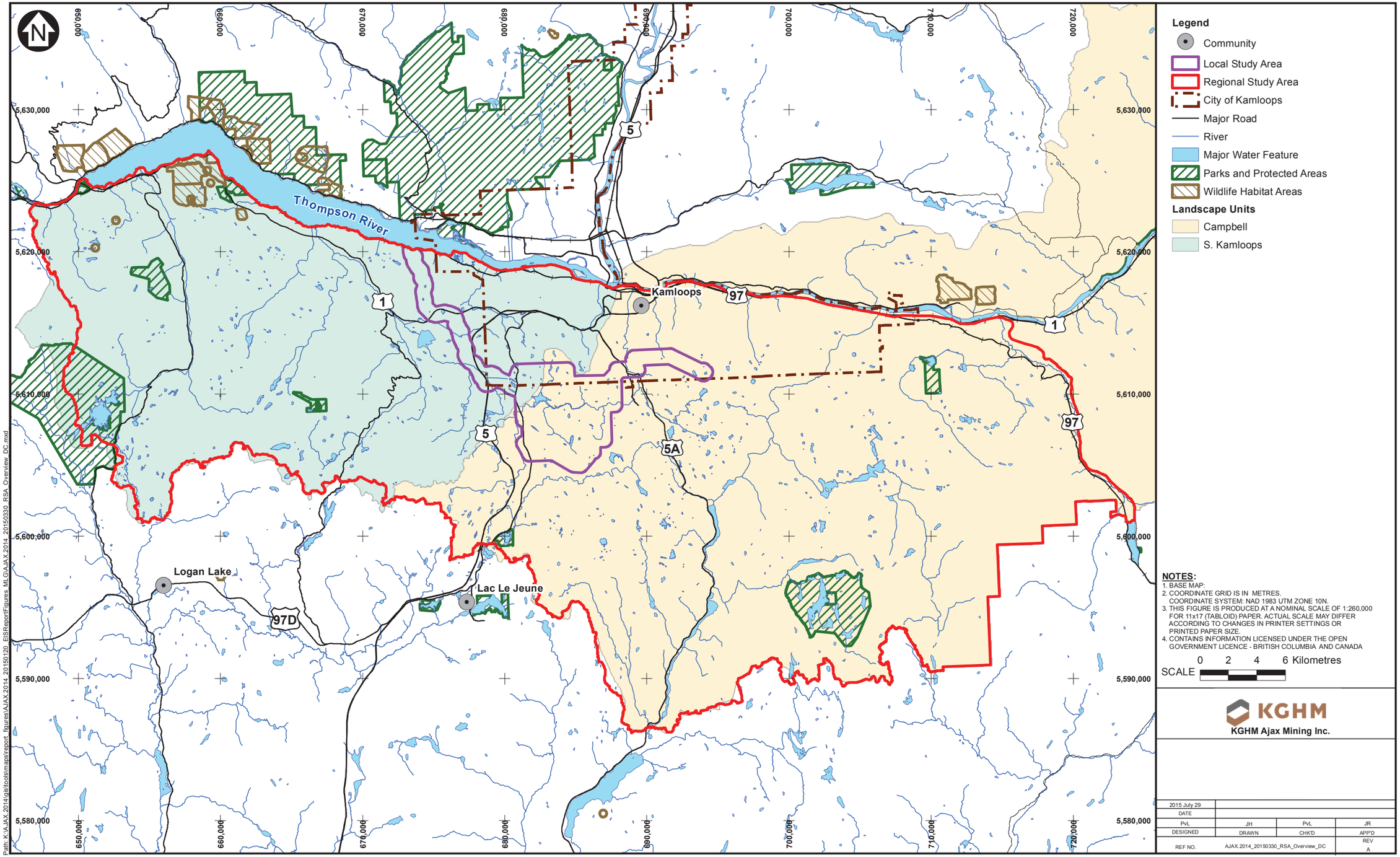
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KGHM Ajax Mining Inc.

2015 July 28			
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Figure 6.13-3
Regional Study Area and Wildlife Habitat Areas



6.13.3 Background

6.13.3.1 Regulatory and Policy Framework

The Kamloops Land and Resources Management Plan (LRMP) (1995) outlines that: special attention to Red- and Blue-listed species should be considered; forests are to be managed to ensure diversity, as well as to ensure critical habitat is identified and managed appropriately through local level planning; and habitat improvement projects should be conducted where appropriate. Rattlesnake habitat is identified as a resource value in the Arrowstone Protection Resource Management Zone (P1a,b), Battle Bluffs Wildlife Habitat Area (H10), and the Skull Wildlife Habitat Area (H11).

The Nicola Thompson Fraser Sustainable Forest Management Plan (SFMP) (2015) aims to conserve species diversity by ensuring that habitats for a particular species are maintained, including habitats for known occurrences of species at risk. The SFMP (2015) identifies the need to maintain structural features of forest ecosystems including the provision of large coarse woody debris (CWD) for snake habitat. The CWD management strategy specifies levels of CWD that should be maintained, creation of stubs, and guidelines for enhancing CWD levels.

The gopher snake, rattlesnake and racer are Identified Wildlife under the Forest and Range Practices Act (FRPA). General wildlife goals for all snakes include:

- minimize disturbance and mortality, particularly road mortality;
- maintain critical structural elements such as rock outcrops, talus slopes, friable soils, coarse woody debris, rodent burrows, concentrations of boulders, or other unconsolidated materials and vegetative cover;
- maintain microclimatic conditions of hibernacula;
- maintain moderate to dense cover to conceal snakes and maintain foraging opportunities;
- maintain WHA in a properly functioning condition (BC Ministry of Water, Land and Air Protection 2004).

Specific measures to meet these goals include access management and range management. Critical periods for snakes are identified as spring dispersal (March/April) and fall aggregations (September/October).

All snake species are protected from being killed, collected, or held in captivity without a permit under the BC *Wildlife Act* (Government of British Columbia 1996). The *Species at Risk Act* (Government of Canada 2002) requires a recovery strategy or management plan for species within a specific timeframe depending on the species status and schedule. Provincial recovery plans are available for the Rattlesnake (Southern Interior Reptile and Amphibian Recovery Team 2008a) and the Gopher snake (Southern Interior Reptile and Amphibian Recovery Team 2008b), and a management plan has been prepared for the Racer (Racer Management Team Working Group 2013) (Table 6.13-3). Only the racer has a Federal recovery document completed to date which adopted the Provincial Management Plan.

Table 6.13-3. Reptile Recovery Planning Documents

English Name	SARA Schedule/ Status[1]	BC	SARA Timeline
Gopher snake	1-T	RS - 2008	2016-2017
Racer	1-SC	MP - 2013	MP - 2014
Rubber boa	1-SC	-	2015-2016
Rattlesnake	1-T	RS - 2008	2016-2017

[1] *T = Threatened, SC = Special Concern*

Best management practices for amphibians and reptiles (BC Ministry of Forests, Lands, and Natural Resources 2014) provide practices to help maintain a viable native reptile population in areas subject to rural and urban developments. Key recommendations in this plan for snakes in the Thompson-Okanagan include avoiding development adjacent to potential denning sites (e.g., south-facing talus slopes) and provision of crossing structures at known movement corridors.

The BC conservation framework ranks the gopher snake, racer, and rattlesnake as priority 2 under goal 2 (prevent species and ecosystem from becoming at risk). The rubber boa is priority 1 under goal 2.

6.13.3.2 Regional Overview

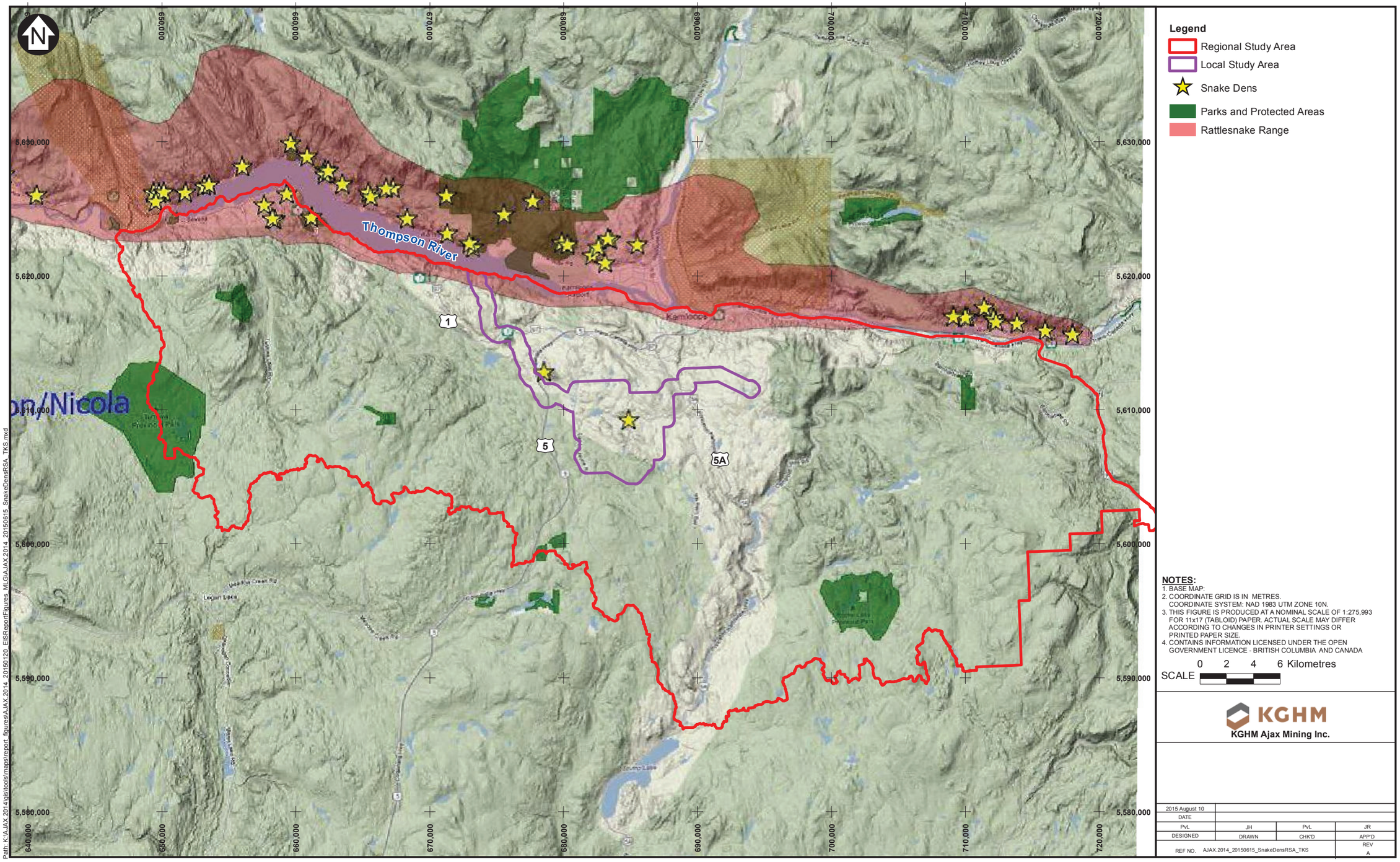
Rocky slopes and crevices provide important hibernacula habitat for reptiles in the region. All reptile species may be found on rock outcrops, along talus slopes, in small mammal burrows, or in coarse woody debris. In most cases critical habitats such as hibernacula have not been identified, making population monitoring difficult for snake species. Significant development has occurred in areas known to support snake species (low elevation grasslands/shrub-steppe habitats) where agricultural development, road mortality and quarrying/mining are significant threats to snake species.

Reptiles need warm temperatures and den sites in the Thompson Region are concentrated along the Thompson River in the Bunchgrass biogeoclimatic zone (Figure 6.13-4). There are 87 confirmed and 16 probable snake dens in the Thompson-Nicola population (Hobbs 2013).

Indicator Species

Provincially, Gopher snakes are Blue-listed and ranked S2S3 (imperiled or special concern, vulnerable to extirpation or extinction), federally they are designated as threatened by SARA and COSEWIC. No comprehensive inventories of the gopher snake population have been conducted in British Columbia, though their population is thought to be declining (COSEWIC 2013). Threats to this species include habitat loss, degradation and fragmentation resulting from agricultural and urban development. Mortality through road kill and persecution are also significant threats (Southern Interior Reptile and Amphibian Recovery Team 2008b). In the summer Gopher snakes inhabit grasslands, shrub-steppe, deciduous and coniferous woodlands, and other open habitats below 1700 m elevation. Overwintering habitat consists of rock outcroppings, talus slopes and rodent burrows. Observations of Gopher snakes in the RSA have been recorded by consultants in 2009 as well as by local landowners.

Figure 6.13-4
Snake Den Sites in relation to the Regional and Local Study Areas



In BC, Racers are Blue-listed and ranked S3 (special concern, vulnerable to extirpation or extinction), federally they are designated as special concern by SARA and COSEWIC. An accurate population size of the racer within BC is unknown, though population declines of up to 45% have likely occurred (Racer Management Team Working Group 2013). Racers are threatened by habitat loss due to urbanization and agriculture, along with road mortality, human persecution and hibernacula disturbance (BC Ministry of Water, Land and Air Protection 2004). Racers are associated with low-elevation (below 900 m) bunchgrass, ponderosa pine, interior Douglas-fir, and dry interior cedar-hemlock biogeoclimatic zones during the summer months. Den sites occur on sparsely vegetated slopes and talus slopes, and hibernacula are most often associated with south-facing rocky features (Racer Management Team Working Group 2013). While limited areas of moderately suitable habitat are present within the LSA, no records of this species in the LSA could be found.

Rubber boas are Yellow-listed ranked S4 (apparently secure) in BC, though is designated as Special Concern by SARA and COSEWIC. The size of the rubber boa population in Canada or BC is currently declining (Cameron & St. Clair 2003). Threats to their population include agricultural and urban development, as well as road/rail mortality. This long-lived species is particularly susceptible to even small increases in mortality rates. Rubber boas require specific habitat for thermoregulation as they are a crepuscular species, spending the days under cover while foraging at night. The major habitat requirements include rocky outcrops and an abundance of coarse woody debris (Cameron & St. Clair 2003). Rubber boas have been observed in the RSA near Sugarloaf Hill during field surveys in 2008.

The subspecies of rattlesnake found in BC is the Northern Pacific rattlesnake (*C. o. oreganus*) (Crother 2000; Hobbs 2013). There are no other subspecies in BC (BC Conservation Data Centre 2014a). Provincially, rattlesnakes are Blue-listed and ranked S3 (special concern, vulnerable to extirpation or extinction), federally they are designated as threatened by SARA and COSEWIC. The population in BC is difficult to estimate but there are likely fewer than 5,000 adults, and the population is considered declining (COSEWIC 2004). Population declines have been greatest in the Okanagan and Kamloops areas (BC Ministry of Water, Land and Air Protection 2004). The greatest threats to rattlesnake are road/rail mortality, den destruction, and the conversion of natural lands for agriculture, urban development, and industrial development. Rattlesnakes are restricted to the very dry BC interior and appear to be locally distributed within the hot and dry subzones of the bunchgrass, ponderosa pine and interior Douglas-fir BEC zones. No records of rattlesnakes in the LSA could be located, but some moderate suitability habitat is present. The Thompson-Nicola population has 76 known rattlesnake dens (Hobbs 2013); the majority of these dens are located on the north side of Kamloops Lake/Thompson River. Within the RSA, there are seven known dens, five of which are located near Savona. Two known dens may occur within the LSA, or in close proximity to it (Hobbs 2013). The Okanagan-Similkameen has tentatively been identified as a management area by the Rattlesnake Recovery Team (Southern Interior Reptile and Amphibian Recovery Team 2008a).

6.13.3.3 Historical Activities

Several past and current projects and activities have occurred throughout the region over the past century. Mines, mills, pipelines, rail lines, agriculture/ranching, forestry, urban sprawl, water treatment, commercial recreation, tourism, hunting, and fishing are some of the activities that occur

within the vicinity of the Ajax Project. Activities that have the greatest potential to interact with reptiles include mines, agriculture/ranching and urban sprawl.

Mining activity in the Project area can be traced back over 100 years with exploration in the Project area beginning in the 1880s and continuing intermittently to present.

The conversion of grassland habitats to agricultural crop fields has affected reptiles.

Urban and rural land development creates multiple challenges for reptiles, notably habitat loss, habitat degradation, barriers to movement, road kill, predation and competition from non-native species, and harassment from humans and their pets (BC Ministry of Forests, Lands, and Natural Resources 2014).

Roads are of special concern as movement barriers because of their linear nature, prevalence in landscapes, and the vast tracts of lands that they intersect (BC Ministry of Forests, Lands, and Natural Resources 2014). Road mortality occurs when reptiles are migrating between habitats, or basking on warm roads.

Recreational access and activities can alter habitats and disturb wildlife. Rock climbers may harm reptile denning and basking sites. Trails also create new pathways for predators and invasive species (BC Ministry of Forests, Lands, and Natural Resources 2014).

6.13.3.4 Baseline Studies

Baseline studies were conducted for reptiles in 2008, 2010 and 2014. Hibernaculum surveys were completed in an effort to determine species presence and abundance. Any reptile observed incidentally at any time during the course of field work was also recorded.

Hibernaculum surveys were undertaken throughout the LSA to: a) establish presence of target species within the LSA, b) identify and characterize reptile hibernacula sites that may be affected by the Project, c) collect data on the location and timing of use of the LSA by target species, and d) provide information to KAM to use during the Project design phase to avoid or minimize impacts to target species.

Terrestrial ecosystem mapping was used to develop wildlife habitat suitability mapping for gopher snake, racer, and rattlesnake. Habitat requirements and resultant maps were similar for all species. Additional mapping was not considered necessary or informative for rubber boa.

<u>Data Sources</u>

General information on species status and distribution was drawn from on-line sources such as the BC Ministry of Environment's Species Explorer and NatureServe (BC Conservation Data Centre 2014a; NatureServe 2014). Occurrence records of reptiles in the region were obtained from the BC Conservation Data Centre (BC Conservation Data Centre 2014b) and from the provincial Species Inventory Database (BC Ministry of Environment 2014).

Other reports providing local reptile data include those by Bertram (2004), Bertram et al. (2001), and Rescan Environmental Services Ltd (2006).

Hobbs (2013) provides a summary of rattlesnake research completed in BC over the last decade.

Hobbs, J. 2001. *Gopher Snakes (and Cohorts): An assessment of selected den sites in the Thompson / Fraser and Okanagan snake populations*. Prepared for John Surgenor, Kamloops Regional Office and Orville Dyer, Okanagan Office, Ministry of Water, Land and Air protection.

Hobbs, J. and M. Sarell. 2000. *Gopher Snakes (and Cohorts): An assessment of selected den sites in the south Okanagan*. Prepared for John Surgenor, Kamloops Regional Office, Ministry of Environment, Lands and Parks, British Columbia 25.

Hobbs, J. and M. Sarell. 2001. *Gopher Snakes (and Cohorts): An assessment of selected den sites in the Penticton, Vernon, Merritt and Boundary Forest Districts*. Prepared for John Surgenor, Kamloops Regional Office, Ministry of Environment, Lands and Parks, British Columbia.

Sarell, M.J. 1993. *Snake hibernacula in the South Okanagan*. Prepared for BC Environment, Penticton, BC and B.C. Habitat Conservation Fund, Victoria, B.C

No Traditional Ecosystem Knowledge and community data was available for reptiles.

Methods

Field Surveys

Surveys for reptiles followed methods described in *Inventory Methods for Snakes* (Resources Inventory Committee (RIC) 1998) and included den (hibernaculum) surveys. Time-constrained searches of suitable habitat were conducted for snakes by a crew composed of two biologists, one of which was a snake biologist experienced in field surveys for hibernacula. Surveyors followed the "chance encounter" method, which involved searching areas that have general characteristics of den sites. South facing rock outcrops, talus slopes, and deep fissured solid rock faces are areas where dens are likely to exist. Polygons rated as moderate suitability for snakes, within the IDA were prioritized for field visits, although small unmapped areas were also searched when encountered if they appeared to be suitable. One area of high suitability denning habitat was identified in the LSA during field surveys.

Detections of reptiles that occurred during other fieldwork were recorded as incidental observations. All reptiles detected were recorded. For a more detailed account of survey methods, see Appendix 6.8-A.

Reptile surveys were conducted in 2008, 2010 and 2014 (Figure 6.13-5). Initial surveys were intended to characterize any potential snake dens occurring in the LSA. Snake dens were characterized as (M. Sarell, pers. comm. 2008):

- Candidate (good structure but no evidence)

- Confirmed III (good structure but no hard evidence at feature but some snakes in general vicinity)
- Confirmed II (good structure with snakes observed in vicinity)
- Confirmed I (snakes observed in feature at appropriate time of year).

Wildlife Habitat Mapping

Habitat suitability mapping based on the TEM was completed for the three listed species, gopher snake, racer, and rattlesnake. Habitat requirements for rubber boa are similar and are captured within the 3 modelled species (Table 6.13-4; Appendix 6.8-A).

Table 6.13-4. Reptile Habitat Suitability Modeling

Species	Season	Life Requisite	Comments
Gopher snake	All Seasons	Living	Foraging, cover and thermoregulation for all ages, Breeding, gestation, egg laying sites, incubation to hatching, Denning for all ages
Racer	Growing season	Living	Includes foraging, cover and thermoregulation and reproduction
	Winter	Hibernation	In crevices in rock outcrops and talus on warm aspect slopes
Rattlesnake	Summer	Living	Including habitats used for foraging (open grasslands, parkland forest, wetlands, and riparian areas), cover, and thermoregulation in summer
	Winter	Hibernation	Includes habitats used for hibernation and birthing; typically rock outcrops, talus slopes

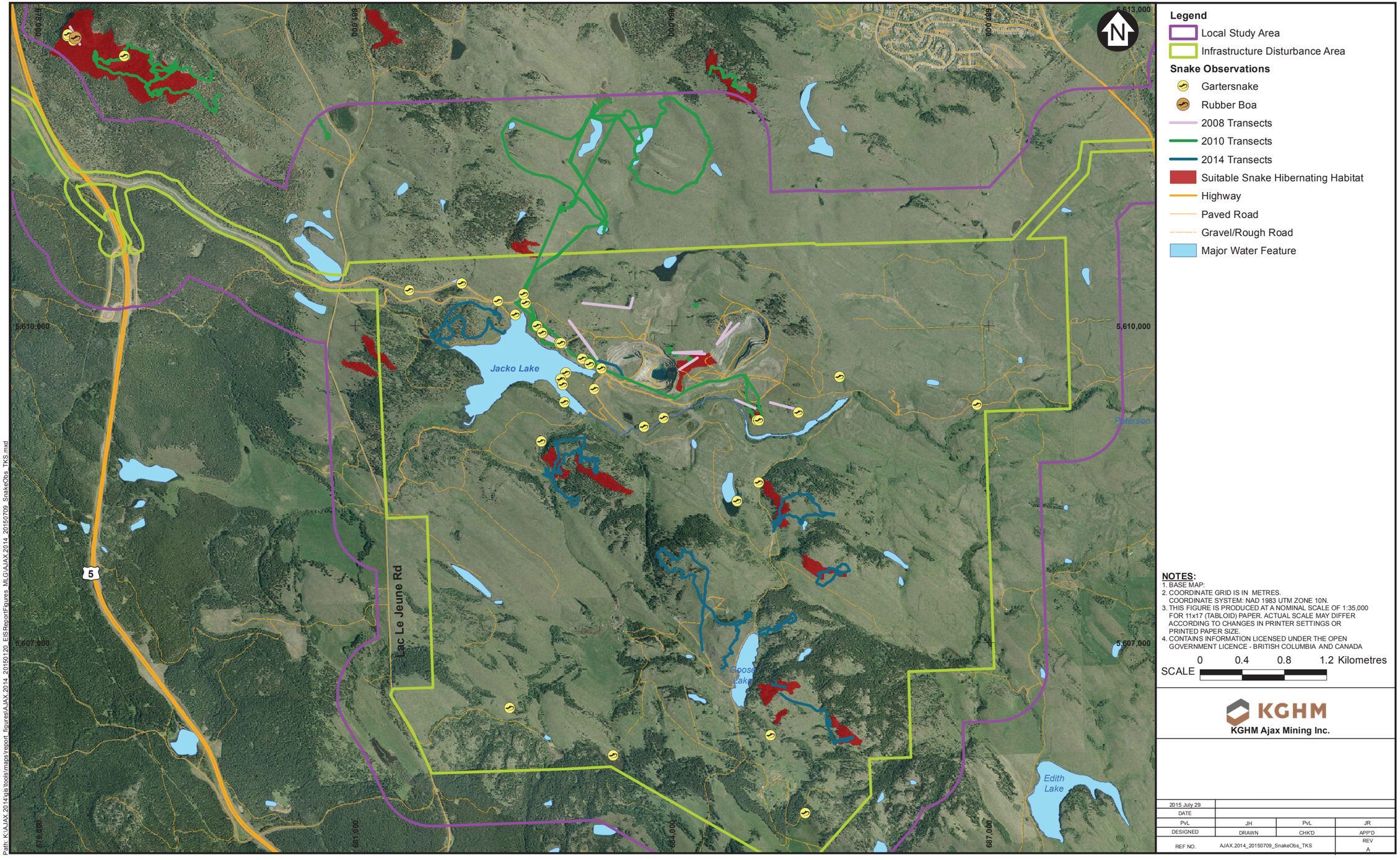
Characterization of Reptile Baseline Condition

Thirty-three separate transects were surveyed during baseline studies for a total survey time of 40 hours and 29 minutes (Table 6.13-5). These surveys resulted in three "Confirmed II" dens and four "Candidate" dens being located based on 2008 field observations (Figure 6.13-5). One additional den (Confirmed II) site was discovered incidentally in 2008. One female rubber boa was observed on Sugarloaf Hill (Table 6.13-5). No rattlesnakes, racers or gopher snakes were observed. Garter snakes were detected during surveys and provided evidence of use at den sites.

Table 6.13-5. Summary of Reptile Den Survey Effort and Results

Year	Month Surveyed	Number of Surveys	Total Crew Survey Time (hhmm)	Target Species Detected	# of Candidate Dens	# of Confirmed Dens
2008	April, May	15	13h37	1 rubber boa	4	3
2010	September	11	15h01	-	-	-
2014	April, May	10	11h51	-	-	1
Incidentals	-	N/A	N/A	-	-	1
Total		**36**	**40h29**	**1**	**4**	**5**

Figure 6.13-5
Snake Hibernacula Surveys and Observations



In 2008, two living adult female and one living juvenile common gartersnakes were observed, while five shed gartersnake skins and one dead gartersnake were also recorded. In 2010, two sub-adult western terrestrial gartersnakes, and one unidentified gartersnake shed were observed. In the spring of 2014, a potential gartersnake den was observed by an exploration drilling crew. Approximately 20 individuals were observed at this time. The follow-up surveys confirmed an active gartersnake den, with five western terrestrial gartersnakes observed by field biologists.

Incidental reptile observations were made in 2008, 2010, and 2014. All incidental observations were of gartersnakes, including 20 records of live snakes, 5 road-killed snakes, and one snake shed. No other species of snake were confirmed during any field surveys.

Only one of the four indicator species (rubber boa) was observed during field surveys. This observation occurred outside of the current LSA boundary, on Sugarloaf Hill. The revised General Arrangement was beneficial to this VC as Sugarloaf Hill provides potential suitable habitat and is outside the LSA.

Anecdotal observations of "bull snakes" (also known as gopher snake) by local landowners and the observation of a gopher snake by Abacus staff in 2009 indicate that this species is likely present in the study area, but probably at low densities. Similarly, Racers and rattlesnakes also may occur in the LSA, but due to no observations, population numbers of both of these species are assumed to be low.

The LSA is dominated by grasslands and no high value suitable habitat was mapped for snakes in any season (Figure 6.13-6, Figure 6.13-7, and Figure 6.13-8). Moderate value Living habitat was mapped for at least 65% of the LSA, while only about 1% or 63 ha of moderate rated Hibernating habitat was mapped in the LSA (Table 6.13-6). Moderate suitability snake hibernating habitat was confirmed present adjacent to, north of, and between the Ajax West and East pits (Figure 6.13-7, Figure 6.13-8).

Table 6.13-6. Habitat Suitability for Gopher Snake, Racer, and Rattlesnake

Species	Mapped Suitable Habitat (ha)	LSA Suitable Habitat (ha)	% of LSA
Gopher snake – Living	11,337.9	5,279.3	89%
Racer – Living	7785.4	3,855.7	65%
Racer - Hibernating	222.7	63.6	1%
Rattlesnake – Living	9012.6	4,352.9	73%
Rattlesnake - Hibernating	204.5	62.6	1%

Field surveys were able to: i) confirm the presence of one of the four indicator species within 200 metres of the LSA, and ii) confirm the presence of potential moderate suitability hibernating habitat for the indicator snake species within the LSA.

6.13.4 Potential Effects of the Project and Proposed Mitigation for Reptiles

6.13.4.1 Identifying Potential Effects on Reptiles

Consistent with the requirements of the AIR/EIS Guidelines, potential effects are considered in relation to: habitat loss; habitat alteration; sensory disturbance; disruption of movement; direct mortality; indirect mortality; wildlife attractants; and chemical attractants. An interaction matrix (Table 6.13-7) is used to help scope potential effects by considering potential interactions with Project activities/components, consistent with approach outlined in the assessment methodology (Section 5.2.4.1). Further rationale for the scoping of potential effects is provided below.

Two primary assumptions were made for the assessment of effects: i) clearing/grubbing and earthworks will be the first activities to take place and will result in complete loss of all suitable habitat within the IF and, ii) once habitat has been removed, individuals will no longer reside in the area where the habitat was removed. These assumptions resulted in a conservative approach as habitat removal will only occur in the IF. This approach ensures that the maximum effect is considered (all habitat in the IDA removed) and allows flexibility in Project design where the relocation of a footprint will not change the assessment. The IDA also includes a 50 metre buffer around Project footprints to account for potential edge effects. To identify the actual predicted impact, the same assumptions were made, but with clearing and grubbing activities occurring only within specific Project footprints. The combination of these two assessments will provide a range of possible impacts from the Project.

Habitat alteration will be assumed to occur in all habitats remaining but adjacent to the Project footprints. This approach will have some overlap between habitat lost and habitat altered, but it will ensure that all effects are considered.

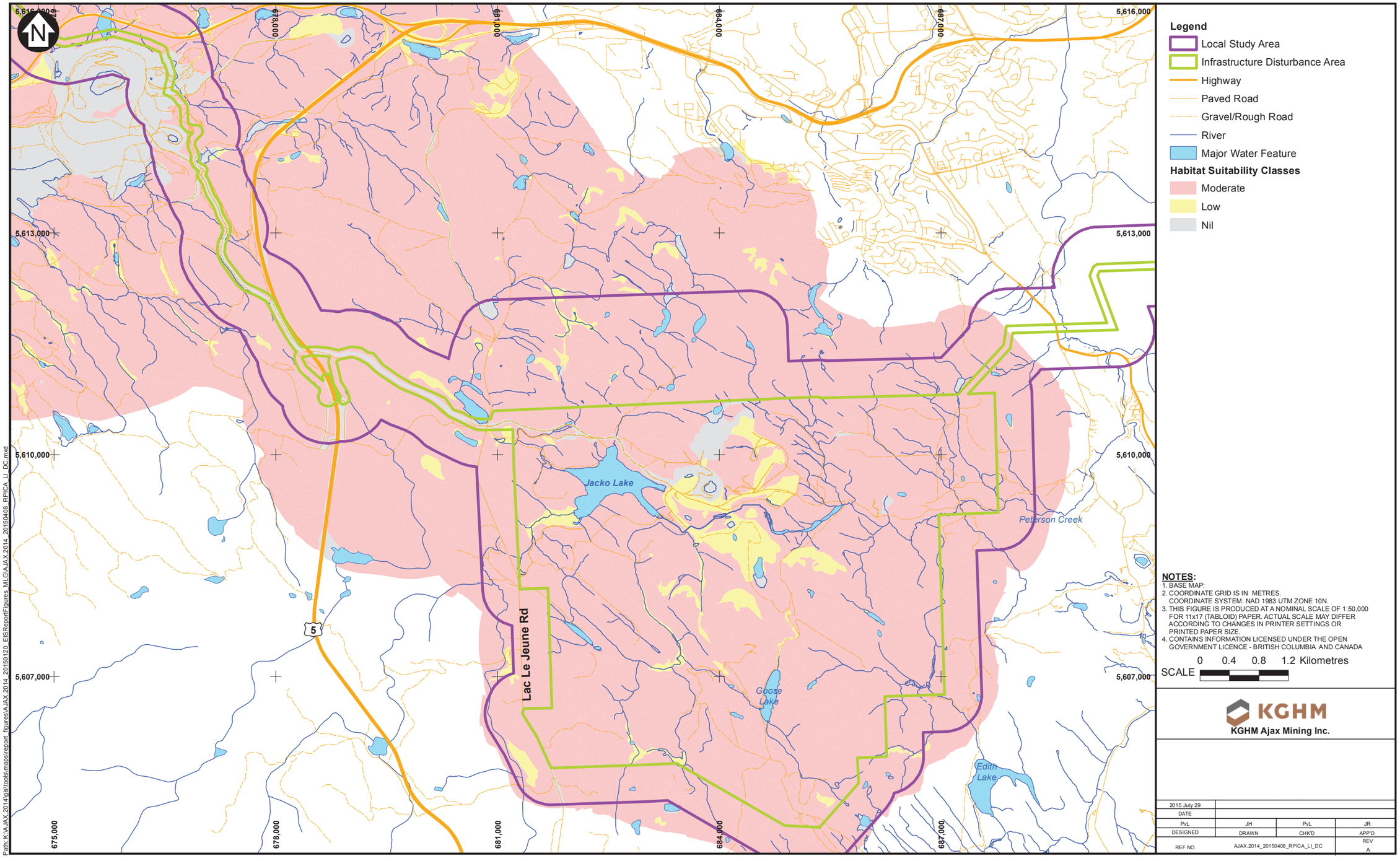
A complete list of Project activities and what effect each activity may have on reptiles is provided below (Table 6.13-7).

<u>Habitat Loss</u>

Habitat loss is defined, for the purposes of this assessment, as the replacement of habitat by Project infrastructure, or, when suitable habitat becomes rendered functionally unable to support the species. Habitat loss will occur during the construction phase of the Project, specifically during vegetation clearing, land excavation, water diversion, and any other changes to the physical landscape. For this assessment all habitat loss will be considered under the initial clearing and grubbing during the construction phase

An interaction between reptiles and the Project is anticipated to lead to the loss moderate rated habitat. Project components and related activities expected to cause habitat loss to snakes are the clearing and grubbing of the land during construction and earthworks. Clearing and grubbing will remove all suitable snake habitat located within the IDA. Earthworks will remove any non-vegetative habitat features (e.g., rock outcrops, talus) that snakes may reside in. A ranking of "moderate" was assigned for these activities, and warrants further analysis as described in Section 6.13.4.2.

Figure 6.13-6
Great Basin Gopher Snake Living Habitat Suitability



NOTES:
1. BASE MAP:
2. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD 1983 UTM ZONE 10N.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:50,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
4. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENCE - BRITISH COLUMBIA AND CANADA

SCALE 0 0.4 0.8 1.2 Kilometres

KGHM Ajax Mining Inc.

2015 July 29			
DATE			
PvL	JH	PvL	JR
DESIGNED	DRAWN	CHK'D	APP'D
REF NO.	AJAX.2014_20150408_RPICA_LI_DC		REV A

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Figure 6.13-7
North American Racer Hibernating Habitat Suitability

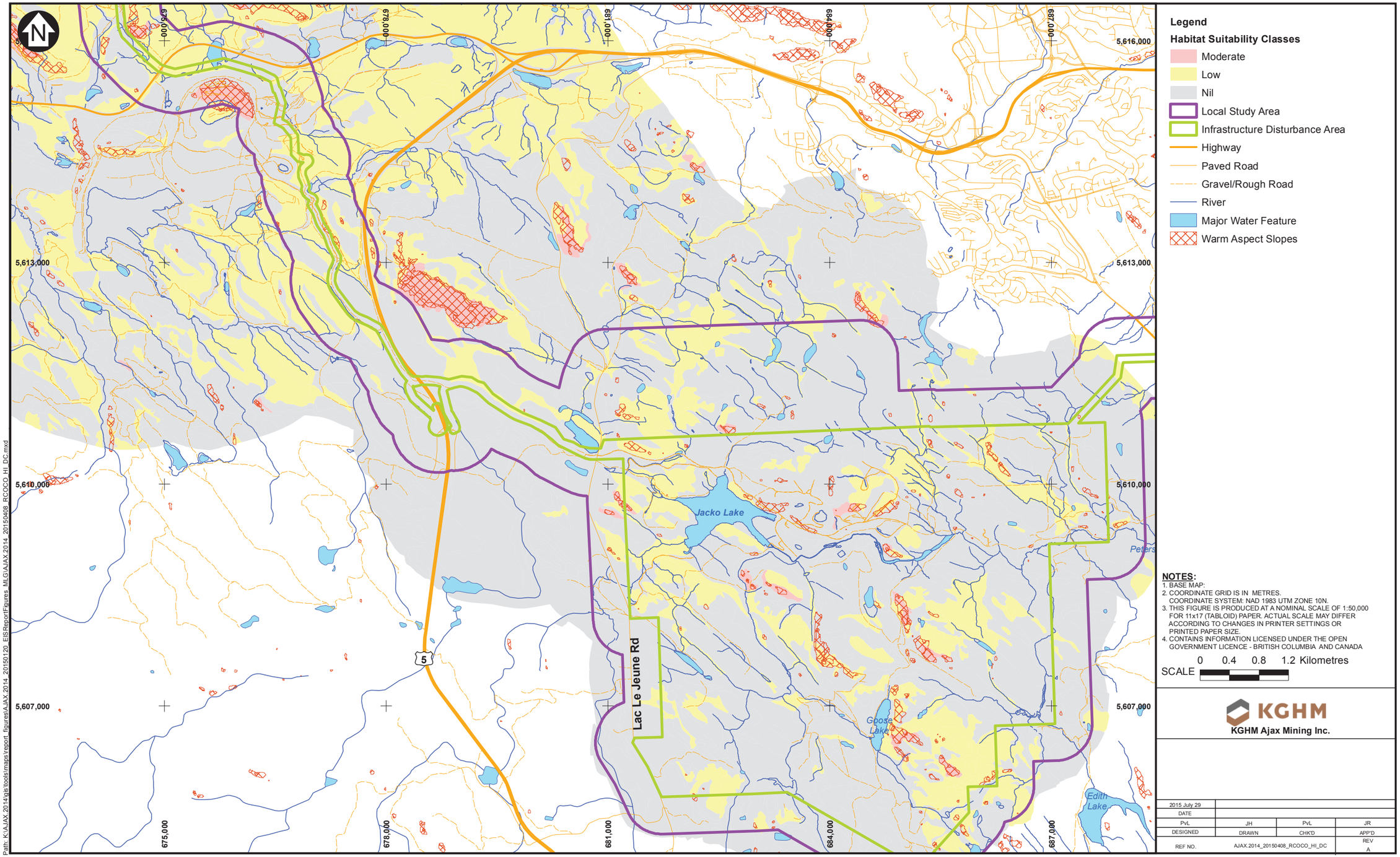


Figure 6.13-8
Western Rattlesnake Hibernating Habitat Suitability

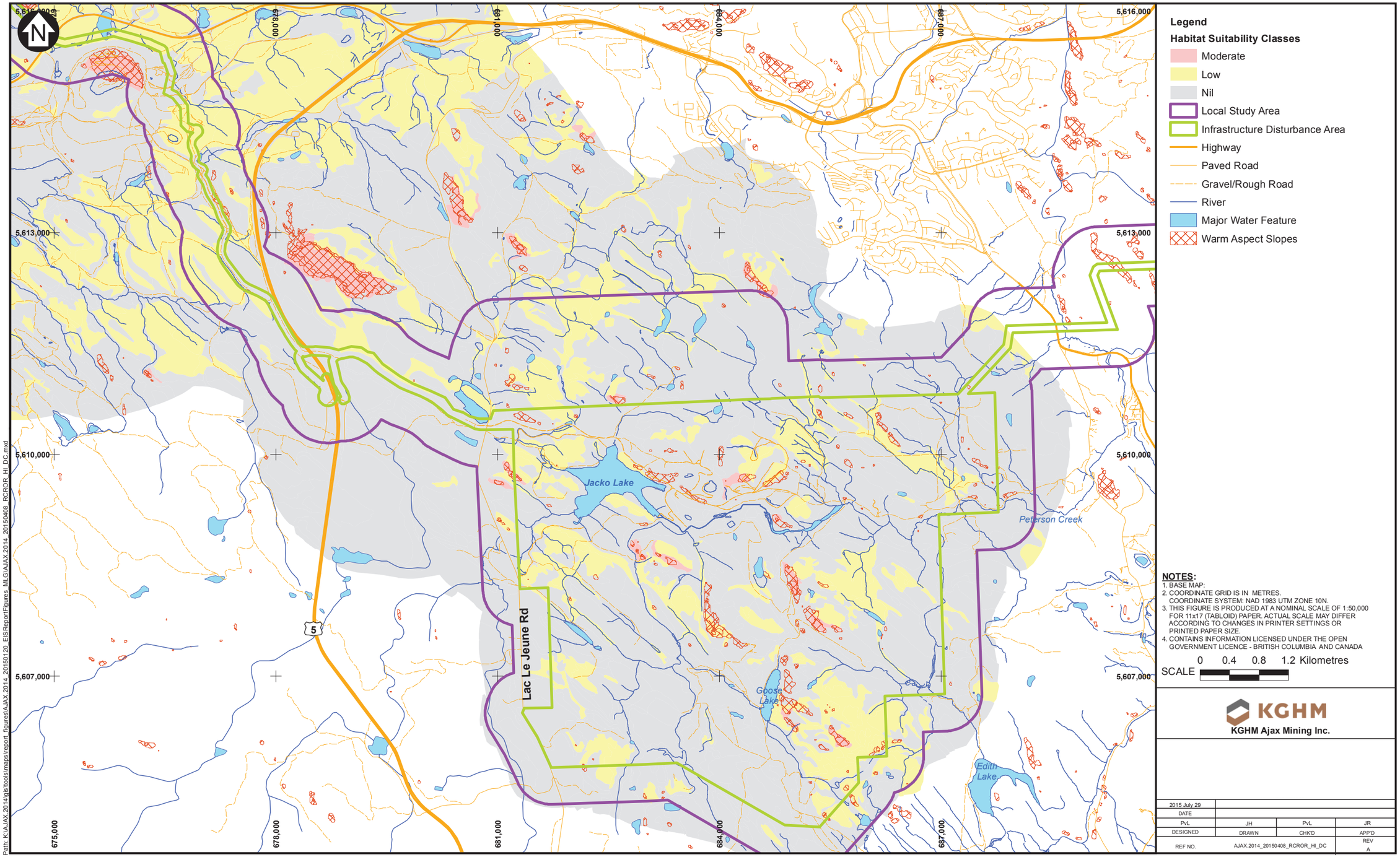


Table 6.13-7. Identifying Potential Project Interactions and Effects on Reptiles

	Project Activities	Potential Effects on Reptiles						
		Habitat Loss	Habitat Alteration	Sensory Disturbance	Disruption of Movement	Direct Mortality	Wildlife Attractants	Chemical Hazards
Construction	Clearing and Grubbing	M	O	O	O	M	O	O
	Earthworks	M	O	O	O	M	O	O
	Overburden/Topsoil Stockpile	O	O	O	O	O	M	O
	Laydown Areas and Storage Yards	O	O	O	O	O	O	O
	Project Lighting	O	O	L	O	O	O	O
	Site Security and Fencing	O	O	O	O	O	O	O
	Fuel Storage and Filling Area	O	O	O	O	O	O	L
	Hazardous Wastes Transport, Storage, and Disposal	O	O	O	O	O	O	L
	Construction Wastes Transport, Storage, and Disposal	O	O	O	O	O	O	O
	Sewage Infrastructure and Disposal	O	O	O	O	O	O	L
	Public Road Realignment, Use, and Maintenance	O	L	L	L	M	O	L
	Site Road Construction, Use and Maintenance	O	L	O	O	M	O	L
	Haul Road Overpass Construction, Use, and Maintenance	O	O	O	O	O	O	O
	Site Buildings and Process Plant	O	O	O	O	O	O	O
	Explosives Magazine and Storage Facilities	O	O	O	O	O	O	O
	Open Pit Development	O	O	O	O	O	O	O
	Drilling and Blasting	O	O	M	O	M	O	O
	Crushing Mine Rock	O	O	L	O	O	O	L
	Loading, Hauling, and Deposition of Mine Rock	O	O	L	O	O	O	L
	Temporary Ore Stockpile	O	O	O	O	O	M	O
	Tailing Storage Facility Development	O	O	O	O	O	O	O

(continued)

Table 6.13-7. Identifying Potential Project Interactions and Effects on Reptiles (continued)

Project Activities		Potential Effects on Reptiles						
		Habitat Loss	Habitat Alteration	Sensory Disturbance	Disruption of Movement	Direct Mortality	Wildlife Attractants	Chemical Hazards
Construction (*cont'd*)	Power Transmission, Distribution	O	O	O	O	O	O	O
	Natural Gas Line	O	O	O	O	L	O	O
	Pipeline Utility Corridor (Potable Water, Sewage, and Site Water)	O	O	O	O	L	O	L
	Water Intake from Kamloops Lake	O	O	O	O	O	O	O
	Fire Suppression Infrastructure	O	O	O	O	O	O	L
	Contact Water	O	O	O	O	O	L	L
	Non-contact Water	O	O	O	O	O	L	O
	Haul Road Overpass	O	O	O	O	O	O	O
	Water Management Dams	O	O	O	O	O	O	O
	Mine Staffing (Direct Employment)	O	O	O	O	O	O	O
	Contracted Employment	O	O	O	O	O	O	O
	Taxation	O	O	O	O	O	O	O
Operations	Open Pit Development	O	O	O	O	O	O	O
	Drilling and Blasting	O	O	M	O	M	O	O
	Hauling Mine Rock and Ore from Pit	O	O	O	O	O	O	L
	Crushing and Conveying Ore	O	O	L	O	O	O	O
	Temporary Ore Stockpile	O	O	O	O	O	M	O
	Development of Mine Rock Management Facilities	O	O	O	O	O	O	O
	Stripping, Loading, Hauling, Deposition, and Contouring of Topsoil and Overburden	O	O	L	O	O	O	O
	Revegetation through Progressive Reclamation	O	O	O	O	O	L	O
	Process Plant Operation	O	O	O	O	O	O	O

(continued)

Table 6.13-7. Identifying Potential Project Interactions and Effects on Reptiles (continued)

Project Activities		Potential Effects on Reptiles						
		Habitat Loss	Habitat Alteration	Sensory Disturbance	Disruption of Movement	Direct Mortality	Wildlife Attractants	Chemical Hazards
Operations (*cont'd*)	Deposition to Tailing Storage Facility	O	O	O	O	O	O	L
	Site Road Use and Maintenance (Materials, Personnel, Supplies)	O	L	L	O	L	O	L
	Concentrate Transport and Storage	O	O	O	O	O	O	L
	Explosives Magazine and Storage Facilities	O	O	O	O	O	O	O
	Fire Suppression Infrastructure	O	O	O	O	O	O	L
	Fuel Storage and Filling Area	O	O	O	O	O	O	L
	Hazardous Wastes Transport, Storage, and Disposal	O	O	O	O	O	O	L
	General Wastes Transport, Storage, and Disposal	O	O	O	O	O	O	O
	Sewage Infrastructure and Disposal	O	O	O	O	O	O	L
	Laydown Areas and Storage Yards	O	O	O	O	O	O	O
	Power Transmission, Distribution	O	O	O	O	O	O	O
	Project Lighting	O	O	M	O	O	O	O
	Site Access, Security and Fencing	O	O	O	O	O	O	O
	Water Intake from Kamloops Lake	O	O	O	O	O	O	O
	Contact Water	O	O	O	O	O	L	L
	Non-contact Water	O	O	O	O	O	L	O
	Potable Water Treatment and Use	O	O	O	O	O	L	O
	Haul Road Overpass	O	O	O	O	O	O	O
	Mine Staffing (Direct Employment)	O	O	O	O	O	O	O
	Contracted Employment	O	O	O	O	O	O	O
	Taxation	O	O	O	O	O	O	O

(continued)

Table 6.13-7. Identifying Potential Project Interactions and Effects on Reptiles (continued)

	Project Activities	Potential Effects on Reptiles						
		Habitat Loss	Habitat Alteration	Sensory Disturbance	Disruption of Movement	Direct Mortality	Wildlife Attractants	Chemical Hazards
Decommissioning and Closure	Dismantling of Ancillary Buildings	O	O	O	O	O	O	O
	Pit Lake Planning	O	O	O	O	O	O	O
	Site Road/Bridge Decommissioning	O	O	O	O	O	O	O
	Tailing Storage Facility Decommissioning and Reclamation	O	O	O	O	O	O	L
	Mine Rock Management Facilities Reclamation	O	O	O	O	O	O	O
	Fuel Storage and Filling Area	O	O	O	O	O	O	L
	Hazardous Wastes Transport, Storage, and Disposal	O	O	O	O	O	O	L
	General Wastes Transport, Storage, and Disposal	O	O	O	O	O	O	O
	Sewage Infrastructure and Disposal	O	O	O	O	O	O	L
	Laydown Areas and Storage Yards	O	O	O	O	O	O	O
	Power Transmission, Distribution	O	O	O	O	O	O	O
	Project Lighting	O	O	L	O	O	O	O
	Site Access, Security and Fencing	O	O	O	O	O	O	O
	Contact Water	O	O	O	O	O	L	L
	Non-contact Water	O	O	O	O	O	L	O
	Potable Water Treatment and Use	O	O	O	O	O	L	O
	Haul Road Overpass	O	O	O	O	O	O	O
	Road use to the Project (Materials, Personnel, Supplies)	O	L	L	O	L	O	L
	Mine Staffing (Direct Employment)	O	O	O	O	O	O	O
	Contracted Employment	O	O	O	O	O	O	O
	Taxation	O	O	O	O	O	O	O

(continued)

Table 6.13-7. Identifying Potential Project Interactions and Effects on Reptiles (completed)

Project Activities		Potential Effects on Reptiles						
		Habitat Loss	Habitat Alteration	Sensory Disturbance	Disruption of Movement	Direct Mortality	Wildlife Attractants	Chemical Hazards
Post Closure	General Site Inspections and Maintenance	O	O	O	O	O	O	O
	Contact Water	O	O	O	O	O	L	L
	Non-contact Water	O	O	O	O	O	L	O
	Road use to the Project (Materials, Personnel, Supplies)	O	O	L	O	L	O	L
	Mine Staffing (Direct Employment)	O	O	O	O	O	O	O
	Contracted Employment	O	O	O	O	O	O	O

Notes:

O *No interaction anticipated.*

L *Negligible to minor interaction expected; implementation of best practices, standard mitigation and management measures; no monitoring required, no further consideration warranted.*

M *Potential moderate interaction requiring unique active management/monitoring/mitigation; warrants further consideration.*

H *Key interaction; warrants further consideration.*

Habitat Alteration

Habitat alteration is defined as a reduction in habitat suitability. Activities that affect the physical characteristics or accessibility of an area, either permanently or temporarily can result in a change in habitat suitability. Habitat alteration will occur throughout the construction and operation phases of the Project, specifically as a result of drilling, blasting, crushing and road use (fugitive dust deposition), soil compaction, linear feature use and maintenance (invasive species introduction, vegetation maintenance) and changes in drainage and water quantity. Included within the IDA is a minimum 50 m buffer between the edge of the IDA and any project infrastructure. Any habitat alteration within this buffer as a result of edge effects is incorporated into habitat loss. As all suitable habitat within the IF was assumed to be removed during initial Project construction activities, habitat alteration effects are limited to areas where suitable habitat may still exist.

Habitat fragmentation can be associated with corridors of unsuitable habitat (i.e. open roads) that may function as filters or barriers for some wildlife populations (Jalkotzy et al. 1997). The loss of vegetative cover can restrict road crossings to a few individuals (filter) or no individuals (barrier). The degree of loss of connectivity will vary with the width of the corridor, the frequency of vehicular traffic, the habitat on either side of the corridor and the species being considered. The resulting fragmentation and obstruction can limit the ability of species to disperse, breed and survive if it cannot access critical habitats or travel corridors. Project activities that can lead to habitat fragmentation will be considered under disruption of movement.

As all suitable habitat within the IF was assumed to be removed during initial Project construction activities, any habitat alteration effects will be limited to areas outside of the IF. A ranking of "M" has been assigned for project interactions and further discussion is warranted.

Sensory Disturbance

Sensory disturbance refers to a Project related activity (e.g., noise, light, human presence) that causes individuals to change their behaviour or avoid certain habitats that would otherwise be suitable. Little is known about the impacts of sensory disturbance for most reptilian species. Disturbance can interrupt normal activity and cause an animal to move away from the source of disturbance. This movement may have energetic costs to the individual, as well as disrupting the activity (e.g., foraging, courting, resting, tending young) of the individual (Gill and Sutherland 2000; Blanc et al. 2006). Disturbed individuals may choose to temporarily vacate areas of suitable habitat, which may result in increased energy expenditures or utilization of sub-optimal habitats (Ward et al. 1999; Gibeau et al. 2002; Bautista et al. 2004). For some VCs, noise can mask the sounds that individuals use to find prey, and avoid predators. In some cases, habituation and adaptation can allow wildlife to accommodate the presence of noise in their environment. Some species will tolerate a considerable amount of human presence, providing there is no perceived risk.

Loud construction-related Project activities, such as drilling, blasting, pile driving and tree falling, can disturb a variety of species depending on the type of activity, season, how close the activity is, and the frequency of the activity. The source, duration, and intensity of noise all influence how an animal may respond, whether it is disturbance, displacement, or habituation.

Drilling and blasting will occur in the construction and operations phases of the Project; this activity includes very loud, short-duration disturbances that may have an interaction with some snake species. Snakes are not as sensitive to pressure hearing as most other terrestrial vertebrates, but are able to hear through substrate vibration (Hartline 1971; Christensen et al. 2012; Knight 2012). Vibrations that arise from drilling and blasting activities have the potential to affect snakes within the blast radius. Effects of ground vibrations on snakes are not well understood, especially those originating from blasting activities. As blasting activities are anticipated to create ground vibrations, the potential for an interaction exists. A threshold of 120db was used to identify areas which could be effected by noise or associated vibrations. A ranking of "moderate" was assigned for this activity and warrants further analysis as described in Section 6.13.4.2.

Artificial lighting during evening construction and operations activities may have a negative interaction with nocturnal snake species (Perry & Fisher 2006), but the relationship between this taxa and this activity are not well understood. Sensory disturbance may occur during Project construction from artificial lighting. Light may attract reptiles because of increased availability of prey (e.g., insects, small mammals), which may lead to increased vehicular mortalities (i.e., trucks and machines work where there is light) (Perry et al. 2008). Both nocturnal and diurnal snake species may be attracted to artificial light, with potentially very different effects (Perry & Fisher 2006). Increased light levels at night may allow for a nocturnal predator to locate prey easier, but it may also increase the likelihood that the prey sees the predator before it can attack (*ibid*.). Artificial night lighting may affect diurnal species by extending the period in which they hunt. Trade-offs for increased forage opportunities are an increased risk for predation. A ranking of "moderate" was assigned for this activity and warrants further analysis as described in Section 6.13.4.2.

Disruption of Movement

A wildlife movement corridor is a linear habitat that connects two significant habitat areas (Beier & Loe 1992). Disruption of movement refers to Project related activities that may cause an interruption to animal movements or migration, or may cause complete avoidance of certain habitats that would otherwise be suitable. Displaced individuals may choose to temporarily vacate habitats, resulting in increased energy expenditures. Wildlife movement may be affected directly as a result of Project related activities, such as excavation of the mine (movement barrier) or road construction (corridors).

Roads are often cited as having the greatest effects of disturbance on wildlife (Jalkotzy et al. 1997). Repeated disturbances from traffic may cause some species to avoid the area around active roads, resulting in a net decrease in available habitat, as well as changes in daily and seasonal movement patterns.

As no highly suitable habitat exists in the LSA for any indicator snake species, and as home ranges for each snake species are relatively small compared to the size of the Project, disruption of movement between areas of suitable habitat is not anticipated. Project components and related activities are not expected to cause a disruption of movement. A ranking of "L" has been assigned. No further discussion is warranted.

Direct Mortality

Direct mortality is defined as the death of an individual resulting directly from a project related activity. Direct mortality can result from any number of project activities, and are typically associated with vehicle/machinery use on roads and individuals getting killed while the habitat they are in is being removed.

The possibility for direct mortality during Project construction exists for a variety of specific activities. Clearing/grubbing and earthworks activities during construction have the potential to kill denning individuals unable to navigate to safer habitat. These activities were ranked "moderate" for the likelihood of potential mortality on reptiles. The risk of road mortality is anticipated to be highest during construction and operations phases, when traffic use in the LSA will be most frequent. As only one indicator snake was observed over the course of field surveys, public and site road use are anticipated to have a "moderate" likelihood of interaction with snakes and further discussion is warranted.

Project components and related activities expected to cause direct mortality to the indicator species are listed in Section 6.13.4.2.

Indirect Mortality

Indirect mortality is defined as the death of an individual resulting indirectly from a Project related activity. Wildlife mortality may be caused indirectly from increased access for hunting or poaching, or from range shifts leading to increased resource competition between individuals. The likelihood for an indirect mortality interaction resulting from Project activities was determined to be "nil" for all phases of the Project.

As reptiles are not harvested species by Aboriginal and non-Aboriginal Groups, indirect mortality are expected as a result of any Project activities.

Wildlife Attractants

Wildlife attractants are defined as features or materials that may attract wildlife away from their natural environments, to areas that are superficially superior. Odours, food waste, sewage, garbage, lumber debris and stored chemicals from construction crews and camps are examples of types of attractants that may entice individuals, but that ultimately will have a detrimental effect on the species.

During construction, the presence of non-contact and treated potable water (potential sources of drinking water) throughout the LSA may attract reptiles away from otherwise superior habitat. Contact water may also attract wildlife, however, for the purpose of this assessment, contact water will be assessed under chemical hazards. Regenerating vegetation on road sides, artificial ditches near roads, and the presence of both contact and non-contact water may attract reptiles away from suitable habitat during the operations, decommissioning and closure, and post-closure phases of the Project. As the occurrence of non-contact water will be limited to Project footprints, the anticipated interaction between wildlife attractants and any reptile indicator species is "low", and will not be discussed further.

Temporary ore stockpiles and overburden/topsoil stockpiles may attract snakes to them for thermoregulating purposes. Any stockpiles that are south facing and located near the edge of the IDA have the potential to interact with this VC. As some potentially suitable hibernacula habitat exists in proximity to these stockpile locations, a ranking of "moderate" was assigned for these activities and warrants further analysis as described in Section 6.13.4.2

Chemical Hazards

Chemical hazards are defined as chemicals that result from Project related activities that have the potential to cause an adverse health effect on wildlife. Wildlife may ingest, inhale, or absorb chemicals (e.g., metals, dust, organic anthropogenic substances, etc.) from improperly stored substances, dust on soil or vegetation, or bioaccumulation from prey.

During construction, the fuel storage and filling area has the potential to result in a chemical hazard to snakes. Hazardous waste transport and sewage infrastructure, as well as oil, fuel, other petroleum-based fluids and antifreeze from machinery can cause direct mortality and habitat contamination if they are allowed to escape into the environment. Petroleum compounds can affect organisms physically (smothering, reduced light), via habitat modification (alterations in pH or diminished food availability) or via toxic action (Albers 2003).

Contact water, which is any water that may have come in contact with potentially toxic materials, may have a negative effect on reptiles. Heavy metals such as copper, cadmium, lead, chromium and mercury are known to be persistent and mobile in the environment, and to be potentially toxic to many forms of life. Potential sources of metal contamination within the LSA include terrestrial (i.e., Mine Rock Storage Facilities (MRSF)) and aquatic (pit lake, Tailings Storage Facilities (TSF)). The water quality in the pit depends on the interaction of the water with the rock in the pit walls, and with the pH of the water. Acidified water will have increased metal loading (Miller 2002). Ranking of "M" has been assigned for potential chemical hazard interactions and further discussion will follow in Section 6.13.4.2.

6.13.4.2 Effects on Reptiles

For effects ranked "M" or "H" in Section 6.13.4.1, further analysis was undertaken, and is described below to quantify the potential effects of Project activities on reptiles.

Habitat Loss

Methods to Predict Impacts of Project Activities on Reptiles

Although multiple Project activities will result in habitat loss, it is assumed that clearing/grubbing and earthworks activities will occur in the IF prior to construction. To avoid double counting of effects, clearing/grubbing and earthworks were considered the only Project activities to result in habitat loss during any phase of the Project.

The potential exists for an adverse effect on all reptile species and populations if suitable habitat is present within the Project disturbance area. Habitat suitability mapping was completed for Gopher snake, racer, and rattlesnake. The amount of habitat lost for reptiles was calculated as a maximum amount and as a predicted amount. First, the IDA footprint was overlaid on the habitat suitability

modelling to establish the maximum impact of habitat loss on reptiles. To calculate the maximum or upper limit of potential effect on reptiles, it was assumed that all habitats (moderate suitability) within the IDA were lost. The second assessment of habitat loss involved overlaying the Project specific footprints on habitat suitability mapping to establish a predicted amount of habitat loss. The combination of these approaches allowed for the disturbance of both the IDA footprint and Project specific footprints to be reported. The amount of suitable habitat lost within the IDA was then compared to the total amount of suitable habitat within the LSA to calculate the percent of suitable habitat lost within the LSA.

Predicted Impacts of Project Activities on Reptiles

Habitat loss is expected to have an impact on Gopher snakes. For the assessment of maximum habitat loss, of the 5,279.3 ha of moderately suitable gopher snake habitat in the LSA, up to 2,690.5 ha (51%) will be removed by the Project during construction (clearing/grubbing and earthworks). For the assessment of predicted habitat loss, 1,485 ha (28%) of suitable Gopher snake habitat is anticipated to be removed as a result of Project activities (Table 6.13-8). Habitat loss is regarded as one of the biggest threats to this species (COSEWIC 2013).

Table 6.13-8. Summary of Habitat Loss by Indicator Species

Species and Life Requisite	Suitable Habitat (High and Moderate Class) and Features Available					
	TEM (ha)	LSA (ha)	Max Area Lost - IDA (ha)	Min Area Lost - IF (ha)	Max % Loss (IDA/LSA)	Min % Loss (IF/LSA)
Gopher snake – Living	11,338	5,279	2,690	1,485	51	28
Racer – Living	7785	3,856	2,004	1,109	52	29
Racer - Hibernating	223	64	34	23	53	36
Rattlesnake – Living	9013	4,353	2,224	1,228	51	28
Rattlesnake - Hibernating	204	63	30	22	49	35

Habitat loss is anticipated to have an effect on Racers as well. For the assessment of maximum habitat loss, of the 3,855.7 ha of moderately suitable living habitat and 63.6 ha of suitable hibernating habitat, up to 2,003.5 ha (52%) and 33.5 ha (53%) respectively will be removed during Project construction. For the assessment of predicted habitat loss, 1,108.9 ha (29%) and 23.1 ha (36%) respectively will be removed during Project construction (Table 6.13-8). Habitat loss resulting from the expansion of urban areas is thought to be one of the greatest threats to this species (Government of Canada 2014).

Habitat loss is also anticipated to have an effect on rattlesnakes. For the assessment of maximum habitat loss, of the 4,352.9 ha of moderately suitable living habitat and 62.6 ha of suitable hibernating habitat, up to 2,223.6 ha (51%) and 30.4 ha (49%) respectively will be removed during Project construction activities. For the assessment of predicted habitat loss, 1,228.1 ha (28%) and 21.8 ha (35%) respectively will be removed during Project construction (Table 6.13-8). Rattlesnakes in the northern region of their range have slower juvenile growth rates and delayed sexual maturity; as such habitat loss for this species may have a disproportionately high impact (Lomas 2013).

Habitat suitability mapping was not conducted for rubber boa, therefore habitat loss cannot be quantified. However, as rubber boas are able to live in a wide variety of habitats (e.g., dry conifer forests, grassland/shrub, riparian forest), the threat of habitat loss may not be as serious as it is for other species with more restricted habitat requirements (BC Conservation Data Centre 2014a, 2015).

As hibernating habitat is considered the more limiting habitat type for all snake species potentially found in the LSA, the loss of this habitat type will be the focus of the predicted impact to this VC. While percentage amounts seem high for the loss of this type of habitat, the actual amount of moderate suitability hibernating habitat (<65ha) within the LSA must be considered. For both snakes that had hibernating habitat modeled (racer and rattlesnake), less than 1% of the LSA is considered moderate suitability habitat. As only one observation was made of one of the indicator species, and this observation occurred outside of the LSA, the impact of habitat loss is not anticipated to negatively affect the population of any listed snake species in the area.

Of the four confirmed snake den sites located during field work two will be lost due to the Project (Figure 6.13-9).

Habitat Alteration

The habitat throughout the IDA is disturbed from past projects (open pit mine) as well as current land use (ranching). Low snake densities in the area may be a result from these disturbances. These low snake densities suggest that any habitat alteration will have a "low" to negligible effect on snakes. No further discussion on habitat alteration will occur.

Sensory Disturbance

Methods to Predict Impacts of Project Activities on Reptiles

Disturbance to individual snakes from ground vibrations is not well understood. It was assumed that blasting noise would cause ground vibrations in the northern section of the LSA. This assumption was based on the location of the 120 dB noise radius, and was determined by overlaying the blasting noise contour line over the LSA. Drilling activities may also cause ground vibrations. Ground vibrations cannot be quantified, so professional judgement will be used within areas which could be affected.

Predicted Impacts of Project Activities on Reptiles

As a relatively small amount of suitable habitat may be affected by noise (ground vibrations), snakes are anticipated to experience a low to nil level of sensory disturbance due to Project noise. The snake population is not anticipated to be adversely affected by noise.

Direct Mortality

Methods to Predict Impacts of Project Activities on Reptiles

Direct mortality for reptiles could not be measured. A qualitative approach based on potential suitable habitats, timing of habitat removal, and professional judgement was used. Since the density of snakes in the project area is very low the potential for direct mortalities is also very low.

Predicted Impacts of Project Activities on Reptiles

During the clearing/grubbing and earthworks activities of the construction phase of the Project, snakes unable to escape may be crushed by rock or machinery during the initial excavations. Hibernating individuals may be vulnerable to mortality from IDA development if the substrate in which snakes are hibernating is disturbed. Reptiles of all life stages are not anticipated to move quickly enough to escape mortality from these activities. Since few hibernacula are expected within a small portion of the IDA, the risk of direct mortality is not anticipated to have a noticeable effect on this VC. The effects of road mortality were also considered to be minor for snakes.

Wildlife Attractants

Methods to Predict Impacts of Project Activities on Reptiles

The impacts of wildlife attractants on reptiles were not measured directly. A qualitative approach based on presence of suitable habitat, potential attractants expected to occur, and professional judgement was employed. The effects of wildlife attractants were considered to be potentially moderate for snakes.

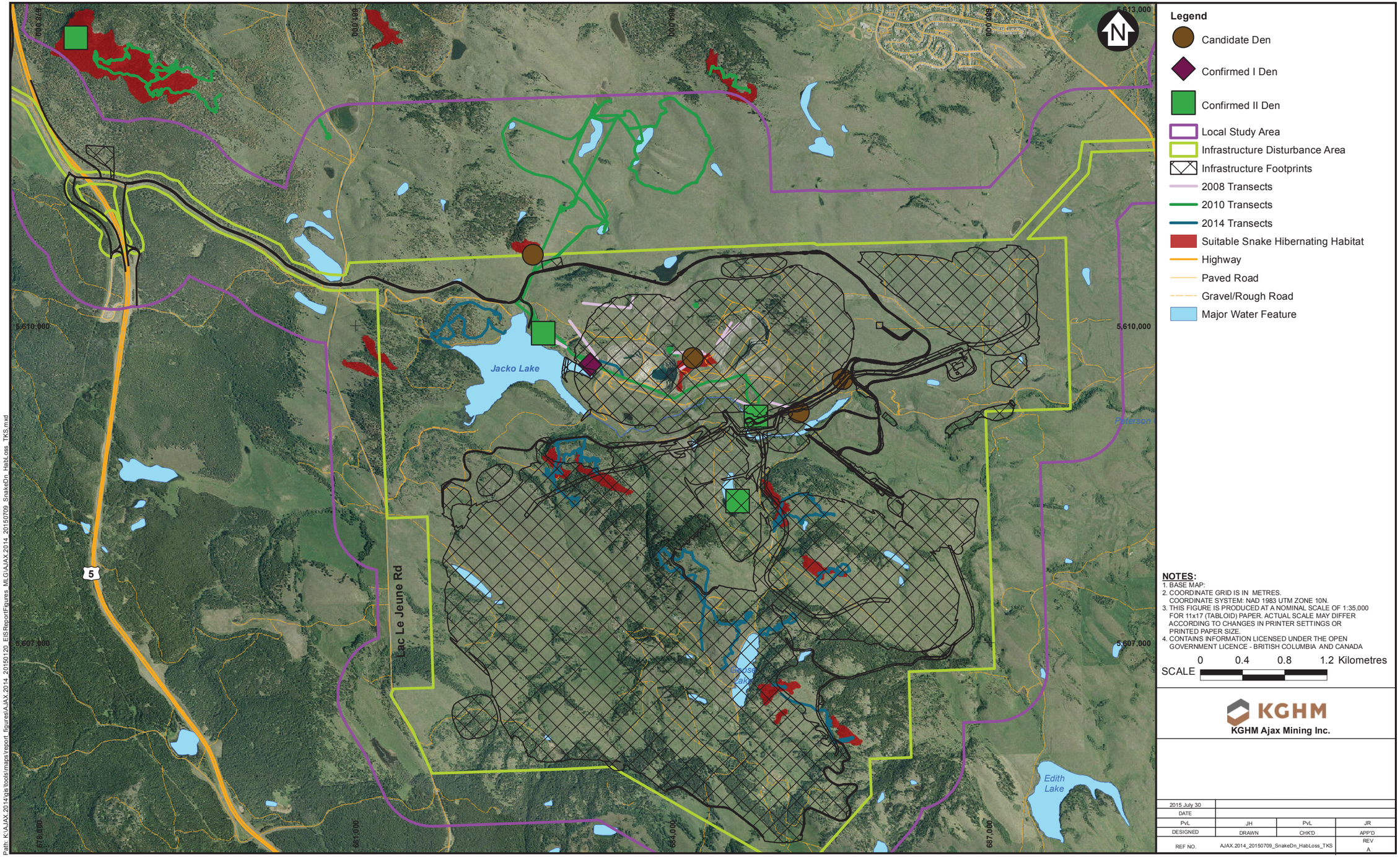
Predicted Impacts of Project Activities on Reptiles

The presence of stockpiles in the IDA may have similar characteristics to areas of efficient thermoregulation. As snakes have been observed using areas of unsuitable habitat, such as roads, for thermoregulating (Evans et al. 2011), the potential to use stockpiles for the same activity exist. As very little suitable habitat exists in proximity to these proposed stockpile locations, and assuming there is no machinery actively working on these stockpiles, the potential for this activity to have a negative interaction with reptiles is likely nil and will not be included in further discussions.

Chemical Hazards

Project components and related activities that may cause a chemical hazard to the indicator species during Project construction include fuel storage and filling area, hazardous waste transport, storage, and disposal, sewage infrastructure and disposal, public road realignment, use, and maintenance, pipeline utility corridor, fire suppression infrastructure and water treatment. In operations, the same activities, plus the transport and storage of concentrate as well as the presence of contact water may result in a chemical hazard. In addition to these activities, the decommissioning and reclamation of the TSF may result in chemical hazards during the decommissioning and closure of the Project. As a chemical hazard from any of these activities would have to be the result of an accident or malfunction, the expected interaction of these activities on any snake species was given a ranking of "low" and will not be discussed further. Contact water may result in an interaction with reptiles, however, as it will all be contained to within the IDA, and snakes are not anticipated to occur in the IDA because suitable habitat in Project footprints will be removed, the activity was also given a ranking of "low" for potential to result in an interaction with any snake species.

Figure 6.13-9
Potential Impacts to Snake Dens



NOTES:
1. BASE MAP:
2. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD 1983 UTM ZONE 10N.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:35,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
4. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENCE - BRITISH COLUMBIA AND CANADA

SCALE 0 0.4 0.8 1.2 Kilometres

KGHM Ajax Mining Inc.

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6.13.4.3 Mitigation Measures for Reptiles

Mitigation measures proposed to address potential effects during all phases of the Project are discussed below. The document *Guidelines for Amphibian and Reptile Conservation during Urban and Rural Land Development in British Columbia* (BC Ministry of Forests, Lands, and Natural Resources 2014) will be reviewed before any Project activities commence.

Habitat Loss

Habitat loss will be kept minimal and restricted to the IF where practical. Sensitive sites (e.g., rock outcrops, talus slopes) should be avoided if at all possible and whenever practical. Some loss of moderately suitable living or hibernating habitat is not avoidable. Suitable habitat in the LSA will be maintained. Habitat and suitable den sites will be restored through the reclamation and revegetation processes.

Shrub/grassland habitat created on mine rock areas, may not necessarily equate to the same suitability habitat as before the Project. Reclaimed grassland, rock outcrops, and coarse woody debris piles may also provide feeding and security habitat for various snake species. Progressive reclamation and revegetation of areas will occur during operations, closure, and post closure.

A diversity of habitat features such as coarse woody debris, rocky outcrops, talus and areas used for burrowing will be restored. Artificial structures (rock or brush piles) to provide shelter, over-wintering sites or nesting sites for reptiles will also be constructed.

Sensory Disturbance

Noise causing ground vibrations is anticipated to have a low impact on snakes. Noise may come from roads or Project specific activities, such as drilling and blasting. A *Noise and Vibration Management Plan* (Section 11.22) will be developed with the objective to ensure that noise levels during all phases of the Project are acceptably low for human and wildlife receptors, as per human health guidelines (Health Canada 2011).

Noise mitigation measures relevant to snakes include:

- considering noise ratings when selecting equipment;
- adjusting blasting configurations to minimise simultaneous blasting effects;
- optimizing the operation of equipment to minimize noise (e.g., reduced speed limits);
- optimizing the site layout to minimize noise impact (e.g., through use of natural screens such as buildings, facing away from relevant receptors); and
- noise dampening measures will be applied where possible, including conducting loud procedures indoors, where practical.

Direct Mortality

Direct mortality has the potential to occur for all species of reptiles during the construction and operation phases of the Project. Hatchlings disperse from hibernacula between August and October.

Limiting activities that involve the removal of potential nesting sites to outside of this window and pre-clearing surveys will reduce mortality of snake hatchlings.

Vehicular mortalities may occur throughout all phases of the Project, especially during construction and operations when road use will be higher than in later stages. These collisions may be reduced through the implementation of speed limits and minimizing the number of vehicles using sites roads (*Transportation Management Plan*; Section 11.21). Roads will be designed with berms to prevent snakes from accessing.

Measures to mitigate mortality of reptiles include:

- avoidance of clearing vegetation during breeding/rearing periods (August through October) and working within timing windows as required when possible (BC *Wildlife Act* Government of British Columbia 1996);
- yielding to snakes observed along Project roads and communicating these observations;
- minimizing traffic along roads by providing a vehicle parking lot for staff, and mine personnel will be shuttled from this site to the mine and;
- implementing speed limits and wildlife signage to alert drivers of potential collisions.

If limiting clearing/grubbing and earthworks activities to specific windows is deemed not practical, then a Registered Professional Biologist, experienced with snake biology will conduct an assessment of the area prior to any activities. If hibernacula or snakes occur in the area, appropriate measures to relocate the wildlife will take place.

Chemical Hazards

Chemical hazards from various Project activities (e.g., fuel storage and filling area, deposition to the TSF, vehicle/machinery leaks) are expected to be low in all phases of the Project. Management Plans that will be in place to minimize chemical hazards include:

- a *Surface Water Quality Management and Monitoring Plan* (Section 11.23);
- proper transportation, handling, and storage of contact and non-contact water;
- a *Hazardous Waste Management Plan* (Section 11.10);
- a *Risk Management Plan (Accidents and Malfunctions)* (Section 11.12);
- an *Emergency Response Plan* (Section 11.14)
- an *Air Quality and Dust Management Plan* (Section 11.6); and
- a *Solid Waste Management Plan* (Section 11.9).

A *Surface Water Quality Management and Monitoring Plan* (Section 11.23) will allow for continued monitoring of water quality within the LSA. Chemical hazards resulting from the presence of contact water are not anticipated to interact with any indicator species due to the limited availability of suitable habitat in proximity to contact water.

6.13.5 Residual Effects and Their Significance

Habitat loss is unavoidable, however the habitat currently present is unoccupied, not of high quality and exists only in small, unconnected patches across the LSA. A residual effect of habitat loss is not anticipated to occur for reptiles as a result of the Project.

The loudest Project related noise (blasting) will be limited to specific times of day, and will be of short duration. This activity is anticipated to produce the highest intensity ground vibrations. As this disturbance will not be continuous, but will rather average once per day, a residual effect is not anticipated for noise-related sensory disturbance on reptiles.

Direct mortalities may occur throughout all phases of the Project, especially during construction and operations when road use will be higher than in later stages. After the implementation of mitigation processes, the anticipated interaction is reduced to low for all reptile indicator species, and therefore, no residual effects for mortality are anticipated.

As chemical hazards are expected to have a low likelihood of interaction with reptiles, a residual effect is not expected for this species group.

Mitigation will alleviate the potential effects of habitat loss, sensory disturbance and direct mortality and no residual effects are expected for reptiles.

6.13.6 Cumulative Effects Assessment

As there are no residual effects on reptiles as a result of the Project there is no contribution to cumulative effects.

6.13.7 Conclusion

Reptiles were assessed as a VC to determine likely interactions with specific Project activities and how these interactions would affect this species group. No observations of listed snake species were recorded in the LSA. All potential effects (habitat loss, sensory disturbance, disruption of movement, direct mortality, wildlife attractants and chemical hazards) arising from each Project activity were identified and evaluated. After the implementation of mitigation measures, there are no anticipated Project-related residual effects for reptiles.

6.14 MIGRATORY BIRDS

6.14.1 Rationale

This section includes a description of the scoping process used to identify migratory birds for inclusion in the assessment. Scoping is fundamental to focusing the Application/EIS on those issues where there is the greatest potential to cause significant adverse effects. Valued components (VCs) are components of the natural and human environment that are considered to be of scientific, ecological, economic, social, cultural, or heritage importance (CEAA 2006; EAO 2013). To be included in the EA, there must be a perceived likelihood that the VC will be affected by the proposed Ajax Project (the Project).

For migratory birds the following was considered for inclusion as a valued component in the environmental assessment:

- federal or provincial listing or regulation:
  - lists of Red- and Blue-listed taxa thought to occur within the Kamloops Forest District (BC Conservation Data Centre 2014a),
  - information on actual known locations of Red- and Blue-listed species in or near the Project area provided by the BC Conservation Data Centre (2010),
  - information on SARA- or COSEWIC-listed taxa available from the Government of Canada,
  - taxa listed as part of the Identified Wildlife Management Strategy (IWMS),
  - taxa of regional concern; and data from targeted wildlife surveys and from incidental observations;
- Aboriginal interest;
- public or other stakeholder input;
- scientific/professional knowledge; and
- relevant legislation or policy concerning the VC.

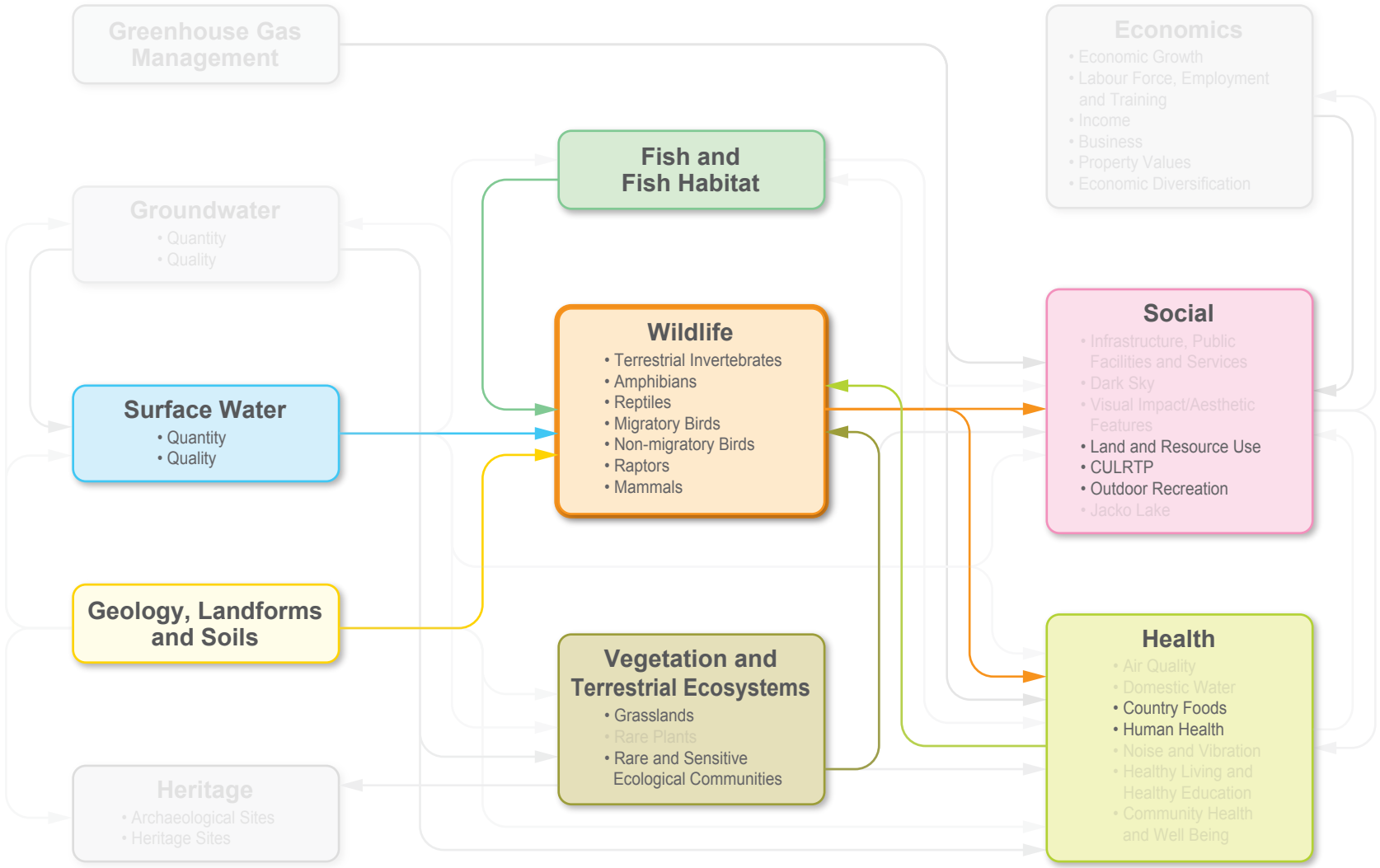
Migratory birds offer the potential for short and long term monitoring of the impact of increasing development, changing land use practices, and climate change for the region's aquatic and terrestrial ecosystems. Bird species use grassland, forested and wetland habitats which are determined by surface and ground water, geology, landform and soils. The assessment of effects to migratory birds is largely related to disturbances from Project activities (as described further in Section 6.14.4). The information developed to support the analysis of this VC may also contribute to Outdoor Recreation (Figure 6.14-1).

6.14.1.1 Selection of Migratory Birds as a Valued Component

Under the *Migratory Birds Convention Act* (MBCA), a migratory bird is defined as the following groups of bird species: waterfowl, cranes, rails and coots, shorebirds, gulls, terns, pigeons, doves, insectivorous songbirds (excluding blackbirds), seabirds, loons, grebes, herons, egrets, and bitterns.

Figure 6.14-1

VC Interactions for Wildlife (Migratory Birds)



The VC "Migratory Birds" was selected as there is an expected interaction between migratory birds and the Project. Some species are habitat specialists, requiring discrete habitats for successful nesting (e.g., wetlands); this makes these species vulnerable to loss or degradation of this habitat type. Migratory birds nest at wetland edges (e.g., waterfowl, shorebirds) and are susceptible to water-borne contaminants. Specific justification for the selection of migratory birds as a VC includes:

1. Federal or provincial listing or regulation guidelines:
   - Fifteen red/blue-listed species in the Project area (Table 6.14-1),
   - Six SARA schedule 1 species in the Project area (Table 6.14-1),
   - Eight Identified Wildlife species in the Project area (Table 6.14-1);
2. Applicable Government Agencies - Environmental Assessment Office, Canadian Environmental Assessment Agency, Environment Canada, and the MFLNRO identified migratory birds as a concern;
3. Stakeholder input (including Aboriginal groups and public):
   - ducks, geese, shorebirds, and their eggs are traditional food sources for Aboriginal peoples (First Nations Health Council no date; Ignace 2014),
   - members of the public and the Kamloops Naturalists Club have expressed concern about the impacts of the Project on migratory birds;
4. Information Sources (baseline studies (Appendix 6.8-A), professional judgement);
5. Spatial scope – migratory bird range overlaps Project area;
6. Temporal scope – migratory birds are typically present from the end of March to mid-August (Environment Canada 2014a); and
7. Interaction with Project/Potential Effects (professional knowledge) – a potential interaction is anticipated.

6.14.1.2 Selection of Indicators

The Ajax Project area is used by a wide variety of migratory birds including songbirds (e.g., woodpeckers, swallows, thrushes, hummingbirds, and warblers), waterfowl and other water-associated birds (e.g., ducks, geese, swans, coots, loons, grebes, and gulls), shorebirds (e.g., sandpipers), pigeons, and herons. The Project area lies along the northern edge of the Douglas Plateau Important Bird Area, where Bobolink (*Dolichonyx oryzivorus*), Brewer's Sparrow (*Spizella breweri*), Sandhill Crane (*Grus canadensis*), Common Nighthawk (*Chordeiles minor*), American Avocet (*Recurvirostra americana*), Black Tern (*Chlidonias niger*), and Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*) are migratory species of note (Bird Studies Canada 2012).

Two hundred and fifty-nine (259) species of birds regularly breed, overwinter, reside year-round or routinely migrate through the region (Environment Canada 2013a). The region also has a disproportionately high number of bird species considered at risk (Special Concern, Threatened or Endangered) by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). A preliminary list of migratory birds was compiled based on professional experience and comments from the public and regulatory agencies. The list was refined based on the biogeoclimatic subzone

and habitat types present in the Project area as identified by ecosystem mapping and known ranges of the taxa (Table 6.14-1).

Table 6.14-1. Potential Indicator Species for Migratory Bird VCs

English Name	Scientific Name	Provincial List	COSEWIC Status	SARA Schedule/ Status[1]	Identified Wildlife	Selected as Indicator?
American Avocet	*Recurvirostra americana*	Red	-	-	No	No
American Bittern	*Botaurus lentiginosus*	Blue	-	-	No	Yes
Barn Swallow	*Hirundo rustica*	Blue	Threatened	-	No	Yes
Bobolink	*Dolichonyx oryzivorus*	Blue	Threatened	-	No	No
Brewer's Sparrow, *breweri* subspecies	*Spizella breweri breweri*	Red	-	-	Yes	No
Canyon Wren	*Catherpes mexicanus*	Blue	Not At Risk	-	No	No
Common Nighthawk	*Chordeiles minor*	Yellow	Threatened	1-T	No	Yes
Great Blue Heron	*Ardea herodias herodias*	Blue	-	-	Yes	Yes
Horned Lark *merillii* subspecies	*Eremophila alpestris merrilli*	Blue	-	-	-	No
Lark Sparrow	*Chondestes grammacus*	Red	-	-	-	No
Lewis's Woodpecker	*Melanerpes lewis*	Red	Threatened	1-T	Yes	Yes
Long-billed Curlew	*Numenius americanus*	Blue	Special Concern	1-SC	Yes	Yes
Olive-sided Flycatcher	*Contopus cooperi*	Blue	Threatened	1-T	No	Yes
Rusty Blackbird	*Euphagus carolinus*	Blue	Special Concern	1-SC	No	No
Sandhill Crane	*Grus canadensis*	Yellow	Not At Risk	-	Yes	Yes
Waterfowl	-	-	-	-	-	Yes
Western Grebe	*Aechmophorus occidentalis*	Red	Special Concern	-	No	No
Williamson's Sapsucker	*Sphyrapicus thyroideus thyroideus*	Blue	Endangered	1-E	Yes	Yes

[1] *E = Endangered, T = Threatened, SC = Special Concern*

Indicator species were selected based on the presence of suitable/capable habitat, the availability of sufficient species knowledge to produce a meaningful assessment, feedback from stakeholders and likely interactions with the Project (geographically and ecologically).

Other birds of concern for First Nations that figure in traditional stories include the: Canada Goose, Northern Flicker, Common Raven, Stellars Jay, swans, Pileated Woodpecker, Common Loon, Gray

Jay, Black-billed Magpie, Black-capped Chickadee, Western Meadowlark, and Wren (Ignace 2014) these species are all yellow-listed.

Yellow-listed species are considered secure and widespread and effects of the Project to these species are not anticipated to have an adverse effect. As such, indicator species were generally at-risk species as these populations are more likely to experience an adverse effect.

Although several occurrences of American Avocet were recorded around the Afton tailings pond in 1989 and 1993, there have been no recent records and no evidence of breeding within the Project area. American Avocets were not selected as an indicator species because they are likely an occasional migrant. Bobolink, Brewer's Sparrow *breweri* subspecies ("Sagebrush" Brewer's Sparrow), and Canyon Wren have not been previously recorded in the Project area, and were not recorded during breeding bird surveys. These species are not anticipated to interact with the Project and were not selected as indicators. The Horned Lark *merillii* subspecies and Lark Sparrow have no known records in the Project area, but suitable habitat is present. These species were not detected during breeding bird surveys and were not selected as indicators. The Rusty Blackbird has not been documented in the Project area, but has been recorded in the Kamloops area. Since very little breeding habitat is present in the Project area, Rusty Blackbirds are not anticipated to be impacted by the Project, and was not selected as an indicator species. The Western Grebe has not been previously recorded in the Project area, and has no known nest colonies in the area. Western Grebe was not selected as an indicator.

Indicators included within the Migratory Bird VC are American Bittern, Common Nighthawk, Great Blue Heron, Lewis's Woodpecker, Long-billed Curlew, Sandhill Crane, Williamson's Sapsucker, waterfowl and two songbirds (Barn Swallow and Olive-sided Flycatcher; Table 6.14-2).

Table 6.14-2. Summary of Indicator Species Selection Rationale and Stakeholder Issues Raised

Indicator Species	Feedback by*				Issues Raised	Rationale
	AG	G	P/S	S/P		
American Bittern	✓	✓	✓	✓	Habitat alteration and loss, disturbance of nest sites and potential mortality as a result of the Project	Species at risk; no surveys done; Potentially suitable habitat present
Barn Swallow		✓	✓	✓	Habitat alteration and loss, disturbance of nest sites and potential mortality as a result of the Project	Species at risk; Confirmed in Project area; vulnerable to Project effects
Long-billed Curlew		✓	✓	✓	Habitat alteration and loss, disturbance of nest sites and potential mortality as a result of the Project	Species at risk; suitable habitat present; Agency concern
Common Nighthawk		✓	✓	✓	Habitat alteration and loss, disturbance of nest sites and potential mortality as a result of the Project	Species at risk; Confirmed in Project area; high potential for effects due to Project
Great Blue Heron	✓	✓	✓	✓	Habitat alteration and loss, disturbance of nest sites and potential mortality as a result of the Project	Species at risk; occasional use of Project area; nesting colonies highly sensitive

(continued)

Table 6.14-2. Summary of Indicator Species Selection Rationale and Stakeholder Issues Raised (completed)

Indicator Species	Feedback by*				Issues Raised	Rationale
	AG	G	P/S	S/P		
Lewis's Woodpecker		✓	✓	✓	Habitat alteration and loss, disturbance of nest sites and potential mortality as a result of the Project	Species at risk; suitable habitat present; confirmed in vicinity
Williamson's Sapsucker		✓	✓	✓	Habitat alteration and loss, disturbance of nest sites and potential mortality as a result of the Project	Species at risk; Previous records in the Project area; Potentially suitable habitat present
Olive-sided Flycatcher		✓	✓	✓	Habitat alteration and loss, disturbance of nest sites and potential mortality as a result of the Project	Species at risk; Confirmed in Project area
Sandhill Crane	✓	✓	✓	✓	Habitat alteration and loss, disturbance of nest sites and potential mortality as a result of the Project	Regional and public concern
Waterfowl	✓		✓	✓	Habitat alteration and loss, disturbance of nest sites and potential mortality as a result of the Project	Inclusion of Waterfowl as an indicator group

**AG = Aboriginal Group (Stk'emlupsemc Te Secwepemc Nation (SSN) and Nlaka'pamux Nation); G = Government; P/S = Public/Stakeholder (e.g., LRMP); S/P = Scientific/Professional Knowledge*

6.14.2 Assessment Boundaries

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

6.14.2.1 Spatial Boundaries

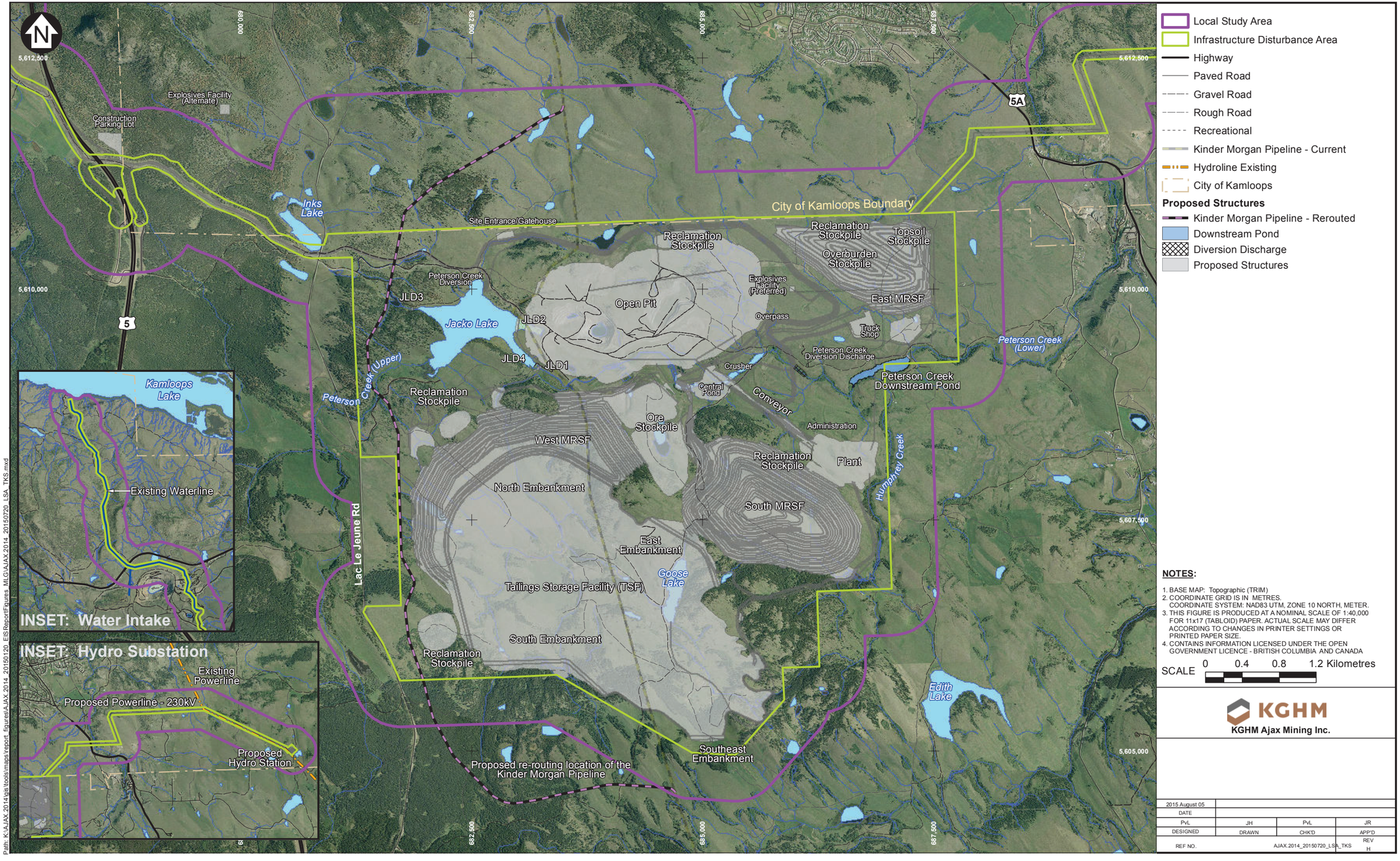
Infrastructure Footprints

The Project infrastructure footprints (IF) include the Open Pit, ancillary buildings and facilities, roads, truck stop, Tailings Storage Facility (TSF), Water Management Ponds, Mine Rock Storage Facilities (MRSFs), and stockpiles (Figure 6.14-2). The Project infrastructure footprints are 1,705 ha in size.

Infrastructure Disturbance Area

The Project infrastructure footprints and linear features (transmission line and water line) were buffered by at least 50 m (Henderson 2011) to determine the Project Infrastructure Disturbance Area (IDA). The 3,185 ha IDA will be used to assess maximum direct Project effects (e.g., mortality, habitat loss, habitat alteration, etc.).

Figure 6.14-2
Local Study Area, Infrastructure Disturbance Area and Project Infrastructure



NOTES:

1. BASE MAP: Topographic (TRIM)
2. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD83 UTM, ZONE 10 NORTH, METER.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:40,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
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SCALE 0 0.4 0.8 1.2 Kilometres

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The IDA includes the Project IF (1,705 ha) used to calculate direct loss of habitat, plus a 1,480 ha buffer around the Project IF that represents a zone of influence for potential disturbance associated with habitat alteration resulting from effects pathways such as contaminants, silt or dust, noxious weeds, and changes in drainage pattern (Figure 6.14-2).

The use of a buffered polygon area rather than individual infrastructure footprints will provide an overestimate of the direct effects of the Project for the assessment. The advantage of this approach is that it enables individual footprints to be moved and/or resized without changing the results of the effects assessment.

The IDA was modified from the General Arrangement Polygon to follow a section of the Kamloops city boundary to more accurately represent the current Project IF.

Habitat alteration by dust and water quantity is accounted for under potential habitat loss within the IDA. Areas outside of the IF that are not lost will be subject to potential alteration effects. However as wildlife species present in the area are adapted to the dry, dusty environmental conditions, these effects were considered mitigable.

The IDA was modified from the General Arrangement Polygon to follow a section of the Kamloops city boundary to more accurately represent the current IF.

Local Study Area

In accordance with the AIR the General Arrangement Polygon was buffered by 500 m to determine the Local Study Area (LSA). This area is the expected area of potential disturbance associated with all Project facilities (BC Environmental Assessment Office 2015). The LSA is 7,167 ha and will be used to assess indirect Project effects (e.g., disturbance) and provide context on the amount of habitat available adjacent to the Project IF (Figure 6.14-2**).**

Regional Study Area

The Regional Study Area (RSA) is the area for which cumulative effects will be assessed. The RSA includes portions of the South Kamloops Landscape Unit and Campbell Landscape Unit, including areas south of the Thompson River and west of Highway 97 (Figure 6.14-3**)** Landscape units were selected for the RSA as they are the geographical framework within which sustainable forest management regimes to maintain biodiversity are implemented. The RSA also includes local watershed basins and is 158,415 ha in size.

6.14.2.2 Temporal Boundaries

The temporal boundaries of the assessment will include the construction phase (short-term), operations (life of the mine), decommissioning and closure (short-term), and post-closure (short-term). The temporal phases of the Project are:

- **Construction**: 2 years (Year -2 to 1);
- **Operation**: 23 years (Year 1 to 23);

- **Decommissioning and Closure**: 5 years (Year 24 to 29, includes Project decommissioning, abandonment and reclamation activities, as well as temporary closure, and care and maintenance); and
- **Post Closure**: 5+ years (includes ongoing reclamation activities and post-closure monitoring).

6.14.2.3 Administrative Boundaries

Wildlife Habitat Areas (WHAs) designate critical habitats in which activities are managed to limit their impact on identified wildlife elements, for which they were established. Although no WHA's occur within the LSA, WHA's for Lewis's Woodpecker and Williamson's Sapsucker occur within the RSA.

6.14.2.4 Technical Boundaries

Terrestrial Ecosystem Mapping (TEM) was only completed within the LSA as this is the area expected to interact with the Project, and thus requires detailed mapping. Areas outside of the LSA were quantified using VRI and other broad mapping sources. Since habitat within the RSA and LSA were quantified using different map products the results are not directly comparable.

The cryptic/reclusive/dispersed nature of rare migratory birds precludes the collection of an adequate sample size to allow statistical analysis of the data. The small sample size limited the analysis for several indicator species, resulting in the use of professional judgement for some components of this assessment. The absence of specific locations may limit the assessment associated with these critical habitat features.

6.14.3 Background

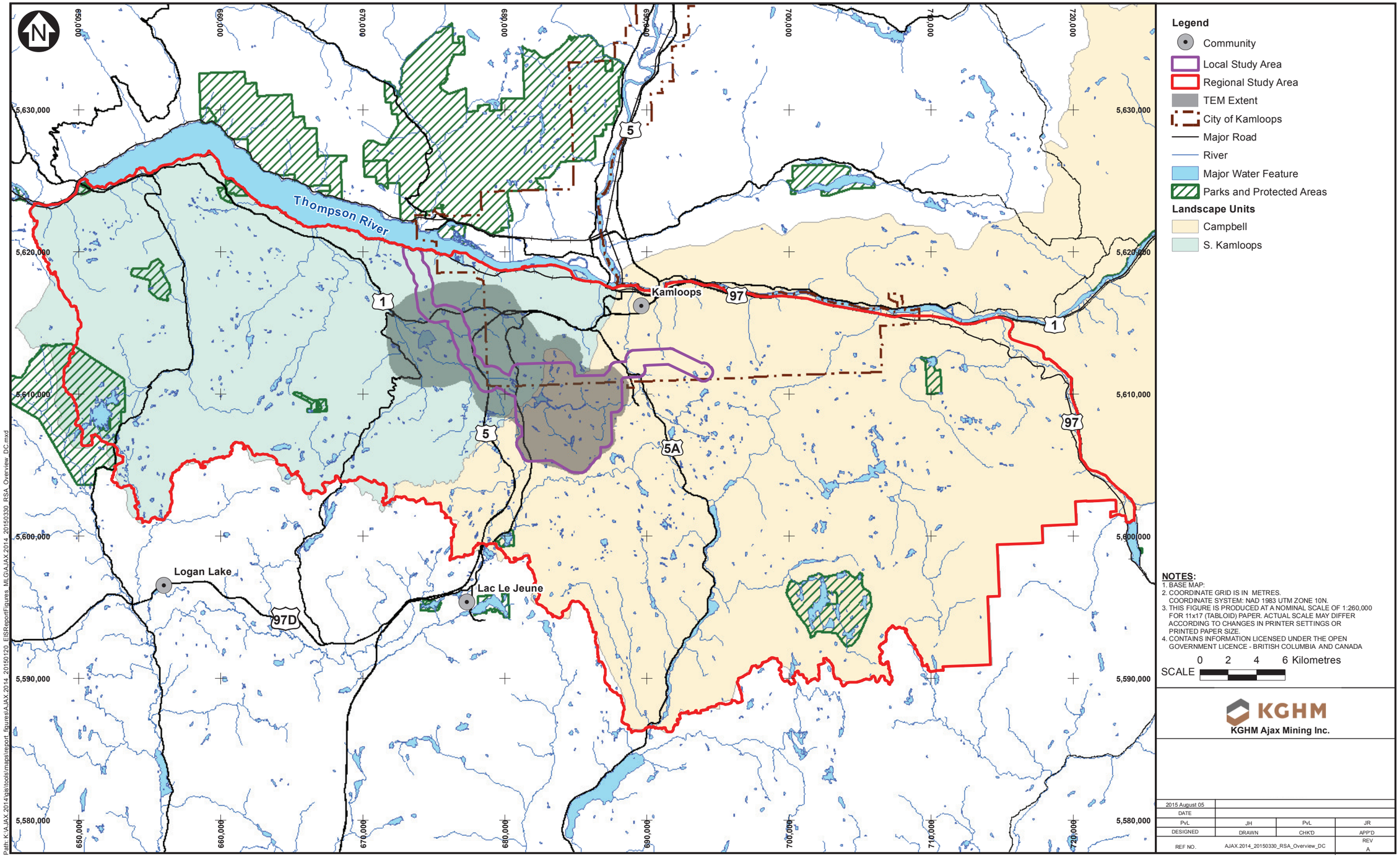
6.14.3.1 Regulatory and Policy Framework

The Kamloops Land and Resources Management Plan (LRMP) (1995) outlines that: special attention to red- and blue-listed species should be considered; forests are to be managed to ensure diversity, as well as to ensure critical habitat is identified and managed appropriately through local level planning; and habitat improvement projects should be conducted where appropriate. Several management zones provide important habitat for birds including: the Bonaparte Resource Management Zone (RMZ), Clearwater River RMZ, Taweel RMZ, Battle Bluffs RMZ, and the Skull RMZ (Kamloops Interagency Management Committee 1995).

The Nicola Thompson Fraser Sustainable Forest Management Plan (SFMP) (2015) aims to conserve species diversity by ensuring that habitats for a particular species are maintained, including habitats for known occurrences of species at risk. The Nicola Thompson Fraser SFMP has set a target of 60 ha of Lewis's Woodpecker habitat to be conserved or managed within the Kamloops TSA (SFMP Working Group 2015).

Long-billed Curlew, Great Blue Heron, Lewis's Woodpecker, Williamson's Sapsucker, and Sandhill Crane are Identified Wildlife under the *Forest and Range Practices Act* (FRPA). General wildlife goals include a number of goals for different groups of migrating birds.

Figure 6.14-3
Regional Study Area



Goals outlined for woodpeckers (Williamson's Sapsucker and Lewis's Woodpecker) include (Gebauer 2004a; Cooper and Manning 2004):

- maintaining large diameter trees for foraging and nesting;
- ensuring WHAs are windfirm (i.e., trees able to withstand heavy winds);
- maintaining open canopies; and
- maintaining shrub cover.

Goals for waders and shorebirds (Great Blue Heron, Long-billed Curlew, and Sandhill Crane) include (Vennesland 2004; Ohanjanian 2004; Gebauer 2004b):

- maintaining vegetation (emergent vegetation, low profile vegetation, suitable nesting trees);
- minimizing disturbance of humans and livestock during the breeding season; and
- restoring historical wetland areas.

Critical periods for migratory birds are identified as the breeding season (April through July) and migratory periods (April/September to October). Goals for songbirds include (BC Ministry of Water, Land and Air Protection 2004):

- minimizing disturbance/trampling by livestock;
- maintaining and enhancing suitable habitat areas (sagebrush, riparian areas); and
- preventing tree encroachment.

Under the *Migratory Birds Convention Act, 1994* (Government of Canada 1994), all breeding birds are protected from being killed, captured, injured, or taken, and all bird nests are protected from being disturbed, damaged, destroyed, or removed, unless a permit to undertake such activities is granted. Under the BC *Wildlife Act* (Government of British Columbia 1996), birds, eggs, and occupied nests may not be taken, injured, molested, or destroyed. Unoccupied heron nest are also protected under the BC *Wildlife Act*.

The *Species at Risk Act* (Government of Canada 2002) requires a recovery strategy or management plan for species within a specific timeframe depending on the species status and schedule. Federal management plans are in place for Long-billed Curlew and Lewis's Woodpecker (Environment Canada 2013b; Environment Canada 2014b). A federal recovery strategy and a provincial recovery plan have been prepared for Williamson's Sapsucker (Ministry of Environment 2012; Environment Canada 2014d). Proposed federal recovery strategies are available for Common Nighthawk and Olive-sided Flycatcher (Environment Canada 2015a, 2015b; Table 6.14-3). A management plan is available for Lewis's Woodpecker (Environment Canada 2014b) and a provincial recovery strategy is currently being prepared, and should be available in 2015 or early 2016 (Environment Canada 2015c).

The BC conservation framework ranks American Bittern, Barn Swallow, Long-billed Curlew, Common Nighthawk, Great Blue Heron, Williamson's Sapsucker, and Olive-sided Flycatcher as priority 2 under goal 2 (prevent species and ecosystem from becoming at risk). Lewis's Woodpecker

is ranked as priority 2 under goal 3 (maintain the diversity of native species and ecosystems). Sandhill Crane is priority 5 under goal 3.

Table 6.14-3. Migratory Bird Recovery Planning Documents

English Name	SARA Schedule/ Status[1]	BC[2]	SARA[2]
Long-billed Curlew	1-SC	-	MP – 2013
Common Nighthawk	1-T	-	RS[3] – 2015
Lewis's Woodpecker	1-T	-	MP – 2014
Williamson's Sapsucker	1-E	RS – 2012	RS – 2014
Olive-sided Flycatcher	1-T	-	RS[3] – 2015

[1] *SC = Special Concern, T = Threatened, E = Endangered*
[2] *RS = Recovery Strategy, MP = Management Plan*
[3] *Proposed Recovery Strategies*

Regionally, the Project lies within "Region 3 – Thompson" of the Hunting and Trapping Regulations Synopsis; three Management Unit (MU) boundaries (3-18, 3-19, and 3-20) divide up the region (Ministry of Forests, Lands and Natural Resource Operations 2014). The hunting of ducks and geese takes place in the Project area (Ministry of Forests, Lands and Natural Resource Operations 2014).

6.14.3.2 Regional Overview

The Great Basin Bird Conservation Region (BCR) is a dry and cold northern desert extending from south-central BC down through several Pacific Northwest states (Environment Canada 2013a). Concerns for migratory birds in the Thompson Region include industrial and agricultural development, as well as widespread livestock grazing, fire suppression, and invasive plant species introduction. Approximately 25% of historic grasslands in the Great Basin BCR have been lost to development and agricultural conversion (Environment Canada 2013a). The loss of mature pine forests to mountain pine beetle also poses conservation problems for a number of priority species (*ibid*.).

The varied habitats of the Thompson region including arid grassland, shrub lands, open forests, cliffs, lakes, and riparian areas support a particularly diverse group of migratory birds. Williamson's Sapsucker are unique to the region, and only occur occasionally elsewhere in the province (BC Conservation Data Centre 2014a). Loss of herbaceous habitat due to ranching and cattle grazing practices is a major threat to Long-billed Curlew, while loss of forested areas is impacting Lewis's Woodpecker and Olive-sided Flycatcher (Environment Canada 2013a). Pollution and pesticides may be impacting the prey availability for species such as Barn Swallow (*ibid*.). Wetlands in the region provided habitat for waterfowl and shorebirds, and rock outcrops and open areas such as grasslands and pastures provide Common Nighthawk nesting habitat (BC Conservation Data Centre 2014a).

Environment Canada has developed strategic plans for Bird Conservation Regions in Canada. The Project lies within Bird Conservation Region 9 (Great Basin region; Environment Canada 2013a). Of the habitats present within the Project LSA, the broad habitat categories of greatest concern are herbaceous (grasslands), and wetlands.

One IBA is located within the LSA, namely the Douglas Lake Plateau (Bird Studies Canada and Nature Canada 2012). The Douglas Lake Plateau IBA is located south of the City of Kamloops. This IBA consists of rolling BG grasslands, small marshy lakes, Douglas-fir/PP forests and aspen parkland. The Douglas Lake Plateau is an important migration breeding area for the Sandhill Crane (a Blue-listed, vulnerable species in BC). The number of Sandhill Cranes that use this area for breeding and migration staging areas represent over 1.5% of the North American population. The area is also a major migration corridor for loons, grebes, waterfowl, raptors, shorebirds, gulls, and passerines. The Lewis' Woodpecker is also known to breed within the Douglas Lake Plateau IBA, though exact numbers of this nationally vulnerable species are not known. Birds that are not common within BC that are known to breed within the Douglas Lake Plateau are Bobolink (Blue-listed), Brewer's Sparrow (Yellow-listed), Common Nighthawk (Yellow-listed), American Avocet (Blue-listed), Black Tern (Yellow-listed), and Yellow-Headed Blackbird (Yellow-listed; Bird Studies Canada and Nature Canada 2012).

Indicator Species

American Bitterns breed in wet areas with dense stands of tall, emergent vegetation, such as cattail, bulrushes and willows, or in areas with tall grasses close to wet areas (Campbell et al. 1990a; Gibbs et al. 1992; Fraser et al. 1999). The total provincial population has declined in the last 20 years, possibly associated with a loss of wetland habitat (Cannings et al. 1987; Fraser et al. 1999). The American Bittern is a secretive species that may use the wetlands in the LSA. In the Tranquille Wildlife Management Area (just north of the Thompson River and west of the City of Kamloops) individuals have been heard calling during the breeding season, although proof of nesting has not been obtained (Howie 2007). American Bitterns are ranked S3B (vulnerable for the breeding population) in BC.

The *herodias* subspecies of Great Blue Herons are ranked S3B,S4N (vulnerable for the breeding population, apparently secure for the non-breeding population) and are found in the province year-round, although much of the interior population migrates south in the winter. Herons require suitable aquatic foraging habitat in close proximity to breeding colonies (Gibbs 1991; Butler 1997; Gebauer & Moul 2001; Campbell et al. 1990a; Vennesland & Butler 2011). Suitable foraging areas during the breeding season include aquatic areas such as lakeshores, marshes, ponds, sloughs, slow-moving rivers, wetlands, lagoons, and irrigation ditches (Campbell et al. 1990a; Vennesland and Butler 2011). No known breeding colonies have been found in or near the LSA, but individuals have been recorded within the LSA (Klinkenberg 2014).

Lewis's Woodpeckers are associated with riparian and open pine forests with snags and defect trees, where abundant shrubby vegetation provides a source of insects. The core breeding range for this species is the Thompson Basin and Okanagan Valley (Cooper et al. 1998). Provincially, Lewis's Woodpeckers are ranked S2B (imperilled for the breeding population), and populations are thought to be threatened by the loss of mature cottonwood and ponderosa pine stands due to urban development, snag removal, firewood cutting, and the impacts of mountain pine beetle (Environment Canada 2014c). A nesting pair of Lewis' Woodpeckers was reported in 2001 on the north side of Ironmask Hill, as well as south of Kamloops in 2006, 2000, 1999, 1983, and in 1982 (BC Conservation Data Centre 2012). According to Environment Canada (2014b) approximately 75 to

124 pairs were thought to be present in the Thompson-Nicola region in 2006-2007. Habitat suitability around Kamloops is Low (Environment Canada 2014c).

Williamson's Sapsuckers mainly occupy coniferous forests, although they have also been found in mixed forest types (COSEWIC 2005). The main threat to Williamson's Sapsuckers is the removal of forests, primarily through harvesting activities (Fraser et al. 1999). A pair of Williamson's Sapsuckers was reported at Jacko Lake in 1994 and 1995 (BC Conservation Data Centre 2007). Williamson's Sapsuckers are ranked S3B (vulnerable for the breeding population) in BC.

Barn Swallows nest primary in anthropogenic structures such as barns, bridges, and outbuildings, while natural sites including cliffs, caves and banks were reportedly used 1% of the time in British Columbia (Campbell et al. 1997). Birds will frequently return to the same nesting area and sometimes the same nest year after year (*ibid.*). Barn Swallows are ranked S3S4B (vulnerable or apparently secure for the breeding population) in BC, and their numbers have been declining in the province (COSEWIC 2011a), perhaps due to changes in farming practices that result in fewer suitable nest sites (Campbell et al. 1997). Parasitism by blowflies can also cause considerable mortality of nestlings (*ibid.*). Barn Swallows have been observed throughout the RSA (Klinkenberg 2014) and may nest within the LSA.

Long-billed Curlews are associated with large, contiguous areas of grassland habitat in the BC interior (BC Ministry of Water, Land and Air Protection 2004). This species is ranked S3B (vulnerable for the breeding population) provincially. Threats to curlews include grassland habitat loss due to urbanization and intensive agriculture, and habitat degradation from forest encroachment, heavy livestock grazing and all-terrain vehicle (ATV) use (BC Ministry of Water, Land and Air Protection 2004). This species breeds in the vicinity of Kamloops (RSA) and may be present from April through June (Howie 2004).

Olive-sided Flycatchers are strongly associated with coniferous forest openings and forested wetlands (COSEWIC 2007b). Olive-sided Flycatcher populations have declined in North America over the past 40 years (COSEWIC 2007b). The cause of this decline is unknown, but loss of winter habitat, the increasing presence of ecological sinks in breeding habitat, or a reduction in insect prey due to pesticides have all been suggested (Diamond 1991; Hutto and Young 1999; Altman and Sallabanks 2012). Olive-sided Flycatchers are present in the Kamloops area between May and early September (Howie 2004), and have been recorded within the LSA (Klinkenberg 2014). In BC, Olive-sided Flycatchers are ranked S3S4B (vulnerable or apparently secure for the breeding population).

Common Nighthawk nesting habitat includes burns, clear-cuts, open pine (*Pinus* spp.) and aspen forests, sagebrush (*Artemesia* spp.), prairie, rock outcrops, gravel roofs in urban areas, dunes, beaches, grasslands, pastures, peat bogs, marshes, lakeshores, roadsides, reclaimed mines and river banks, in sites with little to no vegetation (Campbell et al. 1990b; Campbell et al. 2006; COSEWIC 2007a; Ontario Ministry of Natural Resources 2009; Brigham et al. 2011). Eggs have been found in BC from May to August (Campbell et al. 1990b). Common Nighthawks have been observed around Kamloops and south of the LSA (Klinkenberg 2014), as well as within the LSA during baseline data collection. In BC, Common Nighthawks are ranked S4B (apparently secure for the breeding population).

Sandhill Cranes nest, roost, and forage on the ground and often use coniferous forests for cover (BC Conservation Data Centre 2013). Provincially, Sandhill Cranes are ranked S4B (apparently secure for the breeding population). Breeding areas include wetlands, bogs, marshes, swamps, meadows and estuaries (Blood and Backhouse 1999). Sandhill Cranes are known to breed in the Kamloops vicinity (Howie 2004), and individuals have been observed in the LSA (Klinkenberg 2014).

Species assessed in the 'waterfowl' group include loons, grebes, ducks, geese and swans as well as non-waterfowl species of shorebirds and marsh birds. This group includes species that are closely-associated with waterbodies. Many species from these different groups of waterfowl have been observed in and around the LSA on various waterbodies.

6.14.3.3 Historical Activities

Historical activities considered in this section include mining, mills, pipelines, rail lines, agriculture/ ranching, forestry, urban sprawl, water treatment, recreation/tourism and hunting/fishing. Only those activities expected to interact with migratory birds have been discussed here.

Loss of forest, wetland, and grassland habitat as a result of mining activities and pipelines in the region has likely impacted migratory birds. Continued development in the region may further reduce the amount of available habitat. Historically wetlands in the low valleys of the Thompson-Okanagan region were drained for agricultural purposes (Government of Canada 1991), altering large areas of habitat that could have supported wetland-associated migratory birds. Continued agricultural and ranching may remove additional habitat, and alter remaining habitat to such a degree that they can no longer support some migratory bird species that are habitat specialists.

Forestry has removed and altered large areas of habitat that could have supported breeding communities of several indicator species including: Lewis's Woodpecker, Williamson's Sapsucker, Olive-sided Flycatcher, and Common Nighthawk. Continued forestry practices could reduce or alter remaining habitat to such a degree that they can no longer support these species in the area.

Much like forestry and agriculture, urban expansion will remove habitat that could support migratory birds. The Lewis's Woodpecker (Environment Canada 2014c) and the Long-billed Curlew (BC Ministry of Water, Land and Air Protection 2004) are considered particularly sensitive to urban development.

6.14.3.4 Baseline Studies

Baseline studies were conducted according to Resource Inventory Standards Committee (RISC) standards. Surveys targeting breeding song birds, migratory birds, waterfowl, woodpeckers, American Bitterns, and Common Nighthawks were conducted in 2007, 2008, 2010, 2011 and 2014. Surveys were carried out as described in the AIR (BC Environmental Assessment Office 2015).

Surveys for migratory birds were undertaken throughout the LSA and areas of the RSA to: a) establish the presence of target species and key habitat features within the LSA; b) collect data on the location and timing of use of the LSA by target species; c) confirm habitat ratings used to develop wildlife habitat suitability models; and d) provide information to KGHM Ajax Mining Inc. (KAM) to use during the Project design phase to avoid or minimize the impacts to target species.

Terrestrial ecosystem mapping within the LSA was used to develop wildlife habitat suitability mapping for Lewis's Woodpecker and Williamson's Sapsucker.

Data Sources

General information on species status and distribution was drawn from on-line sources such as the BC Ministry of Environment's Species Explorer and NatureServe (BC Conservation Data Centre 2014a; NatureServe 2014). Occurrence records of migratory birds in the RSA were obtained from the BC Conservation Data Centre (BC Conservation Data Centre 2014b) and from the provincial Species Inventory Database (BC Ministry of Environment 2014b).

Several other reports describing species in the area were consulted, including:

- Birds of Kamloops (Howie 2004);
- Background Document for Tranquille Wildlife Management Area (Howie 2007);
- Bird Conservation Strategy for Bird Conservation Region 9 Pacific and Yukon Region: Great Basin (Environment Canada 2013a);
- The Birds of British Columbia Volume 1: Non-passerines. Introduction, Loons Through Waterfowl (Campbell et al. 1990a);
- The Birds of British Columbia Volume 2: Non-passerines, Diurnal Birds of Prey Through Woodpeckers (Campbell et al. 1990b);
- Status of the Lewis Woodpecker (*Melanerpes lewis*) in British Columbia (Cooper et al. 1998);
- COSEWIC Assessment and Status Report on the Barn Swallow *Hirundo rustica* in Canada (COSEWIC 2011a);
- COSEWIC Status Appraisal Summary on the Long-billed Curlew *Numenius americanus* in Canada (COSEWIC 2011b);
- COSEWIC Assessment and Status Report on the Common Nighthawk *Chordeiles minor* in Canada (COSEWIC 2007a);
- COSEWIC Assessment and Status Report on the Lewis's Woodpecker *Melanerpes lewis* in Canada (COSEWIC 2010);
- COSEWIC Assessment and Status Report on the Williamson's Sapsucker *Sphyrapicus thyroideus* in Canada (COSEWIC 2005);
- COSEWIC Assessment and Status Report on the Olive-sided Flycatcher *Contopus cooperi* in Canada (COSEWIC 2007b);
- Management Plan for the Lewis's Woodpecker (*Melanerpes lewis*) in Canada (Environment Canada 2014c);
- Recovery Plan for the Williamson's Sapsucker (*Sphyrapicus thyroideus*) on Crown Lands in British Columbia (Ministry of Environment 2012);
- Recovery Strategy for the Willamson's Sapsicler (*Sphyrapicus thyroideus*) in Canada (Environment Canada 2014d);

- Recovery Strategy for the Olive-sided Flycatcher (*Contopus cooperi*) in Canada – Proposed (Environment Canada 2015a); and
- Recovery Strategy for the Common Nighthawk (*Chordeiles minor*) in Canada – Proposed (Environment Canada 2015b).

Information regarding Aboriginal harvest of waterfowl in the LSA was taken from Chapter 12, Background and Aboriginal Group Settings. First Nations and Aboriginal Groups are both known to hunt migratory birds.

Methods

Additional details on wildlife survey methods and habitat mapping are presented in Appendix 6.8-A.

Habitat Mapping

Habitat suitability mapping based on the TEM was completed for Williamson's Sapsucker and Lewis's Woodpecker (Table 6.14-4). Suitability mapping methodology is described in provincial standards (BC Ministry of Environment 1996) and is summarized in Appendix 6.8-A.

Table 6.14-4. Summary of Habitat Suitability Mapping for Migratory Birds

Species	Life Requisite	Maximum Rating
Williamson's Sapsucker	Living – Growing Season	Low
Lewis' Woodpecker	Reproducing – Growing Season	Low

Habitat Associations

Habitat suitability mapping was not prepared for other indicator species since the species habitat requirements are well understood and general habitat associations are sufficient to identify suitable habitat. Habitat associations were developed to assess habitat loss for Long-billed Curlew, Common Nighthawk, Great Blue Heron, Olive-sided Flycatcher, Sandhill Crane, and Waterfowl (Table 6.14-5). Since only 1% of Barn Swallow nests in BC are found in natural structures (Campbell et al. 1997), habitat associations based on the ecosystem mapping cannot be used for this species. A qualitative approach will be used to assess habitat loss for Barn Swallows.

Breeding Bird and Migratory Bird Surveys

Breeding bird surveys and migrant bird surveys were completed using point count methods described in *Inventory Methods for Forest and Grassland Songbirds* (Resources Inventory Committee 1999). One kilometre long point count transects for breeding birds were completed on May 22/23 and June 6/7 in 2007, June 7 to 10 in 2008, May 14 to 17 in 2010, and May 10 to 23 in 2014 (Figure 6.14-4).

Migrant surveys were completed during the spring and fall migration periods of 2014, using the same transects laid out for the breeding bird point counts. Surveys took place from April 22 to 26 and August 25 to 27, 2014.

Table 6.14-5. Summary of Habitat Associations for Migratory Birds

Indicator Species	Habitat Association	TEM map units
Barn Swallow	Barns, bridges, and outbuildings (Campbell et al. 1997).	Anthropogenic structures are not mapped.
Long-billed Curlew	Large, contiguous areas of grassland habitat (BC Ministry of Water, Land and Air Protection 2004)	Grasslands (81, 82, 83, 84), cultivated fields (CF).
Common Nighthawk	Burns, clearcuts, open pine (*Pinus* spp.) and aspen forests, sagebrush (*Artemesia* spp.), prairie, rock outcrops, gravel roofs in urban areas, dunes, beaches, grasslands, pastures, peat bogs, marshes, lakeshores, roadsides, reclaimed mines and river banks, in sites with little to no vegetation (Campbell et al. 1990b; Campbell et al. 2006; COSEWIC 2007a; Ontario Ministry of Natural Resources 2009; Brigham et al. 2011)	Structural stage 1 ecosystem units.
Great Blue Heron	Lakeshores, marshes, ponds, sloughs, slow-moving rivers, wetlands, lagoons, and irrigation ditches (Campbell et al. 1990a; Vennesland and Butler 2011)	Wetlands (alkaline pond, open water, lake, pond, alkaline meadow, marsh, swamp) and cultivated fields (CF)
Olive-sided Flycatcher	Coniferous forest openings and forested wetlands (COSEWIC 2007b)	Structural Stage 4 to 7 ecosystem units
Sandhill Crane	Wetlands, bogs, marshes, swamps, meadows and estuaries (Blood and Backhouse 1999).	Wetlands (alkaline pond, open water, lake, pond, alkaline meadow, marsh, swamp)
Waterfowl	Waterbodies	Wetlands (alkaline pond, open water, lake, pond, alkaline meadow, marsh, swamp)

Waterfowl Surveys

Waterfowl surveys were completed following methods described in *Inventory Methods for Waterfowl and Allied Species* (Resources Inventory Committee 1999a). Observation stations were completed at ponds and lakes in the LSA and RSA during breeding and staging periods (Figure 6.14-5).

Call Playback Surveys

Call-playback surveys were completed for various species following the applicable standards. These include: Common Nighthawks following *Inventory Methods for Nighthawks and Poorwills* (Resources Inventory Committee (RIC) 1998b); American Bitterns following *Inventory Methods for Marsh Birds: Bitterns and Rails* (Resources Inventory Committee (RIC) 1998a); and Williamson's Sapsucker following *Inventory Methods for Woodpeckers* (Resources Inventory Committee 1999b). Transects for each species were established in suitable habitat located in the LSA and RSA (Figure 6.14-6, Figure 6.14-7, Figure 6.14-8).

Stand-watch Surveys (or Spot-mapping Surveys)

Stand-watch surveys for Lewis's Woodpecker were conducting following the *Inventory Methods for Woodpeckers* (Resources Inventory Committee 1999b). Stand-watches were completed in areas of apparently suitable habitat (Figure 6.14-8).

Figure 6.14-4
Breeding and Migratory Bird Point Counts

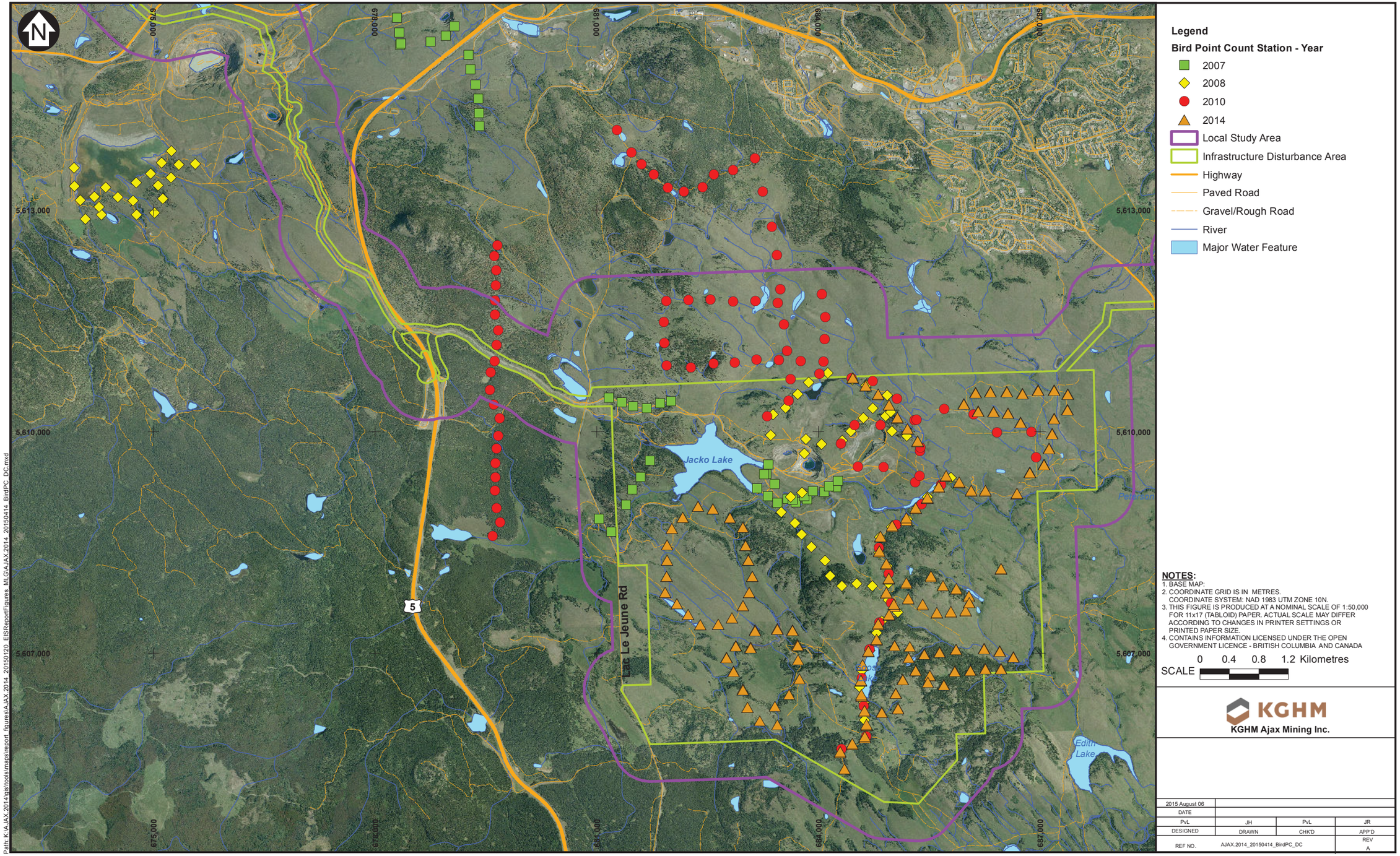


Figure 6.14-5
Locations of Waterfowl/Shorebird Surveys

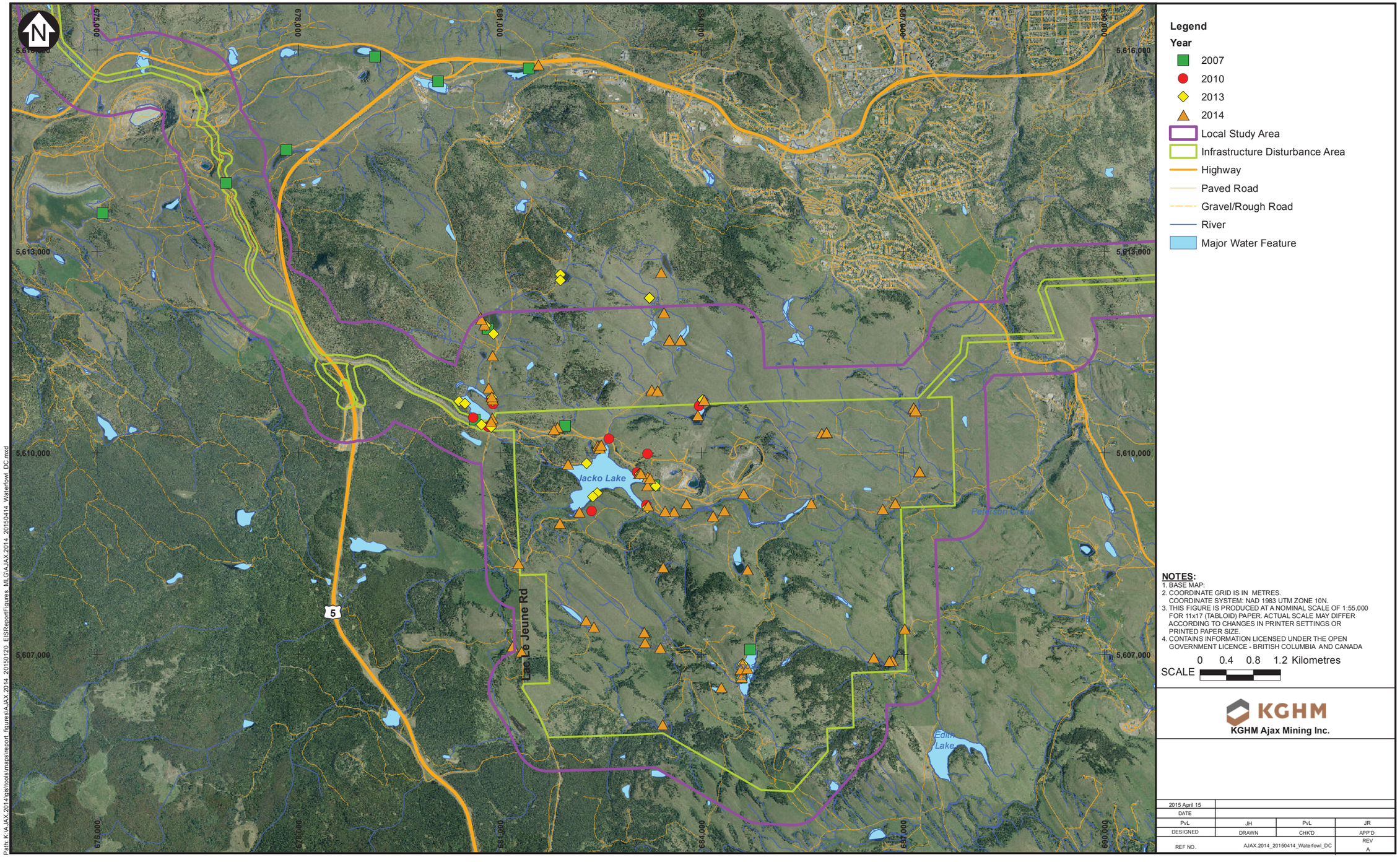


Figure 6.14-6
Common Nighthawk Call-playback Locations and Detections

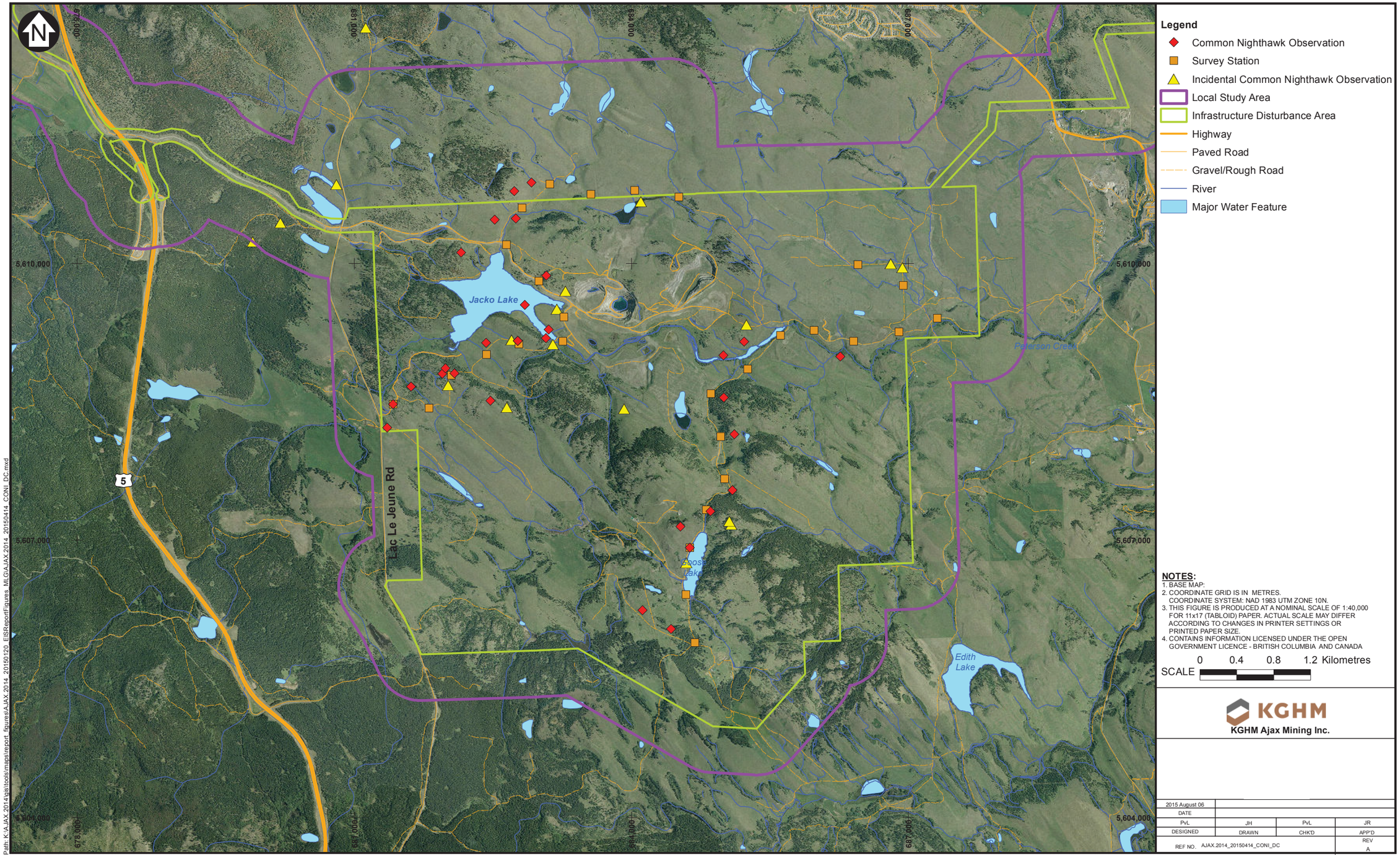


Figure 6.14-7
American Bittern Call-playback Locations

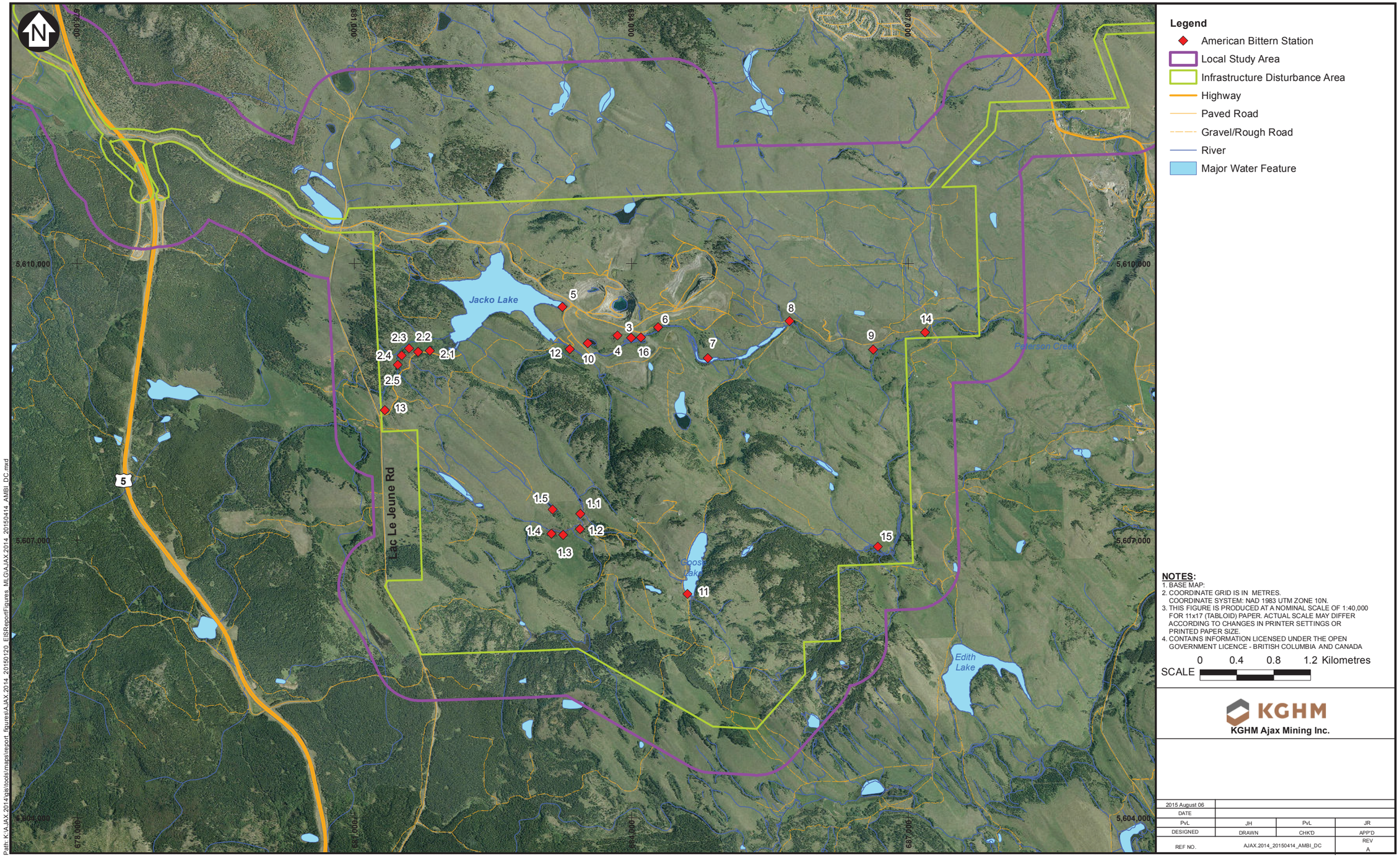
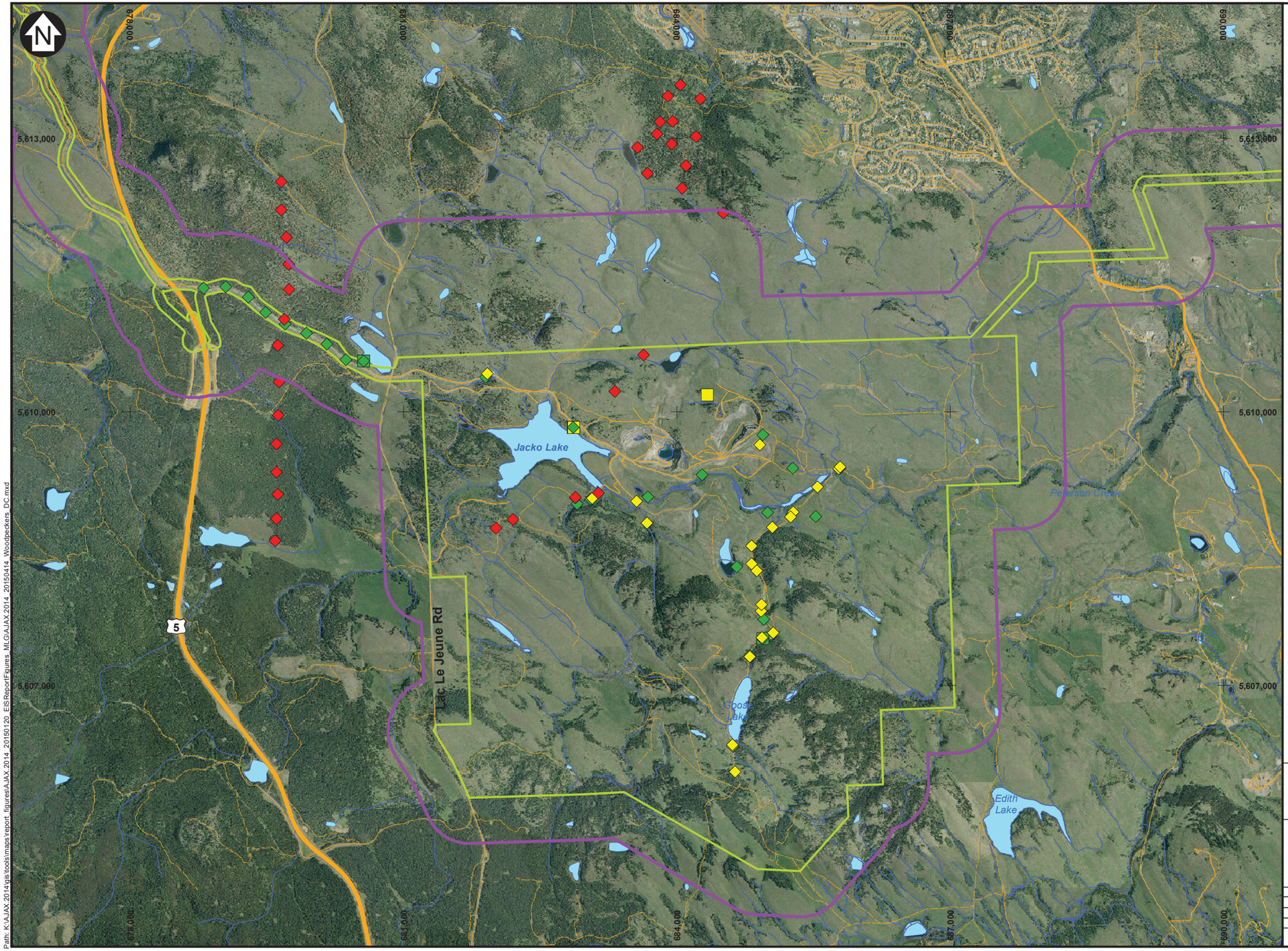


Figure 6.14-8
Woodpecker Survey Locations



Legend

WISA Standwatch - Year
- 2007
- 2008
- 2010

LEWO Standwatch - Year
- 2007
- 2008
- Local Study Area
- Infrastructure Disturbance Area
- Highway
- Paved Road
- Gravel/Rough Road
- River
- Major Water Feature

NOTES:
1. BASE MAP:
2. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD 1983 UTM ZONE 10N.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:45,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
4. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENCE - BRITISH COLUMBIA AND CANADA

SCALE 0 0.4 0.8 1.2 Kilometres

KGHM Ajax Mining Inc.

2015 August 06			
DATE			
PvL	JH	PvL	JR
DESIGNED	DRAWN	CHK'D	APP'D
REF NO.	AJAX.2014_20150414_Woodpeckers_DC		REV A

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Water Quality

Baseline water quality was measured throughout the LSA (Surface Water Quality, Section 6.3). This included portions of Peterson Creek and Humphrey Creek as well as several other areas such as the seepage ponds and south catchment.

Characterization of Migratory Bird Baseline Condition

Habitat Mapping

Lewis's Woodpecker reproducing habitat mapping identified 4,204 ha of low suitability habitat in the LSA (Figure 6.14-9). Little suitable habitat (mature ponderosa pine or black cottonwood forest with a high density of standing snags) is present in the LSA, although scattered large snags are available in grasslands and in young forest.

Mapping for Williamson's Sapsucker (Living Habitat requirements) identified 88.7 ha of low suitability habitat in the LSA (Figure 6.14-10). The limited amount of habitat available is reflective of the scarcity of mature forests with snags and/or large-diameter aspens in the LSA.

Breeding Bird and Migrating Bird Surveys

Between 2007 and 2014, 361 breeding bird point count surveys were completed, resulting in the detection of 85 species (excluding raptors, grouse, waterfowl, water birds, and shorebirds, which are reported elsewhere). Five species listed as Threatened by COSEWIC were detected including: Barn Swallow (Blue-listed), Bank Swallow, Common Nighthawk, Lewis's Woodpecker (Red-listed), and Olive-sided Flycatcher (Blue-listed). Breeding activity was documented for Barn Swallow.

In 2014, 199 migratory bird point count surveys were completed resulting in the detection of 49 species (Appendix 6.8-A). Only two additional species were detected during migrant counts that were not detected during breeding bird point counts (American Pipit and Nashville Warbler). Large flocks of Sandhill Cranes (140 – 150 birds) were observed flying over the RSA on migration, primarily during the last week of April in 2008 and again in 2014. No cranes were observed landing in the LSA but multiple crane tracks were noted in the mud around alkaline ponds in the grasslands north of the historic Ajax pits.

Waterfowl Surveys

A total of 151 observation stations at wetlands were used to survey waterfowl, shorebirds, and water-associated birds. Forty waterfowl/shorebird/water bird species (Appendix 6.8-A) were detected, including one blue-listed species, the Cackling Goose. Incidental observations of two Cackling Geese and a Great Blue Heron were also recorded. Unconfirmed observations of the Long-billed Curlew (Blue-listed) were noted. Single calls of a Long-billed Curlew were heard on two occasions, though the bird itself could not be visually confirmed and its call was not repeated.

Call Playback Surveys

Total survey effort for call-playback surveys is summarized in (Table 6.14-6, Appendix 6.8-A). One Williamson's Sapsucker was detected along Peterson Creek in 2007, on the east side of Goose Lake Road. Thirty-two Common Nighthawk detections were recorded on 20 stations, of which 13 detections

were booming males. Detections were concentrated south of Jacko Lake. Seventeen incidental detections of Common Nighthawk were recorded in 2010, 2011, and 2014 including a nest with two eggs observed on June 26, 2014, and a nest with two well-grown nestlings on August 14, 2014. No American Bitterns were detected.

Table 6.14-6. Summary of Call-playback Surveys

Target Species	Survey Effort (hr:min)	Survey Effort (# call stations)	Survey Observations	Incidental Observations
American Bittern	3:22	17	0	0
Common Nighthawk	2:06	29	32	17
Williamson's Sapsucker	11:18	124	1	0

Stand Watch Surveys (or Spot-mapping Surveys)

The total stand-watch time for Lewis's Woodpecker was 1 hour and 29 minutes. No Lewis's Woodpeckers were detected during stand-watches, but two individuals were observed incidentally north of the historic Ajax pits and near the existing tailings pond.

Water Quality

Antimony, Chromium, Cobalt, Nickel, Uranium, Zinc, Selenium, and Molybdenum were found to exceed aquatic and/or wildlife water quality guidelines in several sites throughout the LSA (Surface Water Quality, Section 6.3). This included portions of Peterson Creek and Humphrey Creek as well as several other areas such as the seepage ponds and south catchment.

Incidental Observations

Several listed species were detected incidentally during surveys targeting other taxa (Figure 6.14-11). A Great Blue Heron was seen in the yard of a ranch near Jacko Lake in 2007, and another heron was observed landing on Peterson Creek south of the historic Ajax pits in 2008. Barn Swallows were seen occasionally flying near the historic Ajax pits, and a Barn Swallow nest with an unhatched egg was found in a crevice on a rock outcrop near the edge of the propsed South Mined Rock Storage in August 2008. A Lewis's Woodpecker was sighted flying north of the historic Ajax pits, and another single bird was observed south of the Afton tailings pond in June 2008.

Summary

Baseline surveys confirmed the presence of Barn Swallow, Common Nighthawk, Great Blue Heron, Lewis's Woodpecker, Sandhill Crane, Olive-sided Flycatcher, Williamson's Sapsucker, and Waterfowl in the LSA. Long-billed Curlew is believed to be present in the LSA, but baseline surveys were unable to visually confirm two potential observations.

Although American Bitterns are likely present in the RSA, breeding has not been confirmed. This information combined with the lack of detections during targeted call-playback surveys, suggest that the Project will not have an interaction with American Bitterns. While effects are not anticipated for this species, the potential of the Project to interact with other species (Great Blue Heron) with similar habitat requirements will still be considered. Mitigation measures suggested for herons will also benefit bitterns that move into the LSA.

Figure 6.14-9
Lewis's Woodpecker Breeding Habitat Suitability and Observations in the LSA

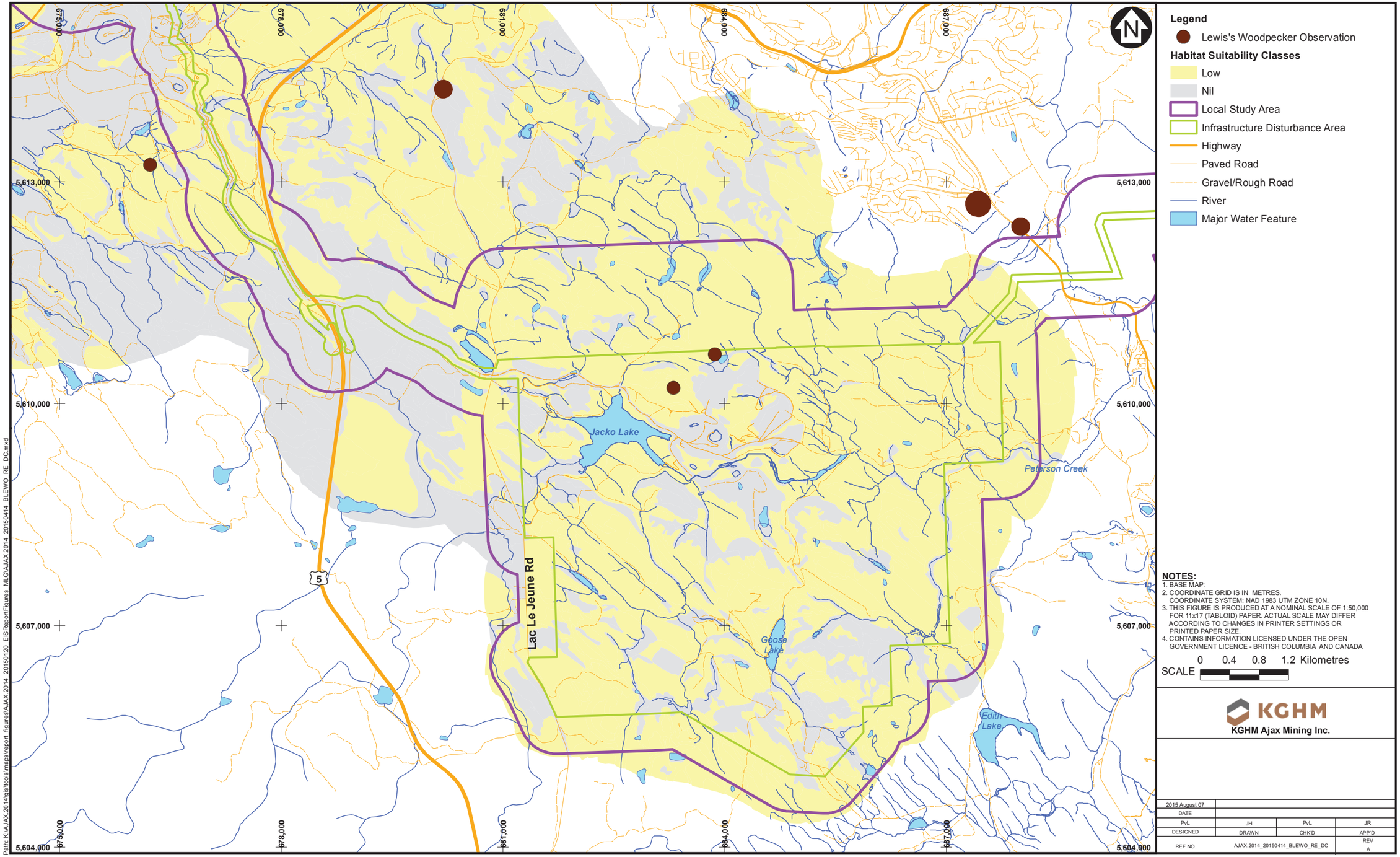


Figure 6.14-10
Williamson's Sapsucker Habitat Suitability and Observations in the LSA

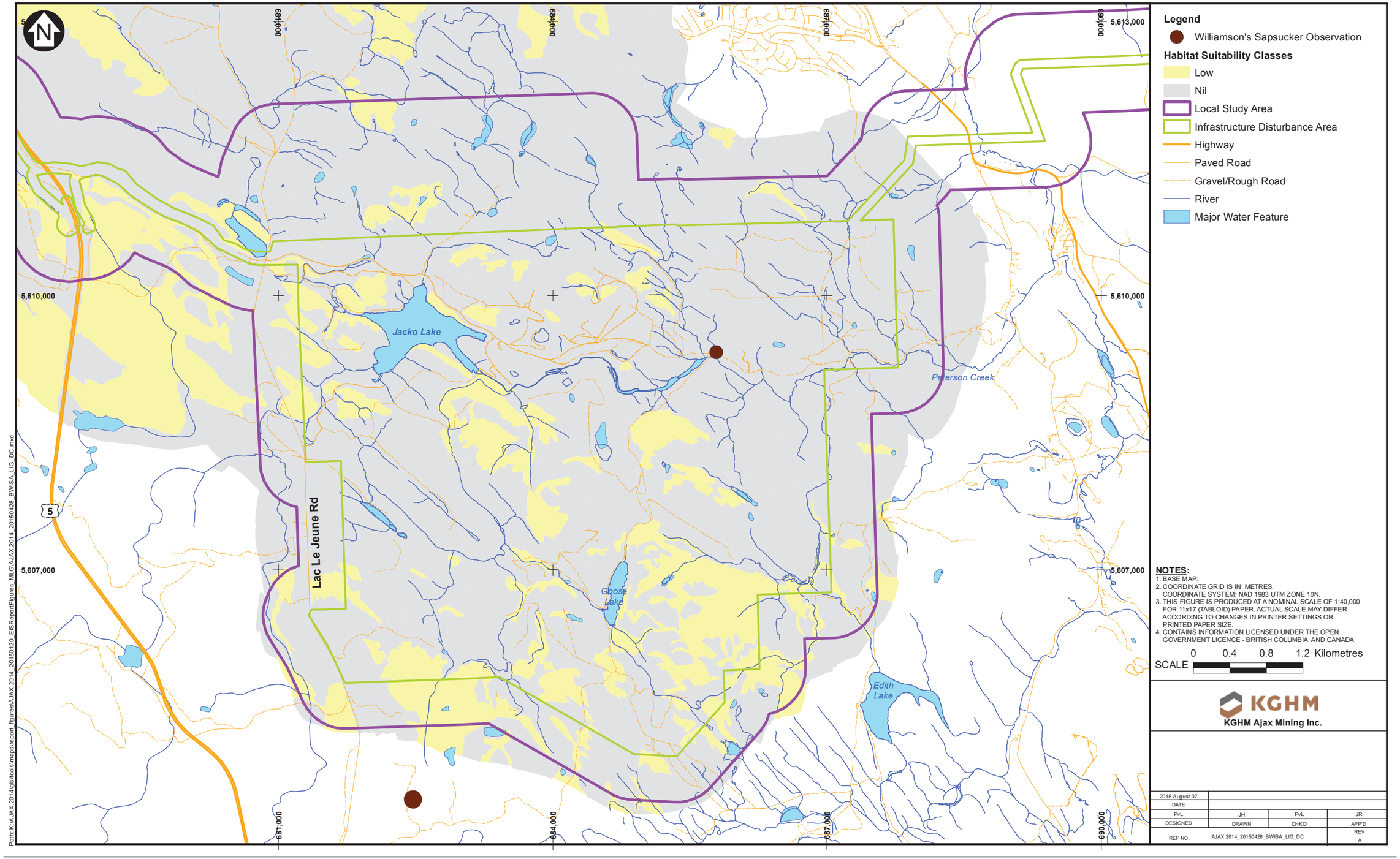


Figure 6.14-11
Migratory Bird Habitat Associations and Observations

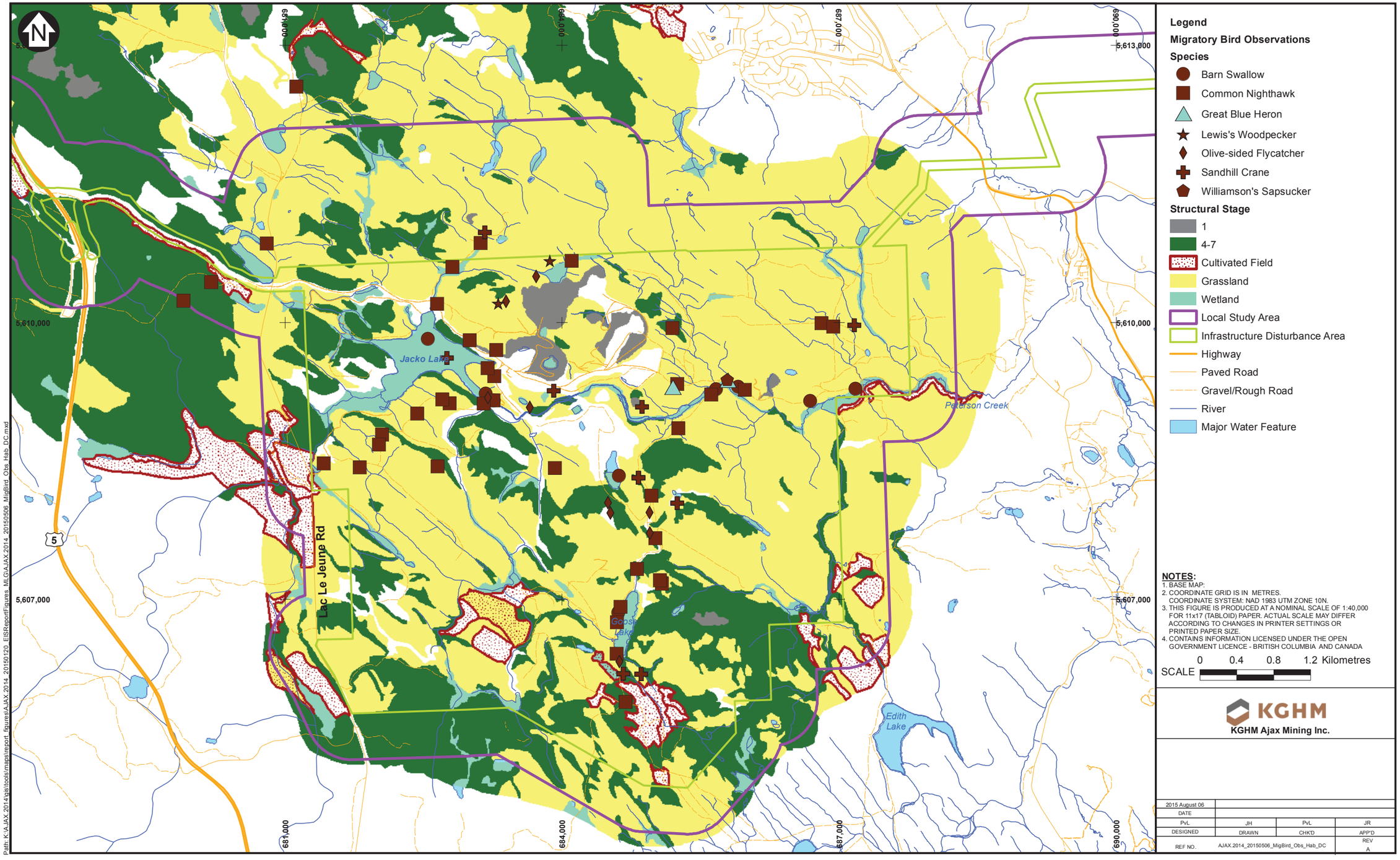


Table 6.14-7. Identifying Potential Project Interactions and Effects on Migratory Birds

	Project Activities	Potential Effects on Migratory Birds							
		Habitat Loss	Habitat Alteration	Sensory Disturbance	Disruption of Movement	Direct Mortality	Indirect Mortality	Wildlife Attractants	Chemical Hazards
Construction	Clearing and Grubbing	H	O	O	O	H	O	O	O
	Earthworks	H	O	O	O	H	O	O	O
	Overburden/Topsoil Stockpile	O	O	O	O	O	O	O	O
	Laydown Areas and Storage Yards	O	O	O	O	O	O	O	O
	Project Lighting	O	O	M	O	O	O	O	O
	Site Security and Fencing	O	O	O	O	O	O	O	O
	Fuel Storage and Filling Area	O	O	O	O	O	O	O	L
	Hazardous Wastes Transport, Storage, and Disposal	O	O	O	O	O	O	O	L
	Construction Wastes Transport, Storage, and Disposal	O	O	O	O	O	O	O	O
	Sewage Infrastructure and Disposal	O	O	O	O	O	O	L	L
	Public Road Realignment, Use, and Maintenance	O	M	M	O	M	O	O	O
	Haul Road Overpass, Use and Maintenance	O	M	M	O	M	O	O	L
	Haul Road Overpass Construction, Use, and Maintenance	O	O	O	O	O	O	O	O
	Site Buildings and Process Plant	O	O	O	O	O	O	O	O
	Explosives Magazine and Storage Facilities	O	O	O	O	O	O	O	O
	Open Pit Development	O	O	O	O	O	O	O	O
	Drilling and Blasting	O	L	H	O	O	O	O	O
	Crushing Mine Rock	O	L	M	O	O	O	O	O
	Loading, Hauling, and Deposition of Mine Rock	O	O	M	O	O	O	O	O
	Temporary Ore Stockpile	O	O	O	O	O	O	O	O
	Tailing Storage Facility Development	O	O	O	O	O	O	O	O
	Power Transmission, Distribution	O	L	O	O	M	O	O	O

(continued)

Table 6.14-7. Identifying Potential Project Interactions and Effects on Migratory Birds (continued)

Project Activities		Potential Effects on Migratory Birds							
		Habitat Loss	Habitat Alteration	Sensory Disturbance	Disruption of Movement	Direct Mortality	Indirect Mortality	Wildlife Attractants	Chemical Hazards
Construction *(cont'd)*	Natural Gas Line	O	L	O	O	O	O	O	O
	Pipeline Utility Corridor (Potable Water, Sewage, and Site Water)	O	L	O	O	O	O	O	L
	Water Intake from Kamloops Lake	O	O	O	O	O	O	O	O
	Fire Suppression Infrastructure	O	O	O	O	O	O	O	L
	Contact Water	O	O	O	O	O	O	O	H
	Non-contact Water	O	O	O	O	O	O	L	O
	Haul Road Overpass	O	L	O	O	O	O	O	O
	Water Management Dams	H	L	O	O	O	O	L	O
	Mine Staffing (Direct Employment)	O	O	O	O	O	O	O	O
	Contracted Employment	O	O	O	O	O	O	O	O
	Taxation	O	O	O	O	O	O	O	O
Operation	Open Pit Development	O	O	O	O	O	O	O	O
	Drilling and Blasting	O	L	H	O	O	O	O	O
	Hauling Mine Rock and Ore from Pit	O	O	M	O	O	O	O	O
	Crushing and Conveying Ore	O	L	M	O	O	O	O	O
	Temporary Ore Stockpile	O	O	O	O	O	O	O	O
	Development of Mine Rock Management Facilities	O	O	O	O	O	O	O	O
	Stripping, Loading, Hauling, Deposition, and Contouring of Topsoil and Overburden	O	O	L	O	O	O	O	O
	Revegetation through Progressive Reclamation	O	O	O	O	O	O	O	O
	Process Plant Operation	O	O	M	O	O	O	O	O
	Deposition to Tailing Storage Facility	O	O	O	O	O	O	O	L

(continued)

Table 6.14-7. Identifying Potential Project Interactions and Effects on Migratory Birds (continued)

Project Activities		Potential Effects on Migratory Birds							
		Habitat Loss	Habitat Alteration	Sensory Disturbance	Disruption of Movement	Direct Mortality	Indirect Mortality	Wildlife Attractants	Chemical Hazards
Operation *(cont'd)*	Site Road Use and Maintenance (Materials, Personnel, Supplies)	O	M	M	O	M	O	O	L
	Concentrate Transport and Storage	O	O	O	O	L	O	O	L
	Explosives Magazine and Storage Facilities	O	O	O	O	O	O	O	O
	Fire Suppression Infrastructure	O	O	O	O	O	O	O	L
	Fuel Storage and Filling Area	O	O	O	O	O	O	O	L
	Hazardous Wastes Transport, Storage, and Disposal	O	O	O	O	O	O	O	L
	General Wastes Transport, Storage, and Disposal	O	O	O	O	O	O	O	O
	Sewage Infrastructure and Disposal	O	O	O	O	O	O	L	L
	Laydown Areas and Storage Yards	O	O	O	O	O	O	O	O
	Power Transmission, Distribution	O	L	O	O	M	O	O	O
	Project Lighting	O	O	M	O	O	O	O	O
	Site Access, Security and Fencing	O	O	O	O	O	O	O	O
	Water Intake from Kamloops Lake	O	O	O	O	O	O	O	O
	Contact Water	O	O	O	O	O	O	O	H
	Non-contact Water	O	O	O	O	O	O	L	O
	Potable Water Treatment and Use	O	O	O	O	O	O	L	O
	Haul Road Overpass	O	L	O	O	O	O	O	O
	Mine Staffing (Direct Employment)	O	O	O	O	O	O	O	O
	Contracted Employment	O	O	O	O	O	O	O	O
	Taxation	O	O	O	O	O	O	O	O

(continued)

Table 6.14-7. Identifying Potential Project Interactions and Effects on Migratory Birds (continued)

	Project Activities	Potential Effects on Migratory Birds							
		Habitat Loss	Habitat Alteration	Sensory Disturbance	Disruption of Movement	Direct Mortality	Indirect Mortality	Wildlife Attractants	Chemical Hazards
Decommissioning and Closure	Dismantling of Ancillary Buildings	O	O	O	O	O	O	O	O
	Pit Lake Planning	O	O	O	O	O	O	O	O
	Site Road/Bridge Decommissioning	O	O	O	O	O	O	O	O
	Tailing Storage Facility Decommissioning and Reclamation	O	O	O	O	O	O	O	L
	Waste Rock Management Facilities Reclamation	O	O	O	O	O	O	O	O
	Fuel Storage and Filling Area	O	O	O	O	O	O	O	L
	Hazardous Wastes Transport, Storage, and Disposal	O	O	O	O	O	O	O	L
	General Wastes Transport, Storage, and Disposal	O	O	O	O	O	O	O	O
	Sewage Infrastructure and Disposal	O	O	O	O	O	O	O	L
	Laydown Areas and Storage Yards	O	O	O	O	O	O	O	O
	Power Transmission, Distribution	O	L	O	O	M	O	O	O
	Project Lighting	O	O	M	O	O	O	O	O
	Site Access, Security and Fencing	O	O	O	O	O	O	O	O
	Contact Water	O	O	O	O	O	O	O	H
	Non-contact Water	O	O	O	O	O	O	L	O
	Potable Water Treatment and Use	O	O	O	O	O	O	L	O
	Haul Road Overpass	O	L	O	O	O	O	O	O
	Road use to the Project (Materials, Personnel, Supplies)	O	L	L	O	L	O	O	L
	Mine Staffing (Direct Employment)	O	O	O	O	O	O	O	O
	Contracted Employment	O	O	O	O	O	O	O	O
	Taxation	O	O	O	O	O	O	O	O

(continued)

Table 6.14-7. Identifying Potential Project Interactions and Effects on Migratory Birds (completed)

Project Activities		Potential Effects on Migratory Birds							
		Habitat Loss	Habitat Alteration	Sensory Disturbance	Disruption of Movement	Direct Mortality	Indirect Mortality	Wildlife Attractants	Chemical Hazards
Post Closure	General Site Inspections and Maintenance	O	O	O	O	O	O	O	O
	Contact Water	O	O	O	O	O	O	O	H
	Non-contact Water	O	O	O	O	O	O	L	O
	Road use to the Project (Materials, Personnel, Supplies)	O	L	L	O	L	O	O	L
	Mine Staffing (Direct Employment)	O	O	O	O	O	O	O	O
	Contracted Employment	O	O	O	O	O	O	O	O

Notes:

O	*No interaction anticipated.*
L	*Negligible to minor interaction expected; implementation of best practices, standard mitigation and management measures; no monitoring required, no further consideration warranted.*
M	*Potential moderate interaction requiring unique active management/monitoring/mitigation; warrants further consideration.*
H	*Key interaction; warrants further consideration.*

Effects of the Project on American Bitterns are not anticipated. The potential effects of the Project will be assessed for Barn Swallow, Common Nighthawk, Great Blue Heron, Lewis's Woodpecker, Long-billed Curlew, Sandhill Crane, Olive-sided Flycatcher, Williamson's Sapsucker, and waterfowl.

6.14.4 Potential Effects of the Project and Proposed Mitigation for Migratory Birds

6.14.4.1 Identifying Potential Effects on Migratory Birds

The AIR identified potential effects as habitat alteration and loss, disturbance and displacement and mortality. These effects were further subdivided into: habitat loss; habitat alteration; sensory disturbance; disruption of movement; direct mortality; indirect mortality; wildlife attractants; and chemical attractants. An interaction matrix (Table 6.14-7) was used to help scope potential effects by considering potential interactions with Project activities/components, consistent with the approach outlined in the assessment methodology (Section 5.2.4.1.). Further rationale for the scoping of potential effects is provided below.

Habitat Loss

For the purposes of this assessment habitat loss is defined as the process by which suitable habitat is rendered functionally unable to support the indicator species. Habitat loss will occur during the Construction phase of the Project, specifically during vegetation clearing, land excavation, dams for water management and any other changes to the physical landscape. Permanent loss results from the replacement of habitat by Project infrastructure footprints (IF) and is considered the minimum spatial effect. All habitat occurring within the Project IF is assumed to be permanently lost. Habitat outside, but in close proximity to the Project IF, may not be permanently lost but is functionally compromised due to interactions with the Project IF. The IDA defines this area and is considered the maximum spatial effect for habitat lost during Project Construction and operation. Additional Project effects will not be considered for the Project IF where habitat has been permanently removed (i.e., a species cannot be displaced from habitat that has already been permanently lost).

Although multiple Project activities will result in habitat loss, for the purpose of this assessment habitat loss will result from clearing and/or grubbing, earthworks and water management dams during Construction. It is assumed that all Project IF will be cleared and/or grubbed prior to Construction. Similarly, earthworks will remove wetland habitat that is required for several indicator species within the IDA. Habitat reclamation during Operation and Decommissioning and Closure phases is considered a habitat gain. Suitable habitat is present in the LSA for migratory birds and an interaction with the Project is anticipated. A ranking of "high" was assigned for Project activities (Table 6.14-7) that will remove migratory bird habitat and warrants further analysis as described in Section 6.14.4.2.

Habitat Alteration

Habitat alteration is defined as a reduction in habitat suitability. Activities that affect the physical characteristics or accessibility of an area, either permanently or temporarily can result in a change in habitat suitability. Habitat alteration will occur throughout the construction and operation phases of the Project, specifically as a result of drilling, blasting, crushing and road use (fugitive dust deposition), soil compaction, linear feature use and maintenance (invasive species introduction,

vegetation maintenance) and changes in drainage and water quantity. Included within the IDA is a minimum 50 metre buffer between the edge of the Project IF and the IDA. This buffer incorporates habitat alteration resulting from edge effects into the maximum spatial habitat loss effect (Gieselman et al. 2013). As all suitable habitat within the Project IF will be permanently lost during initial Project Construction activities (minimum spatial habitat loss effect); habitat alteration will only be considered in intact habitat within the IDA and LSA. For the maximum spatial habitat loss effect (all habitat removed in the IDA), habitat alteration will only be considered in the LSA.

Invasive species can impact food availability and can change the quality of nest habitat for migratory birds (Lloyd and Martin 2005; Ortega et al. 2006; Ortega et al. 2013). The diversity of songbirds is also known to decrease in altered versus natural habitats (Ortega et al. 2006). An increase in invasive species as a result of the Project during all phases may impact migratory birds, particularly the Long-billed Curlew that nests in grasslands, which are particularly susceptible to invasive species. Linear features can act as vectors during Project Construction and operation resulting in the introduction and/or spread of invasive species.

Hydrological changes to wetland areas, specifically the Peterson Creek Diversion and the Downstream Pond, may alter the species composition and water levels at these sites. Changes that reduce the suitability of wetland habitat can be detrimental to wetland dependant migratory birds.

Project activities that will lead to habitat alteration include public and site road realignment, use and maintenance; drilling and blasting; crushing mine rock; crushing and conveying ore; Peterson Creek diversion; and linear features (power transmission, natural gas and pipeline corridor). These activities can degrade the habitat through the creation of fugitive dust, introduction and distribution of invasive species, and changes to hydrology patterns in wetlands. Suitable habitat is present for migratory birds in the LSA and an interaction with the Project is anticipated. A ranking of “low” to “moderate” was assigned for Project activities (Table 6.14-7) that will alter migratory bird habitat, and warrants further analysis as described in Section 6.14.4.2.

Sensory Disturbance

Sensory disturbance refers to a Project related activity (e.g., noise, light, human presence) that causes individuals to change their behaviour or avoid certain habitats that would otherwise be suitable. Disturbance can interrupt normal activity (e.g., foraging, courting, tending young) and cause an animal to move away from the source of disturbance, resulting in increased energy expenditures or utilization of sub-optimal habitats (Ward et al. 1999; Gill and Sutherland 2000; Gibeau et al. 2002; Bautista et al. 2004; Blanc et al. 2006). Disturbance during critical periods (e.g., Nesting season or migration) may be lethal to some species. For some VCs, noise can mask the sounds that individuals use to find prey, mates, and avoid predators (Barber et al. 2010). Masking can reduce fitness (breeding success), especially for species that are highly reliant on their acoustic environment. In some cases, habituation and adaptation can allow wildlife to accommodate the presence of noise in their environment.

Project activities expected to cause noise-sensory disturbance to migratory birds include public and site road construction, use and maintenance; drilling and blasting; crushing mine rock and conveying ore; loading, hauling, and deposition of mine rock/ore from pit; deposition, and contouring of topsoil and overburden; and process plant operation will cause noise-sensory disturbance to migratory birds.

The source, duration, and intensity of noise will influence how an animal will respond, whether it is disturbed, displaced, or becomes habituated. Most migratory birds will be disturbed by noise and an interaction is anticipated. A ranking of "moderate" to "high" was assigned for Project activities causing noise disturbance and further analysis is included in Section 6.14.4.2.

Artificial lighting may impact migratory birds. Tall lit structures can attract migratory birds during nocturnal migration. Birds have been known to circle lit structures to the point of exhaustion, causing collisions and mortality (Gathreaux, Jr. and Belser 2006; Longcore et al. 2013). Sensory disturbance due to Project lighting was given a ranking of "moderate" for migratory birds and further discussion is included in Section 6.14.4.2.

Disruption of Movement

Disruption of movement is likely to have a negligible potential effect on migratory birds. Birds can avoid infrastructure by flying around or over obstacles. The Project will not result in the disruption of migratory bird movement, and this effect will not be considered further.

Direct Mortality

Direct mortality is defined as the death of an individual resulting directly from a Project related activity. Direct mortality can result from any number of Project activities, but are typically associated with collisions with vehicle/machinery on roads, removal of a habitat feature while they are occupied, and interactions with anthropogenic structures (e.g., flying into transmission lines or windows in buildings). The risk of mortality on migratory birds is dependent on the activity, season, time of day and habitat type.

During Construction, some nesting indicator species will be susceptible to direct mortality caused by vegetation clearing during the breeding season. Consequently a ranking of "high" was given for those activities that may disturb or destroy active nests (clearing and grubbing, earthworks). This warrants further analysis as described in Section 6.14.4.2.

All wildlife are potentially vulnerable to mortality from collisions with vehicles. The risk of collisions will vary with the amount of traffic, speed of traffic, time of day, season, habitat type, and wildlife species. The increased traffic along the public road will likely result in increased mortality effects to migratory birds, particularly Olive-sided Flycatchers which are known to use edge habitat. Consequently, a ranking of "moderate" was given, and warrants further analysis as described in Section 6.14.4.2. This ranking was decreased to "low" during Decommissioning and Closure due to a reduced volume in traffic. This ranking was also considered "low" for transport of concentrate to the Port of Vancouver, as the incremental effect of those vehicles to existing highway traffic is very small.

Collisions with transmission lines or electrocutions is another source of mortality for bird species (Avian Power Line Interaction Committee 2006; Avian Power Line Interaction Committee 2012), though it is relatively rare occurrence. The risk of mortality is based on the type of line/ configuration of electrical hardware, proximity to specific habitats (e.g., wetlands), and weather/ visibility (Bevanger 1998). Waterfowl are particularly susceptible to collisions, due to the poor in-flight manoeuvrability (Bevanger 1998). Power lines located between feeding areas and nesting sites

for water associated birds can have increased risk of collision, particularly when a short distance separates the two, as birds must make a short flight at a critical height (McNeil et al. 1985; Bevanger 1994). Consequently the Power Transmission and Distribution Project activity was given a ranking of "moderate" particularly for waterfowl and shore birds. This warrants further analysis as described in Section 6.14.4.2.

Indirect Mortality

Indirect mortality is defined as the death of an individual resulting indirectly from a Project related activity. Wildlife mortality may be caused indirectly from increased access for hunting or poaching, from range shifts leading to increased resource competition between individuals, or from increased hunting pressure by natural predators.

Indirect mortality is not anticipated to impact migratory birds and no further analysis is required.

Wildlife Attractant

Wildlife attractants are defined as features or materials that may attract wildlife away from their natural environments, to areas that are superficially superior. Odours, food waste, sewage, garbage, and stored chemicals from construction crews and camps are examples of types of attractants that may entice individuals, but that ultimately will have a detrimental effect on the species.

During Construction and operation the presence of open water from sewage infrastructure and disposal, water management dams, non-contact, contact and treated potable water (potential sources of drinking water) throughout the LSA may attract waterfowl and other water associated birds. Contact water, for the purpose of this assessment, will be assessed under chemical hazards. As the occurrence of non-contact water will be limited to Project IF, where suitable habitat will be removed, the anticipated interaction between wildlife attractants was ranked as "low", and will be discussed further in Section 6.14.4.2.

Chemical Hazards

Chemical hazards are defined as chemicals that result from Project related activities that have the potential to cause an adverse health effect on wildlife. Wildlife may ingest, inhale, or absorb chemicals (e.g., metals, dust, organic anthropogenic substances, etc.) from improperly stored substances, dust on soil or vegetation, or bioaccumulation from prey. Oil, fuel, other petroleum-based fluids and antifreeze from machinery can cause direct mortality and habitat contamination if they are allowed to escape into the environment. Petroleum compounds can affect organisms physically (smothering, reduced light), via habitat modification (alterations in pH or diminished food availability) or via toxic action (Albers 2003).

During Construction and Operation, Project activities associated with hazardous substances include fuel storage and filling area; hazardous waste transport, storage and disposal; concentrate transport and storage; sewage infrastructure and disposal; fire suppression infrastructure; deposition to Tailing Storage Facility; and use of site roads and the pipeline utility corridor. Any accident or malfunction causing the release of a deleterious substance could result in a chemical hazard to the receiving

environment. Since policies and procedures will be in place to minimize and avoid accidents and malfunctions, the Project activities mentioned above were ranked "low" for chemical hazards.

Contact water, which is any water that may have come in contact with potentially toxic materials, may have a negative effect on migratory birds, particularly waterfowl and wetland associated species. Heavy metals such as copper, cadmium, lead, selenium and mercury are known to be persistent and mobile in the environment, and to be potentially toxic to many forms of life. Both terrestrial (i.e., Waste Rock Storage Facilities (WRSF) and aquatic (Tailings Storage Facilities (TSF) sources of metal contamination are present in the LSA. Contact water was ranked "high" during all Project phases, and warrants further consideration. Details of this analysis are presented in Section 6.14.4.2.

A complete list of Project activities and what effect each activity may have on amphibians is provided below (Table 6.14-7).

6.14.4.2 Effects on Migratory Birds

Further analysis of effects identified in Section 6.14.4.1 will be completed to quantify the impacts of Project activities on migratory birds.

Habitat Loss

Methods to Predict Impacts of Project Activities on Migratory Birds in the LSA

The amount of suitable habitat lost for migratory birds was calculated by determining the maximum and minimum potential effects. The maximum effect was calculated by overlaying the IDA footprint on the habitat suitability mapping or habitat associations for the indicator species (Appendix 6.8-A), while the minimum effect was determined by overlying the Project IF. The potential exists for an adverse effect on wildlife species and populations if high or moderate suitability habitat is present within the IDA or IF. The amount of suitable habitat lost within the IDA or IF was compared to the total amount of habitat within the LSA to calculate the percent of habitat lost within the LSA.

Methods to Predict Impacts of Project Activities on Migratory Birds in the RSA

To put wetland habitat loss into a larger context, the Vegetation Resources Inventory (VRI) mapping was used to assess the presence and distribution of wetlands within the RSA. VRI (2012) mapping was overlaid with a spatial file of the RSA. Wetlands were identified as non-vegetated water wetlands in the VRI.

To put grasslands into a larger context priority grassland areas (Grasslands Conservation Council (GCC) of BC 2004) were used to assess grassland presence and distribution within the RSA. Spatial boundaries of the proposed priority grasslands areas were obtained from the BC MOE and used to quantify the amount of priority grasslands.

Predicted Impacts of Project Activities on Migratory Birds in the LSA

No suitable habitat (ranked High or Moderate or class 1-3) for Lewis's Woodpecker or Williamson's Sapsucker were identified in the LSA. Based on the moderate loss of low suitability habitat and the

few observation of woodpeckers in the LSA, the potential effect of loss of woodpecker habitat is anticipated to be low.

The potential effect of grassland habitat loss for Long-billed Curlew is anticipated to be moderate considering the potential loss of up to 52% of available habitat in the LSA (Table 6.14-8; Figure 6.14-12). The long-billed Curlew was not confirmed in the LSA although this species is believed to breed in the area. The potential effect of wetland habitat loss for waterfowl and cranes ranges from 25 to 61% and is also expected to be moderate. Great Blue Herons will also use cultivated fields so the effect of habitat loss on this indicator species is moderate. Common Nighthawk and Olive-sided Flycatcher will lose up to 42% and 46% of habitat respectively and the effect of habitat loss on these species is moderate. Common Nighthawk were relatively common in the LSA with over 40 observations during baseline surveys. All observations of Barn Swallow were detected in the IDA and the potential effect to this species is moderate.

Table 6.14-8. Summary of Total Habitat Loss within the LSA

Indicator Species	LSA (ha)	Max Area lost (ha) - IDA	Min Area lost (ha)- IF	Range of Loss
Long-billed Curlew	3,564.4	1,859.0	1,064.5	30 – 52 %
Common Nighthawk	256.7	108.6	68.6	27 – 42 %
Great Blue Heron	462.7	216.5	116.5	25 – 47 %
Olive-sided Flycatcher	1,424.6	658.2	326.9	23 – 46 %
Waterfowl, Sandhill Crane	220.6	135.0	54.3	25 – 61 %

Predicted Impacts of Project Activities on Migratory Birds in the RSA

A fish habitat compensation program is being considered for Inks Lake and Jacko Lake. The current proposal includes stocking and raising the water level of the lake. An increase in the surface area of the lake would be considered a habitat gain for wetland associated indicator species and reduce effect.

The analysis of VRI identified 641 ha of wetlands in the RSA of which 13.4 ha occur in the Project LSA. Project activities will affect 0.4% of wetlands identified the RSA.

The BC grasslands mapping project identified 98,340 ha of grasslands in the Thompson Basin (Grasslands Conservation Council (GCC) of BC 2004). Project Construction is anticipated to remove up to 4.4 % of riparian priority areas, and up to 5.0% of terrestrial priority areas in the RSA (Table 6.14-9).

Table 6.14-9. List of Priority Grasslands within RSA, IDA and IF

Classification	Area in RSA (ha)	Area LSA (ha)	Area in IDA (ha)	Area in IF (ha)	Range of Loss
Riparian priority areas	3,249.0	300.3	142.8	31.8	1.0 to 4.4 %
Terrestrial priority areas	23,006.7	2,528.2	1,150.9	671.3	2.9 to 5.0 %
Working landscape	35,604.3	4,202.2	2,092.8	1,015.5	2.9 to 5.9 %

Habitat Alteration

Methods to Predict Impacts of Project Activities on Migratory Birds

Linear features (roads, pipelines, transmission lines) were buffered by 100 metres to determine the area where habitat alteration effects resulting from invasive plant species could occur. The 100 m buffer was determined based on literature review and predominance of grassland habitats (Tyser and Worley 1992; Hansen and Clevenger 2005). Grasslands associated migratory birds will experience the greatest effect since grasslands are susceptible to invasive species. Forest communities are not as sensitive to invasive plants and vectors for aquatic invasive species are not components of the project. The 100 m buffer was overlaid on the habitat suitability mapping or habitat association maps for migratory birds to determine the amount of suitable habitat affected. Habitat alteration cannot occur in areas where habitat has been lost, including the IF (minimum habitat loss effect) and the IDA (maximum habitat loss effect). The amount of suitable habitat altered is reported excluding the IF and the IDA.

Migratory birds are not particularly susceptible to fugitive dust. The area is known to be frequented by dust storms so the species present are expected to have some tolerance to dust. The maximum dust fall (see Air Quality, Section 10.1) is not expected to exceed the BC MOE guideline of 1.75 mg/dm^3/day (British Columbia Ministry of Environment 2014). As such, habitat alteration resulting from dust fall is not expected to occur.

Hydrological changes will only affect wetlands within the IDA and LSA, since all wetlands within the IF will be permanently lost. The location and Project activity was considered to determine the potential effect of hydrological changes to wetlands in the IDA and LSA.

Predicted Impacts of Project Activities on Migratory Birds

The introduction of invasive plants may have an interaction with Long-billed Curlew, Common Nighthawk, Great Blue Heron, Olive-sided Flycatcher, Sandhill Crane, and Waterfowl. Woodpeckers are not expected to be effected by habitat alteration due to the low suitability of habitat in the LSA. Habitat alteration resulting from the spread of invasive plants is anticipated to affect up to 12% of migratory bird habitat (Table 6.14-10, Figure 6.14-13). Long-billed Curlew has the greatest potential to be affected since it is associated with grassland habitat, which is more susceptible to invasive species, and has a maximum effect of 12% of habitat altered. However, Curlews are also associated with agricultural areas indicating they may tolerate invasive species. The potential effect of habitat alteration on migratory birds is anticipated to be low to moderate based on the range of habitat altered.

Table 6.14-10. Summary of Migratory Bird Habitat Alteration

Indicator Species	LSA (ha)	Altered Area (ha) (exclude IF)	Altered Area (ha) (exclude IF & IDA)	Range of Altered Habitat
Long-billed Curlew	3,564.4	429.7	65.9	2 – 12 %
Common Nighthawk	256.7	15.6	0.9	0 – 6 %
Great Blue Heron	462.7	33.0	9.2	2 – 7 %
Olive-sided Flycatcher	1,424.6	146.6	37.8	3 – 10 %
Waterfowl, Sandhill Crane	220.6	17.7	2.2	1 – 8 %

Figure 6.14-12
Habitat Loss forMigratory Birds

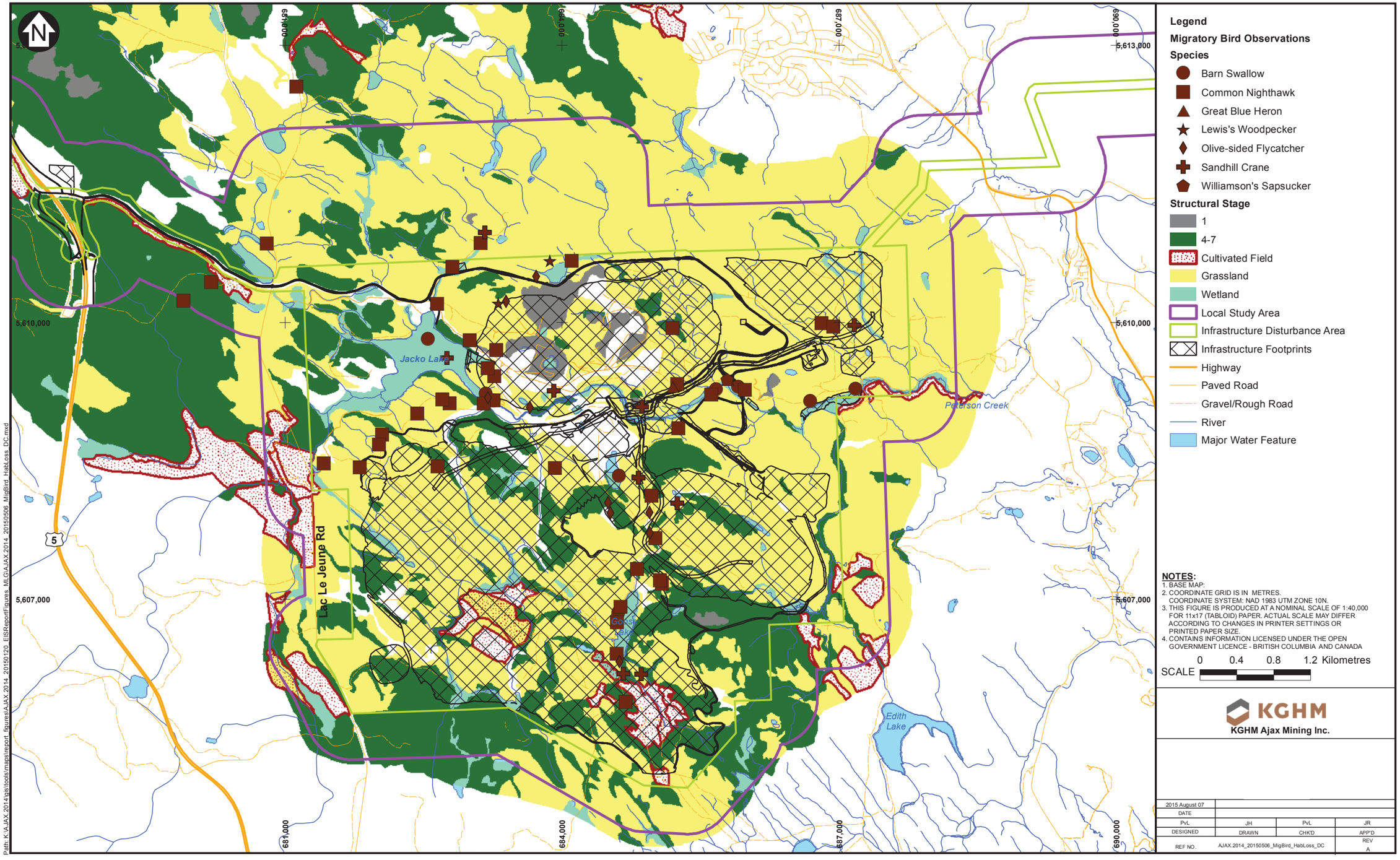
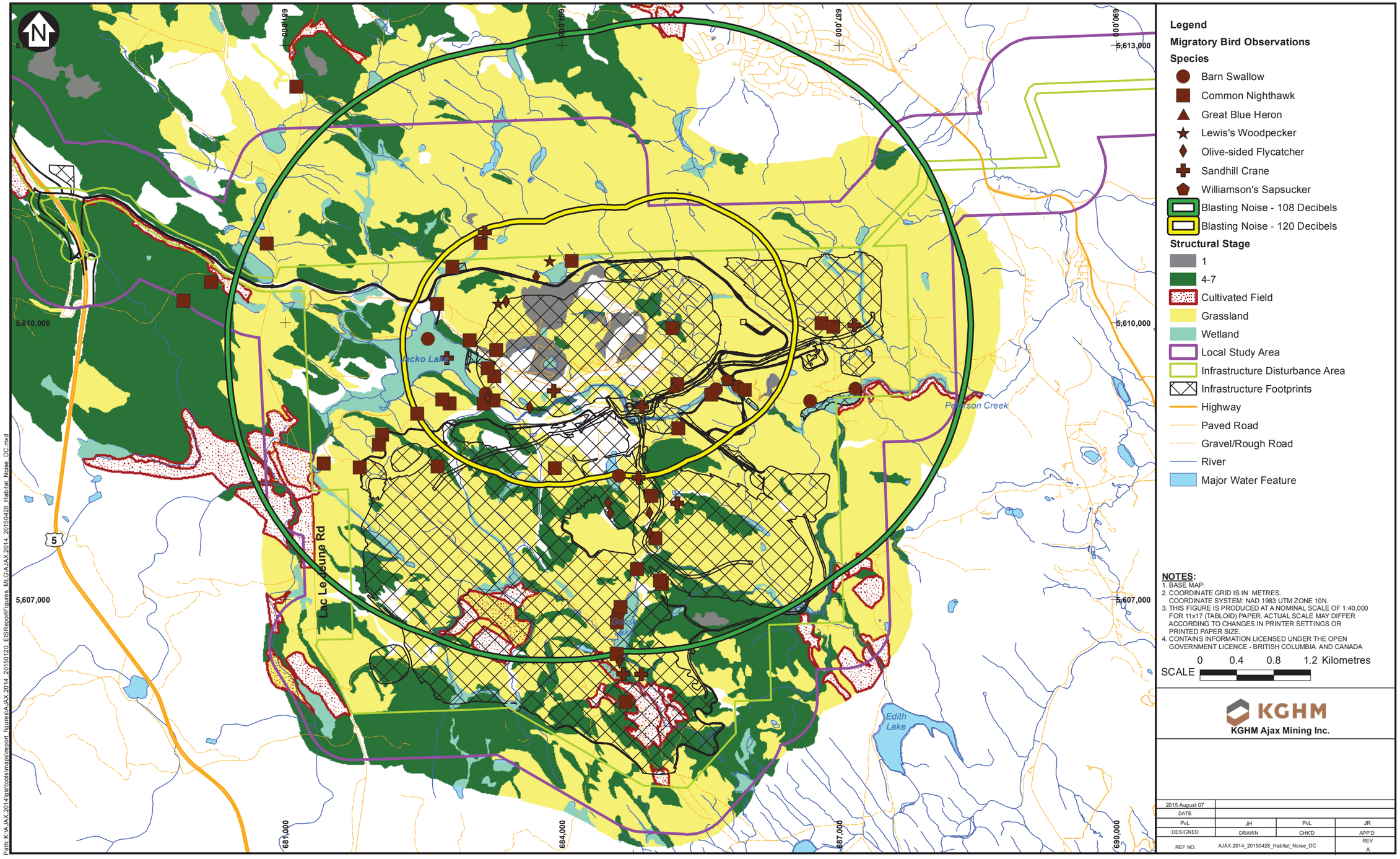


Figure 6.14-13
Migratory Bird Habitat Associations and Noise Disturbance



The diversion of approximately three kilometres of Peterson Creek may alter the watercourse downstream of the proposed diversion. Indicator species were observed along Peterson Creek during baseline surveys and reduced water levels may lead to a reduction in suitable habitat for migratory birds outside of the IF. There are currently 3.2 ha of wetlands along Peterson Creek and the hydrology of these wetlands will be altered. Wet areas will also be retained/created at the point of discharge and upstream of the diversion dam associated with the downstream pond. Peterson creek also has several beaver dams along its length indicating that inter-annual variation in flow rates occurs under current conditions. Based on this information the diversion will still provide habitat for migratory birds. As such, migratory bird habitat alteration resulting from the Peterson Creek diversion is anticipated to be low.

Sensory Disturbance

Methods to Predict Impacts of Project Activities on Migratory Birds

Sensory disturbance was determined for the migratory birds using noise contours modelled for the Noise Effects Assessment (Section 10.5). Continuous noise levels exceeding 47 dB in grasslands is associated with decreased bird abundance and diversity (Reijnen et al. 1996; Reijnen and Foppen 2006). Since continuous Project noise is not expected to exceed 45 dB no interaction with migratory birds is expected. Dooling and Popper (2007) identified noise guidelines for the potential effects of different noise sources on bird species. Noise levels resulting in hearing damage for bird species included 140 dB(A) for a single impulse (e.g., blast) and 125 dB(A) for multiple impulse (e.g., pile driving). Project noise associated with blasting is expected to interact with migratory birds and noise contours at 140 dB and 125 dB were overlaid on migratory bird habitat. The amount of habitat affected by each noise level was determined for each indicator species. Sensory disturbance cannot occur in areas where habitat has been lost, including the IF (minimum habitat loss effect). The amount of suitable habitat disturbed is reported excluding the IF.

Little is known about the impacts of artificial lighting on migratory birds, professional judgement based on sensitivity of the species, proximity of habitat and likelihood of interaction (e.g., time of activity) was used to determine if there is any interaction effect.

Predicted Impacts of Project Activities on Migratory Birds

Sensory disturbance is not anticipated to have an effect on Lewis's Woodpecker or Williamson's Sapsucker based on the low suitability of habitat present for these two indicator species. Although these two species have been confirmed in the Project area they likely occur at low densities in the region and are therefore unlikely to be affected by noise disturbance associated with the Project.

Sensory disturbance is anticipated to impact migratory birds during the Operation phase of the Project. Effective habitat loss will occur in areas that are exposed to noise levels above 140 dB for all migratory bird indicator species. The Long-Billed Curlew will lose an additional 35 ha of available habitat, and all other indicator species will lose up to 2% of available habitat (Table 6.14-11). Effective habitat loss resulting from sensory disturbance is anticipated to have a negligible effect on migratory birds based on the amount and proportion of additional habitat lost.

Table 6.14-11. Suitable Habitat Disturbed by Noise for Migratory Birds

Indicator Species	LSA (ha)	Disturbed Area – 140 dB (ha) (excluding IF)	Disturbed Area – 125 dB (ha) (excluding 140 dB & IF)	Range of Altered Habitat
Long-billed Curlew	3,564.4	34.6	187.6	1 - 5 %
Common Nighthawk	256.7	8.4	5.1	2 - 3 %
Great Blue Heron	462.7	2.7	23.1	1 - 5 %
Olive-sided Flycatcher	1,424.6	3.2	23.5	0 - 2 %
Waterfowl, Sandhill Crane	220.6	2.7	23.1	1 - 10 %

Additional habitat may be effectively lost if multiple blasting events occur at noise levels exceeding 125 dB. The Long-billed Curlew will experience the greatest effect with 188 ha of additional habitat lost, and waterfowl and Sandhill Cranes will have the greatest proportion of habitat affected at 10 % (Table 6.14-11). Noise sensory disturbance at 125 dB is will have a negligible to low effect on migratory birds if it occurs. Since blasting is currently scheduled to occur once a day at noon, and breeding bird's activity is typically highest in the morning for the first few hours after sunrise, this effect is not anticipated to occur.

Project lighting can attract and disorient migratory birds resulting in the depletion of energy reserves. Birds that migrate at night are particularly susceptible to artificial lighting (Gathreaux, Jr. and Belser 2006). No effect of lighting on migratory birds is anticipated during Construction since construction activities are expected to only occur during the day. During Operation the impact of project lighting on migratory birds, particularly waterfowl, is anticipated to be minimal for the majority of the year. During migration periods, the potential for lighting to impact waterfowl migration increases, as waterfowl are more susceptible to changes in lighting, with light systems on tall towers being particularly hazardous. The city of Kamloops is currently a significant source of light pollution. The anticipated effect of Project lighting on migratory birds is anticipated to be low based on the limited time period that the interaction will occur, the presence of significant light pollution in the area and the absence of lighted towers in the project design.

Disruption of Movement

Disruption of movement is unlikely to have an effect on migratory birds as they can fly around or over obstacles. The Project will not result in the disruption of migratory bird movement.

Direct Mortality

Methods to Predict Impacts of Project Activities on Migratory Birds

To determine the effect of direct mortality for Migratory Birds professional judgement was used considering the location and proportion of suitable habitat available in the Project area. Clearing schedules and Project infrastructure location (roads, transmission lines) were also key considerations.

Road mortality depends on the number of additional roads within the IDA, the proposed use of these roads, and the amount of suitable habitat in the IDA and the location of habitat relative to

roads. Those species with low manoeuvrability will be most susceptible to mortality as a result of vehicular collision.

Predicted Impacts of Project Activities on Migratory Birds

Eggs and unfledged juveniles will be lost if active nests are removed during clearing, while adults will be able to flee. Some species may re-nest in other undisturbed habitat following clearing. Habitat loss for indicator species ranges from 23 to 30%. Assuming suitable habitat is occupied, up to 30% of nestlings present in the Project area could be lost, if clearing occurs during the breeding season.

The movement of vehicles and construction machinery on Project roads may cause bird mortality as a result of wildlife-vehicle collisions. Flocking species are most likely to experience road mortalities during winter or early spring (Campbell et al. 1997). Water-associated birds may interact with roads that are adjacent to water bodies. The main access road runs through suitable forested habitat and runs adjacent to suitable water bodies (including Jacko Lake). The Olive-sided flycatcher could interact with roads adjacent to forests while waterfowl, Sandhill Cranes and Great Blue Herons could interact with roads adjacent to wetlands. The anticipated effect of vehicular mortality on migratory birds is anticipated to be low based on the relatedly low volume and frequency of traffic on the Project roads.

Collisions with transmission lines or electrocutions can occur, but are expected to be a rare occurrence. Waterfowl and shorebirds can collide with transmission lines adjacent to water bodies (Bevanger 1998), but few wetlands are present adjacent to the transmission line corridor in the Project area, so the effect on these indicator species is expected to be low. Empirical studies find that the death rate at the population level is low for most species involved in collisions (Brown 1993; Hugie et al. 1993). Static wires which protect against power outages caused from lightning strikes are usually less visible and are particularly difficult for birds to avoid during fog, rain, snow or other weather conditions that decrease overall visibility (Avian Power Line Interaction Committee and US Fish and Wildlife Service 2005). The potential effect of collisions with transmission lines is expected to be low based on the presence of open grassland habitat adjacent to the transmission line and the more agile species associated with this habitat type.

Wildlife Attractants

The presence of any exposed water across the LSA has the potential to attract water-associated birds and interactions with contact water could have toxic effects. Contact water will be assessed as a chemical hazard. Non-contact and potable water may attract water-associated birds if waterbodies are created. Creation of waterbodies would be a habitat gain, provided they are managed appropriately. No potential effects from wildlife attractants on migratory birds are expected to occur.

Chemical Hazards

Methods to Predict Impacts of Project Activities on Migratory Birds

To determine the potential effect of hazardous chemicals a qualitative approach was taken considering the presence of migratory birds or suitable habitat, potential for exposure (e.g., method of uptake such as ingestion or dermal exposure), likelihood of toxicity and likelihood of bioaccumulation. Hazardous chemicals were examined based on BC water quality guidelines for

wildlife (BC Ministry of Environment 2014a). The concentrations of potentially hazardous chemicals were modelled at five locations: Jacko Lake, the Peterson Creek Diversion Pond and Humphrey Creek in the Project IF, and Peterson Creek node 2.3 and 2.0 in the LSA. Seven Project infrastructure sites were also modelled, including three sites on Tailing Storage Facility (TSF, TSF S WMP, and TSF SE WMP) and four sites on the Mine Rock Storage Facility (WMRSF 1, WMRSF 2, SMRSF, and EMRSF). Modelling considered start of Construction to year 124 (100 years Post Closure), with major ions, nutrients and dissolved metals modelled for each month. Only those elements that exceed wildlife guidelines will be discussed (BC Ministry of Environment 2014a). Wildlife guidelines are the maximum recommended concentration of elements to protect wildlife from potentially adverse health effects. Wildlife guidelines have not been developed for the majority of elements due to a lack of sufficient research. Exceeding water quality guidelines does not imply that unacceptable risks exist, but rather that the potential for adverse effects may be increased and additional investigation may be required. Details of the modelling are provided in Section 6.3. An ecological risk assessment (ERA) was conducted to determine risk quotients (RQs) for various avian species. Details for this assessment can be seen in Appendix 10.4-A.

Predicted Impacts of Project Activities on Migratory Birds

Water quality within Jacko Lake and in the Peterson Creek Downstream Pond is not expected to exceed wildlife water quality guidelines for any dissolved metals (Section 6.3).

At Peterson Creek node 2.3, sulphate is anticipated to exceed wildlife guidelines in May of year 1 of Operation (Table 6.14-12).

Table 6.14-12. Modelled Median Water Quality for Peterson Creek 2.3

Dissolved Metals	Wildlife Guideline (mg/L)	No. of Months Guidelines Exceeded	Max Modelled Value (mg/L)
Sulphate (SO_4^{2-})	429	1	667

At Peterson Creek node 2.0, selenium and sulphate will exceed wildlife water quality guidelines (Table 6.14-13). Baseline selenium levels at this node exceeded the wildlife water quality guideline of 0.002 mg/L in April of 2011 and 2013, with a maximum level of 0.004 mg/L. Selenium levels at this node are expected to be above this baseline maximum starting in April and May of year 1 and every April and May thereafter until year 124. Sulphate levels are anticipated to exceed wildlife guidelines in January, February, and September through December of Construction, January through April and September through December of Operations from year 1 to year 24, and January through May and September through December in all subsequent years.

Table 6.14-13. Modelled Median Water Quality for Peterson Creek 2.0

Dissolved Metals	Wildlife Guideline (mg/L)	No. of Months Guidelines Exceeded	Max Modelled Value (mg/L)
Selenium (Se)	0.002	249	0.0034
Sulphate (SO_4^{2-})	429	1,098	989

At Humphrey Creek, mercury, molybdenum, selenium, and sulphate are expected to exceed wildlife water quality guidelines (Table 6.14-14). Mercury will exceed wildlife water quality guidelines in May, August, September, and November in Construction and for the first 29 years of Operations. Molybdenum will exceed wildlife guidelines in April, May, and June of year 26, April and May in years 27 & 28, and April of year 29; molybdenum will again exceed guidelines from December through February, beginning in year 37 & 38, and November through February from year 39 to 55, and again from years 84 to 106. Selenium will exceed wildlife guidelines from January to May, and December of Construction and throughout all of Operations. Sulphate will exceed guidelines in December of year 37, December of through February starting in year 38 and ending in year 50, once in December of year 80, and again from February through December, from year 84 to year 105.

Table 6.14-14. Modelled Median Water Quality for Humphrey Creek

Dissolved Metals	Wildlife Guideline (mg/L)	No. of Months Guidelines Exceeded	Max Modelled Value (mg/L)
Mercury (Hg)	0.00002	120	0.000082
Molybdenum (Mo)	0.05	165	0.0964
Selenium (Se)	0.002	775	0.0065
Sulphate (SO_4^{2-})	429	104	493

Fluoride, mercury, molybdenum, selenium, and sulphate are expected to exceed wildlife water quality guidelines in the TSF (Table 6.14-15). Fluoride is expected to exceed guidelines from November of year 2 of until year 24. Mercury will exceed guidelines from May of year 4 to the end of year 24. Molybdenum will exceed wildlife water quality guidelines throughout Construction and all of Operation, excluding May to December of year 1. Selenium will exceed guidelines throughout Construction and all of Operation, beginning in April of year 2. Sulphate will exceed wildlife guidelines throughout Construction (excluding April), and throughout Operation, beginning in December of year 1.

Table 6.14-15. Modelled Median Water Quality for the TSF

Dissolved Metals	Wildlife Guideline (mg/L)	No. of Months Guidelines Exceeded	Max Modelled Value (mg/L)
Fluoride (F^-)	1	266	1,420
Mercury (Hg)	0.00002	275	0.00025
Molybdenum (Mo)	0.05	292	2.20
Selenium (Se)	0.002	285	0.017
Sulphate (SO_4^{2-})	429	288	7,250

The TSF South and Southeast Embankment water management ponds (WMPs) will exceed wildlife water guidelines for mercury, molybdenum, selenium, and sulphate (Tables 6.14-16 and 6.14-17). In addition to these four exceedances, the southeast embankment will also exceed fluoride and chloride levels (Table 6.14-17). Mercury will exceed wildlife water quality guidelines in the south embankment from year 37 through year 124, and in the southeast embankment from year 35 to 124. Molybdenum will exceed guidelines in the south embankment starting in April of year 24 and in the

southeast embankment in September of year 22 and will continue to exceed at both sites through to year 124. Selenium will exceed guidelines in the south embankment starting in July of year 13 and will continue to exceed through to year 124, whereas the southeast embankment will exceed in June of year 16 to year 124. Sulphate will exceed guidelines at both sites, starting in December of year 41 in the south embankment and in September of year 76 in the southeast embankment. Both sites will continue to exceed sulphate guidelines until year 124, with the exception of a few sporadic months when levels will drop down to just below guideline standards.

Table 6.14-16. Modelled Median Water Quality for the TSF South Embankment WMP

Dissolved Metals	Wildlife Guideline (mg/L)	No. of Months Guidelines Exceeded	Max Modelled Value (mg/L)
Mercury (Hg)	0.00002	1,049	0.000052
Molybdenum (Mo)	0.05	1,209	0.50
Selenium (Se)	0.002	1,338	0.014
Sulphate (SO_4^{2-})	429	993	920

Table 6.14-17. Modelled Median Water Quality - TSF Southeast Embankment WMP

Dissolved Metals	Wildlife Guideline (mg/L)	No. of Months Guidelines Exceeded	Max Modelled Value (mg/L)
Chloride (Cl^-)	600	195	714
Fluoride (F^-)	1	748	1.4
Mercury (Hg)	0.00002	1,061	718
Molybdenum (Mo)	0.05	1,228	0.000068
Selenium (Se)	0.002	1,303	0.0095
Sulphate (SO_4^{2-})	429	565	718

Chloride will exceed wildlife water quality guidelines from year 106 to year 124. Starting in year 106, guidelines will be exceeded for about half the year, increasing by approximately one month per year until year 112, when levels will remain in exceedance until year 124. Fluoride will exceed wildlife guidelines starting in year 61, when levels will be exceeded for approximately half the year. Levels will increase approximately one month per year until year 65, when levels will exceed guidelines until the end of year 124.

The West Mine Rock Storage Facilities (WMRSF) water management ponds (WMP1 and WMP2) will exceed wildlife guidelines for mercury, molybdenum, selenium, and sulphate (Table 6.14-18, Table 6.14-19). Mercury will exceed wildlife water quality guidelines in the WMP1 from May of year 4 until March of year 27. In the WMP2, mercury will exceed guidelines between years 4 and 32 and from year 86 until year 124; between year 32 and 60, mercury levels will remain just below the acceptable wildlife level, while from year 60 to 86, mercury levels will fluctuate between just above and just below acceptable levels. Molybdenum will exceed guidelines starting in June of year 3 in the WMP1 and starting in May of year 4 in the WMP2, and will continue to exceed at both sites until year 124. Selenium will exceed wildlife guidelines in both the WMP1 and WMP2 starting in April of year 3 and continuing through until year 124. Sulphate will exceed wildlife guidelines in WMP1 from August of year 5 until April of year 25, and in WMP2 from August of year 5 until March of year 28.

Table 6.14-18. Modelled Median Water Quality - West Mine Rock Storage Facility North WMP 1

Dissolved Metals	Wildlife Guideline (mg/L)	No. of Months Guidelines Exceeded	Max Modelled Value (mg/L)
Mercury (Hg)	0.00002	272	0.000053
Molybdenum (Mo)	0.05	1,459	0.64
Selenium (Se)	0.002	1,461	0.035
Sulphate (SO_4^{2-})	429	236	784

Table 6.14-19. Modelled Median Water Quality - West Mine Rock Storage Facility North WMP 2

Dissolved Metals	Wildlife Guideline (mg/L)	No. of Months Guidelines Exceeded	Max Modelled Value (mg/L)
Mercury (Hg)	0.00002	896	0.000064
Molybdenum (Mo)	0.05	1,450	0.74
Selenium (Se)	0.002	1,461	0.044
Sulphate (SO_4^{2-})	429	270	963

The South Mine Rock Storage Facility (SMRSF) WMP will exceed wildlife water quality guidelines for fluoride, mercury, molybdenum, selenium, and sulphate (Table 6.14-20). Fluoride will exceed wildlife guidelines in most months between years 5 and 25, with the exception of late spring/early summer for a number of these years. Mercury will exceed guidelines beginning in May of Construction and will continue to exceed until the end of year 124; twenty months will see mercury levels drop below guidelines, but only marginally so. Molybdenum and selenium will both exceed wildlife guidelines from April of Construction until the end of year 124 of Operation. Sulphate will exceed guidelines beginning in August of Construction and will continue until February of year 28; Levels will be below guidelines between March and May in year 1 of Operation and again between May and July of year 27.

Table 6.14-20. Modelled Median Water Quality - South Mine Rock Storage Facility WMP

Dissolved Metals	Wildlife Guideline (mg/L)	No. of Months Guidelines Exceeded	Max Modelled Value (mg/L)
Fluoride (F^-)	1	180	1.4
Mercury (Hg)	0.00002	1,476	0.00048
Molybdenum (Mo)	0.05	1,497	2.54
Selenium (Se)	0.002	1,497	0.086
Sulphate (SO_4^{2-})	429	326	5,606

The East Mine Rock Storage Facility (EMRSF) WMP will exceed wildlife water quality guidelines for mercury, molybdenum, selenium, and sulphate (Table 6.14-21). Mercury will exceed guidelines between May of year 6 and March of year 25. Molybdenum will exceed wildlife guidelines from September of year 9 to February of year 10, and again from July of year 10 through April of year 25. Selenium will exceed wildlife guidelines from April of year 2 though to April of year 25. Sulphate will exceed guidelines from July of year 11 through February of year 25.

Table 6.14-21. Modelled Median Water Quality - East Mine Rock Storage Facility WMP

Dissolved Metals	Wildlife Guideline (mg/L)	No. of Months Guidelines Exceeded	Max Modelled Value (mg/L)
Mercury (Hg)	0.00002	227	0.000049
Molybdenum (Mo)	0.05	184	0.15
Selenium (Se)	0.002	277	0.024
Sulphate (SO_4^{2-})	429	164	634

Waterfowl and the wetland associated indicator species (Great Blue Heron and Sandhill Crane) will all be impacted by chemical hazards if these species are exposed to contact water. Large open bodies of water also provide stop-over habitat for migrating waterfowl. Migrating Sandhill Cranes and waterfowl may be exposed to chemical hazards if they choose to stopover in and around the tailings storage facility. However, exposure to migrants is expected to be of short duration. Resident water associated birds may also be attracted to the tailings storage facility and may attempt to nest in any vegetation nearby. As the amount of wetland habitat in the LSA will be reduced, these species may be more inclined to use sub-optimal habitat. The use of sub-optimal habitat for breeding or as stop-over habitat will have energetic costs to species. Jacko Lake is a primary stopover site for waterfowl presently and the water quality will be maintained above water quality guidelines.

Mercury can lead to adverse reproductive effects in waterfowl, including delayed gonadal development, reduced egg fertility, and depressed growth (Franson 2015). Methylmercury, which forms when inorganic mercury interacts with microbes in sediments and wetlands, is thought to be the most bioavailable and most toxic form of mercury. Mercury levels >2 mg/kg ww (wet weight) in the liver, >0.6 mg/kg ww in eggs, and >5 mg/kg ww in feathers may be associated with impaired reproduction; higher levels can result in mortality (Franson 2015). Mercury contaminated waterbodies occur throughout North America, and have the potential to lead to mercury bioaccumlation in waterfowl species that may use multiple contaminated sites during their yearly migrations (Cristol et al. 2012). This bioaccumulation can reduce reproductive success and can also exceed safe consumption guidelines (Cristol et al. 2012). Cristol et al. (2012) found that mercury exposed waterfowl can be harvested by hunters over 1,000 km from known contaminated sites.

The potential chemical hazard of molybdenum to upper trophic organisms (such as waterfowl) is not clear. Data of molybdenum effects are missing for avian wildlife (Swain 1986). In domestic birds, adverse effects of growth have been reported at dietary Mo concentrations of 200 mg Mo/kg, on reproduction at 500 mg Mo/kg and survival at 6,000 mg Mo/kg (Eisler 1989). Molybdenum levels are expected to exceed wildlife water quality guidelines throughout the life of the Project, particularly in Humphrey Creek, the TSF, the SMRSF, and the EMRSF. An adverse toxicity effect of molybdenum may occur on waterfowl and shorebirds. Monitoring of molybdenum levels in various food sources (algae, insects and fish) will be necessary.

High levels of selenium in waterfowl and shorebirds can cause physical abnormalities as well as high levels of dead and/or deformed embryos (Ohlendorf et al. 1986; Ohlendorf et al. 2011). The estimated toxicity threshold for waterbirds (stilts) was 0.004 mg/L selenium in water or less (ducks may be more sensitive than stilts; Frankenberger & Engberg 1998 p. 331). At 0.015 mg/L or more

selenium in the water led to 10-50% embryo deformation in waterbirds in the Tulare Basin (Frankenberger & Engberg 1998 p. 328). Selenium levels along Peterson Creek, Humphrey Creek, throughout the TSF and all WMPs are expected to exceed wildlife water quality guidelines. An adverse toxicity effect of selenium may occur for waterfowl and shorebirds.

Information from the ecological risk assessment (Appendix 10.4-A) states that aluminum and antimony were not quantitatively evaluated, but that the toxic potential of aluminum on birds is very low (i.e., levels greater than that which are found in the natural environment are needed to elicit an adverse biological response), and that toxicity values of antimony on bird eggs cannot be determined (based on post-hatching environmental exposure). Selenium levels were found to have slightly elevated risk quotients (RQs) for Great Blue Herons at Peterson Creek and for Mallards at Peterson Creek and Jacko Lake, for both the Baseline and Future cases; chromium levels were also found to have a higher RQ for Mallards in Peterson Creek. As Baseline risk (risk before Project activities) for Great Blue Heron only marginally exceeds the risk threshold, and that differences in Baseline and Future case are small, selenium is not anticipated to have an adverse effect on this species. Further biological assessments could assist in determining the risk associated with other fish eating birds. For Mallards (and other waterfowl as Mallards were used as a surrogate), selenium and chromium RQs are the same for Baseline and Future cases, suggesting that exposure to these chemicals of potential concern (COPCs) are not anticipated to manifest into adverse effects.

Ecological risk was also quantified for other avian receptor species', including American Robin and Canada Goose, based on the total exposure to COPCs from the environment relative to benchmark toxicological reference values. The change in potential risk to robins and geese as a result of the Project was deemed to be negligible.

Based on the result of the water quality provided above, mercury and molybdenum, and possibly selenium are likely to have interaction with waterfowl, Sandhill Crane, and Great Blue Heron. Sulphate, and to a lesser extent fluoride and chloride, may also have an interaction with waterfowl and other water associated birds, but specific effects from these compounds and anions on avian species are not well understood. These elements will exceed guidelines in the TSF, WMPs, downstream Peterson Creek and Humphreys Creek, at various times throughout the Project. This effect is anticipated to be moderate to wetland associated species. Other species, Barn Swallow, Common Nighthawk, Olive-sided Flycatcher, Lewis's Woodpecker, and Williamson's Sapsucker are not wetland associated and are not anticipated to experience chemical hazards.

6.14.4.3 Mitigation Measures for Migratory Birds

Mitigation measures proposed to address potential effects during all phases of the Project are discussed below. Management strategies and recovery plan are available for Long-billed Curlew, Common Nighthawk, Lewis's Woodpecker, Williamson's Sapsucker, Olive-sided Flycatcher and relevant measures from these publications have been included.

The objective of the Management Plan for the Lewis's Woodpecker (*Melanerpes lewis*) in Canada (Environment Canada 2014c) is to "increase the breeding population of Lewis's Woodpeckers in the six geographic regions across their current range in Canada to approximately 600 pairs by 2040."

Broad strategies and best management practices include:

- secure unprotected breeding habitat around known nesting locations; and develop and implement a strategy that will maintain the site as suitable in perpetuity;
  - this could include nest boxes, prescribed burning, and fungal inoculations;
- initiate management/stewardship of Lewis's Woodpecker nest trees and foraging habitats on unsecured crow lands, private land and Indian Reserve lands following best management practices;
- maintain open (<25% canopy closure) forests dominated by Ponderosa Pine, Black Cottonwood or Douglas-fir with some large snags, and recruitment trees;
- maintain mature riparian cottonwood stands (paper birch and trembling aspen also beneficial) with variable canopy closure and the presence of large trees;
- where available, maintain larger diameter wildlife trees;
- in areas where Lewis's Woodpecker occur, retain as many standing dead and damaged trees as possible for nesting during thinning and logging;
- provide naturally vegetated linkages between riparian areas, open forests and reserve areas of similar quality;
- livestock grazing should be limited where the Lewis's Woodpecker occurs to maintain understory necessary for insect prey base; and
- avoid frequent or prolonged human disturbance at nest sites during the breeding season (May to August).

The objective of the Recovery Strategy for the Williamsons's Sapsucker (*Sphyrapicus thyroideus*) in Canada/on Crown Lands in BC (Environment Canada 2014d) is to "ensure the persistence of the populations in Canada within each of the identified Areas of Occupancy". The Project area is outside the current area of occupancy but applicable strategies and conservation measures include:

- Habitat protection and management:
  - protect, conserve and manage Williamson's Sapsucker breeding territories,
  - determine the need for and feasibility of habitat element creation (creation of potential nest trees),
  - engage with private land owners who have Williamson's Sapsuckers on their property to facilitate and encourage BMPS on their lands;
- partner with existing organizations to increase awareness of the importance of wildlife trees for Williamson's Sapsucker, educate firewood cutters and forest workers about the importance of these habitat features, develop stewardship plans in cooperation with Aboriginal Groups; and
- develop and implement an inventory and monitoring program to estimate population size, distribution and trends.

The objectives of the Management Plan for the Common Nighthawk (*Chordeiles minor*) in Canada (Environment Canada 2015b) are to halt the national decline, ensure a positive 10-year population trend, and maintain the current extent of occurrence in Canada. Broad strategies and general measure for Common Nighthawk include:

- Habitat and species conservation and management:
  - conserve habitat for species and its prey in breeding and non-breeding areas;
  - reduce pesticide use, or encourage use of environmentally benign pesticides at small scale;
  - restore habitat and natural processes that provide breeding habitat;
  - create habitat for both Common Nighthawk and prey species;
  - control problematic species where feasible;
- Education and awareness, stewardship and partnerships:
  - build cooperative relationships with government, landowners, forest industry, farmers, pet owners, and any other groups to mitigate threats to CONI, prey, and habitat.

The objectives of the Recovery Strategy for the Olive-sided Flycatcher (*Contopus cooperi*) in Canada (Environment Canada 2015a) are to halt the national decline, ensure a positive 10-year population trend, and maintain the current extent of occurrence in Canada. Broad strategies and general measures for Olive-sided Flycatcher include:

- Habitat and species conservation and management:
  - conserve habitat deemed important for this species and its prey in breeding and non-breeding areas,
  - encourage adherence to the principles of Integrated Pest Management and encourage the use of environmentally benign pesticides at small scales,
  - control problematic species, where feasible and deemed necessary;
- Education and awareness, stewardship and partnerships:
  - foster cooperative relationships with government, landowners, foresters, farmers, industry, pet owners and other groups to mitigate threats to species, prey, and habitat.

The objectives of the Management Plan for the Long-billed Curlew (*Numenius americanus;* LBCU) in Canada (Environment Canada 2013b) are to maintain or increase the recent (since 2004) breeding distribution. Broad strategies and general approaches for Long-Billed Curlew include:

- identify, manage, and conserve key breeding and migration sites within the Canadian range:
  - develop habitat use models and use LBCU survey information to identify locations of key sites,
  - ensure LBCU needs are considered in any new or updated management plans for public grassland areas, and
  - ensure that any proposed developments that are subject to the EA process consider the needs of the Long-billed Curlew.

Habitat Loss

Habitat loss will occur throughout the IDA for Long-billed Curlew, Common Nighthawk, Great-blue Heron, Olive-sided Flycatcher, Sandhill Crane, and Waterfowl. No high or moderate suitability habitat occurs within the LSA for Williamson's Sapsucker or Lewis's Woodpecker and habitat loss associated with clearing and grubbing activities will not have an adverse effect on their populations.

During Project planning, specific mine footprints were redesigned to ensure the minimum possible impact on the surrounding environment would occur. During Construction Project footprints will be kept to the minimum size required. Over the long-term, habitat may be restored through reclamation and revegetation processes, though this will not occur until the Decommissioning and Closure phase. Impact avoidance and reduction mitigation proposed for the Project will include:

- Shrub/grassland habitat may be created on waste rock or stockpile areas that will provide feeding and nesting habitat for Long-billed Curlew and Common Nighthawk.
- Reclamation and revegetation of areas during Operation, Decommissioning and Closure, and Post-Closure will include native plant seeds in the seed mix.
- Key areas for grassland dependent species will be identified and fenced off to avoid disturbance (particularly livestock grazing) during sensitive times (April 1 to July 31). Areas will be identified on traditional and KAM owned lands.
- Wetland reclamation will re-create 12 ha of lost wetland/water features (Section 11.20). These features will be revegetated to support nesting and foraging of Waterfowl, Great Blue Heron, and Sandhill Crane.
- Fish habitat offsetting will also create suitable habitat for waterfowl and shorebirds. The shoreline should be revegetated to provide nesting habitat. Nest boxes and other habitat features will also be considered.
- To prevent additional loss or degradation of wetlands the following measures will be taken during Project Construction and operation:
  - construction and maintenance activities in and around watercourses and aquatic habitats will follow the *Standards and Best Practices for Instream Works* (BC Ministry of Water, Land and Air Protection 2004) and the *Land Development Guidelines for the Protection of Aquatic Habitat* (Chilibeck et al. 1992), which are designed to reduce sedimentation and avoid introduction of deleterious substances to aquatic environments. This will be covered in greater detail under the Erosion and Sediment Control Plan (Section 11.2);
  - all known wetland locations will be provided as inputs during the final design phase so further reductions and avoidances are considered. If new Project footprints are added or the area where disturbance is to occur is poorly understood, the new areas will be checked to confirm all habitats present and possible ways to minimize disturbance;
  - if work is required immediately adjacent to any wetlands during sensitive breeding periods then appropriate flagging will be added so as to instruct construction personnel to avoid these sites. Habitat will be cleared in the approved footprint areas only and construction will be monitored to prevent any unnecessary clearing;

  - construction personnel will attend a field-based orientation session where the exclusion areas will be explained, and the importance of avoiding disturbance within them will be stressed;
  - roads and transmission lines will be designed to minimize the number of water crossings and to avoid running parallel to watercourses;
  - place transmission line towers and access roads away from sensitive habitats, when feasible;
  - erosion prevention and bank stabilization techniques will be used to minimize potential for secondary loss of trees after initial clearing efforts (Section 11.2); and
  - new wetland habitat areas will be created as partial compensation for wetland loss.
- A habitat compensation plan will be initiated during project Construction with the aim to conserve and enhance wetland and grassland function within the RSA. This plan will target traditional and KGHM owned lands. Details of this plan will be discussed in the Wildlife and Vegetation Monitoring Plan (Section 11.27).
- Nest boxes for cavity nesting waterfowl will be incorporated in the wetlands mitigation plan. Additional nest boxes will be placed in suitable habitat present on KAM owned lands. Cattle should be excluded from enhancement areas to enhance their use by migratory birds and other at-risk species.
- KAM will collaborate with government, landowners, forest industry, farmers, and First Nations to mitigate additional threats to migratory bird habitat. Awareness and education programs for Common Nighthawk, Long-billed Curlew, and Olive-sided Flycatcher will help maintain existing population of these species.

Habitat loss as a result of Project Construction will be unavoidable for migratory birds. Revegetation efforts cannot fully mitigate for habitat loss, particularly wetland and grassland habitat. A residual effect is expected to occur for Long-billed Curlew, Common Nighthawk, Great-blue Heron, Olive-sided Flycatcher, Sandhill Crane, and Waterfowl.

Habitat Alteration

Some general measures for migratory birds include:

- reduce pesticide use, or use of environmentally benign pesticides at a small scale;
- restore/enhance remaining habitat for migratory birds, including the creation of habitat features.

Invasive Species

Development and implementation of the invasive plant species plan and other measures identified in the Wildlife and Vegetation Monitoring Plan (Section 11.27) is integral to reducing the introduction and spread of invasive species. Avoiding introducing invasive species is central to circumventing costly measures required for their eradication. Reducing traffic by implementing the Access Management Plan (Section 11.21) on site is also a key measure to help reduce the introduction of invasive plant species.

The plan for invasive species will manage for the priority species throughout the Project area. A site-specific plan will be developed by the Project's Environmental Manager through discussion (as needed) with the Invasive Plant Council, environmental scientists, and local governing agencies. The plan will draw upon the *Invasive Alien Plant Program: Reference Guide* (Ministry of Forests and Range 2010) and *Invasive Plant Pest Management Plan for the Southern Interior of British Columbia* (BC Ministry of Forests and Range 2010), which outline an Integrated Pest Management approach for invasive alien plants, under the authority of several partnering ministries.

Reclamation to restore affected areas after Project activities have ceased in those areas will reduce favourable conditions that could allow the establishment of invasive species. The Landscape Design and Restoration Plan (Section 11.26) provides for the rapid revegetation of all temporarily disturbed areas and will use appropriate seed mixes that minimize the spread of invasive plants. The Invasive Plant Management Plan (Section 11.17) will also include objectives for limiting invasive species, monitoring the presence and possible spread of invasive plants in temporarily disturbed areas, and monitoring the success of revegetation programs. Mitigation measures to reduce the spread of invasive species could include:

- prior to work commencing, surveys will be conducted to identify invasive species populations. Treatment will be initiated as required;
- vehicles entering and leaving work sites will be washed thoroughly with special attention to wheel wells, tire treads, and tracks where mud and seeds of noxious weeds may be lodged;
- wash areas will be located away from any waterbody and riparian areas;
- used wash water will be treated to prevent seed dispersal; and
- vehicle wash station will be available for all vehicles entering the site.

In addition, Targeted Invasive Plant Solutions (TIPS) have been produced by the Invasive Plant Council of BC to recommend BMPs and Integrated Pest Management techniques for control of invasive plant introduction and spread (Invasive Plant Council of BC 2007; Invasive Plant Council of BC 2008).

Invasive species will be effectively managed in the Project area, resulting in a negligible effect on Migratory Birds. No residual effects are expected for any indicator species.

Dust

Dust mitigation measures will be addressed under several management and monitoring plans. Mitigation measures to protect air quality are described in the Air Quality Monitoring and Dust Control Plan (Section 11.6). Reducing traffic by implementing the Transportation Management Plan (Section 11.20) and the Access Management Plan (Section 11.21) will also reduce the potential for negative effects of dust. These measures will mitigate the potential effects of fugitive dust altering RSEC and no residual effects are expected.

Hydrology

Maintaining surface flow patterns is important in the retention of functioning wetlands. Measures will be implemented to maintain existing hydrologic patterns where feasible. Hydrological changes

associated with Project Construction will be addressed under the Water Management and Hydrometric Monitoring Plan (Section 11.7). These measures will mitigate the potential effects of water quality on wetlands. Ditches, culverts, and other structures will be placed to maintain natural drainage patterns, were feasible. Residual habitat alteration effects are not anticipated to remain after implementation of mitigation measures for migratory birds.

Sensory Disturbance

Noise is anticipated to have a negligible effect on migratory birds based on the noise level and blast schedule. A Noise and Vibration Management Plan (Section 11.22) will be developed with the objective to ensure that noise levels during all phases of the Project are acceptably low for human and wildlife receptors, as per human health guidelines (Health Canada 2011).

Noise mitigation measures relevant to migratory birds include:

- ensuring impulse events, such as blasting, will be limited to once a day;
- ensure blasting events do not occur during the sensitive time period (sunrise to 4 hours after sunrise) during breeding season;
- considering noise ratings/specifications when selecting equipment for purchase;
- vehicles will be maintained regularly, and mufflers will be installed on vehicles;
- adjusting blasting configurations to minimise simultaneous blasting effects;
- optimizing the operation of equipment to minimize noise (e.g., reduced speed limits);
- optimizing the site layout to minimize noise impact (e.g., through use of natural screens such as buildings, facing away from relevant receptors, minimizing the need for mobile equipment to use their backup alarms);
- noise dampening measures will be applied where possible, including conducting loud procedures indoors, where practical; and
- avoidance of clearing vegetation during bird breeding periods (April – early September) and working within timing windows as required when possible (Government of British Columbia 1996).

Research indicates that blasting noise from a single event can lead to hearing loss in birds if it exceed 140 dB SPL (125 dB for multiple blasts; Dooling and Popper 2007). Project blasting is expected to occur once a day around noon. At this level and frequency noise disturbance will not have a residual effect on migratory birds.

During Operations, the mine facilities are likely to be lit continuously during night-time for worker safety considerations. This increases the potential for lighting effects on wildlife, which will be mitigated by using directed/focused lighting rather than broad area lighting and by shielding lights to minimize stray light. Lighting, where possible, will be limited to within the footprints, and will not be directed outside of the footprints. Lighting will be focused and not widespread when working near the edge of the footprints. Any illumination occurring outside the footprints should be directed away from suitable (grassland, wetland) habitat, particularly during migration periods

(March/April and late summer or fall). Lighting in non-essential areas will only be used when necessary. Project lighting will be covered under the Dark Sky Management and Monitoring Plan (Section 11.19). Project lighting is not anticipated to adversely affect the migratory bird population and no residual effect is anticipated.

Disruption of Movement

As disruption of movement is expected to have a negligible effect on migratory birds and no mitigation is suggested.

Direct Mortality

Direct mortality is anticipated for migratory birds during Construction and Operation of the Project. All clearing activities associated with migratory birds should be limited to outside of the breeding window. By avoiding the sensitive breeding window (Environment Canada 2014a), mortality on eggs and hatchlings will be minimized. If these windows cannot be avoided, pre-clearing surveys will be undertaken by a qualified individual to ensure no egg or hatchling mortalities occur.

Vehicular mortalities may occur throughout all phases of the Project, especially during Construction and Operation when road use will be higher than in later stages. These collisions may be reduced through the implementation of speed limits and minimizing the number of vehicles using sites roads (Transportation Management Plan, Section 11.20).

Measures to mitigate mortality of migratory birds include:

- avoiding vegetation clearing during bird breeding periods (April 1 – July 31; Government of British Columbia 1996):
  - complete pre-clearing surveys if clearing during the breeding bird period cannot be avoided,
  - if nests are found during pre-clearing surveys an exclusion buffer will be established around the nest;
- yielding to wildlife observed along Project roads and communicating these observations to the environmental manager;
- minimizing traffic along roads by providing a vehicle parking lot for staff, and mine personnel will be shuttled from this site to the mine;
- implementing speed limits and signage on roads adjacent to suitable habitats (e.g., Jacko Lake) and at critical times of year (early spring);
- maintaining roadside vegetation to improve drivers' sight lines;
- designing transmission line to follow established guidelines for bird protection (Avian Power Line Interaction Committee 2012).

No listed-indicator species were considered problem wildlife. Measures used to control wildlife attractants are intended to minimize or eliminate problem wildlife situations. However, if a problem wildlife situation does arise, the environmental coordinator will initiate the appropriate response

actions. Any direct intervention with problem wildlife will be done by authorized personnel in consultation with, and as approved or directed by, the British Columbia (BC) Conservation Officer Service. KAM will opt for non-lethal solutions (e.g., aversive conditioning, relocation) whenever appropriate and safe to do so.

After the implementation of the above mentioned measures, direct mortality as a result of the Project is not expected to have a residual effect on migratory birds.

Indirect Mortality

Indirect mortality is expected to have a negligible effect on migratory birds and no mitigation is suggested.

Wildlife Attractants

Mitigation measures to avoid interactions between water-associated birds and exposed water on the mine site will be discussed under chemical hazards.

Chemical Hazards

Chemical hazards from various Project activities (e.g., fuel storage and filling area, deposition to the TSF, contact water, vehicle/machinery leaks) are expected to be low in all phases of the Project. Management Plans that will be in place to further reduce these effects include:

- a Construction Waste Management Plan (Section 11.4);
- a Metal Leaching and Acid Rock Drainage Management and Monitoring Plan (Section 11.5);
- a Water Management and Hydrometric Monitoring Plan (Section 11.7);
- a Contaminated Sites Management Plan (Section 11.8);
- a Solid Waste Management Plan (Section 11.9).
- a Hazardous Waste Management Plan (Section 11.10);
- a Risk Management Plan (Accidents and Malfunctions) (Section 11.12);
- a Natural Hazards Management Plan (Section 11.13);
- an Emergency Response Plan (Section 11.14);
- a Surface Water Quality Management and Monitoring Plan (Section 11.23); and
- a Groundwater Quality Management and Monitoring Plan (Section 11.24).

Waterfowl and shorebirds may be attracted to the tailings storage facility during the operation phase of the Project. Other indicator species are unlikely to interact with water bodies within the Project IF due to the removal of adjacent terrestrial habitat. A Project interaction is not anticipated for Long-billed Curlew, Common Nighthawk, and Olive-sided Flycatcher. In addition to the Surface Water Quality Management and Monitoring Plan (Section 11.23), mitigation measures to reduce the interaction between hazardous chemicals and Great-blue Heron, Sandhill Crane, and Waterfowl include:

- removal of all vegetation and other wildlife attractants from around the TSF and MRSFs, to discourage nesting and use of the area by water associated birds (waterfowl, Great Blue Heron, and Sandhill Crane);
- habitat compensation plan will be initiated during project Construction with the aim to conserve and enhance wetland function within the RSA. This plan will target traditional and KGHM owned lands. Details of this plan will be discussed in the Wildlife and Vegetation Monitoring Plan (Section 11.27);
- monitoring and adaptive management of use of the tailings storage facility by migratory birds (discussed in greater detail in the Wildlife and Vegetation Monitoring Plan, Section 11.27); and
- proper transportation, handling, and storage of contact and non-contact water.

Antimony, chromium, cobalt, molybdenum, nickel, selenium, uranium, and zinc will exceed water quality guidelines in the TSF and mine rock storage facilities (WMRSF, SMRSF, EMRSF). Limiting exposure of water-associated birds will reduce the hazardous effect of these elements. Removal of suitable habitat (all vegetation) around the TSF and MRSFs will reduce the likelihood of breeding and feeding in these areas. Exposure to chemical hazards will therefore be limited to short periods of time, resulting in a low impact on migratory birds. Monitoring of TSF and MRSF will be implemented to confirm these assumptions.

Although both Humphrey Creek and Peterson Creek will have levels of selenium and molybdenum above wildlife guidelines, baseline levels also exceed these guidelines. Observations of Sandhill Cranes and Great-blue Herons in the Project area were limited to the migration period, and migrant species will have limited exposure to contaminants. Selenium and molybdenum are also likely to exceed guidelines in only March and April, in most years, limiting bird exposure to the spring migration period. As such, exposure of migratory shorebirds will be limited to a brief stopover period in the spring and the potential effect is expected to be low.

Waterfowl in the Project area primarily use Jacko Lake for nesting and this waterbody will be present and suitable for the life of the Project. Waterfowl use of Peterson creek was confirmed during the breeding season and a wetland beside Humphrey Creek had observations of waterfowl in the spring. Although waterfowl were confirmed to use these areas, the density was low due to the limited availability of suitable habitat. Exposure of few waterfowl to hazardous chemicals is not expected to effect the regional population and the potential effect is expected to be low.

Although mitigation measure will limit the limited duration and the proportion of the population that may be exposed to chemical hazards a residual effect is expected for waterfowl, Great-blue Herons, and Sandhill Cranes.

6.14.5 Residual Effects and Their Significance

6.14.5.1 Summary of Residual Effects

After the implementation of mitigation measures, residual effects are anticipated to occur as a result of habitat loss (Table 6.14-22). Reclamation and revegetation of the Project footprints will not fully mitigate for the loss of migratory bird habitat, particularly wetland and grassland habitats.

Table 6.14-22. Summary of Residual Effects on Migratory Birds

Valued Component	Project Phase (timing of effect)	Project Component/ Physical Activity	Description of Cause-Effect[1]	Description of Mitigation Measure(s)	Description of Residual Effect
Migratory Birds (Waterfowl, Sandhill Cranes, Great-blue Herons)	Construction	Clearing and grubbing/ earthworks	Removal of vegetation (wetlands and grasslands)	Reclamation/ revegetation	Reduction in the amount of available habitat
	All Phases	Contact water	Chemical hazard	Removal of suitable habitat around TSF and MRSFs	Exposure to selenium, molybdenum and other elements

[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 VC.*

6.14.5.2 Criteria for Characterization of Residual Effects

Specific criteria used to characterize residual effects are outlined below (Table 6.14-23). For habitat loss/alteration effects, magnitude was assigned thresholds based on literature and professional knowledge (Andren 1994). Negligible is a 0-5% change to available habitat in the LSA, Minor was a 5-30% change, Medium was a 30-50% change and Major is a change greater than 50%.

6.14.5.3 Characterization of Residual Effects

Two residual effects are anticipated for the VC migratory birds as a result of the Project: habitat loss and chemical hazards (Table 6.14-24).

Habitat loss will occur for all the indicator species, though the greatest effect will be to wetland and grassland habitat and the associated species. Habitat loss for the Long-billed Curlew and Waterfowl/Cranes as a result of Project Construction may exceeds 50%, which is considered a Major magnitude effect. Limited reclamation and enhancement of this habitat during Project Construction and Operation, will not fully mitigate for the loss of this habitat and the duration is expected to be long-term. Habitat loss will only occur once, during clearing and grubbing and earthworks activities, and the extent is restricted to within the LSA. Reclamation of grasslands and creation of wetlands could reverse this habitat loss in the long-term. Waterfowl, Great Blue Heron, and Sandhill Crane indicators have a low resilience to the loss of wetlands, and will not easily adapt to this habitat loss. The ecological context of this habitat loss is low, since Long-billed Curlews were not confirmed in the Project area, Sandhill Cranes and Great-blue Herons are migratory so will have limited interaction with the Project and all waterfowl are yellow-listed species. In addition, Common Nighthawks, Great-blue Herons, and Long-billed Curlews will use cultivated fields, which is a disturbed anthropogenic habitat type abundant in the Project areas.

Exposure to contact water in the tailings storage facility may lead to adverse chemical hazard effects to waterfowl. The magnitude of this effect is minor since the potential exposure is likely to be limited and the baseline levels of molybdenum and selenium currently exceed water quality guidelines. The duration of the potential exposure to contact water will occur over the long term, lasting over

124 years. The risk of exposure will be continuous, but localized to those contaminated waterbodies. Since chemicals will persist past year 124, the effect is considered irreversible. The waterfowl population has a neutral resiliency since species are likely to tolerate some exposure to chemical hazards and the potential effects of this exposure will likely vary between species and age groups. The ecological context is also considered low since waterfowl species are common and Jacko Lake, which currently supports the majority of the waterfowl population in the LSA, will remain functional.

6.14.5.4 Significance of Residual Effects

The residual effect for habitat loss on migratory birds is anticipated to be Not Significant (moderate). Loss of wetland habitat will affect waterfowl, Great Blue Heron, and Sandhill Crane. Herons and Cranes are not believed to breed in the area and waterfowl species are common. The function of Jacko Lake will be maintained and this site is the primary water body in the LSA providing migratory stop-over habitat and waterfowl breeding habitat. Habitat compensation at Inks Lake will also provide additional suitable breeding and stop-over habitat. Loss of small wetlands and water bodies throughout the LSA will have a residual effect on migratory birds but effects at the population level are unlikely, since a higher density of species will be supported by the larger waterbodies. Habitat loss for Common Nighthawk and Long-billed Curlew can be partially mitigated by revegetation of sites within the Project IF during operation. These species use disturbed, anthropogenic habitats and are therefore more resilient.

The residual effect for chemical hazards on migratory birds is anticipated to be Not Significant (minor) due to limited exposure in the TSF and MRSF. A few waterfowl may breed along Peterson and Humphrey Creek, and could experience a chemical hazard as selenium and molybdenum are anticipated to exceed guidelines. However, this will make up a very small portion of the waterfowl and shorebird population in the area. Several other waterbodies (e.g., Jacko Lake, Inks Lake) provides more attractive breeding habitat and should attract water associated birds away from unsuitable Project IF water bodies.

6.14.5.5 Characterization of Likelihood and Confidence

The probability and confidence of habitat loss for migratory birds was ranked high. Probability was ranked high as suitable habitat within the Project footprints will be cleared and grubbed (i.e., complete vegetation removal), and all suitable habitat within these areas will be lost. Confidence was ranked medium because detailed TEM and extensive field truthing resulted in a high degree of certainty associated with the location of suitable habitats, however the dependence on these habitats by waterfowl is uncertain.

The probability that a chemical hazard effect will occur is medium, as ducks are likely to use the TSF and MRSF during migration, but a toxicity effect may not occur as a result, due to the short exposure time. Similarly, along Peterson and Humphrey Creek, a chemical hazard effect is likely, as selenium and molybdenum exceed wildlife guidelines, though only a small fraction of the waterfowl and shorebird population is likely to be exposed. It is unclear if the concentration of heavy metals and duration of exposure is sufficient to cause a toxicity effect to migratory birds.

Table 6.14-23. Definitions of Characterization Criteria for Residual Effects on Migratory Birds

Magnitude	Duration	Frequency	Geographic Extent (Physical/Biophysical)	Reversibility	Resiliency	Ecological Context	Likelihood of Effects	
							Probability	Confidence Level
How severe will the effect be?	*How long will the effect last?*	*How often will the effect occur?*	*How far will the effect reach?*	*To what degree is the effect reversible?*	*How resilient is the receiving environment or population?*	*What is the current condition of the ecosystem and how commonly is it represented in the LSA?*	*How likely is the effect to occur?*	*How certain is this analysis?*
Negligible: No or very little detectable change from baseline conditions (>5% of available habitat in LSA).	**Short-term:** Effect lasts 1 to 5 years.	**Once:** Effect is confined to one discrete period in time during the life of the Project.	**Local:** Effect extends less than 500 m from infrastructure or activity.	**Reversible Short-term:** Effect can be reversed relatively quickly.	**Low:** The receiving environment or population has a low resilience to imposed stresses, and will not easily adapt to the effect.	**Low:** The receptor is considered to have little to no unique attributes or provision of functions is severely degraded.	**High:** It is highly likely that this effect will occur.	**High:** < 80% confidence. There is a good understanding of the cause-effect relationship and all necessary data are available for the Project area. There is a low degree of uncertainty and variation from the predicted effect is expected to be low.
Minor: Differs from the average value for baseline conditions to a small degree (5% to 30%).	**Medium-term:** Effect lasts 6 to 25 years.	**Sporadic:** Effect an effect that occurs at sporadic or intermittent intervals during any phase of the Project.	**Landscape:** Effect is limited to the LSA or one watershed (i.e., Sub-area).	**Reversible Long-term:** Effect can be reversed within 20 years of Post Closure.	**Neutral:** The receiving environment or population has a neutral resilience to imposed stresses and may be able to respond and adapt to the effect.	**Neutral:** The receiving environment considered to have some unique attributes and provides most functions that an undisturbed environment would provide.	**Medium:** This effect is likely, but may not occur.	**Medium:** 50 to 80% confidence. The cause-effect relationships are not fully understood, there are a number of unknown external variables, or data for the Project area are incomplete. There is a moderate degree of uncertainty; while results may vary, predictions are relatively confident.
Medium: Differs substantially from the average value for baseline conditions and approaches the limits of natural variation (30% to 50%).	**Long-term:** Effect lasts between 26 and 50 years.	**Regular:** Effect occurs on a regular basis during the life span of the Project.	**Regional:** Effect extends across the broader region (e.g., RSA, multiple watersheds, etc.).	**Irreversible:** Effect cannot be reversed (i.e., is permanent).	**High:** The receiving environment or population has a high natural resilience to imposed stresses, and can respond and adapt to the effect.	**High:** The receiving environment or population is uncommon and occurs in a natural state and provides functions at a maximum capacity.	**Low:** This effect is unlikely but could occur.	**Low:** < 50% confidence. The cause-effect relationships are poorly understood, there are a number of unknown external variables, and data for the Project area are incomplete. High degree of uncertainty and final results may vary considerably.
Major: Differs substantially from baseline conditions, resulting in a detectable change beyond the range of natural variation (>50%).	**Far Future:** Effect lasts more than 50 years.	**Continuous:** Effect occurs constantly during the life of the Project.	**Beyond Regional:** Effect extends beyond the regional scale, and may extend across or beyond the province.					

Table 6.14-24. Characterization of Residual Effects, Significance, Likelihood and Confidence on Migratory Birds

Effect	Residual Effects Characterization Criteria							Significance of Adverse Residual Effects	Likelihood and Confidence	
	Magnitude	Duration	Frequency	Geographic Extent	Reversibility	Resiliency	Context		Probability	Confidence
Habitat Loss	Major	Long-term	Once	Local	Reversible Long-term	Low	Low	Not Significant (moderate)	High	Medium
Chemical Hazard	Minor	Long-term	Continuous	Local	Irreversible	Neutral	Low	Not Significant (minor)	Medium	High

6.14.5.6 Summary of Residual Effects Assessment and Significance

After the implementation of mitigation measures two residual effects are anticipated to occur for the VC migratory birds as a result of various Project activities (Table 6.14-25). Habitat loss is anticipated to have a Not Significant (moderate) effect on waterfowl within the LSA. Suitable breeding and stopover habitat will be present in the LSA and additional wetland habitat will be created at Inks Lake. Chemical Hazards are anticipated to have a Not Significant (minor) impact on waterfowl. Only a small fraction of the population occurring in the area are anticipated to breed in areas where water quality exceeds wildlife guidelines.

Table 6.14-25. Summary of Residual Effects, Mitigation, and Significance on Migratory Birds

Residual Effects	Project Phase	Mitigation Measures	Significance
Habitat Loss	Construction	Reclamation	Not Significant (moderate)
Chemical Hazards	All Phases	Removal of suitable breeding habitat around TSF and MRSFs	Not Significant (minor)

6.14.6 Cumulative Effects Assessment

6.14.6.1 Introduction

The cumulative effects assessment (CEA) considers the effects on migratory birds that are likely to result from the residual environmental effects of the Project in combination with the effects of other projects and activities (past, present, or future) with the RSA. The CEA methodology is based on the framework outlined in Section 5.3.

Past land use (e.g., agriculture, forestry, urban development) has shaped much of the regions current wildlife habitat abundance and distribution, and, in turn, has shaped how migratory birds make use of the landscape. Many past, present and future projects have, and will continue to contribute to the abundance and diversity of migratory birds in the RSA. Several projects have been identified as occurring in the region, and could potentially interact with our Project (Section 5.3). Each of these projects will be considered in combination with the result of our residual effects identified above in Section 6.14.5 to determine if there is an interaction, and consequently, if there is the potential for a residual cumulative effect to occur. These interactions can include direct, indirect, additive and synergistic effects. To be included in the CEA projects must occur within the RSA, must have a residual effect, and must have the potential to act cumulatively with the residual effects for migratory birds described in Section 6.14.4.2.

Habitat loss and chemical hazards were considered residual effects for migratory birds. All projects that could potentially occur in the region have been included. Those projects that could have a residual effect associated with migratory bird habitat loss and chemical hazards should be included in the CEA.

6.14.6.2 Identification of Other Actions that May Affect Migratory Birds

A list of past, present, and anticipated future projects and activities known to occur in the region are identified and described in Section 5.3 (Table 6.14-26, Figure 6.14-14). Projects/activities were initially

scoped out if there was no perceived spatial interaction (i.e., the project/activity occurs outside of the RSA). Other projects/activities were scoped into the CEA on a VC by VC basis. If a residual effect from the Project was determined, the likelihood of other projects/activities resulting in the same effect were assessed using reports generated from those projects/activities; in the absence of any data indicating specific effects, professional judgement was used. Other projects/activities considered for cumulative effects on non-migratory gamebirds are listed below).

6.14.6.3 Interactions between Residual Project Effects and Other Project or Activity Effects

Habitat loss and exposure to chemical hazards are potential effects that may be exacerbated by other projects/activities in the region. Habitat loss associated with past, present and future project activities cannot be quantified. In the majority of cases, no information is available on total habitat loss. Consequently, a qualitative analysis was conducted to determine potential interactions based on professional judgement, location of these projects/activities, and the sensitivity of migratory birds to habitat loss.

The Iron Mask Mine has not been in operations for over 90 years, and was considered as part of the baseline condition for this Project. Construction of Lac le Jeune Road, Highway 5A, and the TransCanada Highway occurred previous to 1950, while the Coquihalla Highway was built in the early 1980's. The construction of these roadways was also considered as part of baseline conditions.

Agriculture and forestry has occurred in the region since the 1800s. Habitat loss associated with both of these activities is assumed to have occurred. Approximately 25% of historic grasslands in the Great Basin BCR have been lost to development and agricultural conversion (Environment Canada 2013a). The loss of mature pine forests to mountain pine beetle also poses conservation problems for a number of priority species (*ibid*.). Agriculture is assumed to have removed fertile grassland and wetlands which would have supported Long-billed Curlews, Common Nighthawks, Sandhill Cranes, Great Blue Herons, and waterfowl. Forestry is assumed to have removed areas of suitable Lewis' Woodpecker, Williamson's Sapsucker, Olive-sided Flycatcher, and Barn Swallow habitat (Table 6.14-26).

Future projects/activities, such as Kamloops city expansion or the Kinder Morgan pipeline, have not been finalized, and therefore, footprints are not available. The expansion of the city of Kamloops, specifically the growth of Aberdeen (neighbourhood adjacent to LSA), as well construction of Kinder Morgan's TransMountain pipeline, will likely result in additional habitat loss for several migratory bird species (Table 6.14-26). Aberdeen is expected to continue expanding, from an approximate population of 10,000 people in 2011 to over 16,000 by 2036 years (TRUE Consulting Group 2008; City of Kamloops 2012). If approved, construction of the TransMountain pipeline twinning is anticipated to commence as early as 2016.

From 1977 to 1997, open pit mining operations and ore smelting occurred at the Afton, Crescent-Afton, Pothook and Ajax (East and West) pits, with Hughes Lake serving as the tailings storage facility (Golder Associates 2003). Reclamation activities at some of these sites has included distribution of topsoil and contouring, fertilization, and seeding of rock piles, marsh vegetation development in Hughes Lake, and wetland development in Ajax retention ponds. Vegetation species planted as part of wetland development included cattails, rushes and sedges (Golder Associates 2003).

Figure 6.14-14
Cumulative Effects Regional Study Area

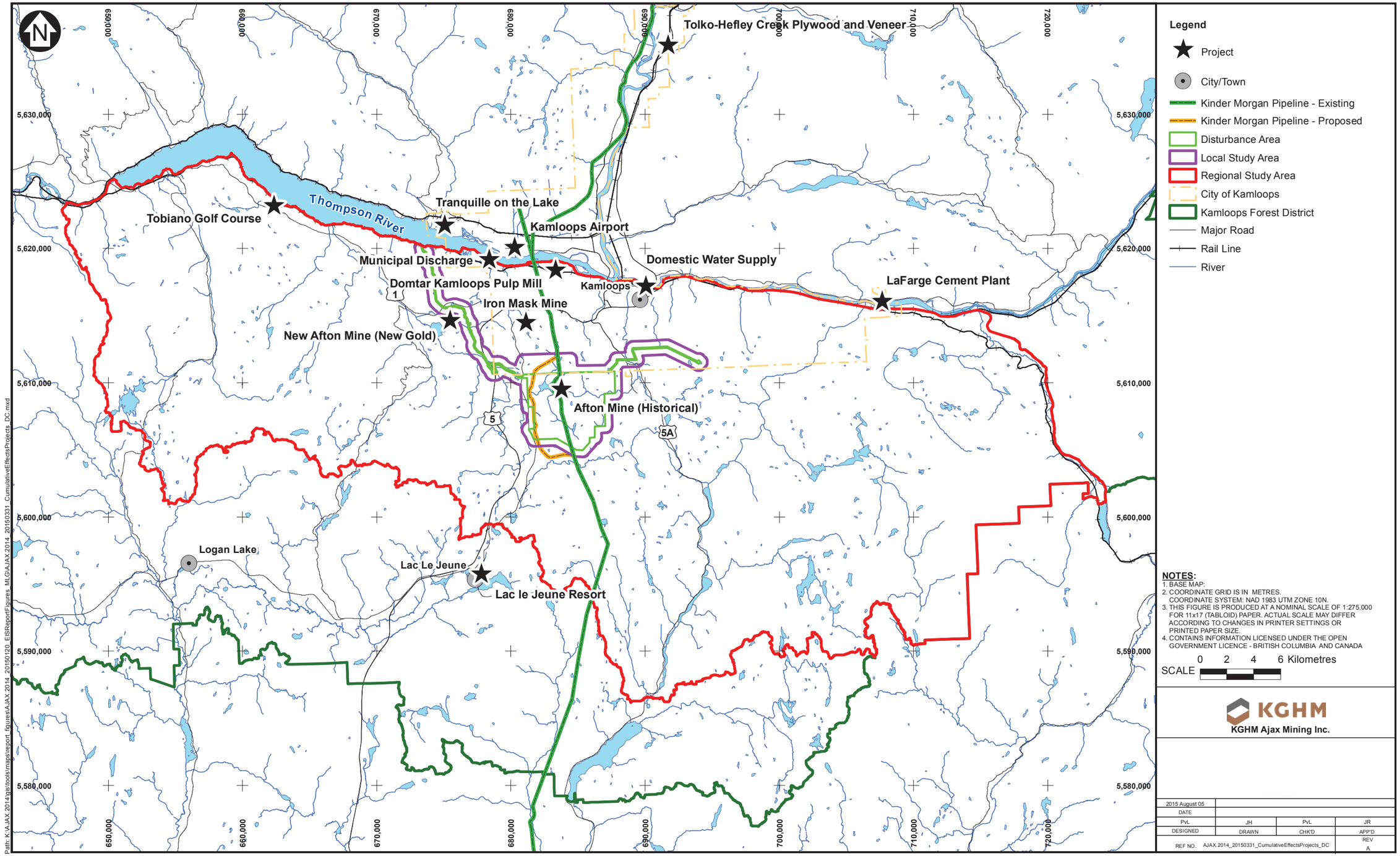


Table 6.14-26. Ranking Potential for Residual Effects to Interact Cumulatively with Effects of Other Human Actions on Migratory Birds

Residual Effect	Industrial Projects/Activities													Natural Resources and Land Use			Tourism and Commercial Recreation Activities					Community Infra-structure			Transportation						
	Vidette Lake Mine	Afton Mine (Historical)	Iron Mask Mine	Bonaparte Mine	New Afton Mine (New Gold)	Highland Valley Copper Mine (Teck)	Domtar Kamloops Pulp Mill	Tolko-Hefley Creek Plywood and Veneer	LaFarge Cement Plant	Trans Mountain Pipeline System (Kinder Morgan)	Trans Mountain Pipeline System - Expansion (Kinder Morgan)	Harper Creek	Highland Valley Copper – Bethlehem Expansion	Kamloops Forest District	Agriculture	Ranching	Tranquille on the Lake	Lac Le Jeune Resort	Tobiano Golf Course	Recreational Hunting, Fishing, Foraging	Recreational Trails	City of Kamloops Wastewater Management	Water Treatment Centre	City Expansion and Growth	Lac le Jeune Road	Highway 1	Highway 5A	Highway 5 (Coquihalla Highway)	Kamloops Airport	Rail Yards and Lines (CP and CN)
Habitat Loss	-	O	O	-	L	-	O	-	-	O	L	-	-	L	L	L	-	-	O	O	O	-	-	L	O	O	O	O	-	O
Chemical Hazards	-	O	O	-	L	-	O	-	-	O	O	-	-	O	O	O	-	-	O	O	O	-	-	O	O	O	O	O	-	O

Notes:

(-) *No spatial or temporal overlap.*

O *No interaction anticipated.*

L *Negligible to minor interaction expected; implementation of best practices, standard mitigation and management measures; no monitoring required, no further consideration warranted.*

M *Potential moderate interaction requiring unique active management/monitoring/mitigation; warrants further consideration.*

H *Key interaction; warrants further consideration.*

6.14.6.4 Proposed Mitigation Measures

As KGHM has limited authority to guide regional initiatives to support the diversity and persistence of habitat, this would be better guided by the provincial government.

Habitat Loss

Mitigation for the impacts of the Project on habitat loss consisted of mine site reclamation and habitat compensation. These measures were not sufficient to reduce the total loss of habitat. Additional habitat loss mitigation will be required to compensate for the cumulative loss of habitat in the RSA. Further habitat reclamation or enhancement activities including the fencing off of grasslands, wetlands and riparian areas, and controlling the timing for livestock grazing during the breeding bird season (April to August). KAM can also foster cooperative relationships with government, landowners, foresters, farmers, industry, pet owners and other groups to mitigate threats to migratory species, prey and habitat.

Habitat loss cannot fully be mitigated, and therefore will be carried forward and evaluated in Section 6.14.6.5.

Chemical Hazards

Mitigation to reduce chemical hazard effects on waterfowl consisted of removal of vegetation around the TSF and MRSFs to discourage breeding in the area, and the creation of alternative breeding areas through wetland compensation.

6.14.6.5 Evaluation of Significance of Residual Cumulative Effects

After the implementation of mitigation measures, two residual cumulative effects are anticipated to occur. The loss of migratory bird habitat, in particular, wetland habitat, cannot be fully mitigated and may result in a cumulative effect (Table 6.14-27). The total wetland habitat within the RSA was estimated from the Vegetation Resource Inventory (VRI) database. VRI contains basic information on wetland presence and distribution on the landscape. To identify wetlands in the RSA, Geographic Information System (GIS) analysis was conducted. VRI spatial files were overlaid with a spatial file of the RSA. Only 13 ha of wetlands were identified within the LSA using the VRI. Considering approximately 220.8 ha of wetlands were mapped in the LSA this indicates that the VRI underestimates the amount of wetlands compared to the TEM, which has a much higher degree of field confirmation.

Table 6.14-27. Summary of Cumulative Effects Mitigation Measures and Residual Effects on Migratory Birds

Ajax Project Activity	Other Human Action Activity	Description of Potential Cumulative Effect	Description of Mitigation Measure(s)	Description of Residual Cumulative Effect
Clearing and Grubbing/ Earth works	Construction of other project infrastructure	Loss of wetland habitat	Reclamation, Wetland Compensation	Reduction in available habitat

(continued)

Table 6.14-27. Summary of Cumulative Effects Mitigation Measures and Residual Effects on Migratory Birds (completed)

Ajax Project Activity	Other Human Action Activity	Description of Potential Cumulative Effect	Description of Mitigation Measure(s)	Description of Residual Cumulative Effect
Contact Water	Tailings storage facilities at New Afton Mine	Exposure to chemical hazards	Removal of vegetation around TSF and MRSFs, Wetland Compensation	Multiple sources of chemical hazards within the RSA

Two residual cumulative effects are anticipated for migratory birds as a result of the Project in combination with other projects and activities occurring throughout the region (Table 6.14-28). Loss of migratory bird habitat has occurred throughout the region. A considerable amount of suitable habitat occurs within the RSA. Less than 0.4% of wetland will be potentially lost as a result of Project Construction. This is a minor magnitude effect, though the impacts may last into the far future, and could be reversible if reclamation of various sites occurs. Migratory birds are somewhat resilient to habitat loss, and are able to move to other suitable habitat in the surround area. The ecological context of migratory bird habitat is neutral. The RSA is somewhat disturbed, but provides most of the function that an undisturbed site (with the exception of old-growth forest). Habitat loss is anticipated to have a Not Significant (minor) effect on migratory birds within the RSA. The probably that this effect will occur is high, but confidence is low due to limited information on historical habitat loss.

A residual cumulative effect of chemical hazards may occur for migratory birds, particularly waterfowl. Waterfowl will be exposed to chemical hazards during migration through contact water in the tailings storage facility. The tailings storage facility at the New Afton Mine may also expose migratory birds to chemical hazards in the RSA. As a large amount of more suitable habitat occurs in the area, and exposure during migration is expected to be limited, the magnitude of the chemical hazard is considered minor. These chemicals can persist on the landscape into the far future, and will be continuous. In the long-term, the chemical hazard effect will be reversible.

6.14.7 Conclusion

Migratory birds were assessed as a VC to determine likely interactions with specific Project activities, and how these interactions would affect this species group. Potential effects (habitat loss, habitat alteration, sensory disturbance, disruption of movement, direct mortality, indirect mortality, wildlife attractants and chemical hazards) arising from each Project activity were identified and evaluated. After the implementation of mitigation measures, two Project-related residual effects and two residual cumulative effects were determined for migratory birds as a result of this Project, as well as in combination with other projects/activities, past, present, and future, occurring within the region (Table 6.14-29).

Habitat loss and chemical hazards are both Project-related and residual cumulative effects. The magnitude and geographic extent of these effects differs, as the scale at which they were assessed was much smaller for the Project-related residual effects than for residual cumulative effects (LSA vs. RSA).

Table 6.14-28. Characterization of Residual Cumulative Effects, Significance, Likelihood and Confidence on Migratory Birds

Residual Cumulative Effect	Residual Effects Characterization Criteria							Significance of Adverse Residual Effects	Likelihood and Confidence	
	Magnitude	Duration	Frequency	Geographic Extent	Reversibility	Resiliency	Context		Probability	Confidence
Habitat Loss	Minor	Long-term	Once	Regional	Reversible Long-term	Neutral	Neutral	Not Significant (minor)	Medium	Low
Chemical Hazard	Minor	Far Future	Continuous	Regional	Reversible Long-term	Low	Low	Not Significant (minor)	Medium	Low

Table 6.14-29. Summary of Project and Residual Cumulative Effects, Mitigation, and Significance for Migratory Birds

Residual Effects	Project Phase	Mitigation Measures	Residual Effect Significance	Residual Cumulative Effect Significance
Habitat Loss	Construction	Avoidance of breeding sites through re-design where possible. Fish offsetting and wetland compensation programs will support bird habitat.	Not Significant (moderate)	Not Significant (minor)
Chemical Hazard	All Phases	Removal of vegetation around TSF and MRSFthat to discourage bird nesting. Make attractive bird habitat at fish offsetting and wetland compensation areas to encourage nesting.	Not Significant (minor)	Not Significant (minor)

The loss of suitable migratory bird habitat, particularly wetlands (for waterfowl, Great Blue Herons, and Sandhill Cranes), and grasslands (for Long-billed Curlews and Common Nighthawks) could impact populations locally, but is not expected to impact populations regionally. Habitat loss was considered Significant (moderate) because of the loss of wetland habitat expected to occur during project Construction. Several other human activities in the RSA have and could contribute to wetland loss within the RSA. However, the relative amount of wetlands within the RSA lost as a result of the project is less than 0.4%. This is a not significant (minor) residual Cumulative Effect.

After the implementation of mitigation measures chemical hazards are expected to have a Not Significant (minor) residual cumulative effect on waterfowl. Only a small fraction of the population occurring in the area is anticipated to breed in areas where water quality exceeds wildlife guidelines. Any waterfowl or shorebirds that use the TSFs and other waterbodies that exceed aquatic and wildlife water quality guidelines is likely to occur during migration, therefore exposure will be limited.

6.15 RAPTORS

6.15.1 Rationale

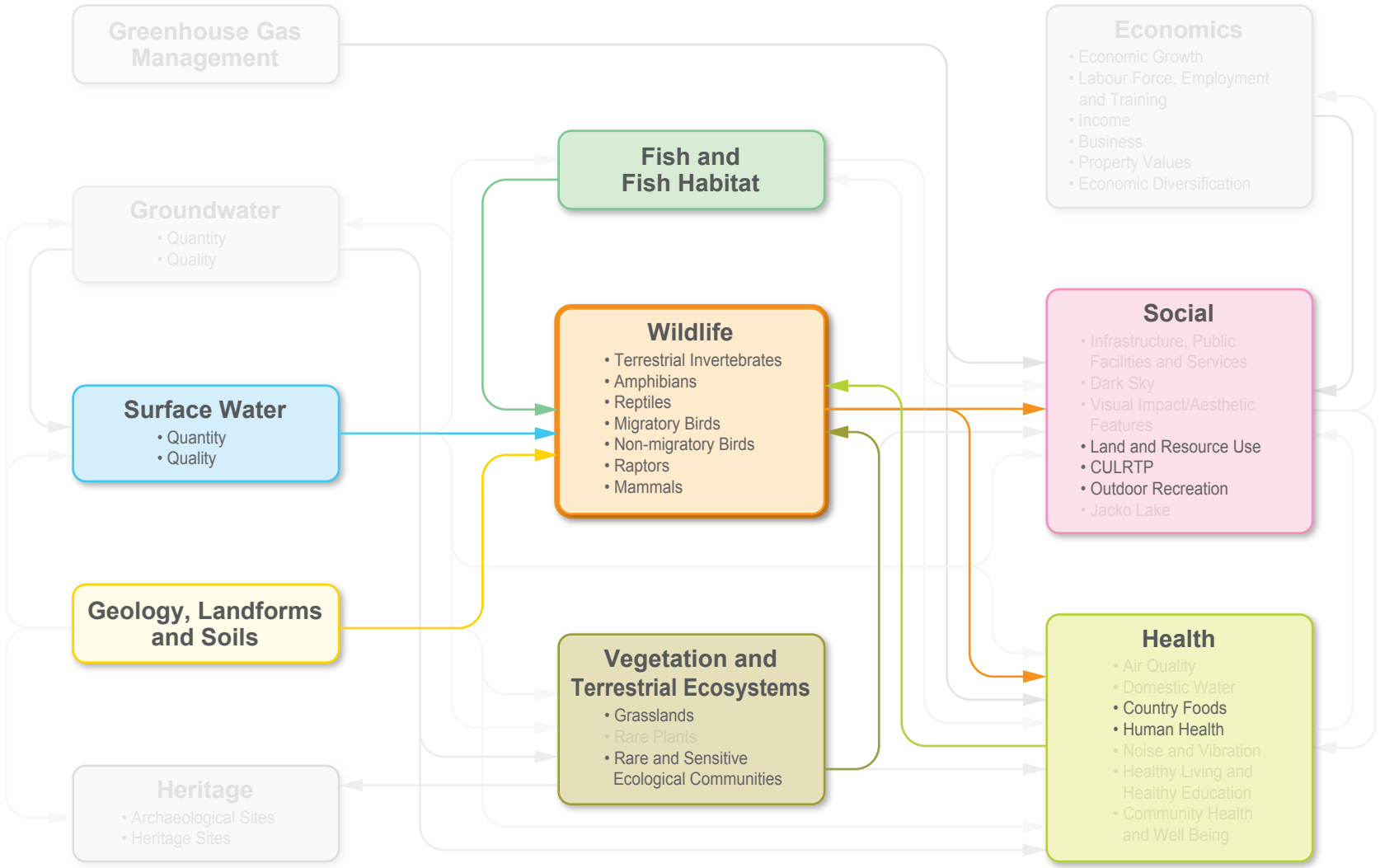
This section includes a description of the scoping process used to identify Raptors for inclusion in the assessment. Scoping is fundamental to focusing the Application/EIS on those issues where there is the greatest potential to cause significant adverse effects. Valued components (VCs) are components of the natural and human environment that are considered to be of scientific, ecological, economic, social, cultural, or heritage importance (CEAA 2006; EAO 2015). To be included in the EA, there must be a perceived likelihood that the VC will be affected by the proposed Ajax Project (the Project). Valued components are scoped into the environmental assessment based on issues raised during consultation with Aboriginal communities, government agencies, the public and stakeholders. Consideration of certain VCs may also be a legislated requirement, or known to be a concern because of previous project experience.

For raptors to be included as a valued component in the environmental assessment, the following were considered:

- federal or provincial listing or regulation (including relevant legislation or policy concerning the VC):
  - lists of Red- and Blue-listed species believed to occur within the Kamloops Forest District, and information on known locations of these species, according to the BC Conservation Data Centre (2014),
  - information on actual known location records of Red or Blue-listed taxa in or near the study area (provided by the BC Conservation Data Centre),
  - information on SARA- or COSEWIC-listed taxa available from the Government of Canada,
  - taxa listed as part of the *Identified Wildlife Management Strategy* (IWMS; BC Ministry of Water, Land and Air Protection 2004),
  - taxa of regional concern, and
  - data from targeted wildlife surveys and from incidental observations;
- Aboriginal interest;
- public or other stakeholder input;
- scientific/professional knowledge; and
- relevant legislation or policy concerning the VC.

Raptors offer the potential for short and long term monitoring of the impact of increasing development, changing land use practices, and climate change for the region's aquatic and terrestrial ecosystems. Raptor species use grassland, forested and cliff habitats which are determined by surface and ground water, geology, landform and soils. The assessment of effects to raptor species is largely related to disturbances from Project activities (as described further in Section 6.15.4). The information developed to support the analysis of this VC may also contribute to Outdoor Recreation (Figure 6.15-1).

Figure 6.15-1
VC Interactions for Wildlife (Raptors)



6.15.1.1 Selection of Raptors as a Valued Component

A variety of raptor species are known to use the area around the Project for various life requisites. Groups such as owls, hawks, eagles and falcons are known to exist on the landscape in and around the Project area.

The VC "Raptors" was selected as there is an expected interaction between raptors and the Project. Specific justification for the selection of raptors as a VC includes:

1. Federal or Provincial listing or regulation guidelines (Table 6.15-1):
   - five Red-listed species (Burrowing Owl, Peregrine Falcon, Prairie Falcon, Swainson's Hawk, Western Screech-owl) may be present in the Project area,
   - three Blue-listed species (Flammulated Owl, Rough-legged Hawk, Short-eared Owl) may be present in the Project area**,**
   - four species included as identified wildlife under FRPA (Burrowing Owl, Flammulated Owl, Prairie Falcon, Short-eared Owl, Western Screech-owl), and
   - Burrowing Owl, Flammulated Owl, Peregrine Falcon, Short-eared Owl, and Western Screech-owl are SARA listed species;
2. Applicable government agencies: Environmental Assessment Office, Canadian Environmental Assessment Agency, Ministry of Forests, Lands, and Natural Resource Operations (MFLNRO) and Ashcroft Indian Band identified raptors as a concern;
3. Stakeholder input:
   - members of the public and the Kamloops Naturalists Club identified raptors as a concern;
4. Information Sources: Baseline studies, professional judgement based on relevant best practices;
5. Spatial scope (species range);
6. Temporal scope (resident and migrant individuals present during all phases of the Project); and
7. Interaction with Project/potential effects (areas of disturbance associated with the project components and activities).

6.15.1.2 Selection of Indicators

A preliminary list of indicator species was prepared (Table 6.15-1) based on the presence of suitable/capable habitat, the availability of sufficient species knowledge to produce a meaningful assessment, feedback from stakeholders and likely interactions with the Project (geographically and ecologically). Wildlife surveys for particular indicators were planned when significant data gaps existed.

Table 6.15-1. Raptor Species Present in the Thompson Region

English Name	Scientific Name	Provincial List	COSEWIC Status[1]	SARA Schedule/ Status[1]	Identified Wildlife	Selected as Indicator?
American Kestrel	*Falco sparverius*	Yellow	-	-	No	No
Bald Eagle	*Haliaeetus leucocephalus*	Yellow	NAR	-	No	Yes
Burrowing Owl	*Athene cunicularia*	Red	E	1-E	Yes	Yes
Cooper's Hawk	*Accipiter cooperii*	Yellow	NAR	-	No	No
Flammulated Owl	*Psiloscops flammeolus*	Blue	SC	1-SC	Yes	Yes
Great Gray Owl	*Strix nebulosa*	Yellow	NAR	-	No	Yes
Great Horned Owl	*Bubo virginianus*	Yellow	-	-	No	No
Golden Eagle	*Aquila chrysaetos*	Yellow	NAR	-	No	No
Long-eared Owl	*Asio otus*	Yellow	-	-	No	No
Merlin	*Falco columbarius*	Yellow	NAR	-	No	No
Northern Goshawk	*Accipiter gentilis*	Yellow	-	-	No	No
Northern Harrier	*Circus cyaneus*	Yellow	NAR	-	No	No
Osprey	*Pandion haliaetus*	Yellow	-	-	No	No
Peregrine Falcon, *anatum* subspecies	*Falco peregrinus anatum*	Red	SC	1-SC	No	Yes
Prairie Falcon	*Falco mexicanus*	Red	NAR	-	Yes	Yes
Rough-legged Hawk	*Buteo lagopus*	Blue	NAR	-	No	Yes
Red-tailed Hawk	*Buteo jamaicensis*	Yellow	NAR	-	No	No
Short-eared Owl	*Asio flammeus*	Blue	SC	1-SC	Yes	Yes
Sharp-shinned Hawk	*Accipiter striatus*	Yellow	NAR	-	No	No
Swainson's Hawk	*Buteo swainsoni*	Red	-	-	No	Yes
Turkey Vulture	*Cathartes aura*	Yellow	-	-	No	No
Western Screech-owl, *macfarlanei* subspecies	*Megascops kennicottii macfarlanei*	Red	T	1-E	Yes	No

[1] *E = Endangered, T = Threatened, SC = Special Concern, NAR = Not at Risk*

Both diurnal raptors (eagles, falcons, hawks, vultures, Osprey, some owls) and nocturnal raptors (owls) are known to be present in the region. Owls such as the Burrowing Owl (*Athene cunicularia*), Flammulated Owl (*Psiloscops flammeolus*), Great Gray Owl (*Strix nebulosa*), Great Horned Owl (*Bubo virginianus*), Long-eared Owl (*Asio otus*), Short-eared Owl (*Asio flammeus*), and Western Screech-owl, *macfarlanei* subspecies (*Megascops kennicottii macfarlanei*) are known to be present in the region. A number of hawks, including Cooper's Hawk (*Accipiter cooperii*), Northern Goshawk (*Accipiter gentilis*), Northern Harrier (*Circus cyaneus*), Rough-legged Hawk (*Buteo lagopus*), Red-tailed Hawk (*Buteo jamaicensis*), Sharp-shinned Hawk (*Accipiter striatus*), and Swainson's Hawk (*Buteo swainsoni*) can also be found throughout the region. Other raptors known to be present include American Kestrel (*Falco sparverius*), Bald Eagle (*Haliaeetus leucocephalus*), Golden Eagle (*Aquila chrysaetos*), Merlin (*Falco columbarius*), Osprey (*Pandion haliaetus*), Peregrine Falcon (*Falco peregrinus*), Prairie Falcon (*Falco mexicanus*), and Turkey Vulture (*Cathartes aura*) (BC Ministry of Forests, Lands, and Natural Resources 2013).

Some raptors are linked to discrete habitat types (e.g., Bald Eagles and Ospreys need open water for foraging habitat, Burrowing Owls need grasslands with abandoned burrows for nest sites), and this means these species may be vulnerable to loss or degradation of these habitat types. Raptors are also susceptible to a variety of environmental contaminants (BC MFLNR 2013).

Many of the raptor species are valued by First Nations groups. The Burrowing Owl, Short-eared Owl, Swainson's Hawk, and Peregrine Falcon are species of concern to First Nations (Ignace 2014). The Golden Eagle, Long-eared Owl, and Great Horned Owl figure prominently in traditional stories (Ignace 2014). Eagle and hawk feathers were used as a trade item and the Bald Eagle is used for ceremonial and spiritual purposes (Ignace 2014).

Yellow-listed species (Northern Harrier, Great Horned Owl, Red-tailed Hawk, American Kestrel and Merlin) are considered secure and widespread and effects of the Project to these species are not anticipated to have an adverse effect. As such, indicator species were generally at-risk species as these populations are more likely to experience a significant adverse effect.

Bald Eagle, Burrowing Owl, Flammulated Owl, Peregrine Falcon, Prairie Falcon, Great Gray Owl, Rough-legged Hawk, Short-eared Owl, and Swainson's Hawk were selected as indicator species in the AIR based on recorded observations of the species in the Project area during baseline studies, incidental observations or reported historical presence, and/or on the presence of suitable habitat which could interact with the Project (Table 6.15-2).

Table 6.15-2. Indicator Species Selection Rationale and Issues Raised

Indicator Species	Feedback by*				Issues Raised	Rationale
	AG	G	P/S	S/P		
Bald Eagle	✓	✓	✓	✓	Loss of suitable habitat, potential disturbance of Bald Eagle	Known nests protected under Wildlife Act; public concern
Burrowing Owl		✓	✓	✓	Loss of suitable habitat, potential disturbance of Burrowing Owl	Species at risk; suitable habitat present; high public concern
Flammulated Owl		✓	✓	✓	Loss of habitat, potential disturbance of Flammulated Owl	Species at risk; nearby records; some potentially suitable habitat present
Great Gray Owl		✓	✓	✓	Loss of habitat, potential disturbance of Great Gray Owl	Regional concern; known use of LSA
Peregrine Falcon, *anatum* subspecies		✓	✓	✓	Loss of habitat, potential disturbance of Peregrine Falcon	Species at risk; possibly suitable nesting habitat on Sugarloaf cliffs
Prairie Falcon		✓	✓	✓	Loss of habitat, potential disturbance of Prairie Falcon	Species at risk; potentially suitable habitat present on Sugarloaf cliffs
Rough-legged Hawk		✓		✓	Loss of habitat for Rough-legged Hawk	Species at risk; known winter use; regional concern
Short-eared Owl		✓		✓	Loss of habitat, potential disturbance of Short-eared Owl	Species at risk; known present
Swainson's Hawk		✓		✓	Loss of habitat, potential disturbance of Swainson's Hawk	Species at risk; known nest sites; high potential for Project effects

**AG = Aboriginal Group (Stk'emlupsemc Te Secwepemc Nation (SSN) and Nlaka'pamux Nation); G = Government; P/S = Public/Stakeholder (e.g., LRMP); S/P = Scientific/Professional Knowledge.*

The Bald Eagle is not considered a species at risk but it is a species of regional, Aboriginal group and public concern and its nests are protected under the BC *Wildlife Act* (Government of British Columbia 1996). The Great Gray Owl is also not at risk but a species of regional concern.

The various raptor species found in the Kamloops may occupy a variety of different habitat types. Many of the indicator raptor species (Bald Eagle, Great Gray Owl, Flammulated Owl, and Swainson's Hawk) build nests in various tree species, such as Douglas-fir (*Pseudotsuga menziesii*), ponderosa pine (*Pinus ponderosa*), balsam poplar (*Populus balsamifera*), and trembling aspen (*Populus tremuloides*), found around the study area. Bald Eagles are often found nesting near open water, or along the edge of forested habitat (Buehler 2000).

Burrowing Owls and Short-eared Owls also nest in habitat found in the area, however, they build their nests on the ground rather than in trees (COSEWIC 2008; Environment Canada 2012). Burrowing Owls typically rely on burrowing mammals (e.g., badgers, ground squirrels, marmots) to create nest habitat for them (Environment Canada 2012). Short-eared Owls build nests by lining a scrape in the ground, usually in areas of dense grassland in close proximity to small mammal prey, with grasses and feathers (COSEWIC 2008). Swainson's Hawks, Rough-legged Hawks, and Short-eared Owls require open grasslands or cultivated fields for foraging.

Peregrine and Prairie Falcons both typically nest on cliff faces, in proximity to suitable foraging habitat and a water source (Cooper & Beauchesne 2004a, 2004b). Nest site availability and foraging opportunities are considered the most limiting factors for raptors (Whittington & Allen 2008).

Several raptor species were not selected as indicators: American Kestrel, Cooper's Hawk, Great Horned Owl, Golden Eagle, Long-eared Owl, Merlin, Northern Goshawk, Northern Harrier, Osprey, Red-tailed Hawk, Sharp-shinned Hawk, Turkey Vulture, and Western Screech-owl. All of these species, with the exception of Western Screech-owl, are provincially yellow-listed, and are either designated Not at Risk by COSEWIC or have no designation. Although the public has reported Ospreys occasionally sighted on Jacko Lake, Ospreys are quickly deterred from remaining there by the resident pair of Bald Eagles. Jacko Lake does not appear to be large enough to allow both of these large raptor species to co-exist.

The interior *macfarlanei* subspecies of Western Screech-owls are ranked S2 (imperiled) in BC. Western Screech-owls prefer riparian forests, especially those dominated by cottonwood (*Populus balsamifera*), water birch (*Betula occidentalis*) and trembling aspen (*Populus tremuloides*) (Cannings & Davis 2007). Most interior Western Screech-owl occurrences are in the Okanagan Valley, with probable irregular occurrences in the Thompson Valley (Cannings 2004). As they are irregular in the Kamloops area, and as deciduous riparian forest is very limited within the Project area, the Western Screech-owl is an unlikely species to be affected by the Project, and was not included as an indicator species for the raptor VC.

6.15.2 Assessment Boundaries

Assessment boundaries define the limit within which the effects assessment is conducted. They encompass the areas within, and times during which, the Project is expected to interact with the VCs, as well as the constraints that may be placed on the assessment of those interactions due to

political, social, and economic realities (administrative boundaries), and limitations in predicting or measuring changes (technical boundaries). The definition of these assessment boundaries is an integral part in scoping for raptors, and encompasses possible direct, indirect, and induced effects of the Project on raptors as well as the trends in processes that may be relevant.

6.15.2.1 Spatial Boundaries

Project Infrastructure Footprints

The Project infrastructure footprints (IF) include the Open Pit, ancillary buildings and facilities, roads, truck stop, Tailings Storage Facility (TSF), Water Management Ponds, Mine Rock Storage Facilities (MRSFs), and stockpiles (Figure 6.15-2). The Project infrastructure footprints are 1,705 ha in size.

Infrastructure Disturbance Area

The Project infrastructure footprints and linear features (transmission line and water line) were buffered by at least 50 m (Henderson 2011) to determine the Project Infrastructure Disturbance Area (IDA). The 3,185 ha IDA will be used to assess maximum direct Project effects (e.g., mortality, habitat loss, habitat alteration, etc.). The IDA includes the Project IF (1,705 ha) used to calculate direct loss of habitat, plus a 1,480 ha buffer around the Project IF that represents a zone of influence for potential disturbance associated with habitat alteration resulting from effects pathways such as contaminants, silt or dust, noxious weeds, and changes in drainage pattern (Figure 6.15-2).

The use of a buffered polygon area rather than individual infrastructure footprints will provide an overestimate of the direct effects of the Project for the assessment. The advantage of this approach is that it enables individual footprints to be moved and/or resized without changing the results of the effects assessment.

The IDA was modified from the General Arrangement Polygon to follow a section of the Kamloops city boundary to more accurately represent the current Project IF.

Habitat alteration by dust and water quantity is accounted for under potential habitat loss within the IDA. Areas outside of the IF that are not lost will be subject to potential alteration effects. However as wildlife species present in the area are adapted to the dry, dusty environmental conditions, these effects were considered mitigable.

Local Study Area

In accordance with the AIR the General Arrangement Polygon was buffered by 500 m to determine the Local Study Area (LSA). This area is the expected area of potential disturbance associated with all Project facilities (BC Environmental Assessment Office 2015). The LSA is 7,167 ha and will be used to assess indirect Project effects (e.g., disturbance) and provide context on the amount of habitat available adjacent to the Project IDA (Figure 6.15-2).

Detailed Terrestrial Ecosystem Mapping (TEM) was prepared for 83% of the LSA, 97% of the IDA and the entire (100%) IF.

Regional Study Area

The Regional Study Area (RSA) is the area for which cumulative effects will be assessed. The RSA includes portions of the South Kamloops Landscape Unit and Campbell Landscape Unit, including areas south of the Thompson River and west of Highway 97 (Figure 6.15-3). Landscape units were selected for the RSA as they are the geographical framework within which sustainable forest management regimes to maintain biodiversity are implemented. The RSA also includes local watershed basins and is 158,415 ha in size.

6.15.2.2 Temporal Boundaries

The temporal boundaries of the assessment will include the construction phase (short-term), operations (life of the mine), decommissioning and closure (short-term), and post-closure (short-term). The temporal phases of the Project are:

- **Construction**: 2 years (Year -2 to 1);
- **Operation**: 23 years (Year 1 to 23);
- **Decommissioning and Closure**: 5 years (Year 24 to 29, includes Project decommissioning, abandonment and reclamation activities, as well as temporary closure, and care and maintenance); and
- **Post Closure**: 5+ years (includes ongoing reclamation activities and post-closure monitoring).

6.15.2.3 Administrative Boundaries

No administrative boundaries have impacted, constrained or expanded the assessment of raptors.

6.15.2.4 Technical Boundaries

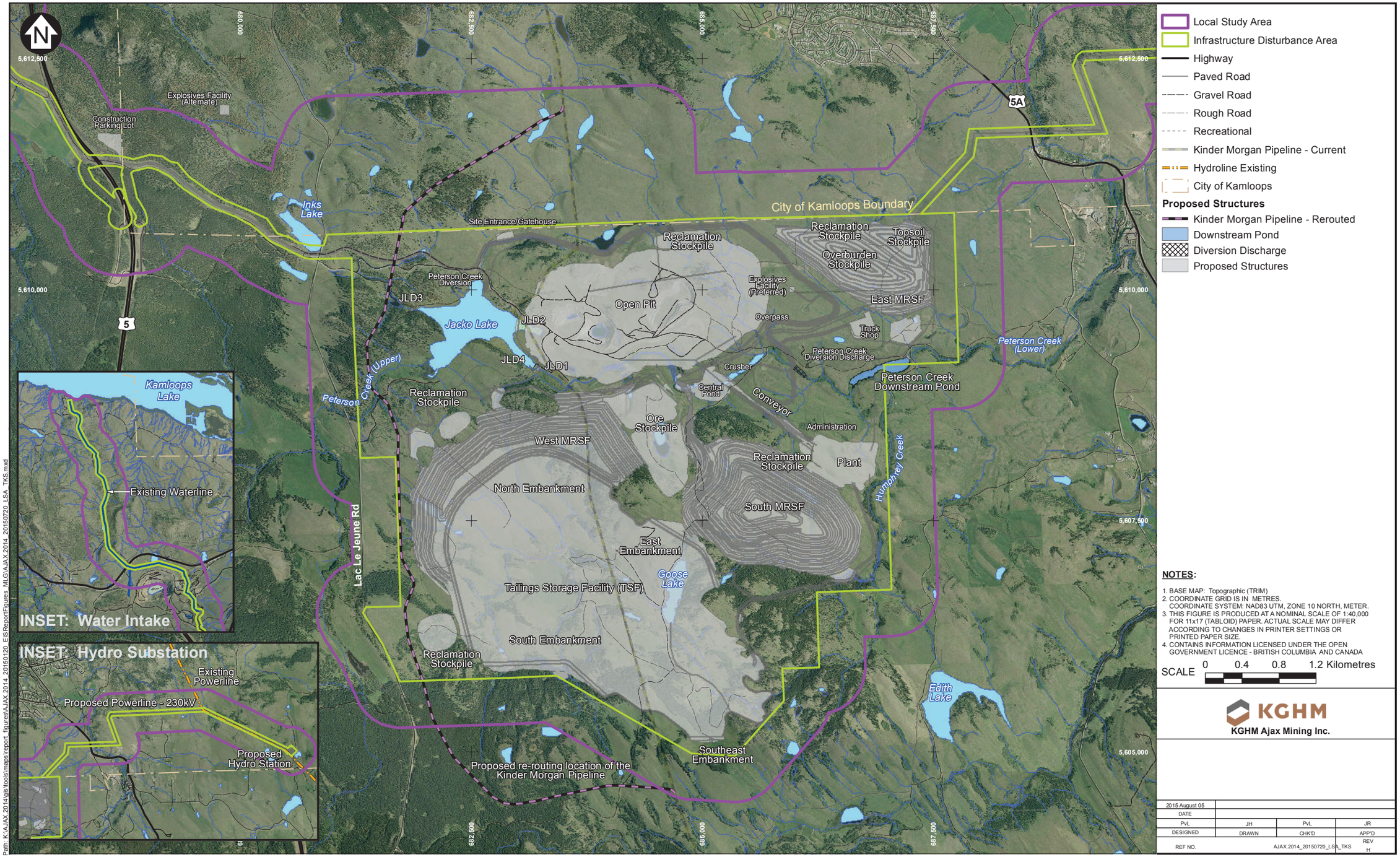
Terrestrial Ecosystem Mapping (TEM) was completed for the majority of the LSA in order to quantify residual habitat loss effects. Regional context and cumulative effects were quantified using VRI and other broad mapping sources.

6.15.3 Background

6.15.3.1 Regulatory and Policy Framework

The Kamloops Land and Resources Management Plan (LRMP) (1995) outlines that special attention to Red- and Blue-listed species should be considered; forests are to be managed to ensure diversity, as well as to ensure critical habitat is identified and managed appropriately through local level planning; and habitat improvement projects should be conducted where appropriate. Maintaining Flammulated Owl habitat is specifically listed as an objective of the Battle Bluffs Wildlife Habitat Resource Management Zone (RMZ) in the Kamloops LRMP. The Nicola Thompson Fraser Sustainable Forest Management Plan (SFMP) (2015) aims to conserve species diversity by ensuring that habitats for a particular species are maintained, including habitats for known occurrences of species at risk. The Nicola Thompson Fraser SFMP has set a target of 3,300 ha of Flammulated Owl habitat to be conserved or managed within the Kamloops TSA (SFMP Working Group 2015).

Figure 6.15-2
Local Study Area, Infrastructure Disturbance Area and Project Infrastructure



NOTES:

1. BASE MAP: Topographic (TRIM)
2. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD83 UTM, ZONE 10 NORTH, METER.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:40,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
4. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENCE - BRITISH COLUMBIA AND CANADA

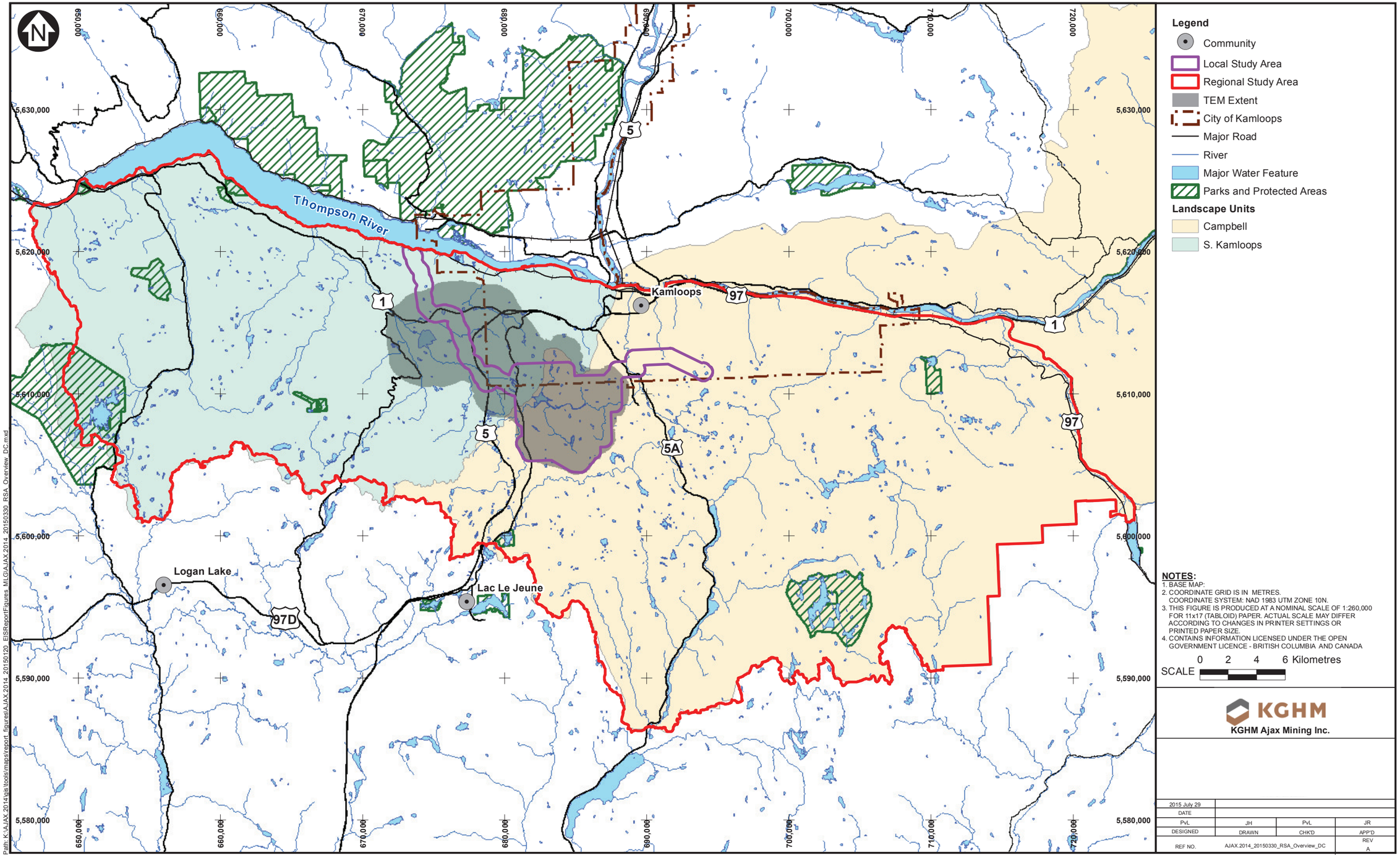
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KGHM Ajax Mining Inc.

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Figure 6.15-3
Regional Study Area andWildlife Habitat Areas



Legislation regarding raptors falls under the Species at Risk Act (Government of Canada 2002), the BC Wildlife Act (Government of British Columbia 1996), as well as the Forest and Range Practices Act (FRPA) (Government of British Columbia 2002). Raptor nests may be identified as Wildlife Habitat Features (WHF) under the Wildlife Act. The Identified Wildlife Management Strategy (IWMS) under FRPA is also a valuable tool for addressing potential management strategies (Wildlife Habitat Areas) for identified species.

Under the *Species at Risk Act* (SARA), the competent Minister(s) must post a recovery strategy or management plan within a specified time frame depending on the species status and schedule. A provincial recovery plan has not yet been prepared for the Burrowing Owl, though a national recovery strategy has been released (Environment Canada 2012); both provincial (Provincial Flammulated Owl Working Group 2011) and federal (Environment Canada 2013) management plans have been prepared for the Flammulated Owl; no management plans have been completed for the Peregrine Falcon or Short-eared owl (Table 6.15-3). Management plans for the Peregrine Falcon, *anatum* subspecies, and the Short-eared Owl are currently being prepared, and should be available in 2015 or early 2016 (Environment Canada 2015).

Table 6.15-3. Raptor Recovery Planning Documents

English Name	SARA Schedule/ Status[1]	BC[2]	SARA[2]
Burrowing Owl	1-E	-	RS - 2012
Flammulated Owl	1-SC	MP - 2011	MP - 2012
Peregrine Falcon, *anatum* subspecies	1-SC	-	-
Short-eared Owl	1-SC	-	-

[1] *E = Endangered, SC = Special Concern*
[2] *RS = Recovery Strategy, MP = Management Plan*

6.15.3.2 Regional Overview

In the Thompson Region, low elevation valley bottoms and riparian habitats are diminishing due to urbanization and changing land uses (BC Ministry of Forests, Lands, and Natural Resources 2013). Riparian and wetland habitats and Antelope Brush ecosystems are severely threatened in these areas. Forestry, ranching, and tourist developments in the region also have altered large areas of both grassland and forest habitats (*ibid*.). Greatest concerns for raptors in these regions include shortage of tree cavities and undisturbed grasslands for nesting purposes and degradation of foraging areas (*ibid*.). Raptor species most affected by these threats include the Burrowing Owl, Western Screech-Owl (*macfarlanei* subspecies), Flammulated Owl, Short-eared Owl, Prairie Falcon, and Swainson's Hawk.

The varied habitats of the Thompson region including arid grassland, shrub lands, open forests, cliffs, lakes and riparian areas support a particularly diverse raptor fauna. The Burrowing Owl, Flammulated Owl, Swainson's Hawk, and Prairie Falcon are unique to the region or occur only occasionally elsewhere in the province. The Western Screech-Owl and Flammulated Owl, in particular, would benefit from the protection and restoration of riparian and valley bottom habitats.

Bald Eagle (*Haliaeetus leucocephalus)*, Flammulated Owl (*Psiloscops flammeolus)*, Great Gray Owl (*Strix nebulosa*), Short-eared Owl (*Asio flammeus*), Peregrine Falcon (*Falco peregrinus),* Prairie Falcon (*Falco mexicanus),* Rough-legged Hawk *(Buteo lagopus)* and Swainson's Hawk (*Buteo swainsoni)*. The Golden eagle, Long-eared Owl, Great horned Owl and Osprey are other raptor species with traditional uses (Ignace 2014).

Indicator Species

Bald Eagles feed primarily on fish, waterfowl and carrion, especially ungulates (Blood & Anweiler 1994). They build large, bulky stick nests in large trees, usually close to waterbodies where food is readily available. Eagles are territorial and will exclude other eagles or competitors such as Ospreys. Bald Eagles that nest in the interior often winter along the coast as food is less available in the interior once most waterbodies freeze, however, some eagles may be seen in the vicinity of Kamloops year-round (Howie 2004). Sub-adults and non-breeding adults may be nomadic during both the winter and the growing season (Blood & Anweiler 1994). Bald Eagles have a moderate to high tolerance to human activity near their nests (BC Ministry of Forests, Lands, and Natural Resources 2013). Provincially, Bald Eagles are ranked S5BS5N (secure for both breeding and nonbreeding populations).

Burrowing Owls are listed as an Endangered Species under the BC Wildlife Act, are classified as Endangered on SARA's Schedule 1, are Red-listed in British Columbia, and are provincially ranked S1B (critically imperilled for the breeding population) (BC Conservation Data Centre 2014a). Burrowing Owls were once thought to be extirpated from the province (Leupin et al. 2000), but captive breeding has re-established populations in the Thompson and Nicola regions (Leupin 2004). Burrowing Owls require fossorial mammals, such as ground squirrels (*Spermophilus* spp.), yellow-bellied marmots (*Marmota flaviventris*), red foxes (*Vulpes vulpes*), American badgers (*Taxidea taxus*), and coyotes (*Canis latrans*) to provide suitable nesting habitat (Leupin 2004). As badgers, coyotes, and yellow-bellied marmots were observed throughout the LSA, the presence of potentially suitable habitat for Burrowing Owls was confirmed to be present.

Flammulated Owls are a small owl that is associated with dry forested habitats in the interior of BC. These owls arrive on their breeding range in BC in late April, with nesting occurring from May to August (Van Woudenberg & Kirk 1999). Suitable nesting stands are composed of old coniferous forests dominated by Douglas-fir and ponderosa pine, with multiple canopy layers and snags with nesting cavities, often in woodpecker-excavated cavities (McCallum 1994; Van Woudenberg & Kirk 1999; Linkhart & Mccallum 2013). Loss and degradation of suitable old-forest nesting habitat is thought to be the primary threat to this species, which has a moderate ability to co-exist in proximity to human disturbance (BC Ministry of Forests, Lands, and Natural Resources 2013). Flammulated Owls were detected in the Cherry Creek area south of the existing Afton tailings pond in 1994 (van Woudenberg et al. 2008) and are known to breed in the vicinity of Kamloops (Howie 2004). Flammulated Owls are ranked S3S4B (vulnerable or apparently secure for breeding populations).

Great Gray Owls nest in coniferous or deciduous forests (Bull & Duncan 1993). Great Gray Owls are sit-and-wait predators that capture small mammals from a perch site with good visibility. They often hunt during the day and are particularly adept at capturing prey beneath snow cover in the winter (Bull & Duncan 1993). Great Gray Owls are tolerant of human activity, but need large tracts of

forested habitat to meet all life requisites (BC Ministry of Forests, Lands, and Natural Resources 2013). In BC, Great Gray Owls are ranked S4B (apparently secure for breeding populations).

Prairie Falcons are known to inhabit the dry interior of BC. Prairie Falcons nest on cliff faces and hunt in adjacent dry grasslands and shrublands (Cooper & Beauchesne 2004a). Availability of prey is believed to be a major factor in reproductive success. Degradation of grassland foraging habitat due to urbanization, agriculture, and forest encroachment is believed to be the greatest threat to Prairie Falcons in BC. There is some evidence that Prairie Falcons are moderately tolerant of human activities, occasionally nesting near human dwellings and disturbance (Cooper & Beauchesne 2004a; BC Ministry of Forests, Lands, and Natural Resources 2013). Prairie Falcons are known to breed in the vicinity of Kamloops (Howie 2004). The only potential nesting habitat in the vicinity of the Project is on the steep rock faces on the west side of Sugarloaf Hill. Most Prairie Falcons in BC are thought to migrate south during the winter, although a few are known to be resident (Cooper & Beauchesne 2004a). Prairie Falcons are ranked S1S2B (critically imperilled or imperilled for the breeding population) in BC, and are also Red-listed in the province.

Peregrine Falcons are known as a highly adaptable species that can use a variety of habitats depending on location (Beebe 1974). The *anatum* subspecies generally occurs in association with wetlands, large rivers, lakes, or other open habitats that can support large numbers of their preferred prey (e.g., shorebirds, waterfowl, and passerines; Cannings et al. 1987; Campbell et al. 1990). Nesting occurs close to or overlooking those habitats, typically on inaccessible cliff ledges (Fraser et al. 1999). Peregrine Falcons have a moderate ability to co-exist near anthropogenic disturbances, with some birds nesting in tall buildings and bridges (BC Ministry of Forests, Lands, and Natural Resources 2013). Destruction and degradation of wetland foraging habitat is a major threat posed by human developments, thus reducing the amount of suitable habitat for prey populations (Fraser et al. 1999). The development of hillsides below nests is also a threat to nesting peregrines, as they are known to be sensitive to repeated human disturbance, potentially abandoning nest sites (Cooper & Beauchesne 2004b). The only potential nesting habitat for peregrines in the vicinity is located on the cliffs on the west side of Sugarloaf Hill, but no current or historical nest sites have been documented there. The Peregrine Falcon may be observed all year round but is not confirmed to breed in the vicinity of Kamloops (Howie 2004); only three nest sites are known in interior BC (BC Conservation Data Centre 2013). In BC, Peregrine Falcons are ranked S2?B (imperilled for the breeding population with uncertainty).

Rough-legged Hawks spend their winters in southern Canada, with the southern migration bringing them into the Kamloops area between October and April (Beebe 1974; Howie 2004). The diet of Rough-legged Hawks is made up almost entirely of small mammals and small birds. This species is tolerant of human activity, foraging in grasslands, cultivated fields/farmland and other open areas in the winter (BC Ministry of Forests, Lands, and Natural Resources 2013). Rough-legged Hawks are ranked S2S3N (imperilled or vulnerable for the nonbreeding population) in the province.

Short-eared Owls nest in grasslands, marshes, old fields, and open habitats (BC Ministry of Forests, Lands, and Natural Resources 2013), and typically lay eggs between March and May. This species roosts on the ground or in shrubs or small trees during the day, and have a moderate tolerance to human disturbance (*ibid*.). Many Short-eared Owls do not winter in the Kamloops area, but rather in

the Fraser Valley (BC Ministry of Water, Land and Air Protection 2004). The loss of wintering habitat due to urbanization and changing agricultural practices is thought to be the greatest threat to the Short-eared Owl (BC Ministry of Water, Land and Air Protection 2004). Prey availability and interspecific egg predation are also threats to this species (Reid et al. 2011). Short-eared Owls are ranked S3B,S2N (vulnerable for the breeding population, imperilled for the nonbreeding population) in BC.

Swainson's Hawks are migratory and are listed as uncommon to fairly common migrants and summer visitants to the Thompson-Okanagan plateau in the southern interior (Cooper 1998). Swainson's Hawks prefer habitat that has components of open woodlands with mixed forests and groves adjacent to grasslands, farmlands and wetlands (Fraser et al. 1999). They feed on insects (especially grasshoppers) as well as on small mammals and birds (Olendorff 1973). The large stick nests are usually built in trees (black cottonwood and aspen), and pairs may re-use old nests in successive years (Beebe 1974; Fraser et al. 1999; Dechant et al. 2001). Swainson's Hawks have a moderate to high tolerance to human activity near their nests (BC Ministry of Forests, Lands, and Natural Resources 2013). Most of the suitable breeding habitat for Swainson's Hawk in the province is on private land, and the species is thought to be threatened by loss of grasslands to agriculture and urbanization. Provincially, Swainson's Hawks are ranked S2B (imperilled for the breeding population).

Two of these indicator species, Bald Eagles and Great Gray Owls, are known to occur year round in the LSA, while the other seven are migrants in to, and out of, the area. Short-eared Owls and Peregrine Falcons have been observed to winter in British Columbia (COSEWIC 2007, 2008), but have not been confirmed in winter in the Kamloops area. Rough-legged Hawks are the only raptor found in the area that does not breed there; they breed in the Arctic and winter in the southern part of Canada (Bechard & Swem 2002).

6.15.3.3 Historical Activities

Historical activities in the region include mining, mills, pipelines, rail lines, agriculture/ranching, forestry, urban sprawl, water treatment, recreation/tourism and hunting/fishing. Only those activities expected to interact with raptors have been discussed here. Mines, agriculture/ranching, forestry and urban sprawl have likely resulted in habitat loss for raptors.

A major threat to raptor habitat in British Columbia is the large-scale conversion of agricultural lands and natural areas to land uses that typically involve impermeable surfaces (e.g., pavement and asphalt) and buildings. Between 1996 and 2006, the total area of urban land in B.C. increased from about 2,900 km^2 to 3,400 km^2, resulting in the loss or degradation of productive agricultural land, valley bottom habitats, and greenspaces. Intensive agricultural practices, such as expansive greenhouse developments, are also reducing raptor habitats. The Lower Fraser Valley and Delta traditionally supported some of the highest densities of wintering raptors in Canada, but populations and habitats have been greatly reduced as a result of human activities over the past century. Development continues in this area of rapidly expanding human population, further shrinking habitats for raptors and other wildlife. The situation unfolding in the Fraser Valley and Lower Mainland is being repeated throughout urban and rural areas of the province, particularly southern and eastern Vancouver Island and the Southern Interior valleys of British Columbia, albeit on smaller scales.

Forestry, ranching, and tourist developments in the Thompson region have altered large areas of both grassland and forest habitats. Greatest concerns for raptors in this region include shortage of tree cavities and undisturbed grasslands for nesting purposes and degradation of foraging areas.

6.15.3.4 Baseline Studies

Baseline studies were conducted specifically for raptors in all years between 2007 and 2014, excluding 2009 and 2013. Surveys were completed in an effort to determine presence and abundance of various raptor species. Observations of raptors were also recorded during breeding bird surveys in 2007, 2008, 2010, and 2014, and as incidental observations during other species-specific surveys.

Surveys for raptors were undertaken throughout the LSA to: a) establish presence of indicator species within the LSA; b) collect data on the location and timing of use of the LSA by indicator species; c) confirm habitat ratings used to develop wildlife habitat suitability models; and d) provide information to KAM to use during the Project design phase to avoid or minimize impacts to target species.

Data Sources

General information on species status and distribution was drawn from on-line sources such as the BC Ministry of Environment's Species Explorer and NatureServe (BC Conservation Data Centre 2014a; NatureServe 2014). Occurrence records of raptors in the RSA were obtained from the BC Conservation Data Centre (BC Conservation Data Centre 2014b) and from the provincial Species Inventory Database (BC Ministry of Environment 2014). Additional information on indicator species included the following reports:

- An Inventory Report on the Status of Diurnal Raptors (Ferruginous Hawk, Swainson's Hawk, Prairie Falcon, Peregrine Falcon) at Risk in the Southern Grasslands of British Columbia (Cooper 1998);
- Birds of Kamloops (Howie 2004);
- 1994 Extensive Survey of Flammulated Owls in the Southern Interior of British Columbia (van Woudenberg et al. 2008);
- An assessment of the Burrowing Owl reintroduction in the Thompson Nicola Region: A summary report (1992-1997) (Leupin & Low 1997);
- Field Monitoring Activities for the Burrowing Owl (*Athene cunicularia*) in the Kamloops/Nicola Region of British Columbia 2002 (Brodie 2002);
- Flammulated Owl Management Plan (Cooper et al. 2005);
- COSEWIC Assessment and Update Status Report on the Burrowing Owl *Athene cunicularia* in Canada (COSEWIC 2006);
- COSEWIC Assessment and Update Status Report on the Flammulated Owl *Otus flammeolus* in Canada (COSEWIC 2010);
- COSEWIC Assessment and Update Status Report on the Peregrine Falcon *Falco peregrinus* (*pealei* subspecies – *Falco peregrinus pealei anatum/tundrius* – *Falco perengriun anatum/tundrius*) in Canada (COSEWIC 2007); and

- COSEWIC Assessment and Update Status Report on the Short-eared Owl *Asio flammeus* in Canada (COSEWIC 2008).

Methods

Habitat Mapping

Habitat suitability mapping based on the TEM was completed for Flammulated Owl (Appendix 6.8-A). Habitat suitability for Flammulated Owl was modeled based on the ability for the habitats around the LSA to meet various life requisites (e.g., feeding, security/thermal cover, and reproducing sites). Habitat suitability for Flammulated Owl was modeled for living habitat (LI), which includes habitats used for all life requisites (feeding (FD), security/thermal (ST), and reproducing (RE)) in the growing season. The modeling was completed for the growing season (late spring through fall). Highly suitable habitat was defined for as dry, open-canopy, mature Douglas-fir or ponderosa pine forests.

Habitat Associations

Standard suitability mapping was not done for the other raptor species. Habitat associations and regional habitat attributes are summarized in Table 6.15-4.

Table 6.15-4. Raptor Habitat Associations

English Name	Habitat	VRI	BEI
Bald Eagle	Nests are primarily found in coniferous forests near water	6-7	
Burrowing Owl	short grass, sparsely vegetated areas with available burrows in which to nest, as well as densely-vegetated areas adjacent to nesting areas to supply an adequate prey base	1-2	BS, SS, (CF, ES)
Great Gray Owl	breeds in coniferous, deciduous, or mixed woodlands, usually in the vicinity of water, including marshes, lakes, muskegs, pastures and wet meadows	6-7	
Peregrine Falcon, *anatum* subspecies	Open habitats that support large populations of suitable birds as prey and the presence of suitable nest sites on cliffs	1	
Prairie Falcon	Extensive open areas such as grasslands and sagebrush steppe habitat, with an abundant prey base and suitable cliffs for nesting	1-3	AB, BS, ME, RO, SS (DF, DP, PP)
Rough-legged Hawk	Open coniferous forests and hunts in flat, open areas, with sparse ground cover (grasslands, marshes, fields and meadows)	6-7	AB, BS, CF, DF, DP, PP, SS
Short-eared Owl	Extensive open areas such as grasslands, savannahs, range land, or marshes with an abundant prey base, suitable nest sites, and adequate roosting sites	2-3	AB, BS, CF, DF, DP, ES, GO, ME, MS, OV, PP, RR, SM, SS, UR, WG, WL, WP, WR, YB
Swainson's Hawk	Grasslands and rangelands, burns and clear cuts. Breeds in open mixed forests and groves near such areas	6-7	DF, DP, PP

VRI information from the RSA was classified into structural stage categories based on presence of trees, crown closure, height, and land cover classification.

Any mature to old forest (structural stages 6 and 7) was considered potential suitable nesting habitat for forest nesting raptors and any open habitat such as grasslands was considered as suitable nesting habitat for ground nesters (Table 6.15-4).

Field Surveys

Raptor field surveys to determine raptor composition around the LSA were carried out between 2007 and 2014 and consisted of call playback surveys, and road-side surveys. Surveys were conducted following methods described in *Inventory Methods for Raptors* (Resources Inventory Committee (RIC) 2001),and *Inventory Methods for Owl Surveys* (Hausleitner 2006) at the present/not detected level. Large stick nests were opportunistically observed from adjacent openings. Taxa specific surveys targeted areas of suitable habitat while more general surveys were carried out in a variety of different habitat types. Detections of any raptor that occurred during other fieldwork were recorded as incidental observations. For a more detailed account of survey methods, see Appendix 6.8-A.

Flammulated Owl Call Playback Surveys

Over 20 hours of call playback surveys specifically targeting Flammulated Owls were completed. These surveys occurred in 2007, 2008, 2010, 2011, and 2014 (Table 6.15-5). These surveys targeted areas of potentially suitable Flammulated Owl habitat (Figure 6.15-4).

Table 6.15-5. Summary of Flammulated Owl Call Playback Survey Effort

Year	Total Survey Stations	Total Listening Surveyed (hr min)
2007	25	06h20m
2008	7	01h45m
2010	8	02h04m
2011	8	02h10m
2014	37	09h15m
Total	**85**	**21h34m**

Playback is not recommended for finding Great gray owl nests because owls will respond from large distances over a wide home range and not from nest sites alone (Resources Inventory Committee (RIC) 2001).

Raptor Roadside Surveys

Road-side surveys did not target any specific habitat type, but rather, attempted to cover as much of the LSA as possible. This type of survey is recommended for diurnally active raptors such as Burrowing Owls, Prairie Falcons, Rough-legged Hawks, and Swainson's Hawks (Resources Inventory Committee (RIC) 2001). Transects were completed from a vehicle, with a crew of two observers watching and listening for soaring and perched raptors. Surveys were conducted during the summer breeding season to target VC indicator species potentially present during the summer, as well as in

winter, to determine which species were present in the different seasons. Road-side surveys took place in 2010 (June), 2012 (February, March), and 2014 (February, June; Table 6.15-6; Figure 6.15-5).

Table 6.15-6. Summary of Road-side Survey Effort

Year	Number of Transects Surveyed	Length of Transects Surveyed (km)	Length of Survey (hr min)
2010	1	17.3	02h10m
2012	4	89.6	07h44m
2014	11	49.1	03h29m
Total	**16**	**156**	**13h23m**

Incidental Observations

Any raptors observed during targeted surveys for other taxa (migratory birds, waterfowl) were recorded as incidental observations. These observations will be reported, but cannot be correlated to any specific survey effort.

Characterization of Raptor Baseline Condition

Habitat Mapping

The LSA is dominated by grasslands and no high suitability Flammulated Owl habitat was mapped in the LSA (Figure 6.15-4). A total of 239.3 ha of moderate suitability habitat was mapped in the LSA, but the majority (87%) of the LSA was mapped as nil (Table 6.15-7).

Table 6.15-7. Habitat Suitability for Flammulated Owl in Growing Season in the LSA

Hectares of Habitat Mapped in TEM		Species and Season Rated For Flammulated Owl – Growing Season
LSA	Nil Suitability	5174.8 (87%)
	Low Suitability	529.5 (9%)
	Moderate Suitability	239.3 (4%)
	High Suitability	-

Flammulated Owl Call Playback Surveys

Call playback surveys targeted suitable habitat within the LSA (Figure 6.15-4). Confirming the habitat suitability mapping, no Flammulated Owl detections were made during any of the call playback surveys. Great Horned Owls were detected three times in July 2014 during these call playback surveys, with one additional observation of an owl of unidentified species, but suspected to be a Great Horned Owl by the surveyors.

Raptor Roadside Surveys

Seven raptor species, with a total of 42 observations, were recorded in 2010, 2012, and 2014, including American Kestrel, Red-tailed Hawk, Bald Eagle, Turkey Vulture, Rough-legged Hawk, Golden Eagle, and Northern Harrier (Table 6.15-8).

Figure 6.15-4
Flammulated Owl Habitat Suitability and Call Playback Survey Stations

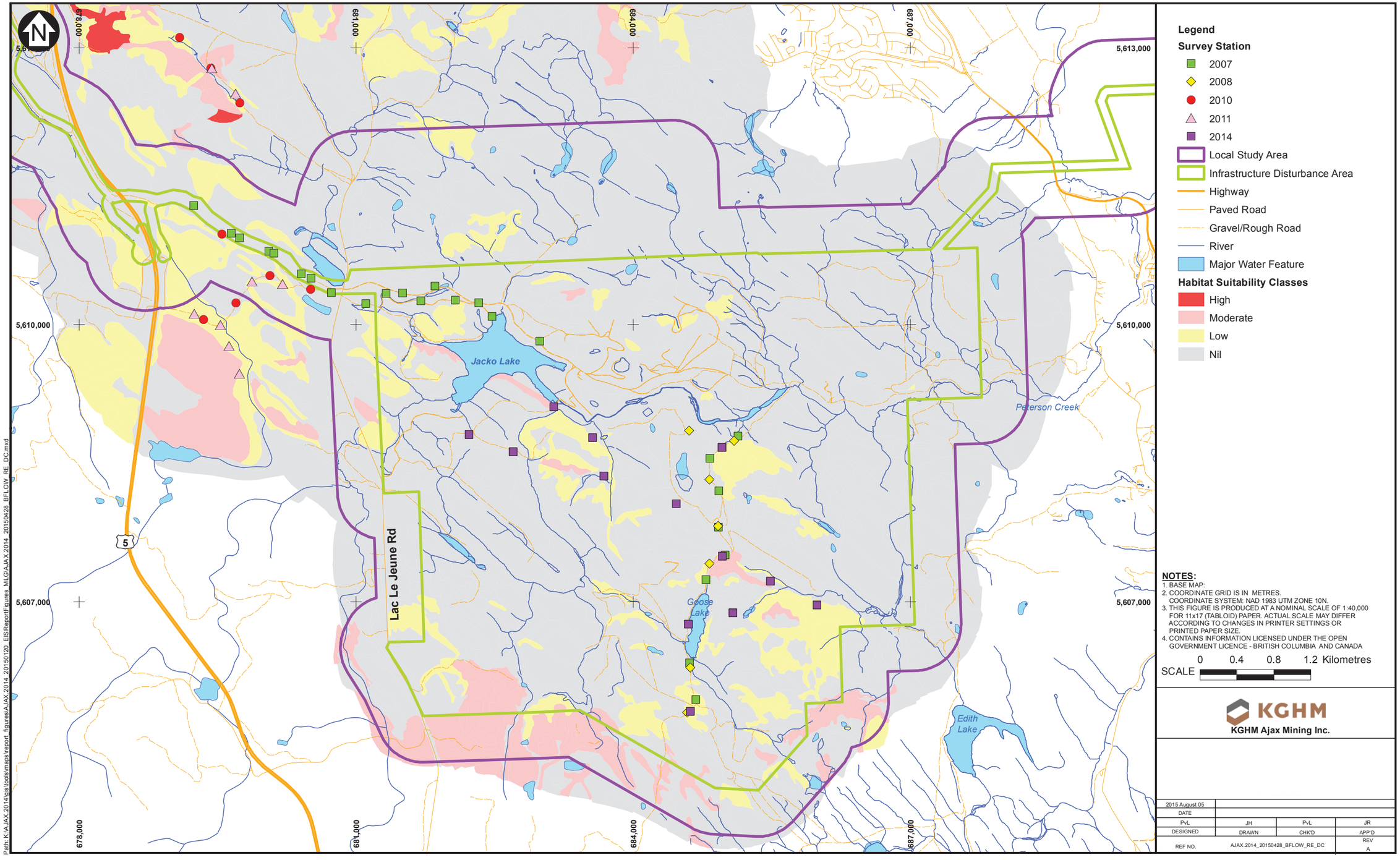


Figure 6.15-5
Raptor Roadside Survey Transect Locations

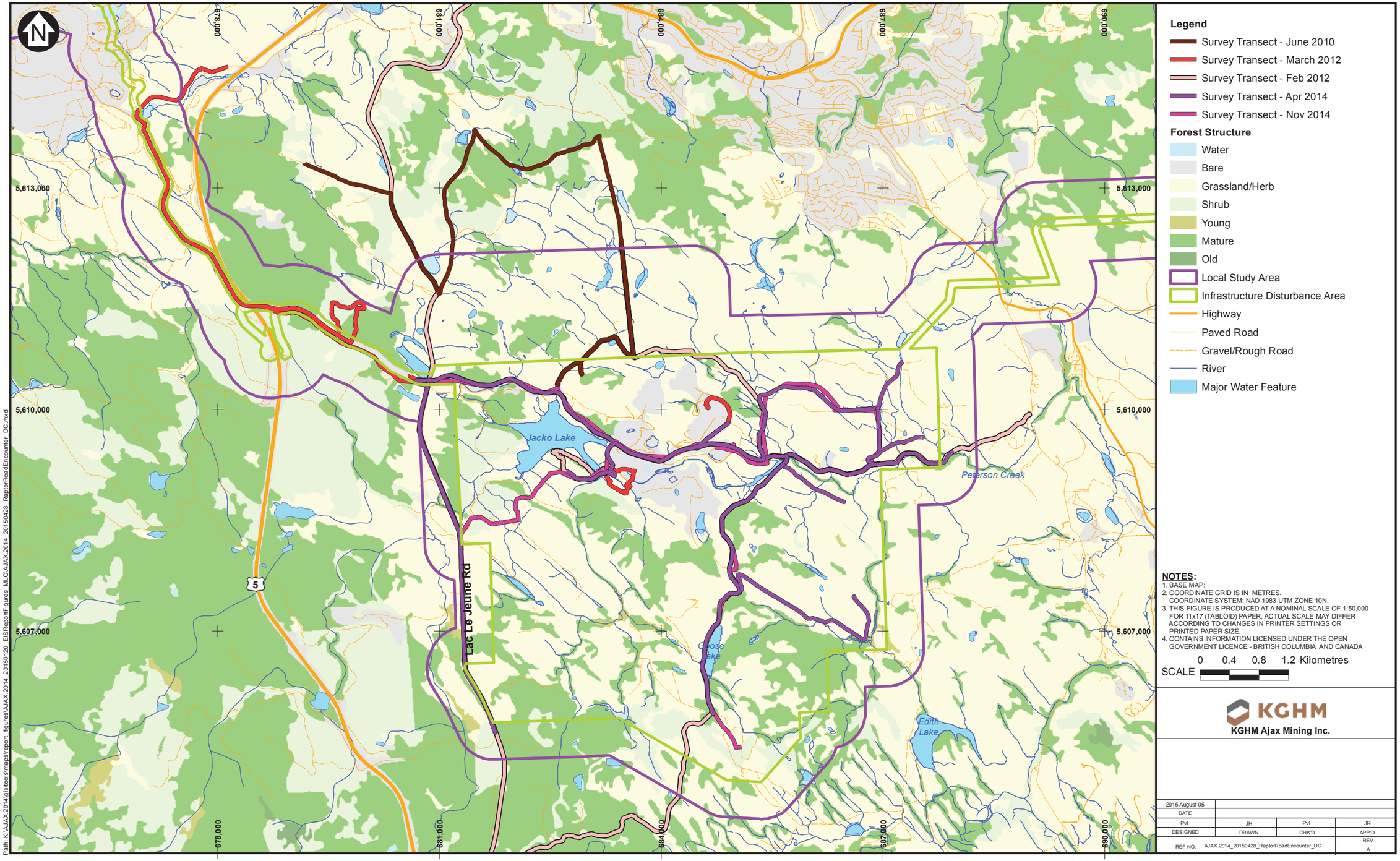


Table 6.15-8. Raptor Road Survey Results

Species	Indicator	Year			
		2010	2012	2014	Total
American Kestrel	No	6	-	1	7
Bald Eagle	Yes	-	3	1	4
Golden Eagle	No	-	1	-	1
Northern Harrier	No	-	1	-	1
Red-tailed Hawk	No	7	7	3	17
Rough-legged Hawk	Yes	-	8	2	10
Turkey Vulture	No	-	-	2	2
Total		**13**	**20**	**9**	**42**

Incidental Observations

Several raptor species were observed incidentally from 2007 to 2014. Twenty-three Bald Eagles, nine Rough-legged Hawks, and twenty-four Swainson's Hawks were observed incidentally during field surveys for other taxa (Table 6.15-9). The Rough-legged Hawks were recorded in 2014, with three of these observations occurring on Lac le Jeune Road, south of the west gate Project entrance site, and the fourth observation occurring approximately 500 metres northeast of Goose Lake on Goose Lake Road. The Swainson's Hawks were observed on Lac le Jeune Road just north of the turnoff to the Abacus camp as well as west of the Ajax pit in every year surveys occurred, except 2007. One Great Gray Owl was observed approximately 750 metres southeast of Jacko Lake in 2014, and one Peregrine Falcon was observed in 2008 at Goose Lake. There was one unconfirmed observation of a Prairie Falcon in 2014; however, the bird flew off before its identification could be verified (Table 6.15-9). Eight Short-eared Owls, five in 2011 during Sharp-tailed Grouse (*Tympanuchus phasianellus*) surveys and three more during drill site surveys in 2014, were also observed.

Table 6.15-9. Summary of Raptors Observed Incidentally

Species	Year						
	2007	2008	2010	2011	2013	2014	Total
American Kestrel	2	7	8	-	-	35	**52**
Bald Eagle	4	4	3	-	1	11	**23**
Cooper's Hawk	-	2	-	-	-	2	**4**
Great Gray Owl	-	-	-	-	-	1	**1**
Great Horned Owl	-	-	1	2	-	17	**20**
Golden Eagle	-	1	1	1	1	7	**11**
Long-eared Owl	-	1	-	-	-	-	**1**
Merlin	-	-	3	-	-	2	**5**
Northern Goshawk	-	-	-	1	-	-	**1**
Northern Harrier	1	-	6	-	-	9	**16**
Osprey	-	2	1	-	-	-	**3**

Species	Year						
	2007	2008	2010	2011	2013	2014	Total
Peregrine Falcon	-	1	-	-	-	-	**1**
Prairie Falcon	-	-	-	-	-	1*	**1***
Rough-legged Hawk	-	-	-	-	-	9	**9**
Red-tailed Hawk	5	11	12	2	-	34	**64**
Short-eared Owl	-	-	-	5	-	3	**8**
Sharp-shinned Hawk	-	-	-	-	-	6	**6**
Swainson's Hawk	-	3	4	8	2	7	**24**
Turkey Vulture	-	1	1	-	-	8	**10**
Total	**9**	**33**	**40**	**19**	**3**	**149**	**253**

**Unconfirmed observation*

Additional raptors incidentally observed during field studies include Cooper's Hawk, Great Horned Owl, Golden Eagle, Long-eared Owl, Merlin, Northern Goshawk, Northern Harrier, Osprey, Red-tailed Hawk, Sharp-shinned Hawk, and Turkey Vulture (Table 6.15-9). The one Long-eared Owl observed was heard in 2008 on Goose Lake Road.

A number of raptor nests were opportunistically located during field work, including: two Red-tailed Hawk nests, two Bald Eagle nests, two Great Horned Owl nests, and two Swainson's Hawk nests (Figure 6.15-6). All nests except for one Red-tailed Hawk nest were confirmed as active. A pair of Bald Eagles is resident on Jacko Lake, and have been confirmed present from March through June in 2007, 2008, 2010, 2012, and 2014. Two nests are present, one on the south shore of the lake at Jacko Creek, and one on the southeast arm of the lake near the Peterson Creek outlet.

Summary

Six of the nine indicator species were confirmed present in the LSA, while a seventh (Prairie Falcon) could not be confirmed, but was suspected (Table 6.15-10, Figure 6.15-6). No observations of Burrowing or Flammulated Owls occurred during baseline studies. Raptors observed incidentally and during breeding bird surveys had an increase in 2014 over previous years (Table 6.15-10, Figure 6.15-4) due to increased survey effort.

Reports of naturally occurring breeding pairs are a rare occurrence and the Burrowing Owl was considered extirpated in British Columbia (Fraser et al. 1999). In 1989, a captive breeding and release program was initiated to reintroduce Burrowing Owls into historical sites. As grassland habitat throughout the LSA is disturbed from the previous mine and cattle grazing, suitable habitat for Burrowing Owls is limited. Reintroduction efforts have been focused on areas that have been subject to fewer disturbances, such as Lac du Bois Park and Beresford (Leupin & Low 1997). Lac du Bois Grasslands Protected Area is a large (over 15,000 ha), protected grassland area that occurs north of the Thompson River. Beresford is a populated locality, located outside of the LSA, to the east of the Project. These locations will be the focus of continued reintroduction efforts, and as such, Burrowing Owls are not anticipated to occupy the LSA over these areas of higher suitability habitat (Figure 6.15-7).

Figure 6.15-6
Raptor Observations and Nest Locations

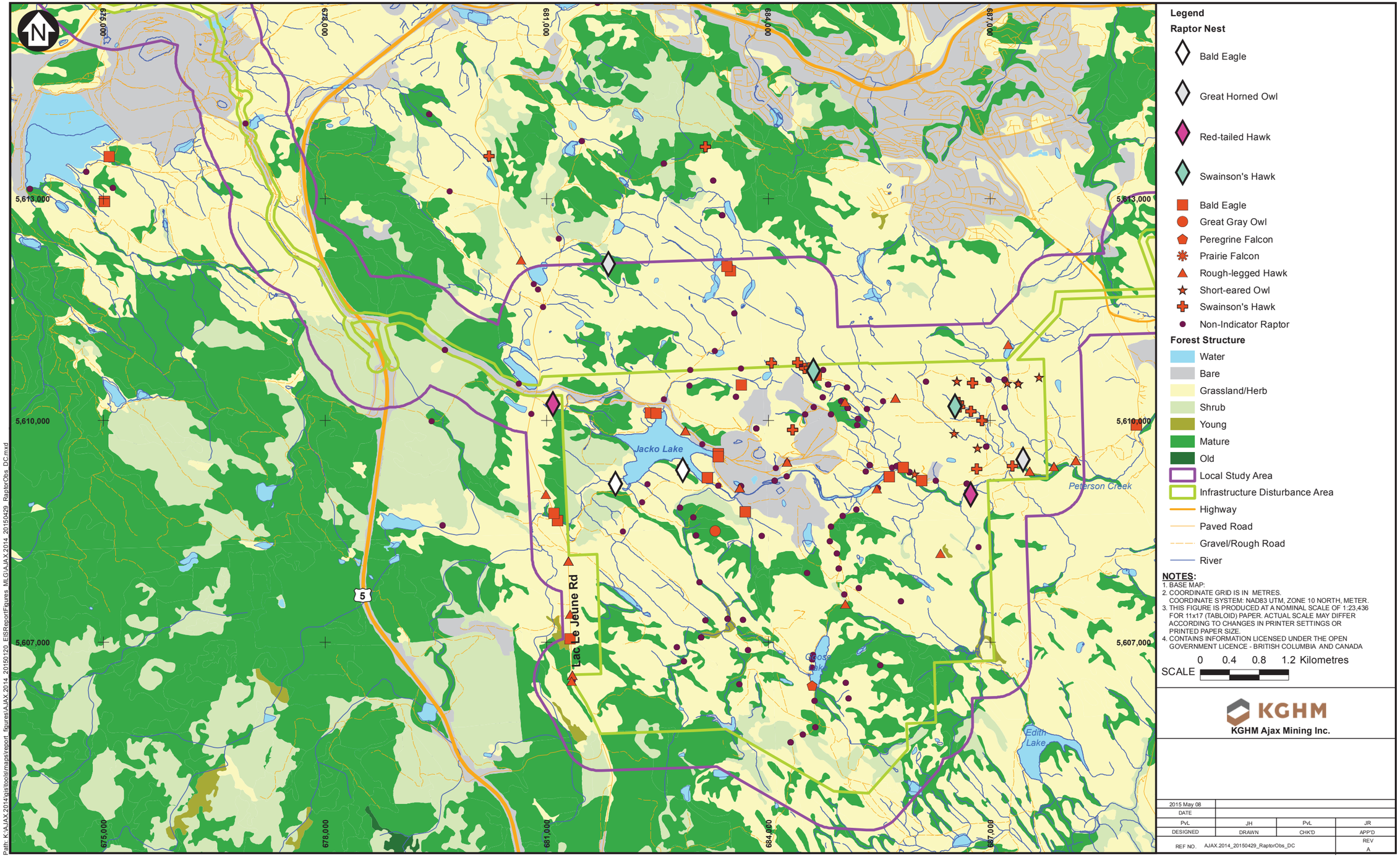


Figure 6.15-7
Raptor Regional Context

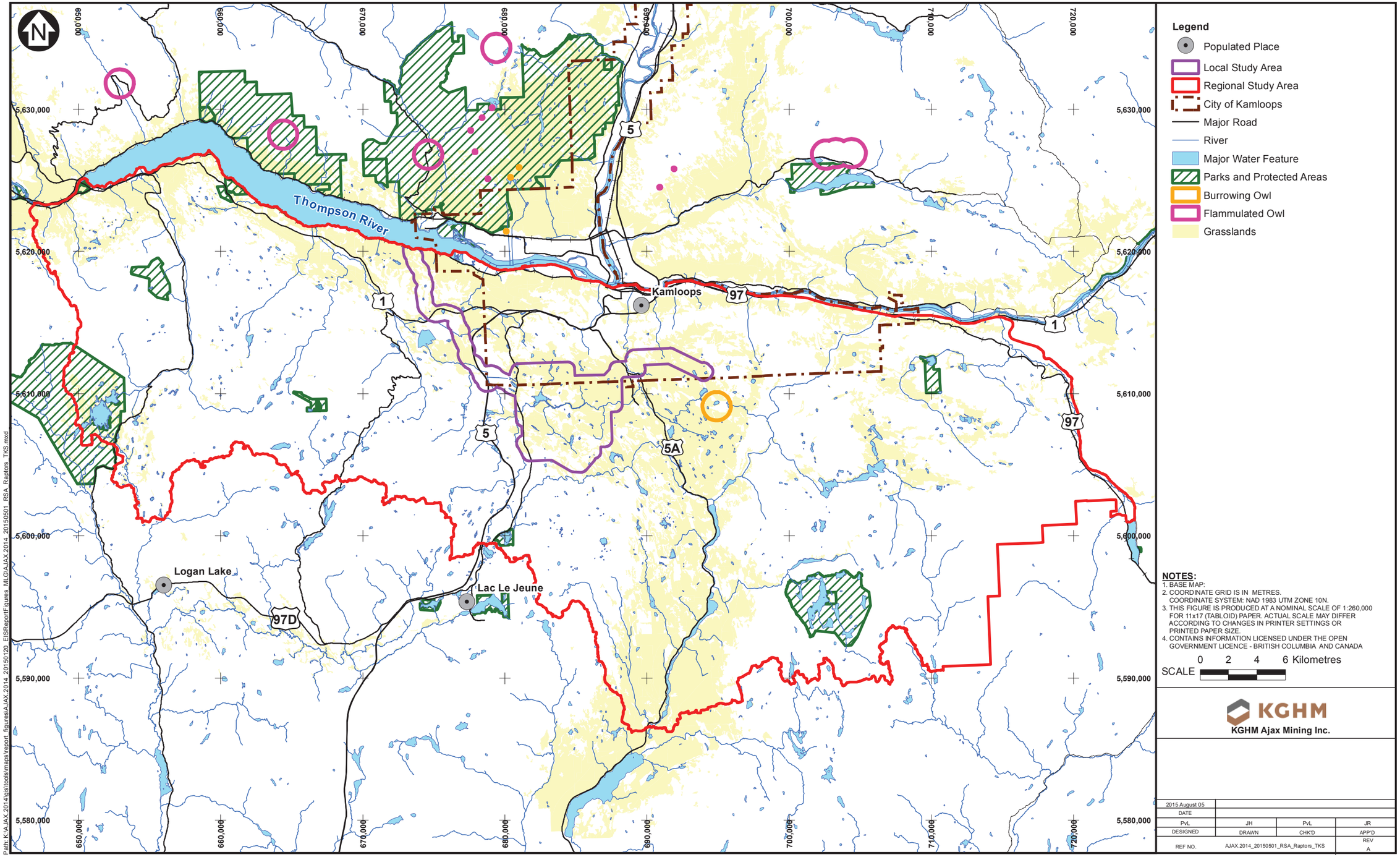


Table 6.15-10. Summary of Raptor Indicator Species Observations

Species	Year							
	2007	2008	2010	2011	2012	2013	2014	Total
Bald Eagle	4	4	3	-	3	1	12	**27**
Burrowing Owl	-	-	-	-	-	-	-	**0**
Flammulated Owl	-	-	-	-	-	-	-	**0**
Great Gray Owl	-	-	-	-	-	-	1	**1**
Peregrine Falcon	-	1	-	-	-	-	-	**1**
Prairie Falcon	-	-	-	-	-	-	1*	**1***
Rough-legged Hawk	-	-	-	-	8	-	12	**20**
Short-eared Owl	-	-	-	5	-	-	3	**8**
Swainson's Hawk	-	3	4	8	-	2	8	**25**
Total	**4**	**8**	**7**	**13**	**11**	**3**	**37**	**76**

**Unconfirmed observation*

As no high suitability habitat for Flammulated Owls exists in the LSA, and the small amount of moderate habitat that exists is highly fragmented, combined with the lack of any individual observations during baseline studies, this species is not anticipated to occur within the LSA, and therefore is not expected to have an interaction with the Project (Figure 6.15-7).

Peregrine and Prairie Falcons are not anticipated to be affected by the Project as there is no suitable cliff nesting habitat for either species within the LSA. Sugarloaf hill contains potential cliff habitat and is located 6 km to the northwest of the Project and within the RSA. While two falcons were observed over the course of field work, it is likely that these individuals were traveling between areas of suitable habitat, and not residing in the LSA.

Field surveys were able to: a) confirm the presence of at least five indicator species within the LSA; b) confirm the sparse amount of Flammulated Owl suitable habitat within the LSA; c) confirm that Burrowing Owls have not recolonized any part of the LSA; and d) confirm the sparse amount of potentially suitable nesting habitat for either Peregrine or Prairie Falcon within the LSA. As a result of these findings, effects of the Project on Burrowing Owl, Flammulated Owl, Peregrine Falcon, and Prairie Falcon are not anticipated. The Project may interact with Bald Eagle, Great Gray Owl, Rough-legged Hawk, Short-eared Owl, and Swainson's Hawk.

6.15.4 Potential Effects of the Project and Proposed Mitigation for Raptors

Birds of prey are particularly vulnerable to habitat destruction due to their requirements for relatively large home ranges and suitable nesting sites (Ehrlich et al., 1988; Kirk and Hyslop, 1998). As predators, these birds are vulnerable to changes in prey populations, as well as changes in habitat which affect the availability of prey (Crocker-Bedford, 1990; Grant et al., 1991; Janes, 1984; Preston, 1990; Schmutz, 1984; Steeger et al., 1992; Steenhof et al, 1999; Widén, 1989). The population status of raptor species can be difficult to estimate because they are often dispersed and/or secretive species that nest in low densities and their population can fluctuate cyclically in relation to prey abundance (Kirk and Hyslop, 1998).

6.15.4.1 Identifying Potential Effects on Raptors

Consistent with the requirements of the AIR, potential effects are considered in relation to habitat alteration and loss, disturbance and displacement and mortality. These effects were further subdivided into: habitat loss; habitat alteration; sensory disturbance; disruption of movement; direct mortality; indirect mortality; wildlife attractants; and chemical attractants. An interaction matrix (Table 6.15-10) is used to help scope potential effects by considering potential interactions with Project activities/components, consistent with approach outlined in the assessment methodology (Section 5.2.4.1). Further rationale for the scoping of potential effects is provided below.

Habitat Loss

For the purposes of this assessment habitat loss is defined as the process by which suitable habitat is rendered functionally unable to support the indicator species. Habitat loss will occur during the construction phase of the Project, specifically during vegetation clearing, land excavation, dams for water management, and any other changes to the physical landscape. Permanent loss results from the replacement of habitat by Project infrastructure footprints (IF) and is considered the minimum effect. All habitat occurring within the Project IF is assumed to be lost for the life of the Project. Habitat within the IDA that does not overlap IF might be physically present but may not remain functional. Loss of this habitat is temporary during construction and operations and is considered the maximum effect. Additional Project effects will not be considered for the Project IFs where habitat has been lost (i.e., a species cannot be displaced from habitat that has already been lost).

Habitat reclamation during operations and closure phases is considered a habitat gain, and will not be considered under this potential effect. Suitable habitat is present in the LSA for raptors, and an interaction with the Project is anticipated. Rankings of "moderate" and "high" were assigned for these activities, and warrant further analysis as described in Section 6.15.4.2.

Habitat Alteration

Habitat alteration is defined as a reduction in habitat suitability. Activities that affect the physical characteristics or accessibility of an area, either permanently or temporarily can result in a change in habitat suitability.

Habitat alteration will occur throughout the construction and operation phases of the Project, specifically as a result of drilling, blasting, crushing and road use (fugitive dust deposition), soil compaction, linear feature use and maintenance (invasive species introduction, vegetation maintenance) and changes in drainage and water quantity. Included within the IDA is a minimum 50 metre buffer between the edge of Project IF and the IDA. This buffer incorporates habitat alteration resulting from edge effects into the maximum habitat loss effect (Gieselman et al. 2013). As all suitable habitat within the IF will be lost during initial Project construction activities, habitat alteration will only be considered in the IDA and LSA.

Habitat fragmentation can be associated with corridors of unsuitable habitat (e.g., open roads) that may function as filters or barriers for some wildlife populations (Jalkotzy et al. 1997). The degree of loss of habitat connectivity will vary with the width of the corridor, the frequency of vehicular

traffic, the habitat on either side of the corridor and the species being considered. The resulting fragmentation and obstruction can limit the ability of a species to disperse, breed and survive if it cannot access critical habitats.

Sensory Disturbance

Sensory disturbance refers to a Project related activity (e.g., noise, light, human presence) that causes individuals to change their behaviour or avoid certain habitats that would otherwise be suitable. Little is known about the impacts of sensory disturbance on raptors, specifically distances at which flushing responses will be elicited (Richardson & Miller 1997). Disturbance can interrupt normal activity and cause an animal to move away from the source of disturbance. This movement may have energetic costs to the individual, as well as disrupting the activity (e.g., foraging, courting, resting, tending young) of the individual (Gill and Sutherland 2000; Blanc et al. 2006). Disturbed individuals may choose to temporarily vacate areas of suitable habitat, which may result in increased energy expenditures or utilization of sub-optimal habitats (Ward et al. 1999; Gibeau et al. 2002; Bautista et al. 2004). Disturbance during critical periods (e.g., nesting) may be more detrimental to some species than others. Birds that are flushed off nests leave their eggs and nestlings vulnerable to predators. For some VCs, noise can mask the sounds that individuals use to find prey, mates, and avoid predators. Masking can reduce fitness (breeding success), especially for species that are highly reliant on their acoustic environment. In some cases, habituation and adaptation can allow wildlife to accommodate the presence of noise in their environment; some species will tolerate a considerable amount of human presence and disturbance (Schueck et al. 2001).

Project activities expected to cause noise-sensory disturbance to raptors during construction include drilling and blasting, crushing mine rock, and loading, hauling, and deposition of mine rock. During operation drilling and blasting; crushing and conveying ore, and stripping, loading, hauling, deposition, and contouring of topsoil and overburden may cause noise-sensory disturbance to raptors.

Raptors are most sensitive during the breeding season. Suitable nesting sites, which vary according to species, must exist in order for breeding to occur successfully. As well, breeding adults are much more prone to persecution (such as shooting) or disturbance. Human activities can cause incubating adults to leave their nests, which can potentially result in the loss of eggs or small chicks, or nest abandonment (Fraser et al., 1985; Holthuijzen et al., 1990). Some species also have a smaller foraging range when breeding than when not breeding (Marzluff et al., 1997; Reynolds et al., 1982). Food availability is critical year round, but during breeding season it is more so. This is because one member of the breeding pair often does most of the hunting, so must be able to catch enough prey for itself, its partner, and the fledglings in order to breed successfully.

The early stages of courtship and nest initiation are the most critical times for nesting raptors, with a high level of sensitivity to disturbance at this time (BC Ministry of Forests, Lands, and Natural Resources 2013). Drilling and blasting includes very loud, short-duration disturbances that may cause raptors to abandon their nests (US Department of the Interior 2014). White and Thurow (1985) found that Ferruginous Hawks (*Buteo regalis*), a grassland associated raptor, had reduced nesting success when exposed to disturbances designed to simulate land development. Some species, such as the Golden Eagle and Peregrine Falcon have been observed to occupy and successfully raise young at new nest sites within a few hundred metres of high disturbance areas, such as blasting,

construction, and quarrying (Haugh 1982; White & Thurow 1985; White et al. 1988). Coulton et al. (2013) found that nest occupancy and hatch success rates of falcons were not negatively affected as a result of two diamond mines in close proximity to nest locations (>5.9 km).

Traffic noise resulting from the Project may also reduce the success of nesting birds (Parris & Schneider 2009; Ortega 2012). Bautista et al. (2004), however, found that six of nine raptor species studied did not appear to elicit a response to increased traffic loads, and therefore increased noise levels, on weekends. Based on preliminary noise modeling, drilling and blasting noise are anticipated to have a "high" interaction on nesting raptors, while all other Project related noise is anticipated to have a "low" interaction on this species. Based on the rankings of "high," sensory disturbance due to noise warrants further analysis as described in Section 6.15.4.2.

Artificial light during evening operations and decommissioning and closure activities may also have an effect on raptors. Increased light levels at night may allow for diurnal species to have an increased ability to forage, as many prey species (e.g., invertebrates, small song birds, bats, etc.) may be attracted to these lights and may be more detectable because of them (Gaston & Bennie 2014). An increase in diurnal animals' ability to forage may result in nocturnal species having an increased prey abundance (Canário et al. 2012; Gaston & Bennie 2014). Project components and related activities expected to cause light-sensory disturbance to the indicator species include Project lighting, which will take place in the construction, operations, and decommissioning and closure phases. A ranking of "low" was assigned for this this activity as artificial light is not expected to have a negative impact on any raptor species in the LSA, and will be discussed further in Section 6.15.4.2.

Disruption of Movement

A wildlife movement corridor is a linear habitat that connects two significant habitat areas (Beier & Loe 1992). Disruption of movement refers to Project related activities that may cause an interruption to animal movements or migration, or may cause complete avoidance of certain habitats that would otherwise be suitable. Displaced individuals may choose to temporarily vacate habitats, resulting in increased energy expenditures. Project infrastructure will not prevent any species from traveling throughout their ranges.

Direct Mortality

Direct mortality is defined as the death of an individual resulting directly from a Project related activity. Direct mortality can result from any number of project activities, but are typically associated with vehicle/machinery use on roads, individuals getting killed while the habitat they are in is being removed, and individuals having an unexpected interaction with an anthropogenic feature (e.g., flying into transmission lines, electrocution from transmission lines).

The possibility for direct mortality during Project construction exists for a variety of specific activities. Clearing/grubbing and earthworks activities during construction have the potential to kill nestling individuals that are unable to fly to safer habitat. These activities were ranked "high" for the likelihood of potential mortality on raptors.

Raptors, especially owls, are susceptible to road mortality (Loos & Kerlinger 1993; Erickson et al. 2005; Whittington & Allen 2008; Bishop & Brogan 2013). The report *Wildlife Accident Monitoring and Mitigation in British Columbia* (Sielecki 2010) was reviewed, and showed that owls are the most frequently killed raptor species in the Project region as a result of vehicle collisions. Public and site road use are anticipated to have a "moderate" likelihood of interaction with raptors. Road mortality is anticipated to be highest during construction and operations phases, when Project traffic will be most frequent. Direct mortality may also occur during transport of concentrate from the Project to the Port of Vancouver. This activity was ranked as "low", as the incremental effect of those vehicles to existing highway traffic is very small.

During all phases of the Project, power transmission and distribution also has the potential to result in mortality of raptors, both in aerial collisions, and potential for electrocution of perching individuals (Avian Power Line Interaction Committee 2006, 2012). An interaction is anticipated for this activity resulting in mortality of this VC. Based on rankings of "high," and "moderate" for these Project activities, further discussion will occur in Section 6.15.4.2.

Indirect Mortality

Indirect mortality is defined as the death of an individual resulting indirectly from a Project related activity. Wildlife mortality may be caused indirectly from increased access for hunting or poaching, or from range shifts leading to increased resource competition between individuals. The likelihood for an indirect mortality interaction resulting from Project activities was determined to be "negligible" for all phases of the Project.

Wildlife Attractants

Wildlife attractants are defined as features or materials that may attract wildlife away from their natural environments, to areas that are superficially superior. Odours, food waste, sewage, garbage, and stored chemicals from construction crews and camps are examples of types of attractants that may entice individuals, but that ultimately will have a detrimental effect on the species. Regenerating vegetation on road sides, and artificial ditches near roads may have potential effects on certain VCs.

The presence of perching/nesting structures (e.g., powerlines, power poles) may attract raptors for foraging and reproducing needs. Site roads may also attract raptors if any carrion (roadkill) is left out as a potential food source. As some potentially suitable habitat exists in proximity to these power distribution locations and site roads, a ranking of "moderate" was assigned for these activities and warrants further analysis as described in Section 6.15.4.2.

Chemical Hazards

Chemical hazards are defined as chemicals that result from Project related activities that have the potential to cause an adverse health effect on wildlife. Wildlife may ingest, inhale, or absorb chemicals (e.g., metals, dust, organic anthropogenic substances, etc.) from improperly stored substances, dust on soil or vegetation, or bioaccumulation from prey.

Lead accumulation generally increases in proportion to the amount of lead in the environment and the duration of exposure (animal age), however, environmental characteristics of temperature, pH and salinity conditions also influence the rate of uptake of lead by aquatic organisms (World Health Organization 1989). Lead concentrates in bottom sediments, with only a minor fraction present dissolved in the water column (World Health Organization 1989).

Roberts et al. (1978) documented increased lead levels in tissues of small mammals captured on metalliferous mine spoils as compared to those trapped on control areas, and suggested that clinical symptoms of lead intoxication could occur in small mammals from specific tailings sites. Tolerance to lead ingestion varies widely between species and is dependent on the form of lead involved (i.e., metallic lead, tetravalent organic lead, lead salts).

Evaluation of potential toxic effects of metals on wildlife and ecosystems is hampered by a wide array of environmental factors operating both independently and synergistically, which are known to affect toxicity and bioaccumulation. Metals bioavailability varies greatly with environmental factors such as temperature, pH, water velocity, season, and salinity. The potential effects of metal contamination may be complicated due to interactions between different metals. Small mammals feeding on invertebrates (i.e., shrews) ingest more metals than do small mammals feeding on vegetation (i.e., voles) (Hunter et al. 1987). As all raptor species in the LSA feed on various small mammals, the potential for bioaccumulation of toxic substances exists.

A complete list of Project activities and what effect each activity may have on raptors is provided below (Table 6.15-11).

6.15.4.2 Effects on Raptors

For effects ranked "M" or "H" in Table 6.15-11, further analysis was undertaken, and is described below to quantify the potential effects of Project activities on raptors.

Habitat Loss and Alteration

Methods to Predict Impacts of Project Activities on Raptors

The potential exists for an adverse effect on raptors if suitable habitat is present within the IF or IDA. Raptors require specific habitats for reproducing (large trees or open grasslands); these habitats were considered the most limiting habitat, and were the focus of the effect of habitat loss.

While some suitable nesting habitat (veteran trees) may exist in other structural stages, these elements were not mapped, and were not considered for the assessment of habitat loss. Any raptor nests observed during field surveys were recorded and will be discussed as part of this assessment. The amount of suitable habitat lost for raptors was calculated by determining the maximum and minimum potential effects. The maximum effect was calculated by overlaying the IDA footprint on the habitat suitability mapping, while the minimum effect was determined by overlying the Project IF. The amount of suitable habitat lost within the IDA or IF was compared to the total amount of suitable habitat within the LSA to calculate the percent of suitable habitat lost within the LSA.

Table 6.15-11. Identifying Potential Project Interactions and Effects on Raptors

Project Activities		Potential Effects on Raptors							
		Habitat Loss	Habitat Alteration	Sensory Disturbance	Disruption of Movement	Direct Mortality	Indirect Mortality	Wildlife Attractants	Chemical Hazards
Construction	Clearing and Grubbing	H	O	O	O	M	O	O	O
	Earthworks	M	O	O	O	M	O	O	O
	Overburden/Topsoil Stockpile	O	O	O	O	O	O	O	O
	Laydown Areas and Storage Yards	O	O	O	O	O	O	O	O
	Project Lighting	O	O	L	O	O	O	O	O
	Site Security and Fencing	O	O	O	O	O	O	O	O
	Fuel Storage and Filling Area	O	O	O	O	O	O	O	L
	Hazardous Wastes Transport, Storage, and Disposal	O	O	O	O	O	O	O	L
	Construction Wastes Transport, Storage, and Disposal	O	O	O	O	O	O	O	O
	Sewage Infrastructure and Disposal	O	O	O	O	O	O	O	L
	Public Road Realignment, Use, and Maintenance	O	L	M	O	M	O	M	L
	Site Road Construction, Use and Maintenance	O	L	M	O	M	O	M	O
	Haul Road Overpass Construction, Use, and Maintenance	O	O	O	O	O	O	O	O
	Site Buildings and Process Plant	O	O	O	O	O	O	O	O
	Explosives Magazine and Storage Facilities	O	O	O	O	O	O	O	O
	Open Pit Development	O	O	O	O	O	O	O	O
	Drilling and Blasting	O	O	H	O	O	O	O	O
	Crushing Mine Rock	O	O	M	O	O	O	O	O
	Loading, Hauling, and Deposition of Mine Rock	O	O	M	O	O	O	O	O
	Temporary Ore Stockpile	O	O	O	O	O	O	O	O
	Tailing Storage Facility Development	O	O	O	O	O	O	O	O
	Power Transmission, Distribution	O	L	O	O	M	O	M	O
	Natural Gas Line	O	L	O	O	O	O	O	O

(continued)

Table 6.15-11. Identifying Potential Project Interactions and Effects on Raptors (continued)

Project Activities		Potential Effects on Raptors							
		Habitat Loss	Habitat Alteration	Sensory Disturbance	Disruption of Movement	Direct Mortality	Indirect Mortality	Wildlife Attractants	Chemical Hazards
Construction *(cont'd)*	Pipeline Utility Corridor (Potable Water, Sewage, and Site Water)	O	L	O	O	O	O	O	L
	Water Intake from Kamloops Lake	O	O	O	O	O	O	O	O
	Fire Suppression Infrastructure	O	O	O	O	O	O	O	L
	Contact Water	O	O	O	O	O	O	O	L
	Non-contact Water	O	O	O	O	O	O	O	O
	Haul Road Overpass	O	O	O	O	O	O	O	O
	Water Management Dams	L	O	O	O	O	O	O	O
	Mine Staffing (Direct Employment)	O	O	O	O	O	O	L	O
	Contracted Employment	O	O	O	O	O	O	L	O
	Taxation	O	O	O	O	O	O	O	O
Operation	Open Pit Development	O	O	O	O	O	O	O	O
	Drilling and Blasting	O	O	H	O	O	O	O	O
	Hauling Mine Rock and Ore from Pit	O	O	M	O	L	O	O	O
	Crushing and Conveying Ore	O	O	M	O	O	O	O	O
	Temporary Ore Stockpile	O	O	O	O	O	O	O	O
	Development of Mine Rock Management Facilities	O	O	O	O	O	O	O	O
	Stripping, Loading, Hauling, Deposition, and Contouring of Topsoil and Overburden	O	O	M	O	O	O	O	O
	Revegetation through Progressive Reclamation	O	O	O	O	O	O	O	O
	Process Plant Operation	O	O	O	O	O	O	O	O
	Deposition to Tailing Storage Facility	O	O	O	O	O	O	O	L

(continued)

Table 6.15-11. Identifying Potential Project Interactions and Effects on Raptors (continued)

Project Activities		Potential Effects on Raptors							
		Habitat Loss	Habitat Alteration	Sensory Disturbance	Disruption of Movement	Direct Mortality	Indirect Mortality	Wildlife Attractants	Chemical Hazards
Operation *(cont'd)*	Site Road Use and Maintenance (Materials, Personnel, Supplies)	O	L	M	O	M	O	M	L
	Concentrate Transport and Storage	O	O	O	O	L	O	O	L
	Explosives Magazine and Storage Facilities	O	O	O	O	O	O	O	O
	Fire Suppression Infrastructure	O	O	O	O	O	O	O	L
	Fuel Storage and Filling Area	O	O	O	O	O	O	O	L
	Hazardous Wastes Transport, Storage, and Disposal	O	O	O	O	O	O	O	L
	General Wastes Transport, Storage, and Disposal	O	O	O	O	O	O	O	O
	Sewage Infrastructure and Disposal	O	O	O	O	O	O	O	L
	Laydown Areas and Storage Yards	O	O	O	O	O	O	O	O
	Power Transmission, Distribution	O	L	O	O	M	O	M	O
	Project Lighting	O	O	L	O	O	O	O	O
	Site Access, Security and Fencing	O	O	O	O	O	O	O	O
	Water Intake from Kamloops Lake	O	O	O	O	O	O	O	O
	Contact Water	O	O	O	O	O	O	O	L
	Non-contact Water	O	O	O	O	O	O	O	O
	Potable Water Treatment and Use	O	O	O	O	O	O	O	O
	Haul Road Overpass	O	O	O	O	O	O	O	O
	Mine Staffing (Direct Employment)	O	O	O	O	O	O	L	O
	Contracted Employment	O	O	O	O	O	O	L	O
	Taxation	O	O	O	O	O	O	O	O

(continued)

Table 6.15-11. Identifying Potential Project Interactions and Effects on Raptors (continued)

Project Activities		Potential Effects on Raptors							
		Habitat Loss	Habitat Alteration	Sensory Disturbance	Disruption of Movement	Direct Mortality	Indirect Mortality	Wildlife Attractants	Chemical Hazards
Decommissioning and Closure	Dismantling of Ancillary Buildings	O	O	O	O	O	O	O	O
	Pit Lake Planning	O	O	O	O	O	O	O	O
	Site Road Decommissioning	O	O	O	O	O	O	O	O
	Tailing Storage Facility Decommissioning and Reclamation	O	O	O	O	O	O	O	L
	Mine Rock Management Facilities Reclamation	O	O	O	O	O	O	O	O
	Fuel Storage and Filling Area	O	O	O	O	O	O	O	L
	Hazardous Wastes Transport, Storage, and Disposal	O	O	O	O	O	O	O	L
	General Wastes Transport, Storage, and Disposal	O	O	O	O	O	O	O	O
	Sewage Infrastructure and Disposal	O	O	O	O	O	O	O	L
	Laydown Areas and Storage Yards	O	O	O	O	O	O	O	O
	Power Transmission, Distribution	O	O	O	O	M	O	M	O
	Project Lighting	O	O	L	O	O	O	O	O
	Site Access, Security and Fencing	O	O	O	O	O	O	O	O
	Contact Water	O	O	O	O	O	O	O	L
	Non-contact Water	O	O	O	O	O	O	O	O
	Potable Water Treatment and Use	O	O	O	O	O	O	O	O
	Haul Road Overpass	O	O	O	O	O	O	O	O
	Road use to the Project (Materials, Personnel, Supplies)	O	L	L	O	L	O	L	L
	Mine Staffing (Direct Employment)	O	O	O	O	O	O	L	O
	Contracted Employment	O	O	O	O	O	O	L	O
	Taxation	O	O	O	O	O	O	O	O

(continued)

Table 6.15-11. Identifying Potential Project Interactions and Effects on Raptors (completed)

Project Activities		Potential Effects on Raptors							
		Habitat Loss	Habitat Alteration	Sensory Disturbance	Disruption of Movement	Direct Mortality	Indirect Mortality	Wildlife Attractants	Chemical Hazards
Post Closure	General Site Inspections and Maintenance	O	O	O	O	O	O	O	O
	Contact Water	O	O	O	O	O	O	O	L
	Non-contact Water	O	O	O	O	O	O	O	O
	Road use to the Project (Materials, Personnel, Supplies)	O	L	L	O	L	O	O	L
	Mine Staffing (Direct Employment)	O	O	O	O	O	O	L	O
	Contracted Employment	O	O	O	O	O	O	L	O

Notes:

O	*No interaction anticipated.*
L	*Negligible to minor interaction expected; implementation of best practices, standard mitigation and management measures; no monitoring required, no further consideration warranted.*
M	*Potential moderate interaction requiring unique active management/monitoring/mitigation; warrants further consideration.*
H	*Key interaction; warrants further consideration.*

Predict Impacts of Project Activities on Raptors

Clearing and grubbing activities will remove suitable raptor habitat, such as large diameter trees, and vegetation cover for ground nesters (Short-eared Owls). The potential for combined habitat loss within the IDA is about 40% of the habitat available in the LSA and 6% of the RSA (Table 6.15-12). The minimum loss predicted is between up to 24% of the LSA and 3% of the RSA (Table 6.15-12).

Table 6.15-12. Structural Stage Distribution (ha) by Spatial Boundaries

Habitat	Raptor Use	RSA	LSA	IDA	Max Habitat Loss and Alt	IF	Min Habitat Loss
Grassland	Foraging (Ground Nesting)	46,682	4,733	2,072	44%	1,135	24%
Shrubland	Foraging (Ground Nesting)	25,443	483	199	41%	68	14%
Mature Forest	Nesting	77,257	1,394	592	42%	309	22%
Old Forest	Nesting	1,217	0	0	0%	0	0%

A pair of breeding Bald Eagles currently resides on Jacko Lake during the growing season, with two known nest locations present. In 2010, one nest had confirmed activity while the other nest had eagles observed near it, but not actively using it. Bald Eagles are quite territorial (Blood & Anweiler 1994), and Jacko Lake has not been observed historically to support more than one breeding pair. As the nests at Jacko Lake, as well as Jacko Lake itself, will not be removed as a result of the Project, the resident Bald Eagles are not anticipated to be negatively affected as a result of habitat loss.

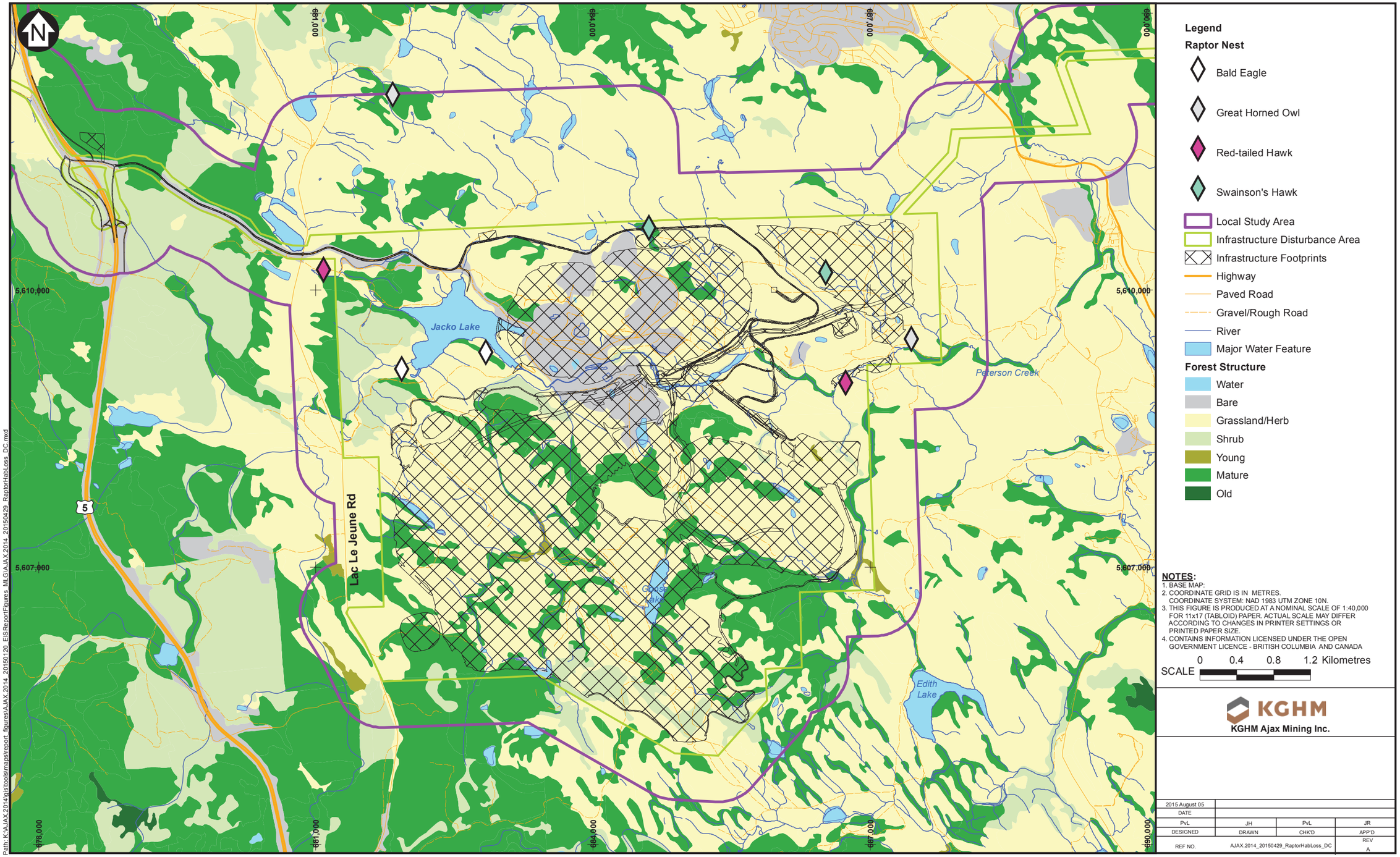
Great Gray Owls often nest in dense coniferous and hardwood forests, especially pine, spruce, birch and poplar (BC Conservation Data Centre 2014a). Approximately 1,394 ha of potentially suitable mature forested habitat exists within the LSA; between 309 ha (22%) and 592 ha (42%) of the potentially suitable habitat may be removed as a result of the Project (Table 6.15-12). This is less than 1% of the available mature forest in the RSA.

Rough-legged Hawks rely on open fields and grasslands for wintering habitat to provide adequate forage opportunities. A reduction in suitable prey habitat will likely result in a reduction of prey, reducing the ability of this species to meet its energy requirements. A total of 483 ha of potentially suitable prey (small mammal) habitat exists within the LSA (Table 6.15-12). A loss of potential prey habitat of between 68 and 199 ha may result due to the Project.

Two known Swainson's Hawk nests are known in the IDA, and both of these occurrences may be lost as a result of the Project. One nest location occurs within the overburden stockpile footprint while the other falls very close to the reclamation stockpile (Figure 6.15-8).

In addition to these indicator species, two Red-tailed Hawk nests and two Great Horned Owl nests were also found in the LSA. Based on Project infrastructure footprints, none of these four nest locations will be removed as a result of the Project.

Figure 6.15-8
Raptor Habitat Loss and Nest Locations



Sensory Disturbance

Methods to Predict Impacts of Project Activities on Raptors

For the noise disturbance assessment, noise contours modelled for the Noise Effects Assessment (Section 10.5) were used to evaluate potential sensory disturbance. Instantaneous blasting noise (120 dB (Lpeak) and 108 dB (Lpeak)) originating from blasting activities during construction and operations was the type of noise evaluated for sensory disturbance on nesting raptors. The blasting noise threshold of 120 db (Lpeak) represent "effective habitat loss" and was selected based off the potential for damage to the ears of most bird species (Dooling and Popper 2007). Two different habitat types were considered as potential nesting habitat: a) forested habitat, structural stage 6/7, for the tree nesting raptors; and b) open habitat, such as grassland, for the ground nesting species.

Sensory disturbance greater than noise levels of 45 dBA (Delaney et al. 1999) were overlaid on raptor habitat mapping to determine potential disturbance to nesting raptors (Figure 6.15-9). Effective habitat loss due to sensory disturbance was determined by overlaying the 120 db (Lpeak) contour line over raptor habitat the LSA. Any suitable habitat and/or nests within the LSA but outside of Project footprints that fell within the 120 dB noise contour were totalled (Table 6.15-13). Any known nests within the 120 dB contour line were considered to be disturbed.

Table 6.15-13. Structural Stage Distribution (ha) by Blasting Noise Levels

Habitat	Raptor Use	RSA	LSA	108	Max	120	Min
Grassland	Foraging (Ground Nesting)	46,682	4,733	1519	32%	146	<1%
Mature Forest	Nesting	77,257	1,394	244	17%	0	0%

Additionally, disturbance to nesting individuals was determined by overlaying the 108 dB (Lpeak) contour lines over the LSA. Any suitable habitat and/or nests outside of Project footprints (and 120 dB contour) that fell within the 108 dB noise disturbance area were totalled. Any known nests within the 108 dB contour line were considered to be potentially disturbed.

Predict Impacts of Project Activities on Raptors

Sensory disturbance is anticipated to impact nesting raptors during the construction and operations phases of the Project. Delaney et al. (1999) found that an continuous noise levels of 46 dBA may affect nesting owls. As any habitat that may be exposed to 45 dBA noise will also be exposed to the 108 dB blasting noise, the latter was used to calculate disturbance.

A total of 146 ha of open habitat will be considered functionally lost due to the 120 dB blasting noise. One of the two Bald Eagle nests falls within this blasting zone, while one Swainson's Hawk nest also falls in this area.

An additional 244 ha of potential forest nesting habitat and 1,519 ha of potential ground nesting habitat may be subject to sensory disturbance as a result of the attenuated 108 dB blasting noise. Five known raptor nests, including two Red-tailed Hawk nests, two Great Horned Owl nests, and one Bald Eagle nest fall within this zone.

Of the eight known raptor nests within the LSA, two may be effectively lost due to blasting noise (120 dB) while the remaining five may be disturbed from attenuated blasting noise (108 dB). Bald Eagles and Swainson's Hawks have a moderate to high tolerance to human disturbance near nest sites, while Great Gray and Short-eared Owls have a moderate tolerance (BC Ministry of Forests, Lands, and Natural Resources 2013).

The impact of project lighting on raptors is anticipated to be minimal. The majority of project lighting is expected to occur within the Project infrastructure footprints, though there is potential that neighbouring habitat will be illuminated during different project phases.

Disruption of Movement

Disruption of movement is likely to have a negligible potential effect on raptors. Birds can avoid infrastructure by flying around or over obstacles. The Project will not result in the disruption of raptor movement, and will not be considered further.

Direct Mortality

Methods to Predict Impacts of Project Activities on Raptors

Direct mortality for raptors could not be measured directly. Clearing/grubbing and earthworks activities may result in the mortality of any individuals who are unable to fly to undisturbed areas (e.g., eggs, hatchlings). The percent of lost potential nesting habitat, as discussed above, was used to estimate the percent of the non-volant (unable to fly) population within the LSA that may experience direct mortality. A qualitative approach based on the number of roads present, number of vehicles expected to use these roads, timing of road use, and professional judgement was used to address this potential effect for roadside mortality. The potential for power transmission and distribution infrastructure to cause direct mortalities was also assessed using professional judgement.

Predict Impacts of Project Activities on Raptors

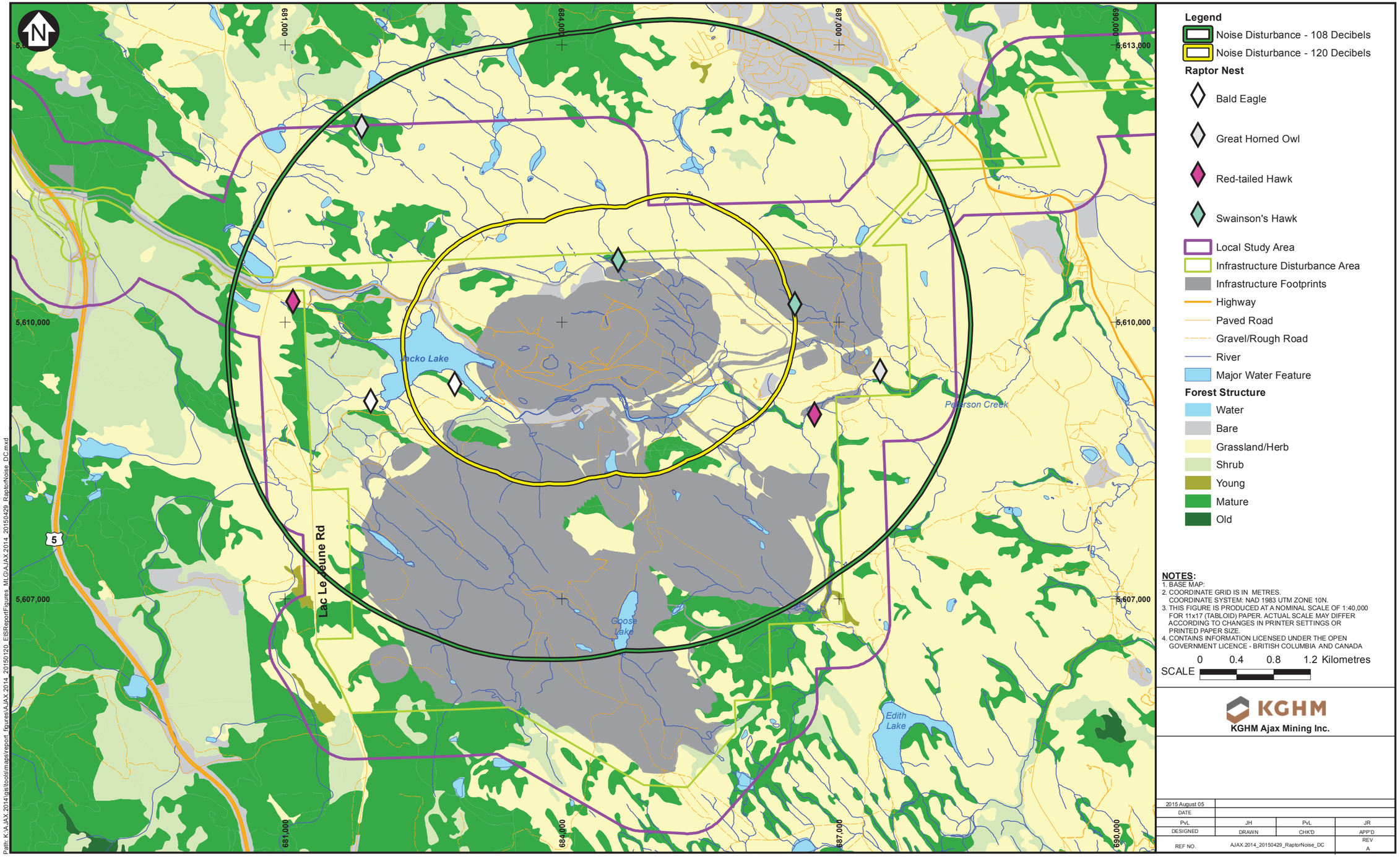
All species of raptors are anticipated to experience mortality as a result of activities such as clearing and grubbing, earthworks, heavy equipment use, and road use during one or more phases of the Project.

There is potential during the clearing of up to 592 ha of forest habitat and 2072 ha of grassland habitat that nesting raptors may suffer direct mortality. This area represents a fraction of a raptor breeding territory, usually several square kilometres.

While road mortalities are less likely for volant (flying) individuals than non-volant ones, the potential for raptor road mortalities is still a concern (Loos & Kerlinger 1993; Erickson et al. 2005). Nocturnal raptors have a habit of hunting along roads, and this may explain why motor vehicle mortalities are higher for this group (Molina-López et al. 2011). The movement of vehicles and construction machinery on Project roads may cause raptor mortality as a result of wildlife-vehicle collisions.

Collisions with power transmission infrastructure as a result of the Project are not anticipated to result in as many potential mortalities as other Project activities, but the potential for interaction still exists.

Figure 6.15-9
Raptor Noise Disturbance



Indirect Mortality

As raptors are not a harvested species group, increased hunting pressure will not result on this VC as a result of any Project activities. The likelihood for an indirect mortality interaction resulting from Project activities was determined to be negligible for all phases of the Project, and therefore will not be discussed further.

Wildlife Attractants

The presence of roadkill along Project and public roads may attract raptors to feed (Dean & Milton 2003; Bautista et al. 2004). Site road use and increased traffic on public roads as a result of the Project may lead to an increase in road mortality of many different wildlife species. As the potential for road mortality is increased with an increase in prey availability along roads, the possibility of site and public road construction/realignment, use, and maintenance attracting wildlife will be assessed under direct mortality.

Power transmission and distribution infrastructure may attract raptors to use these locations as perches for hunting from. There are risks of both aerial collision and electrocution of raptors. Both of these scenarios will be addressed under direct mortality.

Mine staff (direct employment) and contractors (indirect employment) may leave out attractants, such as food and garbage, which may attract raptor prey species, and in turn, raptors. As the occurrence of direct and contracted employees, will be limited to the IDA, especially within Project footprints, the anticipated interaction between wildlife attractants as a result of mine staff and contractors on any raptor indicator species is “low”, and will not be discussed further.

Chemical Hazards

Project components and related activities that may cause a chemical hazard to Raptors during Project construction include fuel storage and filling area, hazardous waste transport, storage, and disposal, sewage infrastructure and disposal, public road realignment, use, and maintenance, pipeline utility corridor, and fire suppression infrastructure. In operations, the same activities, plus the transport and storage of concentrate, and deposition to the Tailings Storage Facility (TSF) may result in a chemical hazard. In addition to these activities, the decommissioning and reclamation of the TSF may result in chemical hazards during the decommissioning and closure of the Project. As a chemical hazard from any of these activities would have to be the result of an accident or malfunction, the expected interaction of these activities on raptors was given a ranking of low and will not be discussed further.

Contact water, which is any water that may have come in contact with potentially toxic materials, may have a negative effect on raptors. Heavy metals such as copper, cadmium, lead, chromium and mercury are known to be persistent and mobile in the environment, and to be potentially toxic to many forms of life. Potential sources of metal contamination within the LSA include terrestrial (i.e., Mine Rock Storage Facilities (MRSF)) and aquatic (pit lake, TSF) components. The water quality in the pit depends on the interaction of the water with the rock in the pit walls, and with the pH of the water. Acidified water will have increased metal loading (Miller 2002). The potential for

interaction between contact water and raptors was ranked "low," as there will be limited exposure to contact water and raptors.

An ecological risk assessment (ERA) was conducted to determine risk quotients (RQs) for various avian species. Details for this assessment can be seen in Appendix 10.4-A. Ecological risk was quantified for various receptor species', including Bald Eagle, based on the total exposure to chemicals of potential concern (COPCs) from the environment relative to benchmark toxicological reference values. The change in potential risk to Bald Eagles as a result of the Project was deemed to be negligible.

6.15.4.3 Mitigation Measures for Raptors

Mitigation measures proposed to address potential effects during all phases of the Project are discussed below. The document Guidelines for Raptor Conservation During Urban and Rural Land Development in British Columbia (BC Ministry of Forests, Lands, and Natural Resources 2013) will be reviewed before any Project activities commence.

Habitat Loss

Over the long-term, habitat will be restored through reclamation and revegetation processes. Shrub/grassland habitat will be created on mine rock areas to provide feeding, nesting, and security life requisites for ground nesting raptors such as the Short-eared Owl. Reclaimed aspen groves will also provide feeding and security habitat for several raptor species, once an appropriate structural stage is reached, although this will take many years. Reclamation and revegetation of areas will occur during operations, closure, and post closure. New nesting locations will be specifically created, the details of which are provided in the Wildlife and Vegetation Monitoring Plan (Section 11.27).

Habitat loss will occur within the IDA. Sensitive nesting sites (e.g., large diameter trees and snags) and known nest locations will be avoided if at all possible and whenever practical. All known nest locations will be provided to reduce or avoid impacts to these sites. Eight known active raptor nests occur in the LSA, with six of these occurring in the IDA (Figure 16.5-6). Both Swainson's Hawk nests are located in proximity to Project footprints, specifically the reclamation and overburden stockpiles, and the loss of these nests is likely to occur. As one of these nest locations is approximately 50 metres away from a Project footprint (reclamation stockpile), the removal of this nest may be avoided if the location of this nest is provided before activities commence in this area. The removal of the other Swainson's Hawk nest will be unavoidable. As some species will go several years or even decades before reusing a nest, removing inactive nests will also be avoided (Whittington & Allen 2008).

Mitigation for raptor nests will include: i) pre-clearing surveys to locate active and inactive nests in the IDA, ii) clearing trees outside of the raptor breeding period where active nests are present, and iii) consultation with BC MFLNRO and establishing buffers around active nests if work must occur during sensitive periods (February to August). Known active nests that cannot be avoided will be relocated where practical, with nest habitat site creation a secondary option. As Swainson's Hawks may take several decades to re-nest on an altered landscape after reclamation begins, it was recommended that 10 artificial nest structures be placed once the grassland community has developed and rodents are observed to have colonized the reclaimed areas (Aspen Park Consulting

2013). These nest structures will be placed close to grasslands that are anticipated to remain undisturbed, and will be erected early in the reclamation process (*ibid*.).

Clearing and grubbing will result in the loss of some nests, but with mitigation measures, these lost nests are not anticipated to have a residual effect on forest nesting raptors. Short-eared Owls have been observed in the LSA, and the loss of potential nesting habitat for this species may occur, despite no confirmed nest detections. No other species of ground nesting raptor has been observed in the LSA, and the loss of potential nesting habitat for other ground nesting species is therefore not anticipated to have a residual effect.

Despite a loss of up to 4% of potential open habitat, raptors in the region are anticipated to be able to find adequate forage opportunities in the areas outside of the LSA that do not have specific Project footprints on them. A residual effect for this VC is not anticipated as a result of habitat loss.

Habitat Alteration

Dust and invasive plant species are expected to have a low magnitude impact on raptors. The Air Quality Monitoring and Dust Control Plan (Section 11.6) in combination with the Transportation Management Plan (Section 11.20) will reduce the impact of dust even further. The Soil Salvage and Handling Plan (Section 11.3) and the Landscape Design and Restoration Plan (Section 11.26) as well as the Invasive Species Management section in the Wildlife and Vegetation Monitoring Plan (Section 11.27) will also help to reduce the impact of invasive plants. A vehicle wash station for all vehicles entering and leaving the site will be in place to further reduce the spread of invasive plants.

As habitat alteration is expected to have a negligible to low impact on raptors, no residual effects are expected for any indicator species.

Sensory Disturbance

Noise is anticipated to have a negative effect on raptors, specifically nesting individuals close to Project noise exceeding 45 dB. Noise will come from roads or Project specific activities, such as drilling and blasting. A Noise and Vibration Management Plan (Section 11.22) will be developed with the objective to ensure that noise levels during all phases of the Project are acceptably low for human and wildlife receptors, as per human health guidelines (Health Canada 2011).

Noise mitigation measures relevant to raptors include:

- avoiding vegetation clearing and ensuring impulse events, such as blasting, will be limited to certain times of the day, and limiting these events to the fewest possible occurrences during sensitive bird breeding periods (i.e., courtship, egg laying, and early incubation – February through June) and working within timing windows as required when possible (Government of Canada 1994; Government of British Columbia 1996);
- considering noise ratings when selecting equipment;
- adjusting blasting configurations to minimise simultaneous blasting effects;
- optimizing the operation of equipment to minimize noise (e.g., reduced speed limits);

- optimizing the site layout to minimize noise impact (e.g., through use of natural screens such as buildings, facing away from relevant receptors, minimizing the need for mobile equipment to use their backup alarms); and
- applying noise dampening measures where possible, including conducting loud procedures indoors, where practical.

The Bald Eagle nests on Jacko Lake are anticipated to receive some level of sensory disturbance, depending on location and timing of specific Project activities. One Swainson's Hawk nest that will be avoided during vegetation clearing will likely receive some level of disturbance. A 500 m buffer from any anthropogenic noise for raptors is typical (Richardson & Miller 1997; Environment Canada 2009; BC Ministry of Forests, Lands, and Natural Resources 2013), however, as responses to disturbance will vary among individuals, no single buffer distance can protect against all disturbances (Demarchi & Bentley 2004). Specific buffers for the Project will be established to avoid work in proximity to these nests if work must be completed during sensitive windows.

As Project related activities will not be able to be completely avoid critical times of year, a residual effect of sensory disturbance on nesting raptors is anticipated to occur.

While the impact of artificial Project lighting is anticipated to be minimal, light design (layout) and use (timing) will be modified to ensure that minimal interaction occurs with raptors.

Disruption of Movement

As disruption of movement is not expected to have an impact on raptors, no residual effects are expected for any indicator species, and therefore, no mitigation is suggested.

Direct Mortality

Direct mortality is anticipated for all species of raptor during construction and operations of the Project. Activities that involve the removal of vegetation and erection of infrastructure will be limited to outside of the window critical nesting activities (e.g., incubation, hatchling rearing). By avoiding the sensitive courting and breeding window (February to August), mortality on eggs and hatchlings will be avoided. If this window is not able to be completed avoided, a Registered Professional biologist will confirm the absence or presence of any raptor nests in areas where work is to occur.

To decrease the potential for power distribution infrastructure mortalities (collisions), measures will be taken to increase the visibility of them (Avian Power Line Interaction Committee 2012). Birds may be electrocuted by simultaneously contacting an energized and a grounded structure. Placing two of these structures a minimum of 1.5 metres apart or applying insulated covers if additional spacing is not practical will reduce the likelihood of mortality by electrocution (Avian Power Line Interaction Committee 2006).

Vehicular mortalities may occur throughout all phases of the Project, especially during construction and operations when road use will be higher than in later stages. These collisions will be reduced through the implementation of speed limits (<50 km/h) and minimizing the number of vehicles using site roads (Transportation Management Plan, Section 11.20). Any roadkill detected will be removed promptly by Ajax staff to deter scavenging by raptors.

Measures to mitigate mortality of raptors include:

- avoiding vegetation clearing during bird breeding periods (February to August) and working within timing windows as required when possible (Government of Canada 1994; Government of British Columbia 1996);
- yielding to wildlife observed along Project roads and communicating these observations;
- minimizing traffic along roads by providing a vehicle parking lot for staff, and mine personnel will be shuttled from this site to the mine;
- implementing speed limits and wildlife signage to alert drivers of potential raptor collisions;
- training and education programs will occur to explain the importance of road safety to all staff;
- maintaining a specific height for roadside vegetation to improve drivers' sight lines; and
- ensuring the public road realignment does not overlap any known nest sites.

No listed-indicator species were considered nuisance wildlife. Measures used to control wildlife attractants are intended to minimize or eliminate problem wildlife situations. However, if a problem wildlife situation does arise, the environmental coordinator will initiate the appropriate response actions. Any direct intervention with problem wildlife will be done by authorized personnel in consultation with, and as approved or directed by, the British Columbia (BC) Conservation Officer Service. KAM will opt for non-lethal solutions (e.g., aversive conditioning, relocation) whenever appropriate and safe to do so.

After the implementation of these mitigation processes, the anticipated interaction is low for all species of raptor, and therefore, no residual effects for mortality are anticipated.

Indirect Mortality

Indirect mortality may occur as a result of an increased competition for resources due to range shifts will be difficult to avoid. As there is a low risk of occurrence, a residual effect for indirect mortality is not expected for raptors.

Wildlife Attractants

The attraction of raptors to sub-optimal habitat is expected as a result of roads throughout the LSA (increased potential for foraging), as well as power distribution infrastructure. These potential effects were discussed under direct mortality, as were all relevant mitigation measures. No residual effects are expected for any raptor species.

All employees and contractors will be educated about the importance of reducing wildlife attractants in the area and the proper storage and handling of garbage. A Solid Waste Management Plan (Section 11.9) will be in place to limit attractants.

Mitigation measures for roadkill and perching structures as attractants have been discussed under direct mortality, and will not be discussed further.

Chemical Hazards

Chemical hazards from various Project activities (e.g., fuel storage and filling area, deposition to the TSF, contact water, vehicle/machinery leaks) are expected to be low in all phases of the Project. Management Plans that will be in place to further reduce these effects include:

- a Construction Waste Management Plan (Section 11.4);
- a Metal Leaching and Acid Rock Drainage Management and Monitoring Plan (Section 11.5);
- a Water Management and Hydrometric Monitoring Plan (Section 11.7);
- a Contaminated Sites Management Plan (Section 11.8);
- a Solid Waste Management Plan (Section 11.9).
- a Hazardous Waste Management Plan (Section 11.10);
- a Risk Management Plan (Accidents and Malfunctions) (Section 11.12);
- a Natural Hazards Management Plan (Section 11.13);
- an Emergency Response Plan (Section 11.14).
- a Surface Water Quality Management and Monitoring Plan (Section 11.23); and
- a Groundwater Quality Management and Monitoring Plan (Section 11.24).

The Surface Water Quality Management and Monitoring Plan (Section 11.23) will be the most significant plan to reduce the interaction with potentially toxic water. As chemical hazards are expected to have a negligible to low impact on raptors, no residual effects are expected for this VC.

6.15.5 Residual Effects and Their Significance

6.15.5.1 Summary of Residual Effects

After the implementation of mitigation measures, two residual effects are anticipated to occur (Table 6.15-14). The loss of habitat will impact some species more than others, specifically species who have more specialized life requisites. The removal of known Swainson's Hawk nests may not be avoidable, but creation of nesting structures was included in the *Wildlife Habitat Objectives for Reclamation Plan* (Aspen Park Consulting 2013). Sensory disturbance on nesting individuals from Project activities such as drilling, blasting, and rock crushing may be mitigated for by limiting these activities to specific windows to avoid critical periods. However, limiting all Project noise to avoid wide ranging sensitive times of year is not practical, and may result in a residual effect to reproducing raptors.

6.15.5.2 Criteria for Characterization of Residual Effects

Specific criteria used to characterize residual effects are described in Section 5.2.5.2. For habitat loss/alteration effects, magnitude was assigned thresholds based on literature and professional knowledge (Andren 1994). Negligible is a 0-5% change to available habitat in the LSA, Minor was a 5-30% change, Medium was a 30-50% change and Major is a change greater than 50%.

Table 6.15-14. Summary of Residual Effects on Raptors

Valued Component*	Project Phase (Timing of Effect)	Project Component/ Physical Activity	Description of Cause-Effect1	Description of Mitigation Measure(s)	Description of Residual Effect
Raptors (Great Gray Owl, Rough-legged Hawk, Short-eared Owl, **Swainson's Hawk**)	Construction	Clearing/ grubbing, earthworks	Removal of vegetation and nests – Habitat Loss	Reclamation / revegetation, artificial nest creation	Reduction in available habitat, living and reproducing
Raptors (**Bald Eagle**, Great Gray Owl, Short-eared Owl, **Swainson's Hawk**)	Construction, Operations	Drilling and blasting/loud Project activities	Displacement from nests – Sensory Disturbance	Limit noise to certain windows (outside of breeding season)	Uncertain, but nests may be abandoned

[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 VC.*
**Bold indicates species anticipated to experience greatest impact.*

6.15.5.3 Characterization of Residual Effects

Two residual effects are anticipated on raptors as a result of the Project (Table 6.15-14). Habitat loss will occur for raptors with the potential removal of greater than 43% of suitable habitat and one known nest. The magnitude of this effect is medium for raptor habitat loss as less than 50% of suitable habitat may be removed. The duration will be long-term as the habitat will be lost for at least the duration of the Project, as revegetation and recolonization of these areas will not occur instantaneously, but rather, over several years. The effect will occur sporadically, during the construction and operation phases when all suitable habitat will be removed, and will be limited locally to within the Project footprints. This effect may be reversible in the long-term, upon closure of the mine. The resiliency of the species that may experience habitat loss is neutral as none of these raptor species are dependent on any rare habitat features (e.g., old-growth forest, cliffs).

Sensory disturbance is anticipated for courting and nesting activities for raptors. Drilling and blasting noise, combined with road noise, human presence, and other Project activities, may disturb various raptor species from remaining at their nests at critical times. The potential disturbance to the remaining known nest sites will be of minor magnitude, in that the conditions may differ from baseline conditions to a small degree. The potential disturbance to nesting raptors will have a minor magnitude in that the conditions are anticipated to vary from baseline only slightly (blasting to occur only once per day). Sensory disturbance will occur over the medium-term (activity causing noise disturbance is anticipated to decrease as the Project progresses). Activities will occur regularly on the landscape (within the LSA). This effect is reversible in the short-term as cessation of the activities will result in cessation of the disturbance. While many raptor species are sensitive to anthropogenic noise (White & Thurow 1985; Delaney et al. 1999), many species are able to habituate to this type of disturbance (Haugh 1982; White & Thurow 1985; White et al. 1988; Coulton et al. 2013) indicating a neutral resiliency to sensory disturbance.

6.15.5.4 Significance of Residual Effects

Habitat loss is anticipated to have a not significant (minor) effect on raptor species within the LSA. These species may be resilient to some anthropogenic change, and suitable nesting habitat (> 802 ha) of forested areas, structural stage 6 and 7 for the forest nesting species and > 2945 ha of grasslands for the ground nesting species) will still be present with the LSA. The loss of one known Swainson's Hawk nests may be detrimental to this species; however, mitigation measures to erect 10 artificial nest structures will help to alleviate this potentially negative effect.

Sensory disturbance of nesting raptors is also anticipated to have a not significant (minor) effect on raptors within the LSA. Effects to these species were reviewed as resiliency of this species to noise is not well documented. Bald Eagles appear to habituate to noise disturbance relatively quickly, often nesting in close proximity to human disturbances (Brown et al. 1999; Johnson 2008). Great Gray and Short-eared Owls and Swainson's Hawks may be more sensitive to disturbance, but each of these species may also habituate (Woodbridge 1998; COSEWIC 2008). If resiliency of these raptors to sensory disturbance at nests is neutral, then use of nests by individuals may continue within the LSA.

6.15.5.5 Characterization of Likelihood and Confidence

In the characterization of residual effects, significance, likelihood and confidence on raptors (Table 6.15-15), the greatest potential adverse effects on any indicator species were selected for each of the parameters. The specific characterization of likelihood and confidence for each indicator will be discussed below.

The probability that the Project would have a habitat loss effect on Great Gray Owls, Rough-legged Hawks, Short-eared Owls, and Swainson's Hawks was giving a rank of high as suitable habitat and at least one active Swainson's Hawk nest will be lost. Confidence was ranked medium as the assessment provided a range of suitable habitat that may be removed, but the actual amount remains unknown.

The probability and confidence of sensory disturbance on Bald Eagles, Great Gray Owls, Short-eared Owls, and Swainson's Hawks were both ranked medium. Probability was ranked medium as effects of noise on all of these raptor species specifically is not well understood; however, Bald Eagles appear to habituate to sensory disturbance quicker than some other raptor species (Johnson 2008). The effect, therefore, is likely to have some level of impact on some raptor species, but it also may not occur. Confidence was ranked medium for the same reasons.

6.15.5.6 Summary of Residual Effects Assessment and Significance

Two residual effects are anticipated to occur on the raptor VC as a result of various Project activities and after the implementation of mitigation measures (Table 6.15-16). Habitat loss is anticipated to have a not significant (minor) effect on four raptor species within the LSA. Sensory disturbance is also anticipated to have a not significant (minor) effect on four raptor species within the LSA.

Table 6.15-15. Characterization of Residual Effects, Significance, Likelihood and Confidence on Raptors

	Residual Effects Characterization Criteria							Significance of Adverse Residual Effects	Likelihood and Confidence	
	Magnitude	Duration	Frequency	Geographic Extent	Reversibility	Resiliency	Context		Probability	Confidence
Habitat Loss (Great Gray Owl, Rough-legged Hawk, Short-eared Owl, Swainson's Hawk)	Medium	Long-term	Sporadic	Local	Reversible Long-term	Neutral	Neutral	Not Significant (minor)	High	Medium
Sensory Disturbance (Bald Eagle, Great Gray Owl, Short-eared Owl, Swainson's Hawk)	Minor	Medium-term	Regular	Landscape	Reversible Short-term	Neutral	Neutral	Not Significant (minor)	Medium	Medium

Table 6.15-16. Summary of Residual Effects, Mitigation, and Significance on Raptors

Residual Effects	Project Phase	Mitigation Measures	Significance
Habitat Loss	Construction	Reclamation/revegetation, artificial nest creation	Not Significant (minor)
Sensory Disturbance	Construction, Operations	Limit noise to certain windows (outside of breeding season)	Not Significant (minor)

These residual effects will be carried forward into the cumulative effects assessment section, and discussed in relation to other projects within the RSA (Section 6.15.6).

6.15.6 Cumulative Effects Assessment

6.15.6.1 Introduction

The cumulative effects assessment (CEA) considers the effects on wildlife and wildlife habitat that are likely to result from the residual environmental effects of the Project in combination with the effects of other projects and activities (past, present, or future) with the RSA. The CEA methodology is based on the framework outlined by the *Canadian Environmental Assessment Act* (1992) guidelines (Hegmann et al. 1999) with additional guidance provided in the AIR.

Past land use has shaped much of the regions current wildlife habitat abundance and distribution, and, in turn, has shaped how wildlife makes use of the landscape. Many past, present and future projects have, and will continue to contribute to the amount of raptor habitat in the RSA. Several projects have been identified as occurring in the region, and could potentially interact with our Project. Each of these projects will be considered in combination with the result of our residual effects assessment to determine if there is an interaction, and consequently, if there is the potential for a cumulative residual effect to occur. These interactions can include direct, indirect, additive and synergistic effects. To be included in the CEA projects must occur within the RSA, must have a residual effect, and must have the potential to act cumulatively with the residual effects for raptors described in Section 6.15.5.

Both habitat loss and sensory disturbance were considered residual effects for raptors. All projects that could potentially occur in the region have been included in Table 6.15-17. A list of past, present, and anticipated future projects and activities known to occur in the region were provided. Projects/activities were initially scoped out if there was no perceived spatial interaction (i.e., the project/activity occurs outside of the RSA). Other projects/activities were scoped into the CEA on a VC by VC basis. If a residual effect from the Project was determined, the likelihood of other projects/activities resulting in the same effect were assessed using reports generated from those projects/activities; in the absence of any data indicating specific effects, professional judgement was used. Other projects/activities considered for cumulative effects on raptors are listed below. Those projects that could have a residual effect associated with raptor habitat loss and sensory disturbance will be included in the CEA.

Table 6.15-17. Ranking Potential for Residual Effects to Interact Cumulatively with Effects of Other Human Actions on Raptors

Residual Effect	Industrial Projects/Activities													Natural Resources and Land Use			Tourism and Commercial Recreation Activities					Community Infrastructure			Transportation						
	Vidette Lake Mine	Afton Mine (Historical)	Iron Mask Mine	Bonaparte Mine	New Afton Mine (New Gold)	Highland Valley Copper Mine (Teck)	Domtar Kamloops Pulp Mill	Tolko-Hefley Creek Plywood and Veneer	LaFarge Cement Plant	Trans Mountain Pipeline System (Kinder Morgan)	Trans Mountain Pipeline System - Expansion (Kinder Morgan)	Harper Creek	Highland Valley Copper – Bethlehem Expansion	Kamloops Forest District	Agriculture	Ranching	Tranquille on the Lake	Lac Le Jeune Resort	Tobiano Golf Course	Recreational Hunting, Fishing, Foraging	Recreational Trails	City of Kamloops Wastewater Management	Water Treatment Centre	City Expansion and Growth	Lac le Jeune Road	Highway 1	Highway 5A	Highway 5 (Coquihalla Highway)	Kamloops Airport	Rail Yards and Lines (CP and CN)
Habitat Loss	-	O	O	-	O	-	O	-	-	O	L	-	-	M	L	L	-	-	O	O	O	-	-	L	O	O	O	O	-	O
Sensory Disturbance	-	O	O	-	O	-	O	-	-	O	L	-	-	L	O	O	-	-	O	L	L	-	-	L	L	L	L	L	-	O

Notes:

O	*No interaction anticipated.*
L	*Negligible to minor interaction expected; implementation of best practices, standard mitigation and management measures; no monitoring required, no further consideration warranted.*
M	*Potential moderate interaction requiring unique active management/monitoring/mitigation; warrants further consideration.*
H	*Key interaction; warrants further consideration.*

6.15.6.2 Identification of Other Actions that May Affect Raptors

A list of past, present, and anticipated future projects and activities known to occur in the region were provided. Projects/activities were initially scoped out if there was no perceived spatial interaction (i.e., the project/activity occurs outside of the RSA). Other projects/activities were scoped into the CEA on a VC by VC basis. If a residual effect from the Project was determined, the likelihood of other projects/activities resulting in the same effect were assessed using reports generated from those projects/activities; in the absence of any data indicating specific effects, professional judgement was used. Other projects/activities considered for cumulative effects on raptors are shown below (Table 6.15-17; Figure 6.15-10).

6.15.6.3 Interactions between Residual Project Effects and Other Project or Activity Effects

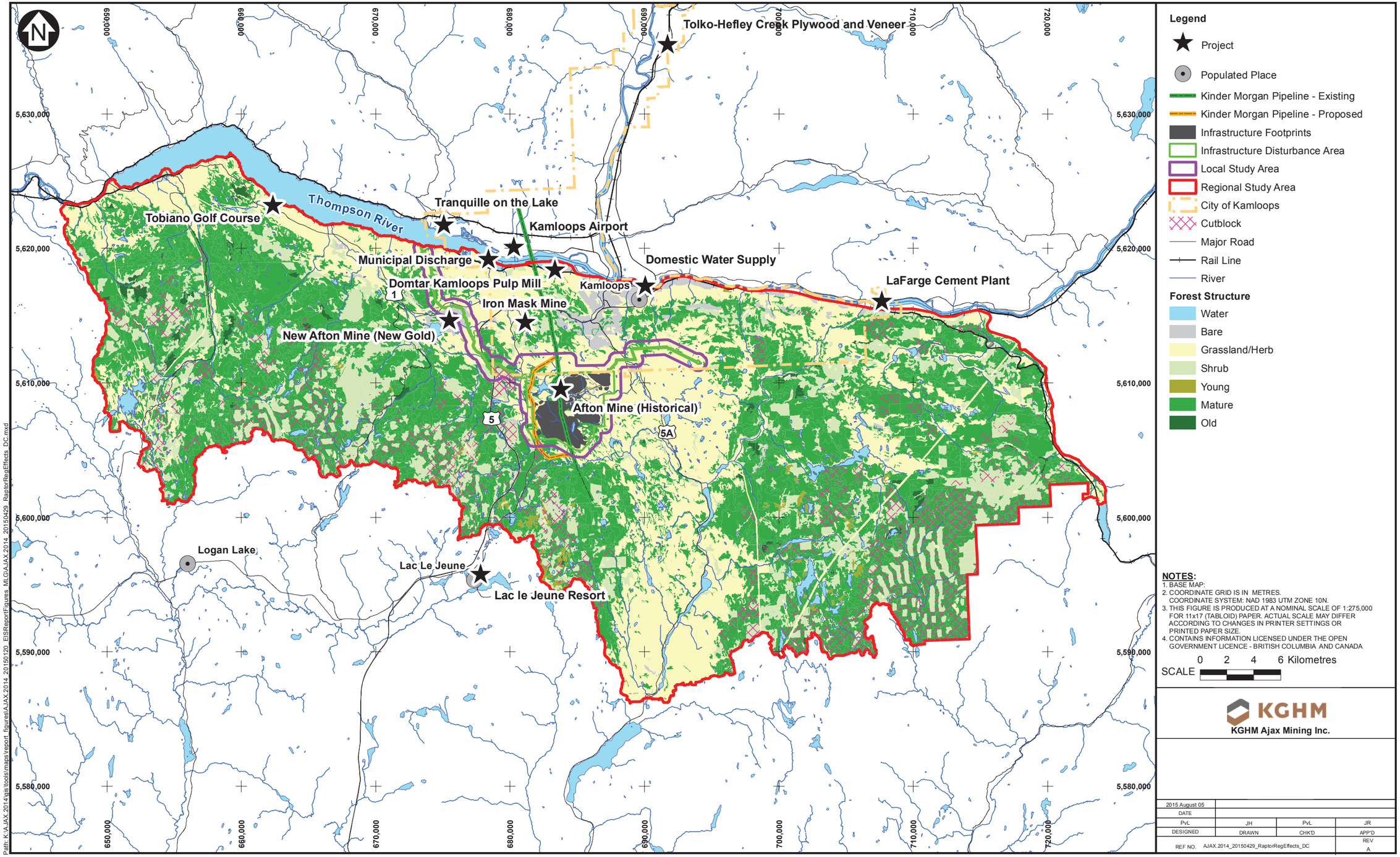
Habitat loss and sensory disturbance of raptors are potential effects that may be exacerbated by other projects/activities in the region. Habitat loss associated with past, present and future project activities cannot be quantified. In the majority of cases, no information is available on total habitat loss. Consequently, a qualitative analysis was conducted to determine potential interactions based on professional judgement, location of these projects/activities, and the sensitivity of raptors to habitat loss.

Agriculture and forestry has occurred in the region since the 1800s. Habitat loss associated with both of these activities is assumed to have occurred, however, it cannot be quantified. Future harvesting may occur on about 24% of the mature and old forest available based on cutblock information. Agriculture is assumed to have removed fertile grassland habitat used by ground nesting raptors, while forestry is assumed to have removed areas of suitable nesting habitat for tree nesting raptors. Continued active timber harvesting also has the potential to have a sensory disturbance effect on all raptor species (Table 6.15-16).

Future projects/activities, such as the expansion of the City of Kamloops, specifically the growth of Aberdeen (neighbourhood adjacent to LSA) and the Southwest Industrial Area, as well construction of Kinder Morgan's TransMountain pipeline, will likely result in additional habitat loss and sensory disturbance of raptors (Table 6.15-16). Aberdeen is expected to continue expanding, from an approximate population of 10,000 people in 2011 to over 16,000 by 2036 years (TRUE Consulting Group 2008; City of Kamloops 2012). If approved, construction of the TransMountain pipeline twinning is anticipated to commence as early as 2016. Construction of this project would likely result in raptor tree nesting and ground nesting habitat loss, as well as sensory disturbance. The amount of habitat lost as a result of this project will likely be relatively small within the region.

Construction of Lac le Jeune Road, Highway 5A, and the TransCanada Highway occurred previous to 1950, and the Coquihalla Highway was built in the early 1980's. All raptor species have areas of suitable habitat on one or both sides of the Coquihalla. As both Lac le Jeune Road and the Coquihalla Highway bisect areas of known suitable habitat, it is anticipated that raptors lost some amount of habitat as a result of the construction of both of these roadways. Quantification of this loss, however, is not possible based on the information available. Continued vehicle use of these roads may have cumulative effect on sensory disturbance to some raptor species (Table 6.15-16).

Figure 6.15-10
Raptor Regional Effects



Sensory disturbance effects from recreational use of the region (hunting, foraging, ATV/snowmobile use) are also unable to be quantified. While these activities are anticipated to be lower in duration and frequency than other activities, the intensity of the noise and the effect of this intensity are unknown. The potential for disturbance exists from these activities (Table 6.15-16).

6.15.6.4 Proposed Mitigation Measures

As KGHM has limited authority to guide regional initiatives to support the diversity and persistence of habitat, this would be better guided by the provincial government. Many raptor species can coexist with people in human-modified landscapes if certain habitat needs are met (BC Ministry of Forests, Lands, and Natural Resources 2013). Raptors and most other birds are protected in British Columbia under Section 34 of the *Wildlife Act*.

Habitat Loss

Mitigation for the impacts of habitat loss consisted of retaining existing habitats and features; minimizing the loss of natural vegetation, and protecting raptor nest sites. Further habitat enhancement activities including the fencing off of grasslands and controlling the timing for livestock grazing in sensitive areas could return some damaged grasslands to "baseline conditions". Furthermore, discussions with the provincial government will be initiated in an effort to develop Wildlife Habitat Areas (WHAs) on KAM owned land. Habitat loss cannot fully be mitigated, and therefore will be carried forward and evaluated in Section 6.15.6.5.

Sensory Disturbance

Mitigation to reduce sensory disturbance to nesting raptors consisted of nesting buffers (BC Ministry of Forests, Lands, and Natural Resources 2013). Limiting work to avoid critical periods when practical was also considered. This was not sufficient to fully reduce the potential impact of noise on nesting raptors. Traffic noise throughout the RSA cannot be controlled by KAM, and therefore, cannot be mitigated. Any mitigation measures taken will not be sufficient to fully reduce the potential impact of noise on nesting raptors. As a result, any habitat compensation or offsets will be located in areas situated away from known or anticipated anthropogenic disturbance to minimize the potential for further sensory disturbance to raptors. Sensory Disturbance cannot fully be mitigated, and therefore will be carried forward and evaluated in Section 6.15.6.5.

6.15.6.5 Evaluation of Significance of Residual Cumulative Effects

After the implementation of mitigation measures, two residual cumulative effects are anticipated to occur. The loss of potential foraging habitat for wintering Rough-legged Hawks, as well as the loss of potential nesting habitat for Great Gray Owls, Short-eared Owls, and Swainson's Hawks cannot be fully mitigated and may result in a cumulative effect (Table 6.15-18). Sensory disturbance on nesting Bald Eagles, Great Gray Owls, Short-eared Owls, and Swainson's Hawks from project activities may be mitigated for by minimizing these activities to specific windows. However, limiting road traffic in the region is not practical, and may result in a cumulative effect to courting and nesting raptors (Table 6.15-18).

Table 6.15-18. Summary of Cumulative Effects Mitigation Measures and Residual Effects on Raptors

Ajax Project Activity	Other Human Action Activity	Description of Potential Cumulative Effect	Description of Mitigation Measure(s)	Description of Residual Cumulative Effect
Clearing and grubbing	Construction of other project infrastructure	Loss of nests and suitable foraging habitat	Reclamation/ enhancement of suitable habitat to offset habitat loss	Reduction in available habitat, reproducing and foraging
Blasting/ Crushing, Road Use	Access to other project sites / activities	Sensory disturbance due to loud, short duration noises, sensory disturbance associated with traffic on project and public roads	Timing of blasting, access restrictions	Uncertain, but nest abandonment may occur

Two residual cumulative effects are anticipated on raptors as a result of the Project and other projects/activities occurring throughout the region (Table 6.15-19). Habitat loss has, and will continue to occur for raptors. Habitat loss is anticipated to have a not significant (minor) effect on raptors within the RSA. As grasslands provide suitable habitat for this Short-eared Owl and Rough-legged Hawk, the removal of these areas may have a detrimental effect. However, as a considerable amount of suitable habitat likely exists within the RSA to the southeast of the Project. The area southeast of the Project is composed of large patches of grassland that have not been heavily disturbed and do not have any anticipated projects/activities. Suitable Great Gray Owl and Swainson's Hawk nesting habitat (mature and old-growth forest) can also be found in abundance throughout the region, especially to the west and southwest of the Project.

Sensory disturbance is anticipated to affect nesting raptors. Drilling and blasting noise, road noise and other Project activities, combined with noise from roads throughout the region and noise from various other project activities, may cause some individuals to abandon nesting efforts. The level of disturbance on the four raptor species anticipated to be affected, however, is not as well understood. Sensory disturbance is anticipated to have a not significant (minor) effect on all raptor species for nesting activities. Areas where suitable Short-eared Owl nesting habitat may occur are located to the southeast of the Project, where limited anthropogenic noise is anticipated to occur. Areas where suitable Bald Eagle, Great Gray Owl, and Swainson's Hawk nesting habitat may occur are located to the west and southwest of the Project, also where limited anthropogenic noise is anticipated to occur. Roads exist in these areas, but traffic occurs at relatively low volume. Large areas of suitable nesting habitat away from any noise disturbance are anticipated to exist within the RSA.

6.15.7 Conclusion

Raptors were assessed as a VC to determine likely interactions with specific Project activities, and how these interactions would affect this species group. All potential effects (habitat loss, habitat alteration, sensory disturbance, disruption of movement, direct mortality, indirect mortality, wildlife attractants and chemical hazards) arising from each Project activity were identified and evaluated. After the implementation of mitigation measures, two Project-related residual effects and two cumulative residual effects were determined for raptors as a result of this Project, as well as in combination with other projects/activities, past, present, and future, occurring within the region (Table 6.15-20).

Table 6.15-19. Characterization of Cumulative Residual Effects, Significance, Likelihood and Confidence on Raptors

	Residual Effects Characterization Criteria							Significance of Adverse Residual Effects	Likelihood and Confidence	
	Magnitude	Duration	Frequency	Geographic Extent	Reversibility	Resiliency	Context		Probability	Confidence
Habitat Loss	Minor	Long-term	Sporadic	Regional	Reversible Long-term	Neutral	Neutral	Not Significant (minor)	Medium	Low
Sensory Disturbance	Minor	Far Future*	Regular	Regional	Reversible Short-term	Neutral	Neutral	Not Significant (minor)	Medium	Low

** Cars will continue using roads for >50 years*

Table 6.15-20. Summary of Project and Cumulative Residual Effects, Mitigation, and Significance for Raptors

Residual Effects	Project Phase	Mitigation Measures	Residual Effect Significance	Residual Cumulative Effect Significance
Habitat Loss	Construction	Avoidance of breeding sites through re-design where possible. Progressive reclamation/revegetation. Artificial nest creation.	Not Significant (minor)	Not Significant (minor)
Sensory Disturbance – nests	Construction, Operations	Limit noise to certain windows (outside breeding season, if practical)	Not Significant (minor)	Not Significant (minor)

Habitat loss and sensory disturbance are both Project-related and cumulative residual effects. The magnitude and geographic extent of these effects differs as the scale at which they were assessed was much smaller for the Project-related residual effects than for cumulative residual effects (i.e., LSA vs. RSA). Duration of sensory disturbance differs as Project related noise will stop upon closure of the mine, but anthropogenic noise across the region will continue. Due to these differences, the likelihood and confidence, as well as the significance of the residual effects, also differs between assessments.

The loss of suitable Great Gray Owl, Rough-legged Hawk, Short-eared Owl, and Swainson's Hawk habitat, and additionally, the loss of at least one known Swainson's Hawk nest, may result in an impact to these species. As two of these species are Blue-listed (special concern) in BC (Rough-legged Hawk, Short-eared Owl), and one is Red-listed (threatened) in the province (Swainson's Hawk), the loss of sensitive sites could impact populations both locally, and regionally. Habitat loss is considered not significant (minor) for these species for Project-related residual effects as a relatively small amount of suitable forested area will be removed (< 90 ha) as a result of Project activities, and the grassland habitat that will be removed is currently heavily disturbed, and not highly suitable for any raptor species. Habitat loss is considered not significant (minor) for cumulative residual effects as large, undisturbed patches of suitable habitat still exists within the region, and that habitat has very little current or anticipated disturbances (projects/activities).

Sensory disturbance near raptor nests may result in abandonment of these sites (Cooper & Beauchesne 2004b; US Department of the Interior 2014). This effect is considered not significant (minor) for both Project-related and cumulative residual effects as the effect is easily reversible in the short-term and all species that may be affected were observed across the landscape in the LSA, an area already subject to a number of anthropogenic disturbances, indicating some resistance to this disturbance. Also, additional nesting habitat exists throughout the region, and that habitat has very little current or anticipated disturbances (projects/activities).

6.16 NON-MIGRATORY GAMEBIRDS

6.16.1 Rationale

This section includes a description of the scoping process used to identify Non-migratory Gamebirds for inclusion in the assessment. Scoping is fundamental to focusing the Application/EIS on those issues where there is the greatest potential to cause significant adverse effects. Valued components (VCs) are components of the natural and human environment that are considered to be of scientific, ecological, economic, social, cultural, or heritage importance (CEAA 2006; EAO 2013). To be included in the EA, there must be a perceived likelihood that the VC will be affected by the proposed Ajax Project (the Project).

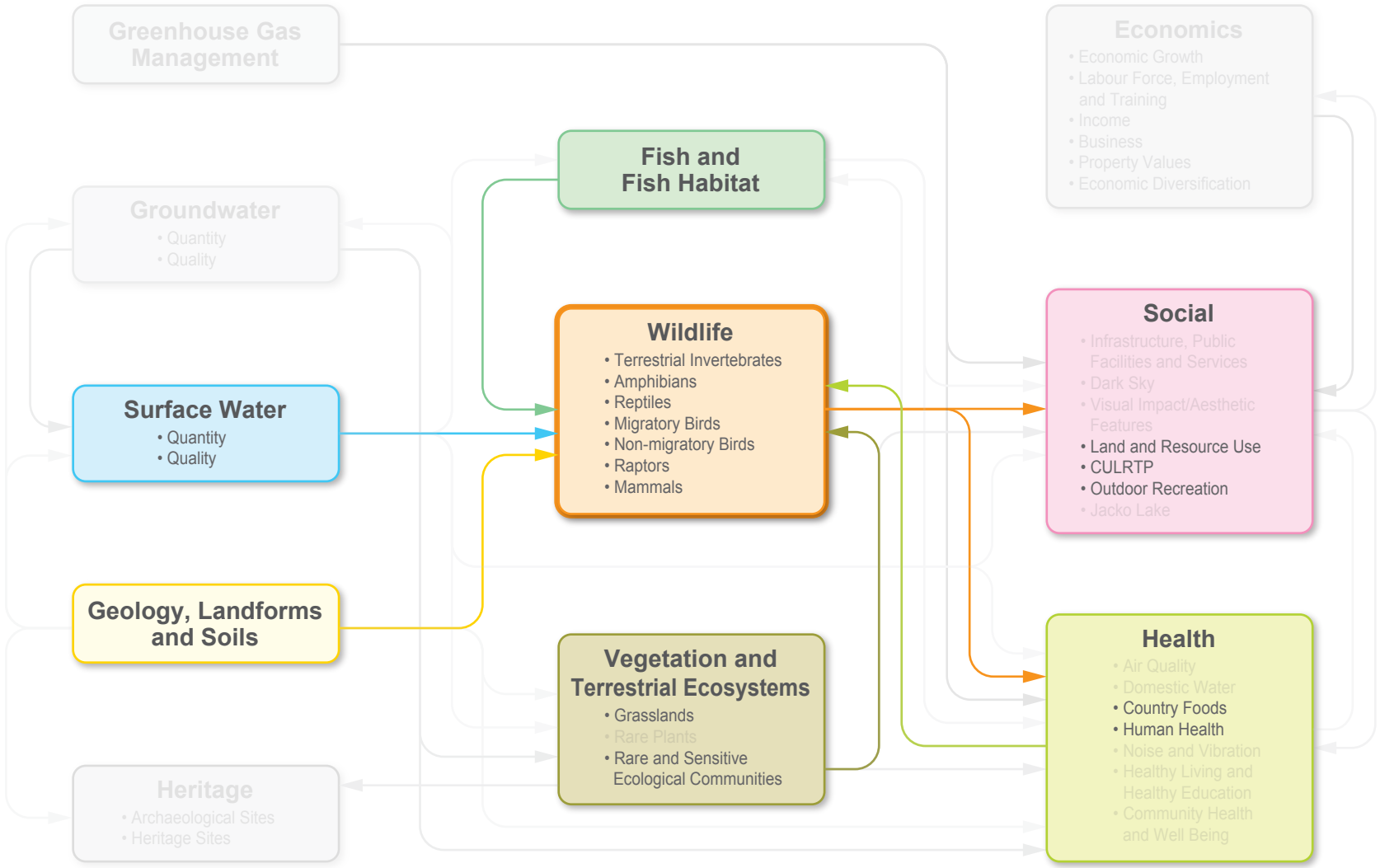
For non-migratory gamebirds to be considered for inclusion as a valued component in the environmental assessment, the following were considered:

- Federal or provincial listing or regulation (including relevant legislation or policy concerning the VC);
  - Lists of Red- and Blue-listed species believed to occur within the Kamloops Forest District, and information on known locations of these species, according to the BC Conservation Data Centre (2010); and
  - Information on SARA- or COSEWIC-listed taxa available from the Government of Canada;
  - Taxa listed as part of the Identified Wildlife Management Strategy (IWMS);
  - Taxa of regional concern; and data from targeted wildlife surveys and from incidental observations;
- Aboriginal interest;
- Regional significance;
- Public or other stakeholder input;
- Scientific/professional knowledge; and
- Relevant legislation or policy concerning the VC.

Non-migratory gamebirds offer the potential for short and long term monitoring of the impact of increasing development, changing land use practices, and climate change for the region's terrestrial ecosystems. Non-migratory gamebirds use grassland and forested habitats which are determined by surface and ground water, geology, landform and soils. Gamebirds may be a food source for wildlife such as raptors and mammals, as well as a source of country food for Aboriginal and non-Aboriginal consumption (Section 10.3). The assessment of effects to gamebirds is largely related to disturbances from Project activities (as described further in Section 6.16.4). The information developed to support the analysis of this VC may also contribute to outdoor recreation and land and resource use (Figure 6.16-1).

Figure 6.16-1

VC Interactions for Wildlife (Non-migratroy Gamebirds)



6.16.1.1 Selection of Non-migratory Gamebirds as a Valued Component

Gamebirds include grouse, ptarmigan, partridge, pheasant, quail, chukar, and columbids (doves and pigeons). They inhabit a number of habitat types, from desert-like conditions to arctic tundra (Resources Inventory Committee (RIC) 1997). In terms of habitat requirements and courtship behaviour, gamebirds are a very diverse group. Occurrence records of non-migratory gamebirds in the Local Study Area were obtained from the BC Conservation Data Centre (BC Conservation Data Centre 2014c) and the provincial Species Inventory Database (BC Ministry of Environment 2014). A total of 10 gamebird species may be present in the LSA. Non-migratory Gamebirds are not protected under the *Migratory Birds Convention Act, 1994*, but are included under the BC *Wildlife Act*.

The VC "Non-migratory Gamebirds" was selected as there is an expected interaction between gamebirds and the Project. Specific justification for the selection of gamebirds as a VC includes:

1. Federal or provincial listing or regulation guidelines;
   - Two Blue-listed gamebird taxa thought to occur within the Kamloops forest district (Table 6.16-1) as provided by the BC Conservation Data Centre (2010);
   - Information on actual known location records of Blue-listed taxa in or near the study area (provided by the BC Conservation Data Centre);
   - Information on SARA- and COSEWIC-listed taxa available from the Government of Canada;
   - Taxa listed as part of the Identified Wildlife Management Strategy (IWMS); and
   - Taxa of regional concern, and data from targeted wildlife surveys and from incidental observations.
2. Applicable government agencies (e.g., MFLNRO, EC, CWS, EAO, CEA Agency);
3. Stakeholder input (e.g., members of the public, Kamloops Naturalist Club, local Aboriginal Groups);
   - Gamebirds are a traditional food source for Aboriginal peoples (Chapter 12) (University of Northern British Columbia, et al. 2011; Ignace 2014).
4. Spatial scope (species range – gamebirds are found in the vicinity of the Project);
5. Temporal scope (e.g., non-migratory gamebirds are resident year-round); and
6. Interaction with Project/potential effects (professional knowledge).

6.16.1.2 Selection of Indicators

A preliminary list of indicator species was prepared (Table 6.16-1) based on the presence of suitable/capable habitat, the availability of sufficient species knowledge to produce a meaningful assessment, feedback from stakeholders and likely interactions with the Project (geographically and ecologically). Wildlife surveys for particular indicators were planned when significant data gaps existed.

Table 6.16-1. Gamebird Species Present in the Area

English Name	Scientific Name	Provincial List	COSEWIC Status	SARA Schedule/ Status	Identified Wildlife	Selected as Indicator?
Dusky Grouse	*Dendragapus obscurus*	Yellow	--	--	No	No
Ruffed Grouse	*Bonasa umbellus*	Yellow	--	--	No	Yes
Spruce Grouse	*Falcipennis Canadensis*	Yellow	--	--	No	No
Sharp-tailed Grouse	*Tympanuchus phasianellus columbianus*	Blue	--	--	Yes	Yes
Mourning Dove	*Zenaida macroura*	Yellow	--	--	No	No
Band-tailed Pigeon	*Patagioenas fasciata*	Blue	Special Concern	1-SC	No	No

** SC = Special Concern*

Gamebirds known to be present in the region include four grouse species: Dusky Grouse (*Dendragapus obscurus*), Ruffed Grouse (*Bonasa umbellus*), Spruce Grouse (*Falcipennis canadensis*), and the Blue-listed Columbian Sharp-tailed Grouse (*Tympanuchus phasianellus columbianus*) (Table 6.16-1). Mourning Doves (*Zenaida macroura*) and the Blue-listed Band-tailed Pigeon (*Patagioenas fasciata*) are also found in the region. The Band-tailed Pigeon is the only gamebird that is SARA-listed (Schedule 1 – Special Concern).

Chukars (*Alectoris chukar*), Gray Partridges (*Perdix perdix*), Ring-necked Pheasants (*Phasianus colchicus*), and California Quails (*Callipepla californica*) also occur throughout the region. However, as these are exotic species, they were not considered for this assessment.

Ruffed Grouse and Columbian Sharp-tailed Grouse were selected as indicators based on recorded observations of the species in the Project area, reported historical presence, significance to Aboriginal communities (Section 12), regional significance, and the presence of suitable habitat (Table 6.16-2).

Table 6.16-2. Indicator Species Selection Rationale and Issues Raised

Indicator Species	Feedback by*				Issues Raised	Rationale
	AG	G	P/S	S/P		
Ruffed Grouse	✓		✓		Loss of habitat, increased disturbance, displacement and mortality of Ruffed Grouse	Known to be present; Aboriginal Groups concern; Potential for interaction with Project
Sharp-tailed Grouse	✓	✓	✓	✓	Loss of lekking habitat, increased disturbance, displacement and mortality of Sharp-tailed Grouse	Known to be present; known lek sites; sensitive species; grasslands indicator; Aboriginal Groups concern

**AG = Aboriginal Group (Stk'emlupsemc Te Secwepemc Nation (SSN) and Nlaka'pamux Nation); G = Government; P/S = Public/Stakeholder (e.g., LRMP); S/P = Scientific/Professional Knowledge.*

Yellow-listed species are considered secure and widespread and effects of the Project to these species are not anticipated to have an adverse effect on the VC. As such, indicator species are generally at-risk species as these populations are more likely to experience an adverse effect.

Spruce Grouse were not selected as an indicator as their general habitat requirements (spruce forests) are not present throughout the Project area. In BC, Spruce Grouse are ranked S5 (demonstrably widespread, abundant, and secure). Dusky Grouse were not selected as indicators as they have more general habitat requirements that overlap the habitat requirements of Ruffed Grouse. Dusky Grouse are ranked S4 (apparently secure) in BC.

Mourning Doves occur throughout the region, but were not selected due to their widespread distribution, stable populations, and varied habitat associations. Mourning Doves are ranked S4B (apparently secure for the breeding population) in British Columbia. Band-tailed Pigeons, while Blue-listed, were not selected as indicators. They may occur in the region, however, their general habitat associations are not present in the area, and there are no recorded observations in proximity to the Project. Band-tailed Pigeons are ranked S3S4B (special concern, vulnerable to extirpation or extinction, or apparently secure for the breeding population) provincially.

6.16.2 Assessment Boundaries

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

6.16.2.1 Spatial Boundaries

Infrastructure Footprints

Project infrastructure footprints (IF) include the Open Pit, ancillary buildings and facilities, roads, truck shop, Tailings Storage Facility (TSF), Water Management Ponds, Mine Rock Storage Facilities (MRSFs), and stockpiles (Figure 6.16-2). The Project infrastructure footprints are 1,705 ha in size.

Infrastructure Disturbance Area

The Project infrastructure footprints and linear features (transmission line and water line) were buffered by at least 50 m (Henderson 2011) to determine the Project Infrastructure Disturbance Area (IDA). The 3,185 ha IDA will be used to assess maximum direct Project effects (e.g., mortality, habitat loss, habitat alteration, etc.). The IDA includes the Project IF (1,705 ha) used to calculate direct loss of habitat, plus a 1,480 ha buffer around the Project IF that represents a zone of influence for potential disturbance associated with habitat alteration resulting from effects pathways such as contaminants, silt or dust, noxious weeds, and changes in drainage pattern (Figure 6.16-2).

The use of a buffered polygon area rather than individual infrastructure footprints will provide an overestimate of the direct effects of the Project for the assessment. The advantage of this approach is that it enables individual footprints to be moved and/or resized without changing the results of the effects assessment.

The IDA was modified from the General Arrangement Polygon to follow a section of the Kamloops city boundary to more accurately represent the current Project IF.

Habitat alteration by dust and water quantity is accounted for under potential habitat loss within the IDA. Areas outside of the IF that are not lost will be subject to potential alteration effects. However as wildlife species present in the area are adapted to the dry, dusty environmental conditions, these effects were considered mitigable.

Local Study Area

In accordance with the AIR, the General Arrangement Polygon was buffered by 500 metres to determine the Local Study Area (LSA). This area is the expected area of potential disturbance associated with all Project facilities (BC Environmental Assessment Office 2015). The LSA is 7,167 ha and will be used to assess indirect Project effects (e.g., disturbance) and provide context on the amount of habitat available adjacent to the Project (Figure 6.16-2).

Regional Study Area

The Regional Study Area (RSA) is the area for which cumulative effects will be assessed. The RSA includes portions of the South Kamloops Landscape Unit and Campbell Landscape Unit, including areas south of the Thompson River and west of Highway 97 (Figure 6.16-3). Landscape units were selected for the RSA as they are the geographical framework within which sustainable forest management regimes to maintain biodiversity are implemented. The RSA includes local watershed basins and is 158,415 ha in size.

6.16.2.2 Temporal Boundaries

The temporal boundaries of the assessment will include the construction phase (short-term), operations (life of mine), de-commissioning and closure (short-term) and post-closure (short-term) activities.

The temporal phases of the Project are:

- **Construction**: 2 years (Year -2 to 1);
- **Operation**: 23 years (Year 1 to 23);
- **Decommissioning and Closure**: 5 years (Year 24 to 29, includes Project decommissioning, abandonment and reclamation activities, as well as temporary closure, and care and maintenance); and
- **Post Closure**: 5+ years (includes ongoing reclamation activities and post-closure monitoring).

Figure 6.16-2
Local Study Area, Infrastructure Disturbance Area and Project Infrastructure

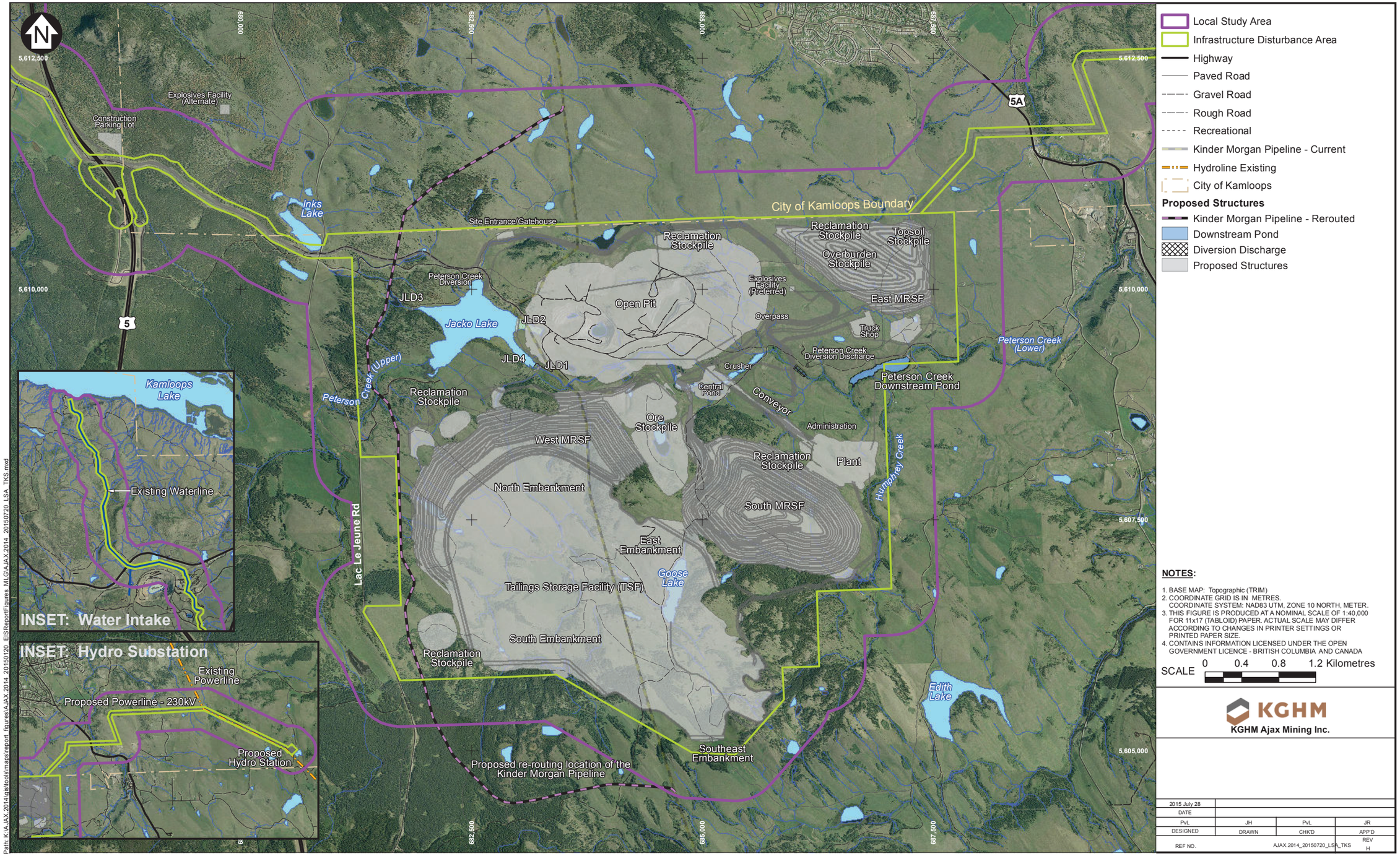
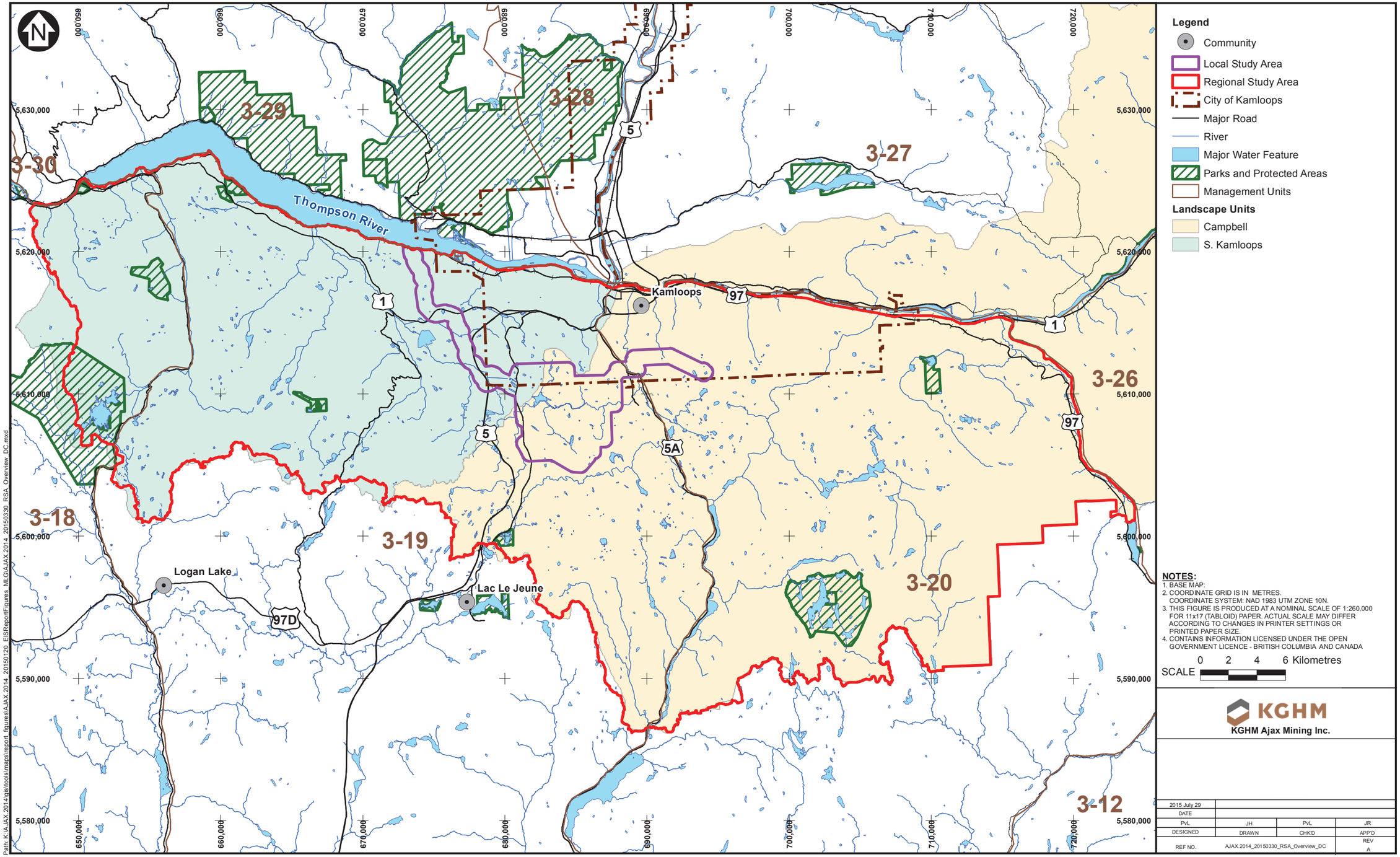


Figure 6.16-3
Regional Study Area and Wildlife Management Units



6.16.2.3 Administrative Boundaries

The *Freedom of Information and Protection of Privacy Act*, SBC 1996, c. 165 (the Act), provides for the disclosure of information about species and ecosystems except where such disclosure could reasonably be expected to result in damage to, or interfere with the conservation of the species or ecosystem.

As Sharp-tailed Grouse are sensitive to disturbance at lek sites, specific locations of these sites could not be provided. Masked locations were used instead in order to provide context for general locations relating to suitable habitat.

6.16.2.4 Technical Boundaries

Terrestrial Ecosystem Mapping (TEM) was only completed within the LSA as this is the area expected to interact with the Project, and thus requires detailed mapping. Areas outside of the LSA were quantified using VRI and other broad mapping sources (Grassland Mapping, Broad Ecosystem Mapping). Since habitat within the RSA and LSA were quantified using different map products the results are not directly comparable.

6.16.3 Background

6.16.3.1 Regulatory and Policy Framework

Sharp-tailed Grouse are Identified Wildlife under the Forest and Range Practices Act (FRPA). The Identified Wildlife Management Strategy (IWMS) is a valuable tool for addressing potential management strategies for this identified species. General wildlife goals for sharp-tailed include: maintain known lek sites in native grassland habitats, establish WHAs at known lek sites in native grasslands (typically 700 ha), minimize disturbance during critical times, maintain winter food supply, maintain secure nesting and rearing habitat, and minimize forest encroachment. Specific measures to meet these goals include: access restriction during the lekking season, ban on pesticide use, restriction on range. Critical periods for Sharp-tailed Grouse include the lekking season (April 1 to May 31).

Legislation regarding non-migratory gamebirds falls under the BC *Wildlife Act* (Government of British Columbia 1996). Sharped-tailed Grouse and Ruffed Grouse, their nests, and their eggs are protected from direct persecution by the provincial *Wildlife Act*.

Regionally, the Project lies within "Region 3 – Thompson" of the Hunting and Trapping Regulations Synopsis. Three Management Unit (MU) boundaries (3-18, 3-19, and 3-20) divide up the RSA (Ministry of Forests, Lands and Natural Resource Operations 2014). Grouse (Dusky/Blue , Ruffed and Spruce) have an open hunting season from Sept 10 – Nov 30 with a bag limit of 5 each and an aggregate possession limit of 15 each (Ministry of Forests, Lands and Natural Resource Operations 2014). Within the region Sharp-tailed grouse have an open season only in MUs 3-30 (Bonaparte) and 3-31 (northwest of Clinton).

6.16.3.2 Regional Overview

Ruffed Grouse and Sharp-tailed Grouse can be found in the RSA all year round, utilizing forested habitat and grassland habitat respectively. Both grouse species are traditionally harvested food sources by the SSN and are figured prominently in traditional stories/laws.

Indicator Species

The Ruffed Grouse is a ground-nesting game bird. Ruffed Grouse prefer habitats with a deciduous component and are closely associated with aspen forests, but may be found in many forested habitats with available cover and food (Rusch et al. 2000). Males choose a particular drumming log to 'drum' with their wings in early spring to attract nearby females. Ruffed Grouse eat a variety of seeds, fruits, buds, and invertebrates (Campbell et al. 1990). They do not migrate, but remain on the same home ranges year-round. In British Columbia, Ruffed Grouse are ranked S4 (apparently secure). This species is a common target of hunters and a traditional food source for Aboriginal peoples (Section 12) (University of Northern British Columbia, et al. 2011).

The Columbian Sharp-tailed Grouse is a bird of open grassland and sage habitats. The species is considered a resident, as it does not migrate. During the breeding season, males gather at lekking areas in open but secluded grassy habitats to display to females. Males begin to gather in late March, with peak attendance by females typically occurring between mid to late April (Alberta Conservation Association 2010). After selecting a mate, hens breed one time, and then find a location to nest, usually in late April/early May. Leks are traditional and may be used for many years (Connelly et al. 1998; BC Ministry of Water, Land and Air Protection 2004). Hens lay their eggs in tall grass or shrubby cover. Habitats with security cover and abundant insect prey are critical for successful rearing of chicks. High-quality wintering habitat includes shrubby riparian areas where berries and catkins are available, as well as dense thickets of shrubs such as rose and water birch for roosting (BC Ministry of Water, Land and Air Protection 2004). Just north of the RSA lies Lac du Bois Grasslands Protected Area, which contains the largest contiguous grassland area under protection, as well as the greatest number of Sharp-tailed Grouse leks within the Thompson Basin (The Grasslands Conservation Council of British Columbia 2009). In British Columbia, Columbian Sharp-tailed Grouse are ranked S2S3 (imperiled or special concern, vulnerable to extirpation or extinction).

Columbian Sharp-tailed Grouse are thought to be threatened by agricultural and residential development of native grasslands, disturbance of traditional lekking grounds, and overgrazing by livestock, which removes the tall grass cover needed as security habitat. A decline of 43% of active leks occurred in the Thompson Okanagan Plateau between 1986 and 1999 (Ritcey & Jury 2004). Leupin and Chutter (2007) reported that 23% of known active leks in the region became inactive between 1986 and 2002, but that populations in the Thompson-Nicola appear to have stabilized or even increased between 1995 and 2005. Lek distribution in the region for this species is not well documented. In 2005, there were 39 known lek locations (active and inactive) in the Kamloops-Merritt area (Howie 2005). Locations of known lek sites around the Project area were provided by the BC Data Conservation Centre (BC CDC). In the neighbouring Cariboo-Chilcotin region, an estimated 110 to 120 leks exist (BC Conservation Data Centre 2014a). Regional lek surveys in 2014 by FLNRO south of the Thompson River had 11 of 14 leks active.

6.16.3.3 Historical Activities

Historical activities considered in this section include mining, mills, pipelines, rail lines, agriculture/ranching, forestry, urban sprawl, water treatment, recreation/tourism and hunting/fishing. Only those activities expected to interact with non-migratory gamebirds have been discussed here.

Loss of grassland and forest habitat, as well as wetland, to a lesser extent, as a result of mining activities and pipelines in the region has likely impacted gamebirds. Continued development in the region may further reduce the amount of available habitat. Continued agricultural and ranching may remove lekking habitat, and alter remaining habitat to such a degree that they can no longer support some gamebird species that are habitat specialists.

Forestry has removed and altered large areas of habitat that could have supported breeding communities of both indicator species. Continued forestry practices could reduce or alter remaining habitat to such a degree that they can no longer support these species in the area.

Much like forestry and agriculture, urban expansion will remove habitat that could support gamebirds. Sharp-tailed Grouse may be sensitive to urban development as openness is an important requirement of a lek site as it allows individuals to detect predators that may be attracted to the noise generated by the displaying males (The Grasslands Conservation Council of British Columbia & Biospherics Environmental Inc 2008).

6.16.3.4 Baseline Studies

Baseline studies were conducted according to Resource Inventory Standards Committee (RISC) standards, specifically for non-migratory gamebirds (Resources Inventory Committee (RIC) 1997). Surveys were completed in 2010, 2011 and 2014 in an effort to determine Sharp-tailed Grouse lek presence and abundance within the LSA. Observations of grouse species were also recorded during breeding bird surveys in 2007, 2008, 2010, and 2014, and as incidental observations during other species-specific surveys. Known Sharp-tailed Grouse lek locations were provided by the BC CDC.

Surveys for Sharp-tailed Grouse leks were undertaken in and around the LSA to: a) establish presence of target species and key habitat features within the LSA, b) collect data on the location and timing of use of the LSA by target species, c) confirm habitat ratings used to develop wildlife habitat suitability models, and d) provide information to KAM to use during the Project design phase to avoid or minimize impacts to target species. Occurrences of any gamebird species were also recorded during breeding bird surveys.

Terrestrial ecosystem mapping was used to develop wildlife habitat suitability mapping for Columbian Sharp-tailed Grouse within the LSA.

<u>Data Sources</u>

General information on species status and distribution was drawn from on-line sources such as the BC Ministry of Environment's Species Explorer and NatureServe (BC Conservation Data Centre 2014b; NatureServe 2014, Klinkenberg 2014). Occurrence records of non-migratory gamebirds in the

LSA were obtained from the BC Conservation Data Centre (BC Conservation Data Centre 2014c) and the provincial Species Inventory Database (BC Ministry of Environment 2014).

Other reports describing species in the area were consulted, including:

- the "Columbian" Sharp-tailed Grouse section of Accounts and Measures for Managing Identified Wildlife (Ritcey & Jury 2004);
- Status of the Sharp-tailed Grouse *columbianus* - subspecies in British Columbia (Ritcey 1995);
- Status of the Sharp-tailed Grouse (*Tympanuchus phasianellus*) in British Columbia (Leupin 2003);
- Status of the Sharp-tailed Grouse *columbianus* subspecies (*Tympanuchus phasianellus columbianus*) in British Columbia (Leupin & Chutter 2007);
- Sharp-tailed Grouse Leks on Sugarloaf Ranch Properties, Knutsford, BC (Howie 2005);

Information regarding Aboriginal harvest of grouse in the LSA was taken from Section 12, *Background and Aboriginal Group Settings*. The Stk'emlupsemc te Secwepemc Nation (SSN), Skeetchestn Indian Band (SIB), Nlaka'pamux Nation, and Metis Nation of British Columbia (MNBC) are all known to hunt grouse. Additional traditional use of grouse was taken from the report *SSN Cultural Heritage Study - Final Report* (Ignace 2014). Ruffed and Sharp-tailed Grouse are used for story and food purposes, while Ruffed Grouse is also used for ceremonial purposes (*ibid*.).

Methods

Wildlife Habitat Mapping

RISC Standard habitat suitability mapping based on the TEM was completed for Sharp-tailed Grouse (BC Ministry of Environment 1996) (Appendix 6.8-A). Habitat suitability for Sharp-tailed Grouse was modeled based on the ability for habitat in the LSA to meet various life requisites (e.g., feeding, security/thermal cover, and reproducing sites). The modeling was completed for both winter and the growing season (spring through fall). Highly suitable habitat for the growing season was defined as native grasslands with perennial bunch grass and shrubby areas with a high diversity of vegetation and a high abundance of insects. Highly suitable winter habitat was defined as shrub and deciduous habitat, structural stage 3-7, and native grasslands in low-snow periods. For a more detailed species account of limitations and assumptions, see Appendix 6.8-A.

Regional Mapping

The regional habitat for the Sharp-tailed grouse was assessed using the Broad Terrestrial Ecosystem Inventory (BEI) habitat mapping (Demarchi et al. 2003). Ratings were cross referenced with distribution among the broad ecosystem units (Ritcey & Jury 2004).

Habitat Suitability Index

Habitat Suitability Index (HSI) models predict the suitability of habitat for a species based on an assessment of habitat attributes such as habitat structure, habitat type and spatial arrangements between habitat features. HSI models for the ruffed grouse have been completed for the Foothills

Model Forest (FMF) in Alberta (Schaffer et al. 1999) and areas of Aspen within the states (Cade & Sousa 1985). Information from these models was used to determine ruffed grouse habitat.

Field Surveys

Field surveys to confirm use at known lek sites, and to identify any additional lek sites, were conducted following methods described in *Inventory Methods for Upland Gamebirds* (Resources Inventory Committee (RIC) 1997). Surveys targeted areas of suitable habitat in and around the LSA. The BC Conservation Data Centre (CDC) provided locations of known Sharp-tailed Grouse lek sites in the LSA, and all sites were visited to confirm use. Additional surveys in suitable habitat were also completed using survey stations placed 800 metres apart. Surveys were conducted between 30 minutes before sunrise to 2 hours after sunrise, although one reconnaissance visit was done during one afternoon in 2011. All visual and auditory detections of Sharp-tailed Grouse were recorded. For a more detailed account of survey methods, see Appendix 6.8-A.

Breeding bird point count surveys were also conducted to document grouse in the LSA, and followed the methods described in *Inventory Methods for Forest and Grassland Songbirds* (Resources Inventory Committee (RIC) 1999). Surveys were stratified to cover the variety of habitats present in the LSA. Detections of grouse that occurred during other fieldwork were recorded as incidental observations.

Non-migratory gamebird surveys were carried out between 2007 and 2014, and consisted of lek surveys and breeding bird surveys (see Migratory Birds VC, Section 6.14). Lek surveys were completed in 2010, 2011, and 2014. Additional transects targeted areas of potentially suitable habitat for Sharp-tailed Grouse leks. Breeding bird surveys sampled a wide variety of habitats throughout the area. Surveys were completed in 2007, 2008, 2010, and 2014, and targeted all bird species that may occur within the LSA. All lek surveys occurred during the spring (March or April) and breeding bird surveys occurred during the breeding season (April through August).

Characterization of Non-migratory Gamebird Baseline Condition

Wildlife Habitat Mapping

Habitat suitability for Sharp-tailed Grouse was modeled for living habitat, which includes habitats used for all life requisites (feeding, security/thermal, and reproducing) in the growing season as well as living in the winter season. For Sharp-tailed Grouse, 3,578 ha of suitable habitat associated with grasslands in the growing season (Figure 6.16-4), and 1,260 ha of suitable habitat associated with shrubby and forested sites in the winter season (Figure 6.16-5) were mapped in the LSA (Table 6.16-3**)**.

Table 6.16-3. Habitat Suitability for Sharp-tailed Grouse by Season

Suitability Class		Species and Season Rated For	
		Sharp-tailed Grouse – Growing Season ha (%)	Sharp-tailed Grouse – Winter Season ha (%)
LSA	Moderate Suitability	914 (15%)	1,099 (18%)
	High Suitability	2,664 (45%)	161 (3%)
	Total	**3,578 (60%)**	**1,260 (21%)**

Habitat suitability mapping was not completed for Ruffed Grouse. Instead, general habitat associations for this species were identified. Ruffed Grouse are associated with deciduous or mixed forests, especially those with a dominant aspen component, as well as areas with a shrubby component (Cade & Sousa 1985).

Regional Mapping

Suitable habitat for Sharp-tailed grouse was defined as grasslands, cultivated fields and open Ponderosa pine forests in the BG, IDF or PP biogeoclimatic units (Table 6.16-4) (Demarchi et al. 2003; Ritcey & Jury 2004).

Table 6.16-4. Broad Habitat Ratings for Sharp-tailed Grouse

Habitat	Structural Stage	BG	PP	IDF
BS Bunchgrass Grassland	All	1	1	1
CF Cultivated Field	All	3	3	3
DP Fd – Py	2,3	3	3	3
PP Ponderosa Pine	2,3	3	3	3
SS Big Sagebrush Shrub	All	2	2	3

Grassland habitat defined from the VRI was also used to demonstrate potential habitat for Sharp-tailed Grouse.

Habitat Suitability Index

The habitat variables in the Alberta model (Schaffer et al. 1999) are available in the VRI and were applied to the RSA. This model was for winter foraging and the best habitat is provided by deciduous or mixed sites with >20% deciduous tree composition, >6% tree canopy closure, with trees >10 m tall (Figure 6.16-6). Aspen forests are common throughout the RSA and Ruffed Grouse are well distributed as well (Table 6.16-5).

Table 6.16-5. Ruffed Grouse Habitat Availability

Habitat	RSA (ha)	LSA (ha)	IF (ha)
Winter Feeding Habitat (HSI)	8,391	363	179
Aspen leading Forests	2,795	96	43

Field Surveys

Lek locations within the LSA were surveyed in order to confirm activity. Leks with any adult Sharp-tailed Grouse observations during the breeding season were recorded as active. All leks had more than one Sharp-tailed Grouse observed. Three leks were surveyed in multiple years, while one new lek was located in 2014. The maximum number of birds detected at a single site was eight in 2010, ten in 2011 and seven in 2014. The BC MoE conducted surveys in late April 2012 at three known active leks within the LSA and observed 22 birds (Table 6.16-6), (P. Belliveau, pers. comm. 2012). Sharp-tailed Grouse lek surveys completed by KWR resulted in the observation of 62 Sharp-tailed Grouse (Table 6.16-6).

Figure 6.16-4
Sharp-tailed Grouse Growing Season Habitat Suitability and Observations

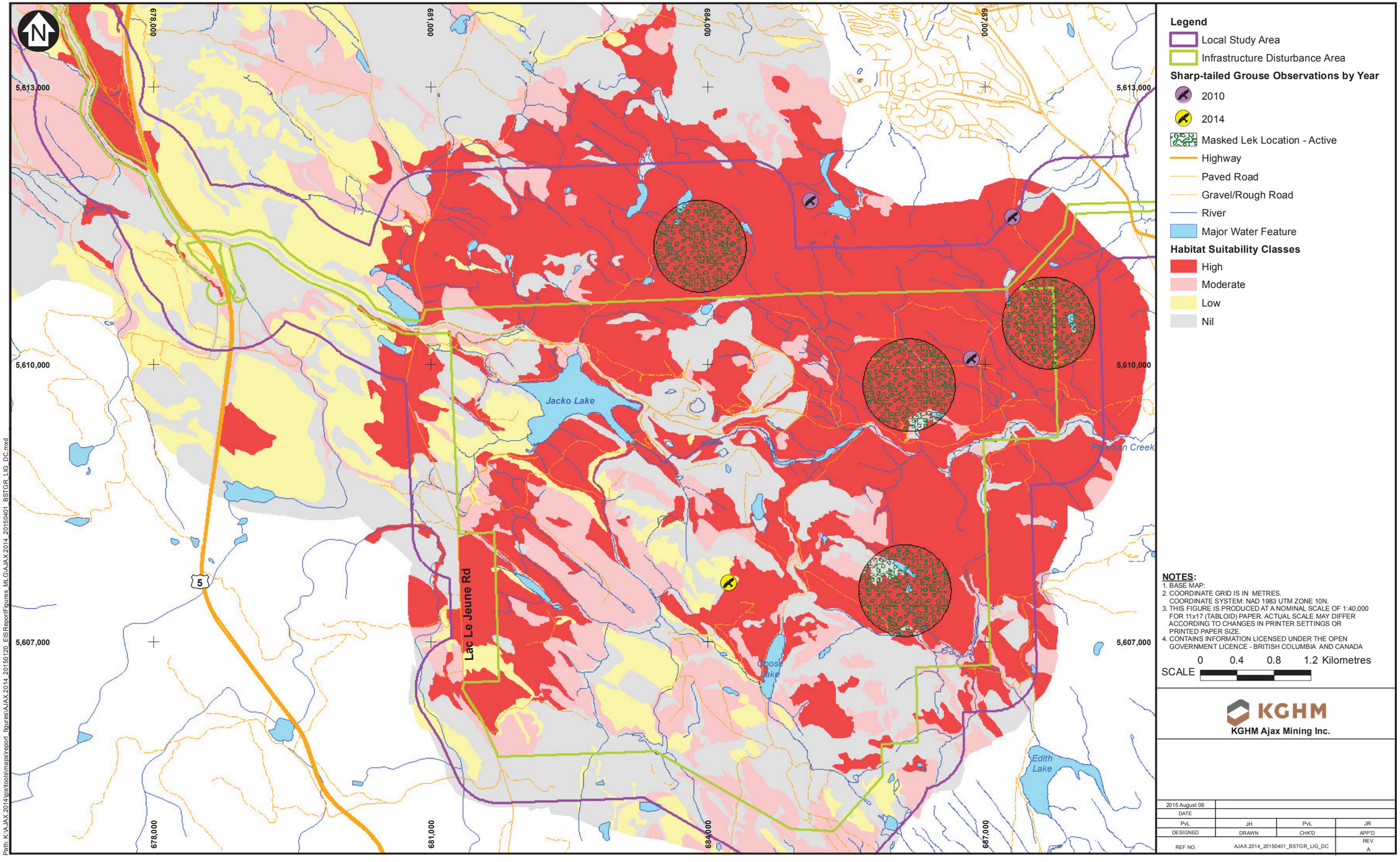


Figure 6.16-5
Sharp-tailed Grouse Winter Season Habitat Suitability

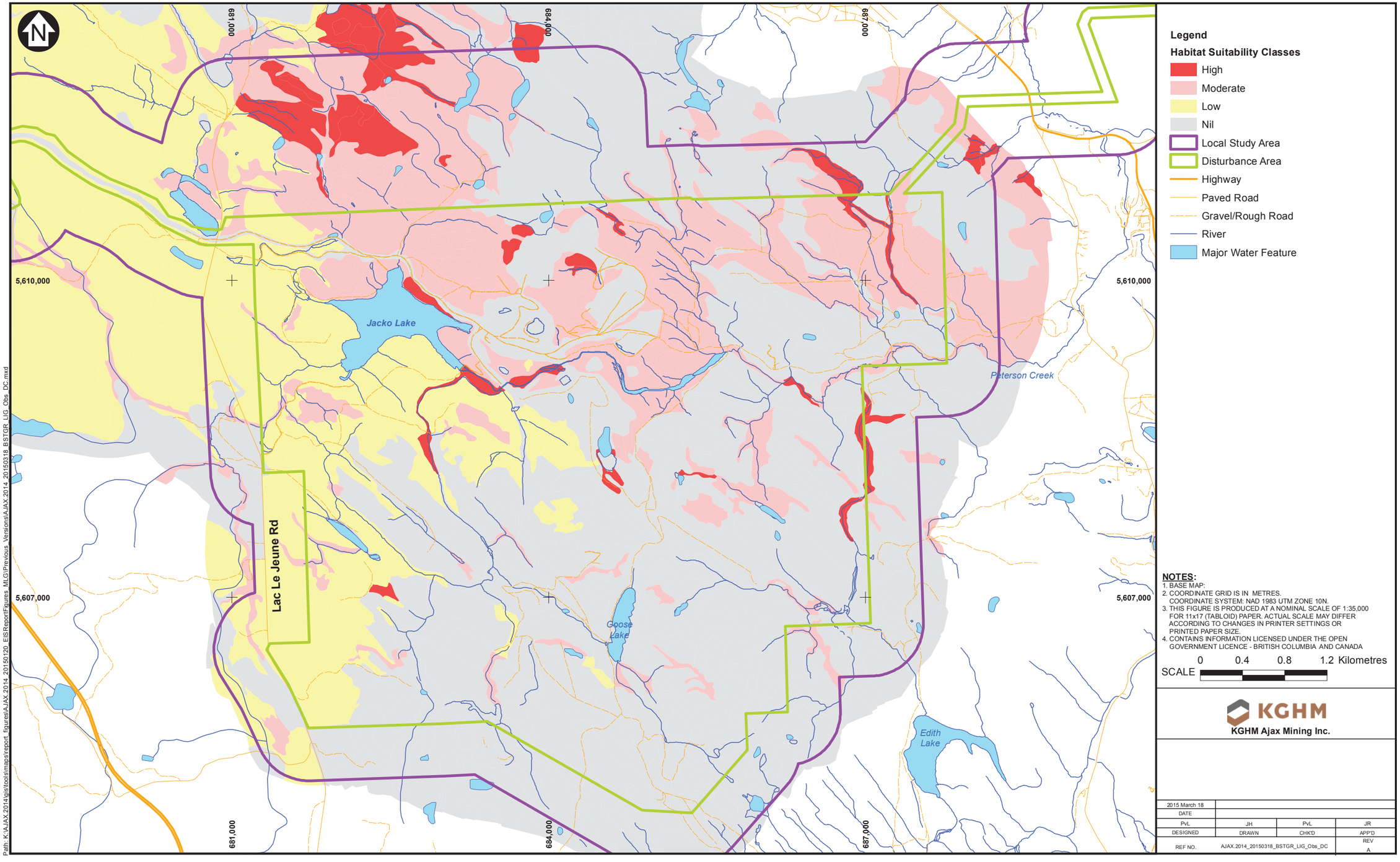
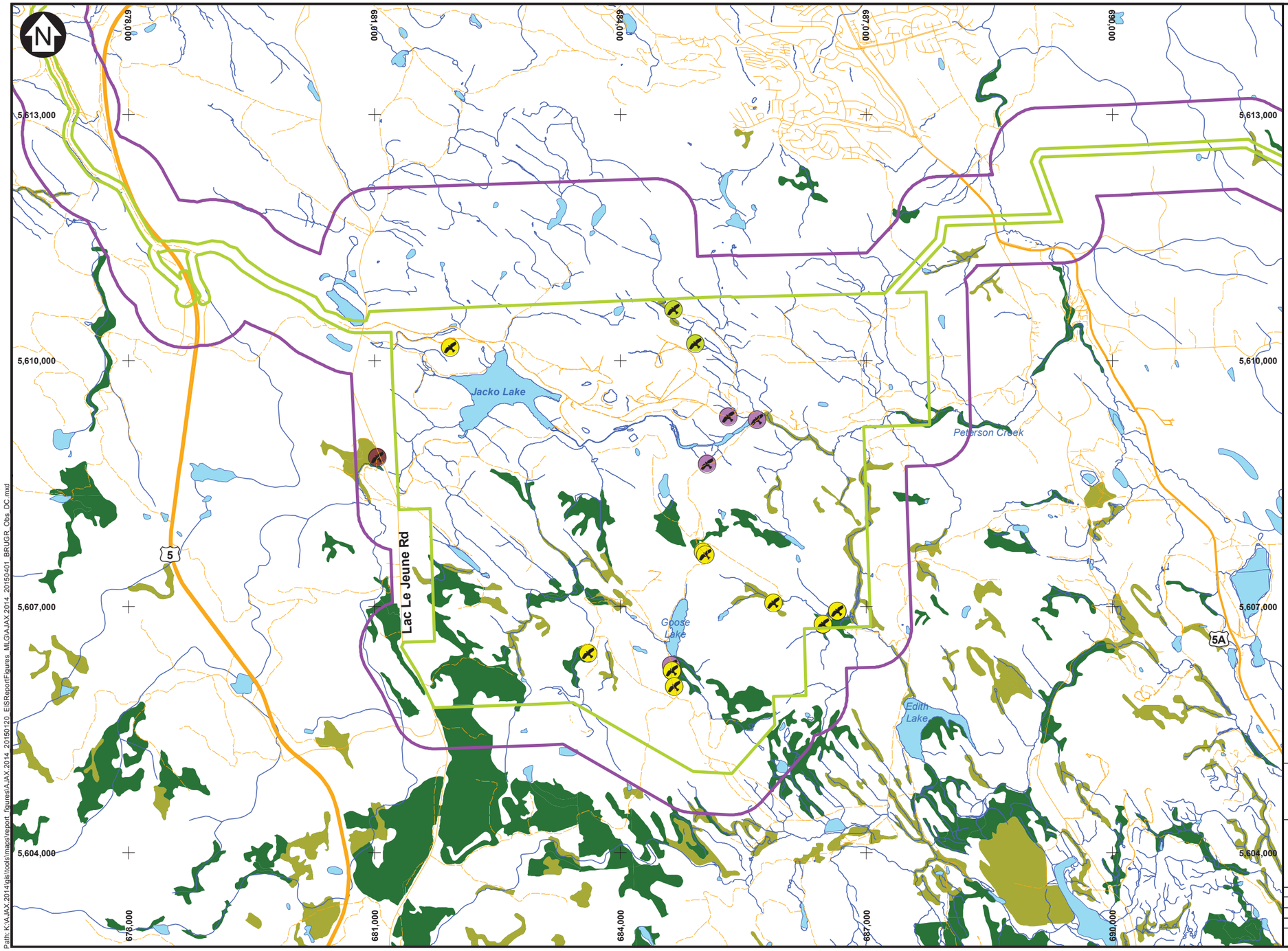


Figure 6.16-6
Ruffed Grouse Observations, Aspen stands and Winter Habitat



Legend

Ruffed Grouse Observations By Year

- 2007
- 2008
- 2010
- 2014
- Local Study Area
- Infrastructure Disturbance Area
- Highway
- Paved Road
- Gravel/Rough Road
- River
- Major Water Feature
- Aspen forests
- Winter Habitat

NOTES:

1. BASE MAP:
2. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD 1983 UTM ZONE 10N.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:50,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
4. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENCE - BRITISH COLUMBIA AND CANADA

SCALE 0 0.4 0.8 1.2 Kilometres

KGHM Ajax Mining Inc.

2015 July 30			
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Table 6.16-6. Summary of Sharp-tailed Grouse Survey Effort and Observations in the LSA

Year	Number of Locations Surveyed (Including Repeat Surveys)	Total Time Surveyed (hr min)	Sharp-tailed Grouse Observed during Lek Surveys	Sharp-tailed Grouse Observed Incidentally
2010	29	01h39m	26	14
2011	7	00h21m	16	2
2012	3	?	22*	--
2014	9	01h01m	20	4
Total	**45 (48)***	**03h01m**	**62 (84)***	**20**

**Surveys completed in 2012 were conducted by the MoE. Complete survey effort was not provided. Totals without parenthesis reflect KWR survey effort, totals in parenthesis reflect total survey effort.*

Incidental Sharp-tailed Grouse observations were made in 2010 (April) and 2011 (June) near lek sites during surveys for other wildlife in the spring, and in 2014 (August) during wildlife surveys along a proposed seismic line; eight detections that totalled 20 birds were recorded. The total number of Sharp-tailed Grouse observed during baseline studies was 104 (Figure 6.16-4, Figure 6.16-6).

Activity at lek sites was fairly consistent throughout the years (Table 6.16-7) and some leks may be used consistently for decades (Howie 2005). It is uncertain whether recently discovered leks are replacements for those abandoned previously (Ritcey & Jury 2004). There is a possibility that Sharp-tailed Grouse may move or switch lek locations between years (S. Jones, pers. comm. 2015).

Table 6.16-7. Lek Activity by Year

Year	Lek1	Lek2	Lek3	Lek4	Lek5
2010	y	y	y	n	-
2011	y	y	y	n	-
2012 (MOE)	y	y	y	-	-
2013	-	-	-	-	-
2014	n	y	y	n	y

Seventeen Ruffed Grouse were observed during breeding bird surveys (Table 6.16-8). Ruffed Grouse were also observed incidentally in 2014 (May and June) along Goose Lake Road and south of the haul road northwest of Jacko Lake. Ruffed Grouse were observed in various habitat types throughout the LSA. A total of 19 Ruffed Grouse were observed during baseline studies (Table 6.16-8; Figure 6.16-6).

Summary

Field surveys were able to: i) confirm the presence of both indicator species within the LSA, ii) confirm the activity status of lek locations, and iii) confirm the presence of suitable habitat for all life requirements for both species of grouse.

Table 6.16-8. Summary of Ruffed Grouse Survey Effort and Observations in the LSA

Year	Number of Breeding Bird Survey Transects	Number of Breeding Bird Point Count Stations	Ruffed Grouse Observed During Breeding Bird Surveys	Ruffed Grouse Observed Incidentally
2007	6	42	1	--
2008	4	71	2	--
2010	4	91	4	--
2014	7	121	10	2
Total	**21**	**325**	**17**	**2**

6.16.4 Potential Effects of the Project and Proposed Mitigation for Non-migratory Gamebirds

6.16.4.1 Identifying Potential Effects on Non-migratory Gamebirds

The AIR identified Habitat Loss/Alteration, Disturbance/Displacement and Mortality as potential effects. These effects were further broken down into: habitat loss; habitat alteration; sensory disturbance; disruption of movement; direct mortality; indirect mortality; wildlife attractants; and chemical attractants. An interaction matrix (Table 6.16-9) is used to help scope potential effects by considering potential interactions with Project activities/components, consistent with approach outlined in the assessment methodology (Section 5.2.4.1). Further rationale for the scoping of potential effects is provided below.

Habitat Loss

Habitat loss is defined, for the purposes of this assessment, as the replacement of habitat by Project infrastructure, or, when suitable habitat becomes rendered functionally unable to support the species. Habitat loss will occur during the Construction and Operation phases of the Project, specifically during vegetation clearing, land excavation, water diversion, and any other changes to the physical landscape. For this assessment, all habitat loss will be considered under the initial clearing and grubbing during the Construction phase. Habitat reclamation during Operation and Closure phases is considered a potential habitat gain, and will not be considered under this potential effect. Habitat loss will be reported as both a maximum (all habitat within the IDA), and minimum (all habitat within buffered Project infrastructure footprints) anticipated loss based on current footprint distribution. A ranking of "high" was assigned for this activity, and warrants further analysis as described in Section 6.16.4.2.

Habitat alteration will be assumed to occur within the LSA in all habitats outside of the Project facility footprints. This approach will have some overlap between habitat lost and habitat altered, but it will ensure that all effects are considered.

Table 6.16-9. Identifying Potential Interactions and Effects on Non-migratory Gamebirds

	Project Activities	Potential Effects on Non-migratory Gamebirds							
		Habitat Loss	Habitat Alteration	Sensory Disturbance	Disruption of Movement	Direct Mortality	Indirect Mortality	Wildlife Attractants	Chemical Hazards
Construction	Clearing and Grubbing	H	O	O	O	M	O	O	O
	Earthworks	O	O	O	O	O	O	O	O
	Overburden/Topsoil Stockpile	O	O	O	O	O	O	O	O
	Laydown Areas and Storage Yards	O	O	O	O	O	O	O	O
	Project Lighting	O	O	L	O	O	O	O	O
	Site Security and Fencing	O	O	O	O	O	O	O	O
	Fuel Storage and Filling Area	O	O	O	O	O	O	O	L
	Hazardous Wastes Transport, Storage, and Disposal	O	O	O	O	O	O	O	L
	Construction Wastes Transport, Storage, and Disposal	O	O	O	O	O	O	O	O
	Sewage Infrastructure and Disposal	O	O	O	O	O	O	O	L
	Public Road Realignment, Use, and Maintenance	O	L	M	L	M	L	O	L
	Site Road Construction, Use and Maintenance	O	M	H	L	M	O	O	O
	Haul Road Overpass Construction, Use, and Maintenance	O	O	O	O	O	O	O	O
	Site Buildings and Process Plant	O	O	O	O	O	O	O	O
	Explosives Magazine and Storage Facilities	O	O	O	O	O	O	O	O
	Open Pit Development	O	O	O	O	O	O	O	O
	Drilling and Blasting	O	O	M	O	O	O	O	O
	Crushing Mine Rock	O	O	H	O	O	O	O	O
	Loading, Hauling, and Deposition of Mine Rock	O	O	H	O	O	O	O	O
	Temporary Ore Stockpile	O	O	O	O	O	O	O	O

(continued)

Table 6.16-9. Identifying Potential Interactions and Effects on Non-migratory Gamebirds (continued)

Project Activities		Potential Effects on Non-migratory Gamebirds							
		Habitat Loss	Habitat Alteration	Sensory Disturbance	Disruption of Movement	Direct Mortality	Indirect Mortality	Wildlife Attractants	Chemical Hazards
Construction *(cont'd)*	Tailing Storage Facility Development	O	O	O	O	O	O	O	O
	Power Transmission, Distribution	O	M	O	O	L	L	O	O
	Natural Gas Line	O	M	O	O	O	O	O	O
	Pipeline Utility Corridor (Potable Water, Sewage, and Site Water)	O	M	O	O	O	L	O	L
	Water Intake from Kamloops Lake	O	O	O	O	O	O	O	O
	Fire Suppression Infrastructure	O	O	O	O	O	O	O	L
	Contact Water	O	O	O	O	O	O	L	L
	Non-contact Water	O	O	O	O	O	O	L	O
	Haul Road Overpass	O	O	O	O	O	O	O	O
	Water Management Dams	M	O	O	O	O	O	O	O
	Mine Staffing (Direct Employment)	O	O	O	O	O	O	O	O
	Contracted Employment	O	O	O	O	O	O	O	O
	Taxation	O	O	O	O	O	O	O	O
Operation	Open Pit Development	O	O	O	O	O	O	O	O
	Drilling and Blasting	O	O	M	O	O	O	O	O
	Hauling Mine Rock and Ore from Pit	O	O	O	O	O	O	O	O
	Crushing and Conveying Ore	O	O	H	O	O	O	O	O
	Temporary Ore Stockpile	O	O	O	O	O	O	O	O
	Development of Mine Rock Management Facilities	O	O	O	O	O	O	O	O
	Stripping, Loading, Hauling, Deposition, and Contouring of Topsoil and Overburden	O	O	O	O	O	O	O	O
	Revegetation through Progressive Reclamation	O	O	O	O	O	O	L	O

(continued)

Table 6.16-9. Identifying Potential Interactions and Effects on Non-migratory Gamebirds (continued)

	Project Activities	Potential Effects on Non-migratory Gamebirds							
		Habitat Loss	Habitat Alteration	Sensory Disturbance	Disruption of Movement	Direct Mortality	Indirect Mortality	Wildlife Attractants	Chemical Hazards
Operation *(cont'd)*	Process Plant Operation	O	O	O	O	O	O	O	O
	Deposition to Tailing Storage Facility	O	O	O	O	O	O	O	L
	Site Road Use and Maintenance (Materials, Personnel, Supplies)	O	M	H	M	M	O	O	L
	Concentrate Transport and Storage	O	O	O	O	L	O	O	L
	Explosives Magazine and Storage Facilities	O	O	O	O	O	O	O	O
	Fire Suppression Infrastructure	O	O	O	O	O	O	O	L
	Fuel Storage and Filling Area	O	O	O	O	O	O	O	L
	Hazardous Wastes Transport, Storage, and Disposal	O	O	O	O	O	O	O	L
	General Wastes Transport, Storage, and Disposal	O	O	O	O	O	O	O	O
	Sewage Infrastructure and Disposal	O	O	O	O	O	O	O	L
	Laydown Areas and Storage Yards	O	O	O	O	O	O	O	O
	Power Transmission, Distribution	O	M	O	O	L	L	O	O
	Project Lighting	O	O	L	O	O	O	O	O
	Site Access, Security and Fencing	O	O	O	O	O	O	O	O
	Water Intake from Kamloops Lake	O	O	O	O	O	O	O	O
	Contact Water	O	O	O	O	O	O	L	L
	Non-contact Water	O	O	O	O	O	O	L	O
	Potable Water Treatment and Use	O	O	O	O	O	O	L	O
	Haul Road Overpass	O	O	O	O	O	O	O	O
	Mine Staffing (Direct Employment)	O	O	O	O	O	O	O	O
	Contracted Employment	O	O	O	O	O	O	O	O
	Taxation	O	O	O	O	O	O	O	O

(continued)

Table 6.16-9. Identifying Potential Interactions and Effects on Non-migratory Gamebirds (continued)

Project Activities		Potential Effects on Non-migratory Gamebirds							
		Habitat Loss	Habitat Alteration	Sensory Disturbance	Disruption of Movement	Direct Mortality	Indirect Mortality	Wildlife Attractants	Chemical Hazards
Decommissioning and Closure	Dismantling of Ancillary Buildings	O	O	O	O	O	O	O	O
	Pit Lake Planning	O	O	O	O	O	O	O	O
	Site Road Decommissioning	O	O	L	O	O	O	O	O
	Tailing Storage Facility Decommissioning and Reclamation	O	O	O	O	O	O	O	L
	Mine Rock Management Facilities Reclamation	O	O	O	O	O	O	O	O
	Fuel Storage and Filling Area	O	O	O	O	O	O	O	L
	Hazardous Wastes Transport, Storage, and Disposal	O	O	O	O	O	O	O	L
	General Wastes Transport, Storage, and Disposal	O	O	O	O	O	O	O	O
	Sewage Infrastructure and Disposal	O	O	O	O	O	O	O	L
	Laydown Areas and Storage Yards	O	O	O	O	O	O	O	O
	Power Transmission, Distribution	O	L	O	O	L	L	O	O
	Project Lighting	O	O	L	O	O	O	O	O
	Site Access, Security and Fencing	O	O	O	O	O	O	O	O
	Contact Water	O	O	O	O	O	O	L	L
	Non-contact Water	O	O	O	O	O	O	L	O
	Potable Water Treatment and Use	O	O	O	O	O	O	L	O
	Haul Road Overpass	O	O	O	O	O	O	O	O
	Road use to the Project (Materials, Personnel, Supplies)	O	L	L	L	L	O	O	L
	Mine Staffing (Direct Employment)	O	O	O	O	O	O	O	O
	Contracted Employment	O	O	O	O	O	O	O	O
	Taxation	O	O	O	O	O	O	O	O

(continued)

Table 6.16-9. Identifying Potential Interactions and Effects on Non-migratory Gamebirds (completed)

Project Activities		Potential Effects on Non-migratory Gamebirds							
		Habitat Loss	Habitat Alteration	Sensory Disturbance	Disruption of Movement	Direct Mortality	Indirect Mortality	Wildlife Attractants	Chemical Hazards
Post Closure	General Site Inspections and Maintenance	O	O	O	O	O	O	O	O
	Contact Water	O	O	O	O	O	O	L	L
	Non-contact Water	O	O	O	O	O	O	L	O
	Road use to the Project (Materials, Personnel, Supplies)	O	O	L	L	L	O	O	L
	Mine Staffing (Direct Employment)	O	O	O	O	O	O	O	O
	Contracted Employment	O	O	O	O	O	O	O	O

Notes:

O	*No interaction anticipated.*
L	*Negligible to minor interaction expected; implementation of best practices, standard mitigation and management measures; no monitoring required, no further consideration warranted.*
M	*Potential moderate interaction requiring unique active management/monitoring/mitigation; warrants further consideration.*
H	*Key interaction; warrants further consideration.*

Habitat Alteration

Habitat alteration is defined as a reduction in habitat suitability. Activities that affect the physical characteristics or accessibility of an area, either permanently or temporarily can result in a change in habitat suitability.

Habitat alteration will occur throughout the construction and operation phases of the Project, specifically as a result of drilling, blasting, crushing and road use (fugitive dust deposition), soil compaction, linear feature use and maintenance (invasive species introduction, vegetation maintenance) and changes in drainage and water quantity. Included within the IDA is a minimum 50 metre buffer between the edge of the IDA and any Project infrastructure. Any habitat alteration within this buffer as a result of edge effects is incorporated into habitat loss (Gieselman et al. 2013). As all suitable habitat within Project infrastructure footprints was assumed to be removed during initial Project Construction activities, habitat alteration effects are limited to areas where suitable habitat may still exist.

Habitat fragmentation can be associated with corridors of unsuitable habitat (e.g., open roads) that may function as filters or barriers for some wildlife populations (Jalkotzy et al. 1997). The loss of vegetative cover can restrict road crossings to a few individuals (filter) or no individuals (barrier). The degree of loss of connectivity will vary with the width of the corridor, the frequency of vehicular traffic, the habitat on either side of the corridor and the species being considered. The resulting fragmentation and obstruction can limit the ability of species to disperse, breed and survive if it cannot access critical habitats or travel corridors. Habitat Alteration was ranked as "M" and will be discussed further in section 6.16.4.2.

Sensory Disturbance

Sensory disturbance refers to a Project related activity (e.g., noise, light, human presence) that causes individuals to change their behaviour or avoid certain habitats that would otherwise be suitable. Little is known about the impacts of sensory disturbance on grouse. Disturbance can interrupt normal activity and cause an animal to move away from the source of disturbance. This movement may have energetic costs to the individual, as well as disrupting the activity (e.g., foraging, courting, nesting, tending young) of the individual (Gill and Sutherland 2000; Blanc et al. 2006). Disturbed individuals may choose to temporarily vacate areas of suitable habitat, which may result in increased energy expenditures or utilization of sub-optimal habitats (Ward et al. 1999; Gibeau et al. 2002; Bautista et al. 2004). Disturbance during critical periods (e.g., nesting or lekking) may be more detrimental to some species than others. Birds that are flushed off nests leave their eggs and nestlings vulnerable to predators. For some VCs, noise can mask the sounds that individuals use to find prey, mates, and avoid predators. Masking can reduce fitness (breeding success), especially for species that are highly reliant on their acoustic environment. In some cases, habituation and adaptation can allow wildlife to accommodate the presence of noise in their environment. Some species will tolerate a considerable amount of human presence, providing there is no perceived risk.

Loud construction-related Project activities, such as drilling, blasting, pile driving and tree falling, can disturb a variety of species depending on the type of activity, season, how close the activity is,

and the frequency of the activity. The source, duration, and intensity of noise all influence how an animal may respond, whether it is disturbance, displacement, or habituation.

Project components and related activities expected to cause noise-sensory disturbance to non-migratory gamebirds include drilling and blasting, public and site road realignment/construction, use and maintenance, crushing mine rock, and loading, hauling and deposition of mine rock. Based on preliminary noise modeling, drilling and blasting noise are anticipated to have a "moderate" interaction on lekking Sharp-tailed Grouse, while all other Project related noise is anticipated to have a "high" interaction on this species. Based on the rankings of "moderate" and "high," sensory disturbance to due noise warrants further analysis as described in Section 6.16.4.2.

Project components and related activities that may cause light-sensory disturbance to the indicator species include Project lighting, which will take place in the Construction and Operation phases. As the majority of artificial light is expected to be directionally focused into the Project infrastructure footprints, the expected interaction of this activity on either grouse species was given a ranking of "low" and will not be discussed further.

Disruption of Movement

A wildlife movement corridor is a linear habitat that connects two significant habitat areas (Beier & Loe 1992). Disruption of movement refers to Project related activities that may cause an interruption to animal movements or migration, or may cause complete avoidance of certain habitats that would otherwise be suitable. Displaced individuals may choose to temporarily vacate habitats, resulting in increased energy expenditures. Wildlife movement may be affected directly as a result of Project related activities, such as excavation of the mine (movement barrier) or road construction (corridors).

Roads are often cited as having the greatest effects of disturbance on wildlife (Jalkotzy et al. 1997). Repeated disturbances from traffic may cause some species to avoid the area around active roads, resulting in a net decrease in available habitat, as well as changes in daily and seasonal movement patterns.

As non-migratory gamebirds don't have migration routes and are able to fly around potential obstacles, disruption of movement is not anticipated to affect this VC and a ranking of "L" has been assigned and no further discussion is warranted.

Direct Mortality

Direct mortality is defined as the death of an individual resulting directly from a Project related activity. Direct mortality can result from any number of Project activities, and are typically associated with vehicle/machinery use on roads, individuals getting killed while their habitat they are in is being removed, and individuals having an unexpected interaction with an anthropogenic feature (e.g., flying into transmission lines or windows in buildings).

Based on the rankings of "high" for clearing and grubbing activities and "moderate" for site and public road construction/realignment, use, and maintenance further analysis of this effect is warranted, and will be described in Section 6.16.4.2. This ranking was considered "low" for transport of concentrate to the Port of Vancouver, as the incremental effect of those vehicles to existing highway traffic is very small.

Indirect Mortality

Indirect mortality is defined as the death of an individual resulting indirectly from a Project related activity. Wildlife mortality may be caused indirectly from increased access for hunting or poaching, from range shifts leading to increased resource competition between individuals, or from increased hunting pressure by natural predators.

Wildlife Attractants

Wildlife attractants are defined as features or materials that may attract wildlife away from their natural environments, to areas that are superficially superior. Odours, food waste, sewage, garbage, and stored chemicals from construction crews and camps are examples of types of attractants that may entice individuals, but that ultimately will have a detrimental effect on the species.

Chemical Hazards

Chemical hazards are defined as chemicals that result from Project related activities that have the potential to cause an adverse health effect on wildlife. Wildlife may ingest, inhale, or absorb chemicals (e.g., metals, dust, organic anthropogenic substances, etc.) from improperly stored substances, dust on soil or vegetation, or bioaccumulation from prey.

During Construction, the fuel storage and filling area has the potential to result in a chemical hazard to grouse. Hazardous waste transport and sewage infrastructure, as well as oil, fuel, other petroleum-based fluids and antifreeze from machinery can cause direct mortality and habitat contamination if they are allowed to escape into the environment. Petroleum compounds can affect organisms physically (smothering, reduced light), via habitat modification (alterations in pH or diminished food availability) or via toxic action (Albers 2003).

Contact water, which is any water that may have come in contact with potentially toxic materials, may have a negative effect on grouse. Heavy metals such as copper, cadmium, lead, chromium and mercury are known to be persistent and mobile in the environment, and to be potentially toxic to many forms of life. Potential sources of metal contamination within the LSA include terrestrial (i.e., Mine Rock Storage Facilities (MRSFs)) and aquatic (pit lake, Tailings Storage Facilities (TSF)). The water quality in the pit depends on the interaction of the water with the rock in the pit walls, and with the pH of the water.

6.16.4.2 Effects on Non-migratory Gamebirds

For effects ranked "M" or "H" in Section 6.16.4.1, further analysis was undertaken, and is described below to quantify the potential effects of Project activities on non-migratory gamebirds.

Habitat Loss

Methods to Estimate Habitat Loss for Non-migratory Gamebirds

An interaction between non-migratory gamebirds and the Project is anticipated to lead to habitat loss. Project components and related activities expected to cause habitat loss to grouse is the clearing and grubbing of the land during Construction. This activity will remove suitable grouse habitat (grassland) and lek sites located within the IF.

Although multiple Project activities will result in habitat loss, it is assumed that all footprints will be cleared and/or grubbed at the start of Construction. To avoid double-counting of effects, clearing and grubbing was considered the only Project activity to result in habitat loss during any phase of the Project. As loss of lek habitat is a limiting factor for Sharp-tailed Grouse across the landscape (Alberta Conservation Association 2010; Stinson & Schroeder 2012), the loss of these sites was the primary focus of this assessment; the loss of suitable winter habitat was also assessed. As Ruffed Grouse were observed to be distributed across a variety forest classes (Lane et al. 2003), and are known to be more habitat generalists (Imbeau et al. 2003), habitat loss could not be quantified. A qualitative approach was therefore used instead.

The potential exists for an adverse effect on both grouse species and populations if suitable habitat is present within the IDA. The amount of suitable Sharp-tailed Grouse habitat lost was calculated as a maximum amount and as a predicted amount of habitat lost. First, the IDA footprint was overlaid on the habitat suitability mapping and known lek locations to establish the maximum amount of habitat loss that could occur. For the calculation of the maximum potential effect on gamebirds, it was assumed that all habitats (moderate and high suitability) within the IDA were lost. This approach resulted in a maximum estimated amount of lost habitat. The second assessment of habitat loss involved overlaying the Project specific footprints (IF) on habitat suitability mapping and lek locations to establish a minimum estimated amount of habitat loss. The combination of these approaches allowed for the disturbance of both the IDA footprint and Project specific footprints to be reported. The amount of suitable habitat lost within the IDA and IF was then compared to the total amount of suitable habitat within the LSA to calculate the percent of suitable habitat lost within the LSA.

Predicted Habitat Loss for Non-migratory Gamebirds

Habitat loss is anticipated to impact Columbian Sharp-tailed Grouse during clearing and grubbing activities. For the assessment of maximum habitat loss, of the 3,578 ha of suitable Sharp-tailed Grouse growing season habitat in the LSA, up to 1,957 ha (55%) will be removed by the Project (Table 6.16-10). Of the 1,260 ha of high and moderate suitability Sharp-tailed Grouse winter habitat in the LSA, up to 715 ha (57%) will be removed by the Project (Table 6.16-10, Figure 6.16-7). For the assessment of minimum habitat loss, 1,084.7 ha (30%) and 401.4 ha (32%) of Sharp-tailed Grouse growing season habitat and winter habitat respectively are anticipated to be removed as a result of Project activities. Regionally the Project may disturb 3 to 5 % of suitable open grassland habitat.

Ruffed grouse may lose 45% of aspen habitat within the LSA. These 43 ha represent about 1.5% of the regional habitat available.

Four active leks and one inactive lek are known within the LSA. Of the four active leks, three are located within the IDA. If all habitat within the IDA is assumed to be lost, then three of four active leks (75%) within the LSA would be removed. Based on the current Project infrastructure footprint (IF) arrangement, one of the active leks (25%) would be lost as a result of a MRSF (Figure 6.16-7). Three active leks are anticipated to exist after habitat loss specific to Project infrastructure footprints has been accounted for. The one inactive lek located within the IDA will also be lost.

Table 6.16-10. Suitable Habitat Lost for Sharp-tailed Grouse by Season

Suitability Class		Species and Season Rated For					
		Sharp-tailed Grouse – Growing Season (ha)	Percent of Habitat Available within LSA	Sharp-tailed Grouse Winter Season (ha)	Percent of Habitat Available within LSA	Active Sharp-tailed Grouse Leks	Percent of Active Leks Lost within the LSA
IDA	Moderate Suitability	528.7	55%	663.4	57%	3	75%
	High Suitability	1.428.4		51.8			
	Total	**1,957.1**		**715.3**			
IF	Moderate Suitability	359.5	30%	373.4	32%	1	25%
	High Suitability	725.2		28.0			
	Total	**1,084.7**		**401.4**			

While habitat loss is anticipated for Ruffed Grouse during clearing and grubbing activities, the distribution of this species across various habitat types makes it difficult to quantify habitat loss. A reduction in attractive habitat may result in localized population declines, but this is not anticipated due to the more generalized nature of this species.

Habitat Alteration

Methods to Estimate Habitat Alteration for Non-migratory Gamebirds

As all suitable habitat within the Project infrastructure footprints will be assumed to be removed during initial Project Construction activities, habitat alteration effects will be limited to areas outside of these footprints, and limited to the area outside of these footprints within the IDA. The difference between the maximum and minimum effect of habitat loss quantifies the potential for habitat alteration.

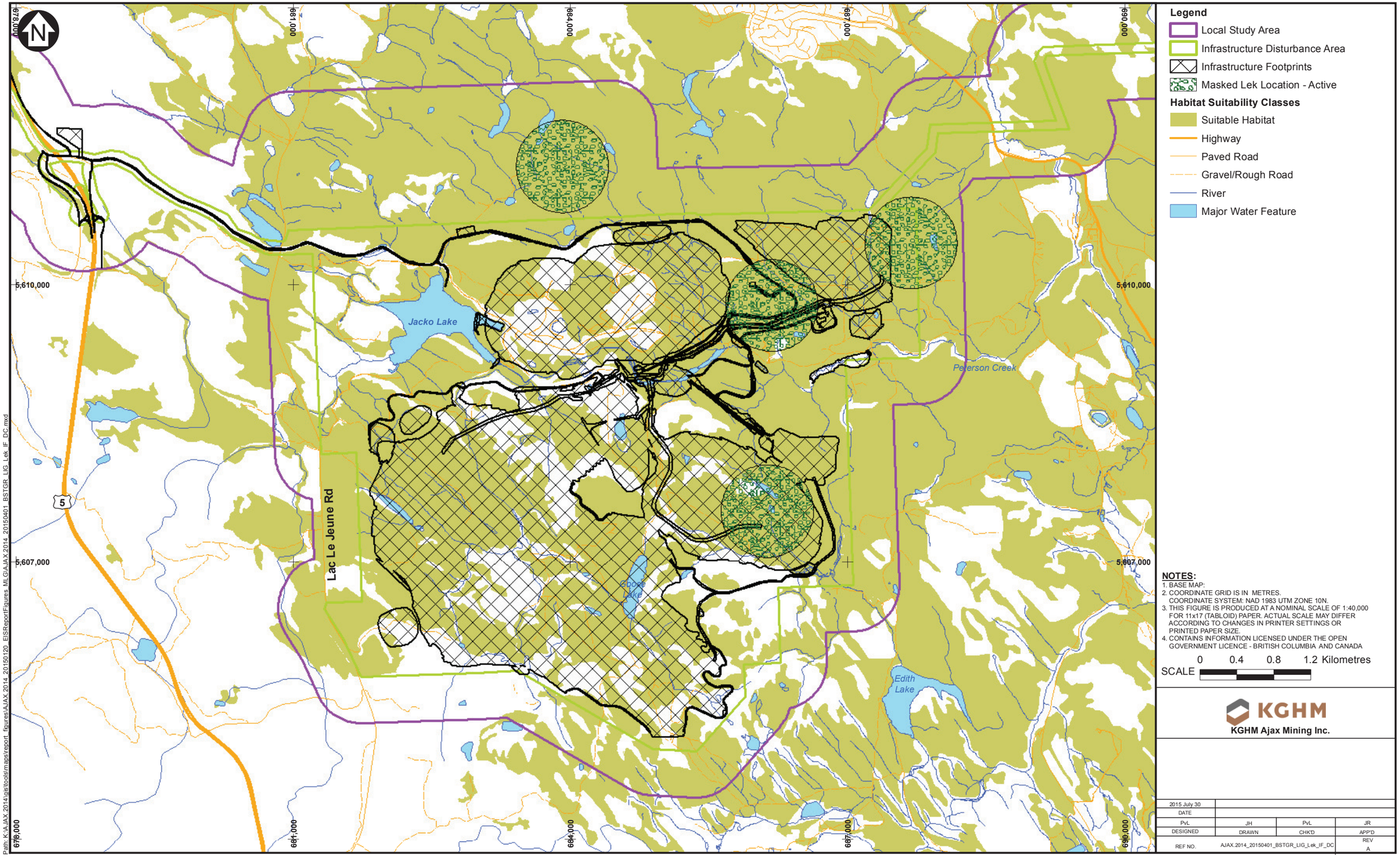
Predicted Habitat Alteration for Non-migratory Gamebirds

Habitat alteration is anticipated to impact Columbian Sharp-tailed Grouse during Construction and Operation activities. For the assessment of maximum habitat alteration, of the 3,578 ha of suitable Sharp-tailed Grouse growing season habitat in the LSA, up to 873 ha (24%) may be altered by the Project (Table 6.16-10). Of the 1,260 ha of high and moderate suitability Sharp-tailed Grouse winter habitat in the LSA, up to 314 ha (25%) may be altered by the Project (Table 6.16-10).

Fugitive dust is not anticipated to have a strong interaction with either species of grouse as dustfall models indicate that dust levels will remain below objectives, and therefore not of concern (Section 10.1).

As the existing habitat throughout the LSA is fragmented from past projects (open pit mine) as well as current land use (ranch land), and as both grouse species are currently present across this fragmented landscape, habitat fragmentation is anticipated to have a low level interaction with either grouse species.

Figure 6.16-7
Sharp-tailed Grouse Habitat Loss



Sensory Disturbance

Methods to Estimate Sensory Disturbance for Non-migratory Gamebirds

Densities of some birds have decreased with the presence of infrastructure areas within one kilometre (Benítez-López et al. 2010). Reduced densities have been observed in some various species of birds adjacent to roadways (Reijnen et al. 1996). Reijnen and Foppen (2006) found traffic noises as low as 36 dBA and 43 dBA may have an impact on woodland and grassland species, respectively. As Sharp-tailed Grouse are a species known to be sensitive to disturbance at lekking sites (Connelly et al. 1998), these numbers were used as a guideline to predict impacts to this species. Patricelli et al. (2013) determined that 10 dB above ambient value may have an effect on Great Sage-grouse; the 40 dBA contour was assumed to be 10 dB above ambient.

Limited reproductive opportunities appear to result from disturbances at Sharp-tailed Grouse leks (Baydack & Hein 1987). Drilling and blasting includes very loud, short-duration disturbances that may cause Sharp-tailed Grouse to stop using leks. Drilling and road-related noise have been observed to have a detrimental effect on Greater Sage-grouse (*Centrocercus urophasianus*), a species similar to the Sharp-tailed Grouse in its use of leks (Blickley et al. 2012; Patricelli et al. 2013). Noise also has the potential to cause stress levels to rise by increasing the perception of predation risk. Continuous Project noise, such as that from road use and machinery operations, has a greater potential to impact Sharp-tailed Grouse lek sites.

Blickley et al. (2012) found that male Greater Sage-grouse lek attendance decreased by 73% in areas adjacent to traffic noise (70 dB (F) unweighted decibels at 16 m, similar to road noise at 400 m). Holloran (2005) recorded a 51% decline in male Greater Sage-grouse attendance at leks the year after natural gas development started. Studies have shown a reduction in breeding males at leks sites within five kilometres of a drilling site or within three kilometres of a mail haul road (Holloran 2005; Naugle et al. 2011). Patricelli et al. (2013) found that an increase of 10 dB above ambient value would likely have an impact to lekking Greater Sage-grouse, as they do not appear to habituate to anthropogenic noise over time. Project related noise also has the potential to reduce the success of some nesting birds (Parris & Schneider 2009; Ortega 2012), but grouse may be less susceptible to disturbance from anthropogenic development (Dinkins 2013).

For the noise disturbance assessment, the area outside of the IDA that would be affected by noise was evaluated using noise contours modelled for the Noise Effects Assessment (Section 10.5). Two types of noise were evaluated: 1) continuous Project noise from roads and associated Project activities (40 dBA) and; 2) instantaneous blasting noise (120 dB (Lpeak) and 108 dB (Lpeak)) during Construction and Operation. Continuous noise was based on noise levels in grasslands associated with decreased bird abundance and diversity (Reijnen et al. 1996; Reijnen and Foppen 2006). The blasting noise threshold of 120 db (Lpeak) represent "effective habitat loss" and was selected based on the potential for damage to the ears of most bird species (Dooling and Popper 2007). The attenuated blasting noise threshold of 108 dB (Lpeak) represents "disturbed habitat" and was selected based on a review of environmental assessments of other mines in the province. Noise modelling considered areas where blasting noise attenuates to 108 dB for instantaneous noise effects.

Effective habitat loss was determined by overlaying the 120 dB (Lpeak) contour line over the LSA (Figure 6.16-8). Any suitable habitat within the LSA but outside of Project infrastructure footprints that fell within the 120 dB noise contour was totalled. Any leks within the 120 dB contour line were considered to be functionally lost. Disturbance to nesting and lekking individuals was determined by overlaying the 120 and 108 dB (Lpeak) contour lines over the LSA (Figure 6.16-9). Any leks outside of Project infrastructure footprints (and 120 dB contour) that fell within the 108 dB noise disturbance area also were totalled. For the purpose of determining sensory disturbance to lekking Sharp-tailed Grouse, it was assumed that leks that fell within the IDA, but not within specific IF, would remain after Construction.

Predicted Sensory Disturbance for Non-migratory Gamebirds

Sensory disturbance is anticipated to impact lekking Columbian Sharp-tailed Grouse during the Construction and Operation phases of the Project. One active leks falls within the 120 dB blast radius (Table 6.16-11, Figure 6.16-9) and would not expected to receive continued use if blasting occurs during critical lekking times. This lek will also receive high levels of disturbance as the main access road and the explosives facility are located in close proximity to this site (<200 m). The two remaining active leks that occur within the LSA but outside of Project infrastructure footprints will fall within the 40 dBA and the 108 dB (Lpeak) contour line (Table 6.16-11), and are expected to receive some level of disturbance (Figure 6.16-9), but are anticipated to receive continued use.

Table 6.16-11. Suitable Habitat Disturbed by Noise for Sharp-tailed Grouse by Season

Suitability Class		Species and Season Rated For					
		Sharp-tailed Grouse – Growing Season (ha)	Percent of Habitat Disturbed within LSA	Sharp-tailed Grouse Winter Season (ha)	Percent of Habitat Disturbed within LSA	Active Sharp-tailed Grouse Leks	Percent of Active Leks Potentially Affected within the LSA
120 dB** Disturbed Area	Suitable Habitat	437.8	12%	192.4	15%	1	25%
108 dB** Disturbed Area	Suitable Habitat	1,314.6	37%	585.3	46%	1	25%
40 dB*** Disturbed Area*	Suitable Habitat	1,036.8	29%	214.3	17%	2	50%

** 40 dB disturbance area based on year 4/8 noise modelling (anticipated loudest year of Operation)*
*** Instantaneous noise*
**** Continual noise*

Effective habitat loss will occur for Sharp-tailed Grouse as a result of blasting noise (120 dB), with the effective loss of 437.8 ha (12% of suitable habitat within the LSA) of suitable habitat during the growing season and the effective loss of 192.4 ha (15% of suitable habitat within the LSA) during the winter season (Table 6.16-11).

Figure 6.16-8
Sharp-tailed Grouse Habitat Alteration

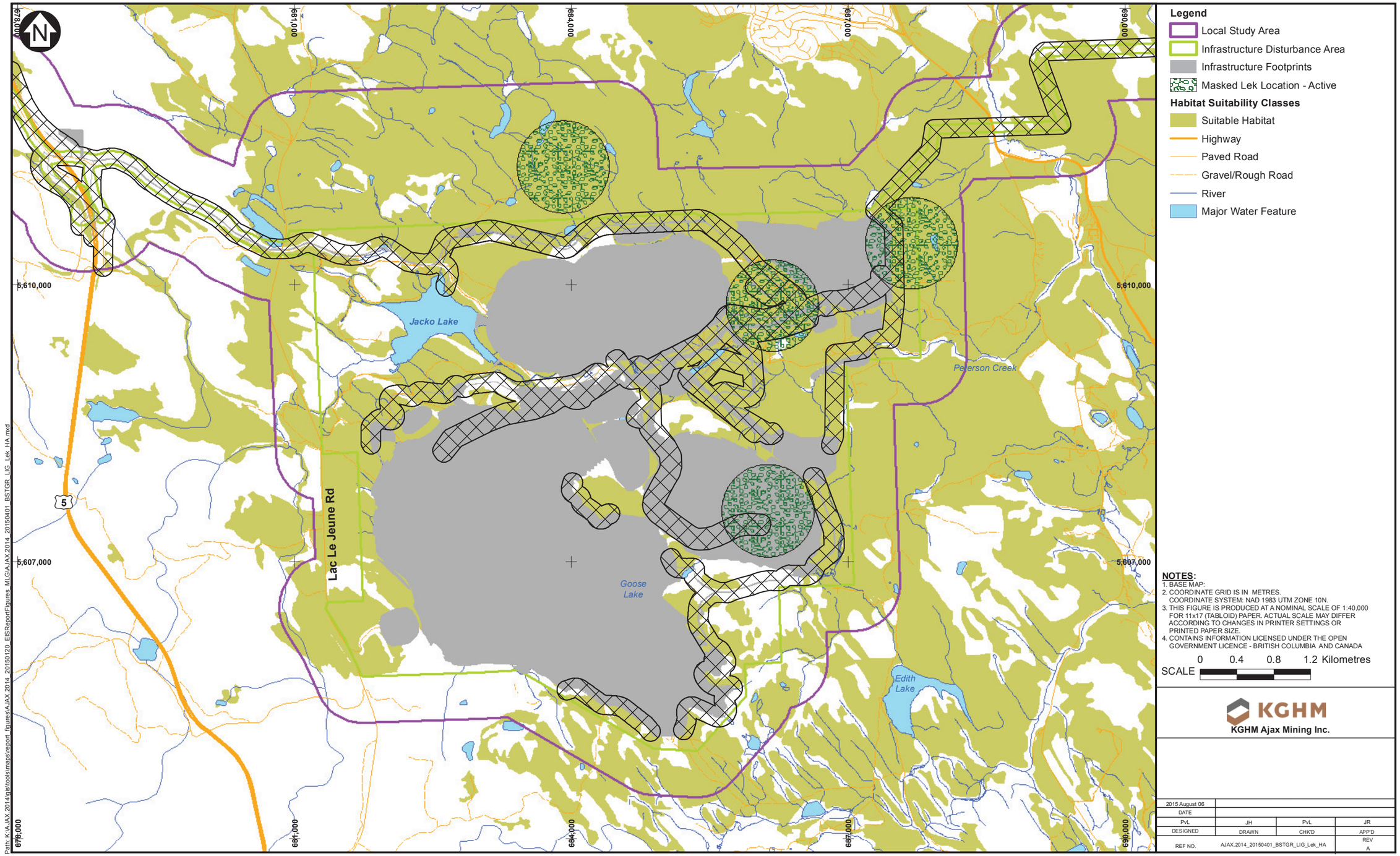
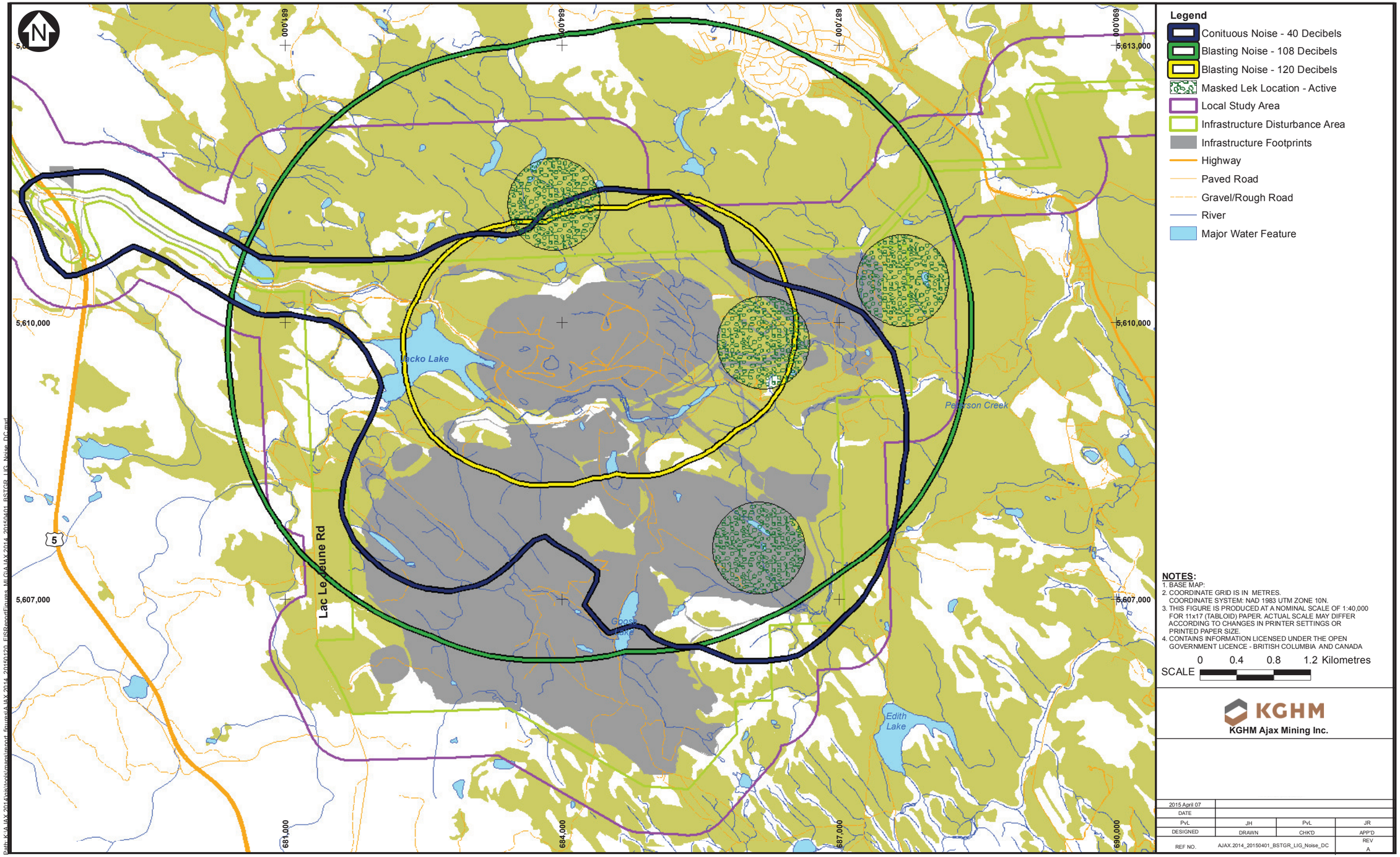


Figure 6.16-9
Noise Disturbances, Sharp-tailed Grouse Leks and Living Requirements Growing Season Suitable Habitat



In addition to the potential lek disturbance, nesting Sharp-tailed Grouse and Ruffed Grouse may experience a disturbance as a result of Project related noise. As a larger area of suitable growing habitat will be affected by sensory disturbance than will winter habitat, and as sensory disturbance during growing season is more detrimental to gamebirds as individuals will be nesting and lekking during this time, the growing season will be the focus of the effect of sensory disturbance on lekking and nesting birds. A total of 1,315 ha (37% of suitable habitat within the LSA) of suitable Sharp-tailed Grouse growing season habitat may be subject to noise disturbance from attenuated blasting noise (108 dB) (Table 6.16-11). A total of 1,037 ha (29% of suitable habitat within the LSA) of suitable Sharp-tailed Grouse growing season habitat may be subject to noise disturbance from Project noise (40 dB).

As few Ruffed Grouse were observed in areas that will be impacted by the 120 dB blast noise, and as very little suitable habitat will remain in the IDA where the blast noise will be occurring, effective habitat loss for this species is difficult to quantify. Ruffed Grouse observations occurred in a variety of forested areas, some which may not necessarily have been considered suitable habitat. Ruffed Grouse are anticipated to inhabit areas outside of the blasting radius if the noise is a disturbance to this species.

Traffic use along Project roads may dissuade grouse from using areas of suitable habitat (nesting and lekking), however, grouse are known to be frequently observed on or adjacent to unpaved roads (Chubbs & Phillips 2010). The majority of the remaining suitable nesting habitat (aspen stands or sites with overhead cover) will not be located in close proximity to continual noise resulting from Project activities, and therefore, nesting gamebirds are anticipated to receive a low level of disturbance.

Direct Mortality

Methods to Assess Direct Mortality for Non-migratory Gamebirds

Direct mortality for non-migratory gamebirds could not be measured directly. A qualitative approach based number of roads present, number of vehicles expected to use these roads, timing of road use, and professional judgement was used to address this potential effect.

The possibility for direct mortality during Project Construction exists for a variety of specific activities. Clearing and grubbing and road use are the activities anticipated to have a “high” to “moderate” likelihood of interaction with grouse. Road mortality is anticipated to be highest during Construction and Operation phases, when traffic use in the Project area will be most frequent. Power transmission and distribution also has the potential to result in mortality of grouse, but only a “low” interaction is anticipated.

Predicted Direct Mortality for Non-migratory Gamebirds

Both species of grouse may experience mortality as a result of activities such as clearing and grubbing, heavy equipment use, and road use during one or more phases of the Project.

While clearing and grubbing are occurring, any eggs or hatchlings will be unable to get clear of activities. The proportion of suitable habitat lost is assumed to equal the proportion of eggs and hatchlings killed within the LSA. As 30 to 55% of suitable Sharp-tailed Grouse growing season habitat may be lost as a result of the Project, between 30 and 50% of Sharp-tailed Grouse eggs and hatchlings may be assumed to be killed. Adult grouse, on the other hand, have the ability to move

away from machinery used for clearing and grubbing; however, some adult mortality may still occur as a result of this activity.

The movement of vehicles and construction machinery on Project roads may cause grouse mortality as a result of wildlife-vehicle collisions. A peak of 394 vehicles trips during Construction and 359 vehicles trips during Operation are anticipated to use Project roads. While grouse are assumed to not be present where there is no suitable habitat (i.e., Project infrastructure footprints), roads that run near the edge of highly suitable habitat and lek locations still have potential for grouse to be on them. Fedy et al. (2014) found that Greater Sage-grouse avoided paved roads across seasons in various regions. As Greater Sage-grouse have been observed to avoid areas within approximately 100 metres of paved roads (TransWest Express LLC 2013), the occurrence of gamebirds on the main access road is anticipated to be low. Other haul roads located throughout the IDA will likely also have a low occurrence of gamebirds on them as these roads will be in close proximity to Project infrastructure that has removed suitable habitat and will be a constant source of sensory disturbance.

Indirect Mortality

As grouse are a commonly harvested species, access road realignment/upgrade has the potential to allow hunters easier access to areas of suitable grouse habitat. Power transmission (right-of-way) and pipeline corridors also have the potential to increase hunting pressure on gamebirds. As hunting of Sharp-tailed Grouse is not permitted in the LSA, Ruffed Grouse should be the only species to see a potential increase in hunting pressure. Increased hunting pressure on Ruffed Grouse is not anticipated to occur, however, as hunting will not be permitted on the mine site. The likelihood for an indirect mortality interaction resulting from Project activities was determined to be "low" for all phases of the Project, and therefore will not be discussed further.

Wildlife Attractants

During the Construction and Operation phases of the Project, the presence of non-contact and treated potable water (potential sources of drinking water) throughout the Project area may attract grouse away from otherwise superior habitat. Contact water may have a similar interaction, however, for the purpose of this assessment, contact water was assessed under chemical hazards. Regenerating vegetation on road sides, artificial ditches near roads, and the presence of both contact and non-contact water may attract gamebirds away from suitable habitat during the Operation, Closure, and Post Closure/Decommissioning phases of the Project. As the occurrence of non-contact water will be limited to Project infrastructure footprints, areas where suitable habitat will no longer exist, the expected interaction between wildlife attractants and either grouse species is "low," and will not be discussed further.

Chemical Hazards

Project components and related activities that may cause a chemical hazard to the indicator species during Project Construction include fuel storage and filling area, hazardous waste transport, storage, and disposal, sewage infrastructure and disposal, access road realignment/upgrade, use, and maintenance, pipeline utility corridor, and fire suppression infrastructure. In Operation, the same activities, plus the transport and storage of concentrate as well as the presence of contact water may result in a chemical hazard. In addition to these activities, the decommissioning and reclamation of

the TSF may result in chemical hazards during the Decommissioning and Closure of the Project. As a chemical hazard from any of these activities would have to be the result of an accident or malfunction, the expected interaction of these activities on either grouse species was given a ranking of "low" and will not be discussed further. Contact water may result in an interaction with grouse, however, as it will all be contained to within the IF, and grouse are not anticipated to occur in the IF because suitable habitat will be removed, the activity was also given a ranking of "low" for potential to result in an interaction with either grouse species.

An ecological risk assessment (ERA) was conducted to determine risk quotients (RQs) for various avian species. Details for this assessment can be seen in Appendix 10.4-A. Ecological risk was quantified for various receptor species', including Ruffed Grouse, based on the total exposure to chemicals of potential concern (COPCs) from the environment relative to benchmark toxicological reference values. The change in potential risk to grouse as a result of the Project was deemed to be negligible.

6.16.4.3 Mitigation Measures for Non-migratory Gamebirds

Mitigation measures proposed to address potential effects during all phases of the Project are discussed below.

Habitat Loss

During Project planning, specific mine footprints were redesigned to ensure the minimum possible impact on the surrounding environment would occur. During Construction, Project infrastructure footprints will be kept to the minimum size required. At the end of mine life, during Decommissioning and Closure, habitat will be restored through reclamation and revegetation processes. Reclamation of the Project site has the potential to regain some habitat lost, if the appropriate seeds are included in the revegetation seed mix. Shrub/grassland habitat will be created on Mine Rock Storage Facilities to provide feeding and security requisites, while existing riparian zones along Peterson Creek and other nearby areas will be enhanced to provide suitable winter habitat. Reclaimed aspen groves may also provide feeding and security habitat for both species of grouse, once an appropriate structural stage is reached. Site road decommissioning and reclamation, mine rock management facilities reclamation, tailing storage facility decommissioning and reclamation, and the dismantling of ancillary buildings will increase the amount of available habitat in the LSA.

Habitat loss will be concentrated in the IF. Sharp-tailed Grouse leks should be avoided if at all possible and whenever practical. All known lek locations will be provided to KAM Construction and Operation personnel and buffered to reduce or avoid impacts to these sites. Four known active leks occur in the LSA, with three of these occurring in the IDA. One of these leks is located in the south mine rock storage facility footprint, and the loss of this lek is unavoidable. Based on the footprints of the pit, overburden stockpile, temporary reclamation pile, and topsoil stockpiles in the northeast section of the IDA, three of the four known active leks within the LSA will not be physically removed as a result of Project Construction activities. Of the three remaining active leks, one will become effectively lost due to high levels of sensory disturbance. The potential for interaction with the two remaining active leks will be further reduced by ensuring that initial stockpile development occurs outside of the lekking season (late March through May).

Legislation and Best Management Practices (BMPs) regarding gamebirds do not exist in BC; however, KAM recognizes the importance of preserving sensitive habitat features for provincially Red- and Blue-listed species. New lek locations will be created to compensate for the one active lek that will be removed. As the success of lek creation is not well known, two potential lek sites should be created for every known lek removed. The initial *Wildlife Habitat Objectives for Reclamation Plan* (Aspen Park Consulting 2013) suggests using flatter areas or gentle hummocks raised slightly above the surrounding land surface, ranging in area from 400 to 1,000 m^2, to be used for lek creation on mine rock piles. These areas will be seeded with bunchgrass to ensure an area of low grass cover. As the creation of these leks will not occur until the end of mine life, lek creation outside of the LSA will need to occur during mine construction.

As the success of recreating lekking grounds is not well understood, combined with the Blue-listing of the species and the sensitive nature of leks, a residual effect is expected for habitat loss on Columbian Sharp-tailed Grouse.

Despite a loss of habitat, very little anticipated Ruffed Grouse suitable habitat associations occur across the landbase within the LSA (< 1%). As Ruffed Grouse were observed throughout the study area (in areas that were not necessarily conducive to expected Ruffed Grouse habitat), combined with the understanding that this species has less specific habitat requirements than Sharp-tailed Grouse, a residual effect for this indicator is not anticipated.

Habitat Alteration

Dust and invasive plant species are expected to have a low magnitude impact on grouse. The *Air Quality Monitoring and Dust Control Plan* (Chapter 11.6) in combination with the *Transportation Management Plan* (Chapter 11.20) will reduce the impact of dust even further. The *Soil Salvage and Handling Plan* and the *Landscape Design and Restoration Plan* (Chapters 11.3 and 11.26, respectively) as well as the *Invasive Species Management Plan* (Chapter 11.17) and a vehicle wash station at site entrance may also help to reduce the impact of invasive plants.

As habitat alteration is expected to have a negligible to low impact on grouse, no residual effects are expected for either grouse species.

Sensory Disturbance

Noise is anticipated to have a negative effect on grouse, specifically Sharp-tailed Grouse and the continued use of leks. Noise may come from roads or Project specific activities, such as drilling and blasting. The *Noise and Vibration Management Plan* (Chapter 11.22) will be developed with the objective to ensure that noise levels during all phases of the Project are acceptably low for human and wildlife receptors, as per human health guidelines (Health Canada 2011).

Noise mitigation measures relevant to Sharp-tailed Grouse include:

- avoidance of clearing vegetation during bird breeding periods (April – early September) and working within timing windows as required when possible (Government of British Columbia 1996)

- ensuring impulse events, such as blasting, will be limited to certain times of the day (outside of the sunrise to 1000 window);
- considering noise ratings when selecting equipment;
- adjusting blasting configurations to minimise simultaneous blasting effects;
- optimizing the operation of equipment to minimize noise (e.g., reduced speed limits);
- optimizing the site layout to minimize noise impact (e.g., through use of natural screens such as buildings, facing away from relevant receptors, minimizing the need for mobile equipment to use their backup alarms); and
- noise dampening measures will be applied where possible, including conducting loud procedures indoors, where practical.

Project related noise (e.g., blasting, drilling, crushing) can be avoided during critical times of day (0600 to 1000), however, it is difficult to limit traffic noise at that time. Traffic noise may be mitigated by minimizing traffic along roads by providing a vehicle parking lot for staff, and shuttling mine personnel from this site to the mine.

Three active lek locations are anticipated to receive some level of sensory disturbance, depending on location and timing of specific Project activities. One lek occurs within the 120 dB blast radius, as well as the 40 dB continuous noise contour, and will likely not be used if blasting occurs during critical times of day (i.e., sunrise – 10:00 am). By limiting blasting activities to outside of this window, it is possible that this lek may receive continued use by Sharp-tailed Grouse, but unlikely that females would nest in close proximity.

The two other active leks in the LSA are anticipated to receive some level of sensory disturbance. As the level of potential disturbance and the resulting response by this VC is not well understood, monitoring of potentially disturbed leks as well as leks outside of the LSA is recommended to determine how this VC reacts to this disturbance (i.e., do Sharp-tailed Grouse relocated to alternate lek sites in response to anthropogenic disturbances) (Chapter 11.18). As the two known remaining active leks are within blast noise disturbance footprints (108 dB), a residual effect for sensory disturbance on Columbian Sharp-tailed Grouse may occur. By limiting blasting (120 dB) to avoid critical lekking hours, the potential effect from this activity is reduced substantially. However, as other Project related activities as well as traffic noise will not be able to be completely limited to avoid critical times of day, a residual effect is anticipated to occur.

A residual effect is anticipated to occur as a result of Project related noise on nesting gamebirds. Both Ruffed Grouse and Sharp-tailed Grouse may abandon their nests during the breeding season as a result of Project related noise.

Direct Mortality

Direct mortality is anticipated for both species of grouse during Construction and Operation of the Project. Activities that involve the removal of vegetation and erection of infrastructure will be limited to outside of the breeding window, where practical. By avoiding the sensitive breeding window (April 1st to May 31st), mortality on eggs and hatchlings should be avoided. If these

windows cannot be avoided, pre-clearing surveys should be undertaken by a qualified individual to ensure no egg or hatchling mortalities occur.

Vehicular mortalities may occur throughout all phases of the Project, especially during Construction and Operation when road use will be higher than in later stages. The frequency of collisions will be reduced through the implementation of speed limits and minimizing the number of vehicles using sites roads (*Transportation Management Plan* Chapter 11.20).

Measures to mitigate mortality of both grouse species include:

- avoidance of clearing vegetation during bird breeding periods (April – early September) and working within timing windows as required when possible (Government of British Columbia 1996);
  - pre-clearing surveys prior to any clearing activities if the breeding bird period cannot be avoided;
- yielding to wildlife observed along Project roads and communicating these observations to the environmental manager;
- minimizing traffic along roads by providing a vehicle parking lot for staff, and mine personnel will be shuttled from this site to the mine;
- implementing speed limits and wildlife signage to alert drivers of potential collisions;
- maintaining roadside vegetation to improve drivers' sight lines;
- ensuring the public road realignment does not overlap any Sharp-tailed Grouse lek sites;
- training and education programs; and
- banning any hunting activities and firearms on sites by any mine employees or contractors.

No listed-indicator species were considered nuisance wildlife. Measures used to control wildlife attractants are intended to minimize or eliminate problem wildlife situations. However, if a problem wildlife situation does arise, the environmental coordinator will initiate the appropriate response actions. Any direct intervention with problem wildlife will be done by authorized personnel in consultation with, and as approved or directed by, the British Columbia (BC) Conservation Officer Service. KAM will opt for non-lethal solutions (e.g., aversive conditioning, relocation) whenever appropriate and safe to do so.

After the implementation of these mitigation processes, the anticipated interaction is low for both species of gamebird, and therefore, no residual effects for mortality are anticipated.

Indirect Mortality

Increased hunting pressure (humans or wildlife) is expected to have a low magnitude impact on grouse. Access to the Project areas will be limited to employees and contractors, with locked gates and patrolling security guards (*Access Management Plan* Chapter 11.21), keeping increased hunting pressure by humans low.

As indirect mortality is expected to have a negligible to low impact on grouse, no residual effects are expected for either grouse species.

Wildlife Attractants

The attraction of grouse to sub-optimal habitat is expected to be low in all phases of the Project. Mitigation Plans and measures that will be in place to further reduce this effect include:

- a *Surface Water Quality Management and Monitoring Plan* (Chapter 11.23);
- proper transportation, handling, and storage of contact and non-contact water;
- avoiding certain seed mixtures in areas of progressive reclamation to minimize use of grouse in the area; and
- avoiding the creation of roadside pools.

As wildlife attractants are expected to have a negligible to low impact on grouse, no residual effects are expected for either grouse species.

Chemical Hazards

Chemical hazards from various Project activities (e.g., fuel storage and filling area, deposition to the TSF, contact water, vehicle/machinery leaks) are expected to be low in all phases of the Project. Management Plans that will be in place to further reduce these effects include:

- a *Construction Waste Management Plan* (Chapter 11.4);
- a *Metal Leaching and Acid Rock Drainage Management and Monitoring Plan* (Chapter 11.5);
- a *Water Management and Hydrometric Monitoring Plan* (Chapter 11.7);
- a *Contaminated Sites Management Plan* (Chapter 11.8);
- a *Solid Waste Management Plan* (Chapter 11.9).
- a *Hazardous Waste Management Plan* (Chapter 11.10);
- a *Risk Management Plan (Accidents and Malfunctions)* (Chapter 11.12);
- a *Natural Hazards Management Plan* (Chapter 11.13);
- an *Emergency Response Plan* (Chapter 11.14);
- a *Surface Water Quality Management and Monitoring Plan* (Chapter 11.23); and
- a Groundwater Quality Management and Monitoring Plan (Chapter 11.24).

The *Surface Water Quality Management and Monitoring Plan* (Chapter 11.23) will be the most significant plan to reduce the interaction with potentially toxic water. Exposure to any contaminants will be reduced by ensuring that any hazardous materials are stored safely and securely. As chemical hazards are expected to have a negligible to low impact on grouse, no residual effects are expected for either grouse species.

6.16.5 Residual Effects and their Significance

6.16.5.1 Summary of Residual Effects

After the implementation of mitigation measures, two residual effects are anticipated to occur (Table 6.16-12). The loss of Sharp-tailed Grouse habitat, as well as the potential removal of known lek locations, will not be completely mitigated. Sensory disturbance on lekking Sharp-tailed Grouse from Project activities such as drilling, blasting, and rock crushing may be mitigated by limiting these activities to specific windows. Limiting road traffic to avoid specific times of day and limiting blasting to avoid the breeding season are not practical, and may result in a residual effect to courting Sharp-tailed Grouse, and nesting Sharp-tailed and Ruffed Grouse.

Table 6.16-12. Summary of Residual Effects on Non-migratory Gamebirds

Valued Component	Project Phase (Timing of Effect)	Project Component/ Physical Activity	Description of Cause-Effect1	Description of Mitigation Measure(s)	Description of Residual Effect
Non-migratory Gamebirds (Sharp-tailed Grouse)	Construction	Clearing/Grubbing	Removal of vegetation and leks – Habitat Loss	Reclamation / revegetation, artificial lek creation	Loss of suitable habitat and known lek sites
Non-migratory Gamebirds (Sharp-tailed Grouse, Ruffed Grouse)	Construction, Operation	Road noise/drilling and blasting/loud Project activities	Displacement from leks and/or nests – Sensory Disturbance	Limit noise to certain windows (0600 – 1000, outside of breeding season)	Decreased lek usage, or abandonment of nests due to sensory disturbance

[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 VC.*

6.16.5.2 Criteria for Characterization of Residual Effects

Specific criteria used to characterize residual effects are outline below (Table 6.16-13). For habitat loss/alteration, magnitude was assigned thresholds based on literature and professional knowledge (Andren 1994). Negligible is a 0-5% change to available habitat in the LSA, Minor was a 5-30% change, Medium was a 30-50% change and Major is a change greater than 50%.

6.16.5.3 Characterization of Residual Effects

Two residual effects are anticipated on non-migratory gamebirds as a result of the Project (Table 6.16-14). Habitat loss will occur for Sharp-tailed Grouse, with the potential removal of greater than 50% of suitable habitat. This species is known to be sensitive at lekking locations, and dependant on grasslands to meet various life requisites. The magnitude of this effect is medium for suitable habitat loss as one active lek (of four active leks within the LSA) will be removed. The duration will be long-term as the lek that will be lost may be reclaimed until the end of mine life; reclamation efforts during Decommissioning and Closure will help suitable habitat to re-establish. Revegetion and recolonization of these areas will not occur instantaneously, but rather, over several years. The effect will occur sporadically, during the Construction and Operation phases when one lek and associated suitable habitat will be removed, and will be limited locally to within the Project infrastructure footprints. This effect may be reversible in the long-term, upon closure of the mine. Sharp-tailed Grouse have a low resiliency to habitat loss, with this being one of the major threats to this species (Leupin 2003).

Table 6.16-13. Definitions of Characterization Criteria for Residual Effects on Non-migratory Gamebirds

Magnitude	Duration	Frequency	Geographic Extent (Physical/Biophysical)	Reversibility	Resiliency	Ecological Context	Likelihood of Effects	
							Probability	Confidence Level
How severe will the effect be?	*How long will the effect last?*	*How often will the effect occur?*	*How far will the effect reach?*	*To what degree is the effect reversible?*	*How resilient is the receiving environment or population?*	*What is the current condition of the ecosystem and how commonly is it represented in the LSA?*	*How likely is the effect to occur?*	*How certain is this analysis?*
Negligible: No or very little detectable change from baseline conditions (<5%).	**Short-term:** Effect lasts 1 to 5 years.	**Once:** Effect is confined to one discrete period in time during the life of the Project.	**Local:** Effect extends less than 500 m from infrastructure or activity.	**Reversible Short-term:** Effect can be reversed relatively quickly.	**Low:** The receiving environment or population has a low resilience to imposed stresses, and will not easily adapt to the effect.	**Low:** The receptor is considered to have little to no unique attributes or provision of functions is severely degraded.	**High:** It is highly likely that this effect will occur.	**High:** < 80% confidence. There is a good understanding of the cause-effect relationship and all necessary data are available for the Project area. There is a low degree of uncertainty and variation from the predicted effect is expected to be low.
Minor: Differs from the average value for baseline conditions to a small degree (5-30%).	**Medium-term:** Effect lasts 6 to 25 years.	**Sporadic:** Effect an effect that occurs at sporadic or intermittent intervals during any phase of the Project.	**Landscape:** Effect is limited to the LSA or one watershed (i.e., Sub-area).	**Reversible Long-term:** Effect can be reversed within 20 years of Post Closure.	**Neutral:** The receiving environment or population has a neutral resilience to imposed stresses and may be able to respond and adapt to the effect.	**Neutral:** The receiving environment considered to have some unique attributes and provides most functions that an undisturbed environment would provide.	**Medium:** This effect is likely, but may not occur.	**Medium:** 50 to 80% confidence. The cause-effect relationships are not fully understood, there are a number of unknown external variables, or data for the Project area are incomplete. There is a moderate degree of uncertainty; while results may vary, predictions are relatively confident.
Medium: Differs substantially from the average value for baseline conditions and approaches the limits of natural variation (30-50%).	**Long-term:** Effect lasts between 26 and 50 years.	**Regular:** Effect occurs on a regular basis during the life span of the Project.	**Regional:** Effect extends across the broader region (e.g., RSA, multiple watersheds, etc.).	**Irreversible:** Effect cannot be reversed (i.e., is permanent).	**High:** The receiving environment or population has a high natural resilience to imposed stresses, and can respond and adapt to the effect.	**High:** The receiving environment or population is uncommon and occurs in a natural state and provides functions at a maximum capacity.	**Low:** This effect is unlikely but could occur.	**Low:** < 50% confidence. The cause-effect relationships are poorly understood, there are a number of unknown external variables, and data for the Project area are incomplete. High degree of uncertainty and final results may vary considerably.
Major: Differs substantially from baseline conditions (>50%), resulting in a detectable change beyond the range of natural variation.	**Far Future:** Effect lasts more than 50 years.	**Continuous:** Effect occurs constantly during the life of the Project.	**Beyond Regional:** Effect extends beyond the regional scale, and may extend across or beyond the province.					

Table 6.16-14. Characterization of Residual Effects, Significance, Likelihood and Confidence on Non-migratory Gamebirds

Residual Effect	Residual Effects Characterization Criteria							Significance of Adverse Residual Effects	Likelihood and Confidence	
	Magnitude	Duration	Frequency	Geographic Extent	Reversibility	Resiliency	Context		Probability	Confidence
Loss of suitable habitat and known lek sites (Sharp-tailed Grouse)	Medium	Long-term	Sporadic	Local	Reversible Long-term	Low	High	Not Significant (moderate)	High	Medium
Decreased lek usage, or abandonment of nests due to sensory disturbance (Sharp-tailed Grouse - lek)	Minor	Medium-term	Regular	Landscape	Reversible Short-term	Low	High	Not Significant (minor)	High	Medium

Sensory disturbance is anticipated for two separate activities for grouse: lekking and nesting. Drilling and blasting noise, combined with road noise and other Project activities, may deter Sharp-tailed Grouse from using leks that occur within the LSA. Attenuated blasting noise may also have an effect on nesting gamebirds within the LSA. The level of disturbance on ground nesting birds, however, is not as well understood as the effects on lekking individuals. As the disturbance of lekking individuals is anticipated to be greater than the disturbance to nesting individuals, the former was the assessed for this potential effect. The potential disturbance to the three remaining lek sites will be of minor magnitude. One of these sites will likely receive a high level of disturbance while the remaining two lek sites will likely receive a low level of disturbance. Males at lek sites may have some tolerance to disturbance, but females appear to be more susceptible to disturbance (Leupin 2003), indicating a low resilience to sensory disturbance.

The potential disturbance to ground nesting birds will have a minor magnitude in that the conditions are anticipated to vary from baseline only slightly (blasting to occur only once per day). Sensory disturbance will occur over the medium-term (activity causing noise disturbance is anticipated to decrease as the Project progresses). Activities will occur regularly on the landscape (within the LSA). This effect is reversible in the short-term as cessation of the activity will result in cessation of the disturbance. As anthropogenic noise is known to occur in the Project area currently, and as both species have been observed throughout the LSA, the resiliency to noise on nesting birds is expected to be high.

6.16.5.4 Significance

Habitat loss is anticipated to have a not significant (moderate) effect on Sharp-tailed Grouse within the LSA. This species is not known to be resilient to anthropogenic change, and leks are not known to be common throughout the area. The loss of one active lek may be detrimental to this species; however, as three other leks exist within the LSA and one additional lek occurs just outside of the LSA (near Edith Lake, just outside of southwest corner of LSA) the use of these alternate sites may reduce the impact of this effect. Habitat creation, specifically artificial leks, may offset the impact to Sharp-tailed Grouse; however, the success of lek creation is not well known.

Sensory disturbance of lekking Sharp-tailed Grouse is anticipated to have a not significant (minor) effect within the LSA. Effects to Greater Sage-grouse were reviewed as resiliency of Sharp-tailed Grouse to noise is not well documented; as both species use leks, effects are thought to be similar. As resiliency of Sharp-tailed Grouse to sensory disturbance at leks appears to low, the use of alternate lek sites in the RSA or establishment of new lek sites will be required.

Sensory disturbance of nesting Ruffed Grouse and Sharp-tailed Grouse is anticipated to have a not significant (minor) effect within the LSA. Habitat features for leks are more specific than that of nest sites, and therefore, leks are the more limiting reproducing habitat feature. Nesting habitat away from disturbed areas exists in greater abundance than additional lek sites within the LSA. As nesting locations are less limiting that lek site locations, and are located in areas that provide some security cover (Connelly et al. 1998; Rusch et al. 2000), sensory disturbance at these sites was anticipated to have less of an impact than at leks.

6.16.5.5 Characterization of Likelihood and Confidence

In the characterization of residual effects, significance, likelihood and confidence on non-migratory gamebirds (Table 6.16-14), the greatest potential adverse effects on any indicator species were selected for each of the parameters. The specific characterization of likelihood and confidence for each effect will be discussed below.

The probability that the Project would have a habitat loss effect on non-migratory gamebirds was given a rank of high as suitable habitat and an active lek will be lost. Confidence was ranked medium as the amount of habitat loss is known, but the amount of suitable habitat required to meet all Sharp-tailed Grouse life requisites is unknown.

The probability and confidence of sensory disturbance on non-migratory gamebirds were ranked high and medium, respectively. Probability was ranked high as noise resulting from Project activities will occur and two species of grouse are known to occur in proximity to the disturbance. Confidence was ranked medium as effects of noise on Sharp-tailed Grouse specifically are not as well understood as other species, such as Greater Sage-grouse (another lekking species), which have been researched over the past 15 years.

6.16.5.6 Summary of Residual Effects Assessment and Significance

Two residual effects are anticipated to occur on the VC non-migratory gamebirds as a result of various Project activities and after the implementation of mitigation measures (Table 6.16-15). Habitat loss is anticipated to have a not significant (moderate) effect on Columbian Sharp-tailed Grouse within the LSA. Sensory disturbance is anticipated to have a not significant (moderate) effect on Sharp-tailed Grouse lek and nesting activity with the LSA.

Table 6.16-15. Summary of Residual Effects, Mitigation, and Significance on Non-migratory Gamebirds

Residual Effects	Project Phase	Mitigation Measures	Significance
Loss of suitable habitat and known lek sites (Sharp-tailed Grouse)	Construction	Reclamation / revegetation, artificial lek creation	Not Significant (moderate)
Decreased lek usage, or abandonment of nests due to sensory disturbance (Sharp-tailed Grouse - lek)	Construction, Operation	Limit noise during certain windows (06:00 – 10:00, breeding season)	Not Significant (minor)

These residual effects will be carried forward into the cumulative effects assessment section, and discussed in relation to other projects within the RSA (Section 6.16.6).

6.16.6 Cumulative Effects Assessment

6.16.6.1 Introduction

The cumulative effects assessment (CEA) considers the effects on non-migratory gamebirds that are likely to result from the residual environmental effects of the Project in combination with the effects

of other projects and activities (past, present, or future) with the RSA. The CEA methodology is based on the framework outlined in Section 5.3.

Past land use (e.g., agriculture, forestry, urban development) has shaped much of the region's current wildlife habitat abundance and distribution, and, in turn, has shaped how grouse and other gamebirds make use of the landscape. Many past, present and future projects have, and will continue to contribute to the amount of non-migratory game bird habitat in the RSA. Several projects have been identified as occurring in the region, and could potentially interact with our Project (Section 5.3). Each of these projects will be considered in combination with the residual effects identified above in Section 6.16.5 to determine if there is an interaction, and consequently, if there is the potential for a residual cumulative effect to occur. These interactions can include direct, indirect, additive and synergistic effects. To be included in the CEA projects must occur within the RSA, must have a residual effect, and must have the potential to act cumulatively with the residual effects for non-migratory gamebirds described in Section 6.16.5.

6.16.6.2 Identification of Other Actions That May Affect Non-migratory Gamebirds

A list of past, present, and anticipated future projects and activities known to occur in the region are identified and described in Section 5.3 (Table 6.16-16, Figure 6.16-10). Projects/activities were initially scoped out if there was no perceived spatial interaction (i.e., the project/activity occurs outside of the RSA). Other projects/activities were scoped into the CEA on a VC by VC basis. If a residual effect from the Project was determined, the likelihood of other projects/activities resulting in the same effect were assessed using reports generated from those projects/activities; in the absence of any data indicating specific effects, professional judgement was used. Other projects/activities considered for cumulative effects on non-migratory gamebirds are listed below.

6.16.6.3 Interactions between Residual Project Effects and Other Project or Activity Effects

Habitat loss and sensory disturbance of grouse are potential effects that may be exacerbated by other projects/activities in the region. Habitat loss associated with past, present and future project activities cannot be quantified. In the majority of cases, no information is available on total habitat loss. Consequently, a qualitative analysis was conducted to determine potential interactions based on professional judgement, location of these projects/activities, and the sensitivity of non-migratory gamebirds to habitat loss.

The Iron Mask Mine has not been in operation for over 90 years, and was considered as part of the baseline condition for this Project. Construction of Lac le Jeune Road, Highway 5A, and the TransCanada Highway occurred previous to 1950, while the Coquihalla Highway was built in the early 1980's. The construction of these roadways was also considered as part of baseline conditions.

Agriculture and forestry has occurred in the region since the 1800s. Habitat loss associated with both of these activities is assumed to have occurred, however, it cannot be quantified. Agriculture has converted fertile grassland habitats into commercial crops, and lower quality rangeland, while forestry has removed areas of suitable winter habitat for Sharp-tailed Grouse and general habitat for Ruffed Grouse. Continued active timber harvesting also has the potential to have a sensory disturbance effect on both grouse species (Table 6.16-16).

Table 6.16-16. Ranking Potential for Residual Effects to Interact Cumulatively with Effects of Other Human Actions on Non-migratory Gamebirds

	Industrial Projects/Activities													Natural Resources and Land Use			Tourism and Commercial Recreation Activities					Community Infra-structure			Transportation						
Residual Effect	Vidette Lake Mine	Afton Mine (Historical)	Iron Mask Mine	Bonaparte Mine	New Afton Mine (New Gold)	Highland Valley Copper Mine (Teck)	Domtar Kamloops Pulp Mill	Tolko-Hefley Creek Plywood and Veneer	LaFarge Cement Plant	Trans Mountain Pipeline System (Kinder Morgan)	Trans Mountain Pipeline System - Expansion (Kinder Morgan)	Harper Creek	Highland Valley Copper – Bethlehem Expansion	Kamloops Forest District	Agriculture	Ranching	Tranquille on the Lake	Lac Le Jeune Resort	Tobiano Golf Course	Recreational Hunting, Fishing, Foraging	Recreational Trails	City of Kamloops Wastewater Management	Water Treatment Centre	City Expansion and Growth	Lac le Jeune Road	Highway 1	Highway 5A	Highway 5 (Coquihalla Highway)	Kamloops Airport	Rail Yards and Lines (CP and CN)
Habitat Loss	-	O	O	-	O	-	O	-	-	O	L	-	-	L	L	L	-	-	O	O	O	-	-	L	O	O	O	O	-	O
Sensory Disturbance	-	O	O	-	O	-	O	-	-	O	L	-	-	L	O	O	-	-	O	L	L	-	-	L	O	O	L	O	-	O

Notes:

(-) *No spatial or temporal overlap*

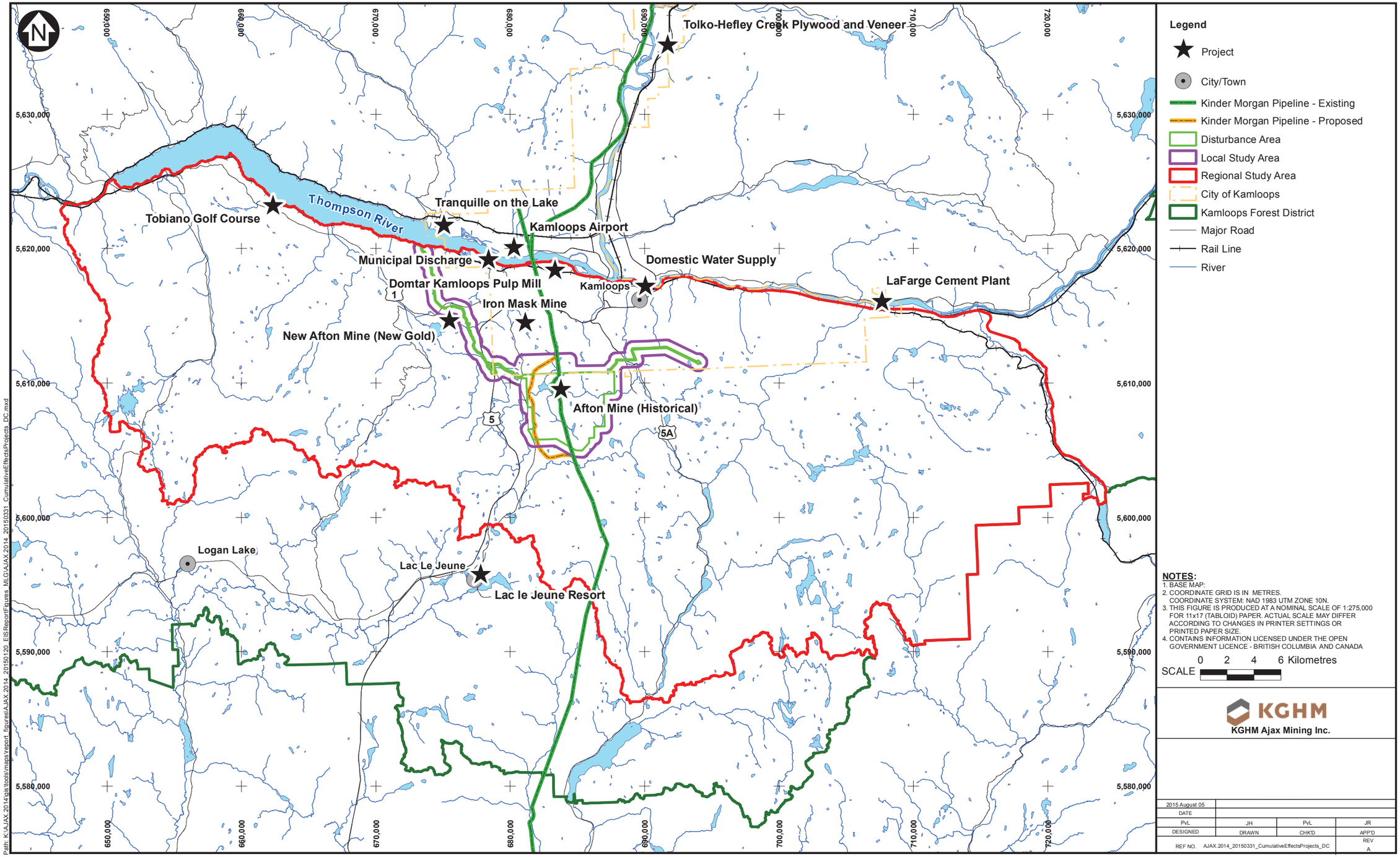
O *No interaction anticipated.*

L *Negligible to minor interaction expected; implementation of best practices, standard mitigation and management measures; no monitoring required, no further consideration warranted.*

M *Potential moderate interaction requiring unique active management/monitoring/mitigation; warrants further consideration.*

H *Key interaction; warrants further consideration.*

Figure 6.16-10
Cumulative Effects Regional Study Area



NOTES:
1. BASE MAP:
2. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD 1983 UTM ZONE 10N.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:275,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
4. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENCE - BRITISH COLUMBIA AND CANADA

SCALE 0 2 4 6 Kilometres

KGHM Ajax Mining Inc.

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Future projects/activities, such as the expansion of the City of Kamloops, specifically the growth of Aberdeen (neighbourhood adjacent to LSA) and the Southwest Industrial Area, as well construction of Kinder Morgan's TransMountain pipeline, will likely result in additional habitat loss and sensory disturbance of both grouse species (Table 6.16-16). Aberdeen is expected to continue expanding, from an approximate population of 10,000 people in 2011 to over 16,000 by 2036 years (TRUE Consulting Group 2008; City of Kamloops 2012). If approved, construction of the TransMountain pipeline twinning is anticipated to commence as early as 2016.

Recreational use (e.g., hunting, foraging, ATV/snowmobile use) is prevalent in the region, and contributes to sensory disturbance for gamebird habitat. While these activities are anticipated to be lower in duration and frequency than other activities, the intensity of the noise and the effect of this intensity are unknown. The potential for disturbance exists from these activities (Table 6.16-16).

Sharp-tailed Grouse appear to be sensitive to noise disturbance (Connelly et al. 1998), particularly noise associated with road use and construction. Although noise contours were not available for any of the below mentioned projects or activates, based on a study on the Greater Sage-grouse (another lekking species), Sharp-tailed Grouse are anticipated to show behavioral responses up to 3,000 metres away from roads (Naugle et al. 2011). Road use associated with logging, recreational hunting/fishing/foraging/ATVs, Lac le Jeune Road, the Coquihalla Highway, Highway 5A, and Highway 1 are all likely to interact with the noise associated with the Project (Table 6.16-16). All lost habitat from these past Projects and all sensory disturbance have influenced the baseline condition described for the Project.

The Kinder Morgan Pipeline follows an existing ROW and as such there will be limited habitat loss, though some temporary sensory disturbance is expected during Construction. The City of Kamloops expansion will discourage development within the Agricultural Land Reserve (City of Kamloops 2004) and may potentially effect 238 ha. Logging practices focus on coniferous species (pine, Douglas-fir and spruce) and constrained areas (private lands, wildlife tree reserves and riparian reserves) are expected to have a low effect on gamebirds. Conversion of grasslands to fields for agricultural purposes is also expected to have a low impact. Disturbance from roads and human presence may temporary displace grouse but much of this disturbance is ongoing and grouse have already adjusted to these disturbances. Grazing is considered a primary threat but can be alleviated with proper range and management practices.

6.16.6.4 Proposed Mitigation Measures

As KAM has limited authority to guide regional initiatives to support the diversity and persistence of habitat, this would be better guided by the provincial government.

Habitat Loss

Mitigation for the impacts of the Project on habitat loss consisted of mine site reclamation and replacement lek creation. These measures were not sufficient to reduce the total loss of habitat. Additional habitat loss mitigation will be required to compensate for the cumulative loss of habitat in the RSA. Further habitat reclamation or enhancement activities could occur on lands owned by KAM outside of the LSA, and include the fencing off of grasslands and controlling the timing for livestock grazing in sensitive areas could in an attempt to return some damaged grasslands to

"baseline conditions". KAM will partner with the *Grassland Conservation Council* (GCC) *of British Columbia* as well as the *Nature Conservancy of Canada* (NCC) to enhance existing grassland habitat within the RSA. Discussions with the provincial government will be initiated in an effort to develop Wildlife Habitat Areas (WHAs) on KAM owned land. Habitat loss cannot fully be mitigated, and therefore will be carried forward as a residual cumulative effect and evaluated in Section 6.16.6.5.

Sensory Disturbance

Project-specific mitigation to reduce sensory disturbance to grouse consisted of steps to minimize noise, as well as continued monitoring of leks within the LSA and outside of the LSA to see how Sharp-tailed Grouse react to disturbance. Traffic noise throughout the RSA cannot be controlled by KAM, and therefore, cannot be mitigated. Any mitigation measures taken will not be sufficient to fully reduce the potential impact of noise on nesting and lekking gamebirds. As a result, any habitat compensation or offsets should be located in areas situated away from known or anticipated anthropogenic disturbance to minimize the potential for further sensory disturbance to non-migratory gamebirds. Sensory Disturbance cannot fully be mitigated, and therefore will be carried forward as a residual cumulative effect and evaluated in Section 6.16.6.5.

6.16.6.5 Evaluation of Significance of Residual Cumulative Effects

After the implementation of mitigation measures, two residual cumulative effects are anticipated to occur. The loss of Sharp-tailed Grouse living habitat cannot be fully mitigated and may result in a cumulative effect (Table 6.16-17). Sensory disturbance on lekking Sharp-tailed Grouse from Project activities may be mitigated for by minimizing these activities to specific windows. However, limiting road traffic in the region is not practical, and may result in a cumulative effect to courting Sharp-tailed Grouse, and nesting Sharp-tailed and Ruffed Grouse (Table 6.16-17).

Table 6.16-17. Summary of Cumulative Effects Mitigation Measures and Residual Effects on Non-migratory Gamebirds

Ajax Project Activity	Other Human Action Activity	Description of Potential Cumulative Effect	Description of Mitigation Measure(s)	Description of Residual Cumulative Effect
Clearing and grubbing	Construction of other project infrastructure	Loss of leks and suitable growing season habitat	Reclamation/ enhancement of suitable habitat to offset habitat loss. Partnering with GCC, NCC to enhance existing grasslands. Discuss creation of WHAs on KAM owned land with provincial government	Loss of suitable habitat and known lek sites (Sharp-tailed Grouse)
Blasting/ Crushing, Road Use	Access to other project sites / activities	Sensory disturbance due to loud, short duration noises. Sensory disturbance associated with traffic on project and public roads.	Timing of blasting, access restrictions. Habitat creation to occur away from areas of anthropogenic disturbance.	Decreased lek usage, or abandonment of nests due to sensory disturbance (Sharp-tailed Grouse - lek; Sharp-tailed Grouse and Ruffed Grouse - nest)

Two residual cumulative effects are anticipated on non-migratory gamebirds as a result of the Project and other projects/activities occurring throughout the region (Table 6.16-18, Figure 6.16-11, Figure 6.16-12). Habitat loss has, and will continue to occur for Sharp-tailed Grouse. Leks have specific habitat features and this species are dependent on grasslands to meet various life requisites. Habitat loss is anticipated to have a not significant (minor) effect on Sharp-tailed Grouse within the RSA. As grasslands provide suitable habitat for this grouse species, the removal of these areas may have a detrimental effect (see Grasslands VC, Section 6.10). However, a considerable amount of suitable habitat likely exists within the RSA to the southeast of the Project, as known lek locations occur in this area (Howie 2005). The RSA contains 14 leks of which 11 were active in 2014 (S. Jones, pers. comm. 2015). The area southeast of the Project is composed of large patches of grassland that have not been heavily disturbed and do not have any anticipated projects/activities (Figure 6.16-11).

Sensory disturbance is anticipated for two separate activities for grouse: lekking and nesting. Drilling and blasting noise, road noise and other Project activities, combined with noise from roads throughout the region and noise from various other project activities, may deter Sharp-tailed Grouse from using leks. Lekking grouse are known to be sensitive to disturbance on these sites. The level of disturbance on ground nesting birds, however, is not as well understood as the effects on lekking individuals. Sensory disturbance is anticipated to have a not significant (minor) effect on both grouse species for both lekking and nesting activities. Areas where suitable lek habitat may occur are located to the southeast of the Project, where limited anthropogenic noise is anticipated to occur. Roads exist in this area, but traffic occurs at relatively low volume. Large areas of suitable lekking and nesting habitat away from any noise disturbance are anticipated to exist within the RSA (Figure 6.16-11).

6.16.7 Conclusion

Non-migratory gamebirds were assessed as a VC to determine likely interactions with specific Project activities, and how these interactions would affect this species group. Potential effects (habitat loss, habitat alteration, sensory disturbance, disruption of movement, direct mortality, indirect mortality, wildlife attractants and chemical hazards) arising from each Project activity were identified and evaluated. After the implementation of mitigation measures, two Project-related residual effects and two residual cumulative effects were determined for non-migratory gamebirds as a result of this Project, as well as in combination with other projects/activities, past, present, and future, occurring within the region (Table 6.16-19).

Habitat loss and sensory disturbance are both Project-related and residual cumulative effects. The magnitude and geographic extent of these effects differs as the scale at which they were assessed was much smaller for the Project-related residual effects than for residual cumulative effects (i.e., LSA vs. RSA). Duration of sensory disturbance differs as Project related noise will stop upon closure of the mine, but anthropogenic noise across the region will continue. Due to these differences, the likelihood and confidence, as well as the significance of the residual effects, also differs between assessments.

Table 6.16-18. Characterization of Residual Cumulative Effects, Significance, Likelihood and Confidence on Non-migratory Gamebirds

Residual Effect	Residual Effects Characterization Criteria							Significance of Adverse Residual Effects	Likelihood and Confidence	
	Magnitude	Duration	Frequency	Geographic Extent	Reversibility	Resiliency	Ecological Context		Probability	Confidence
Loss of suitable habitat and known lek sites (Sharp-tailed Grouse, Ruffed Grouse)	Minor	Long-term	Sporadic	Regional	Reversible Long-term	Low	High	Not Significant (minor)	Medium	Low
Decreased lek usage, or abandonment of nests due to sensory disturbance (Sharp-tailed Grouse - lek; Sharp-tailed Grouse and Ruffed Grouse - nest)	Minor	Far future*	Regular	Regional	Reversible Short-term	Low	High	Not Significant (minor)	Medium	Low

Table 6.16-19. Summary of Project and Residual Cumulative Effects, Mitigation, and Significance for Non-migratory Gamebirds

Residual Effects	Project Phase	Mitigation Measures	Residual Effect Significance	Residual Cumulative Effect Significance
Loss of suitable habitat and known lek sites (Sharp-tailed Grouse, Ruffed Grouse)	Construction	Avoidance of breeding sites through re-design where possible. Progressive reclamation/revegetation. Off-site lek enhancement or artificial lek creation	Not Significant (moderate)	Not Significant (minor)
Decreased lek usage, or abandonment of nests due to sensory disturbance (Sharp-tailed Grouse - lek; Sharp-tailed Grouse and Ruffed Grouse - nest)	Construction, Operation	Limit noise to certain windows (0600 – 1000, outside breeding season)	Not Significant (moderate)	Not Significant (minor)

Figure 6.16-11
Sharp-tailed Grouse Habitat in the Regional Study Area

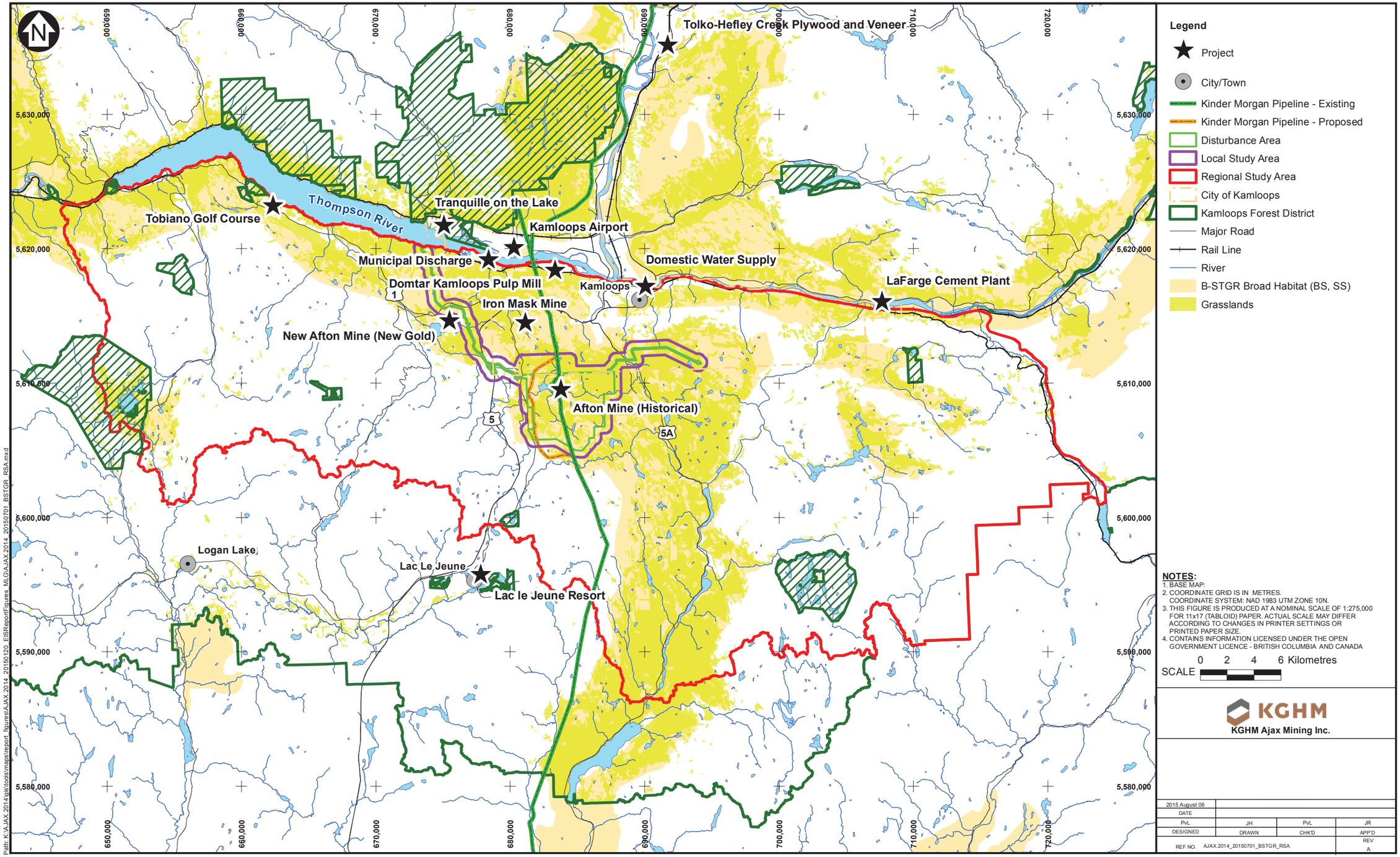
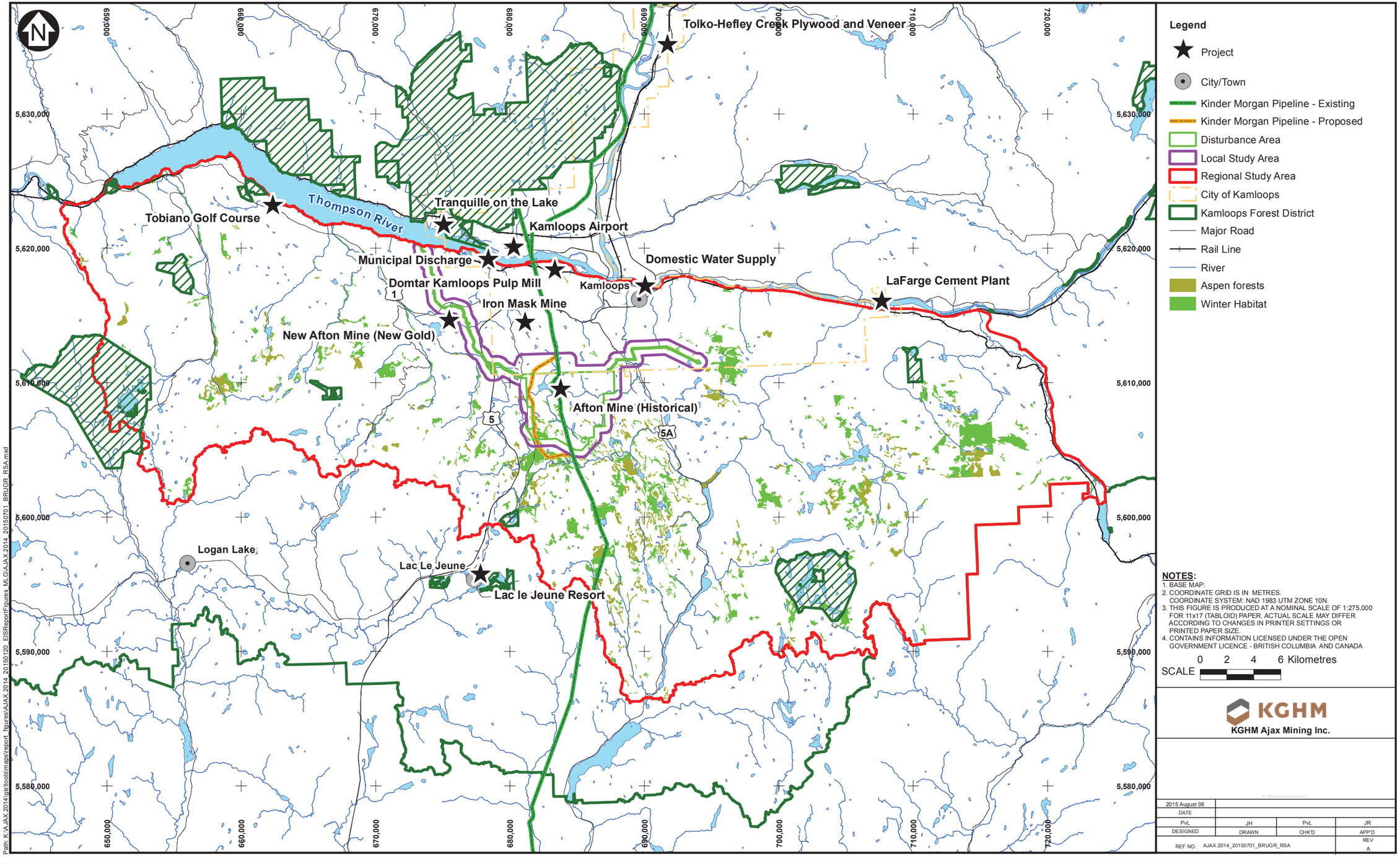


Figure 6.16-12
Ruffed Grouse Habitat in the Regional Study Area



The loss of suitable Sharp-tailed Grouse habitat, and specifically the removal of one known active lek and the effective loss of another due to sensory disturbance, may result in a negative impact to this species. As the Columbian subspecies of Sharp-tailed Grouse present in the area are Blue-listed (special concern) in BC, the loss of sensitive sites could impact populations both locally, and regionally. Habitat loss is considered not significant (moderate) for this species for Project-related residual effects as 25% of known active leks sites will be removed. Habitat loss is considered not significant (minor) for residual cumulative effects as suitable habitat still exists within the region, and that habitat has very little current or anticipated disturbances (projects/activities).

Sensory disturbance at lek sites may result in a reduction of use of these sites (Baydack & Hein 1987). Frequency of Greater Sage-grouse at active leks has been observed to decrease when industrial activity is occurring in proximity (Holloran 2005; Naugle et al. 2011; Blickley et al. 2012; Patricelli et al. 2013). While it is acknowledged that different species have different life requisites and behaviours, the common activity of lek usage allowed for this species to be used as a proxy. Sensory disturbance at lek sites is considered not significant (moderate) for this species for Project-related residual effects as the effect is easily reversible in the short-term and a reduction in lek usage does not equate to lek abandonment (i.e., leks may become less desirable, but they will likely still be used). Sensory disturbance at lek sites is considered not significant (minor) for this species for residual cumulative effects as additional leks exist within the region (Howie 2005), and that habitat has very little current or anticipated disturbances (projects/activities).

Sensory disturbance at nest sites of both Sharp-tailed and Ruffed Grouse may result in a reduction of use or abandonment of these sites (Parris & Schneider 2009; Ortega 2012). This effect is considered not significant (minor) for both Project-related and residual cumulative effects as the effect is easily reversible in the short-term and both species were observed across the landscape in the LSA, an area already subject to a number of anthropogenic disturbances, indicating a high level of resistance to this disturbance.

6.17 MAMMALS

6.17.1 Rationale

This section includes a description of the scoping process used to identify Mammals for inclusion in the assessment. Scoping is fundamental to focusing the Application/EIS on those issues where there is the greatest potential to cause significant adverse effects. Valued components (VCs) are components of the natural and human environment that are considered to be of scientific, ecological, economic, social, cultural, or heritage importance (CEAA 2006; EAO 2015). To be included in the EA, there must be a perceived likelihood that the VC will be affected by the proposed Ajax Project (the Project). Valued components are scoped into the environmental assessment based on issues raised during consultation with Aboriginal communities, government agencies, the public and stakeholders. Consideration of certain VCs may also be a legislated requirement, or known to be a concern because of previous project experience.

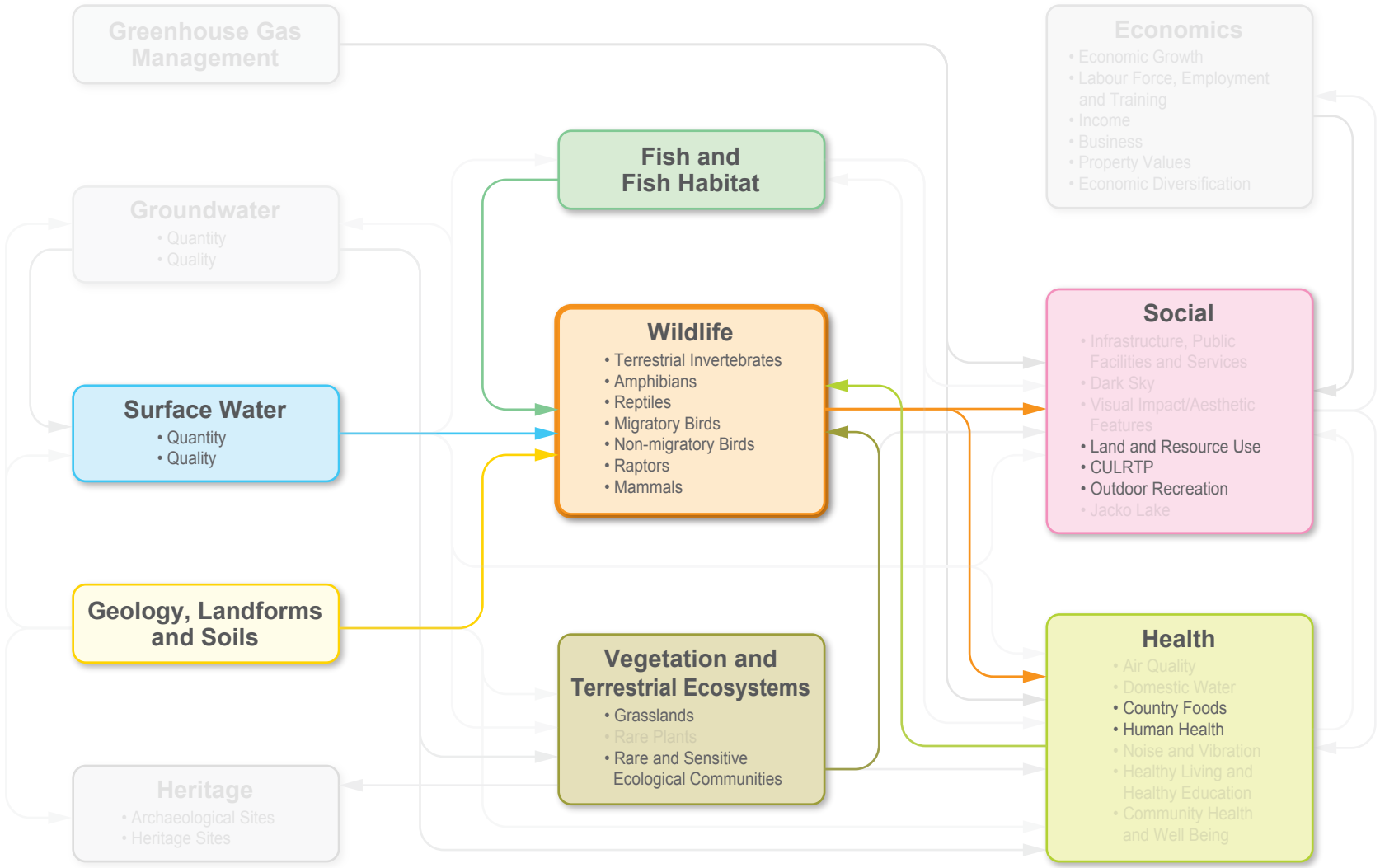
For mammals to be considered for inclusion as a valued component in the environmental assessment, the following were considered:

- Federal or provincial listing or regulation (including relevant legislation or policy concerning the VC):
  - Lists of Red- and Blue-listed species believed to occur within the Kamloops Forest District, and information on known locations of these species, according to the BC Conservation Data Centre (2010);
  - Information on SARA- or COSEWIC-listed taxa available from the Government of Canada;
  - Taxa listed as part of the Identified Wildlife Management Strategy (IWMS); and
  - Taxa of regional concern; and data from targeted wildlife surveys and from incidental observations;
- Aboriginal interest;
- Regional significance;
- Public or other stakeholder input;
- Scientific/professional knowledge; and
- Relevant legislation or policy concerning the VC.

Mammals select habitats based on the ability of the ecosystems to satisfy life requisites. Terrestrial ecosystems are determined by surface and ground water and soils. The assessment of effects to Mammals is largely related to disturbances from Project activities (as described further in Section 6.17.4). The information developed to support the analysis of this VC also contributes to Land and Resource Use, Current Use of Land and Resources for Traditional Purposes, and Country Foods (Figure 6.17-1).

Figure 6.17-1

VC Interactions for Wildlife (Mammals)



6.17.1.1 Selection of Mammals as a Valued Component

Ungulates, mustelids, large carnivores, bats, and small mammals (rodents) are all known to exist on the landscape in and around the Project area. The VC "Mammals" was selected as there is an expected interaction between mammals and the Project. Specific justification for the selection of mammals as a VC includes:

1. Federal or Provincial listing or regulation guidelines:
    a) Two Red-listed species (American badger and Great Basin pocket mouse) and four Blue-listed species (fringed myotis, spotted bat, Townsend's big-eared bat, and western small-footed myotis) may be present in the Project area;
    b) Three SARA schedule 1 species (American badger, little brown myotis, and spotted bat) may be present in the Project area;
    c) American badger is a species of regional concern; and
    d) The fringed bat, spotted bat and badger are identified wildlife under the *Forest and Range Practices Act* (FRPA).
2. Applicable government agencies: Environmental Assessment Office, Canadian Environmental Assessment Agency, Environment Canada, MFLNRO and First Nations identified mammals as a concern;
3. Stakeholder input:
    a) members of the public, Kamloops & District Fish and Game, Kamloops Naturalists Club, Grasslands Conservation Council, and the Thompson Watershed Coalition identified mammals as a concern;
    b) moose and deer are a traditional food source for Aboriginal peoples (University of Northern British Columbia, et al. 2011; Ignace 2014), and American badger have been identified as culturally important (Skeetchestn Indian Band, pers. comm., 2013, as cited in Chapter 12);
4. Scientific/professional knowledge: mammals have been documented in the Project area;
5. Spatial scope: mammals species range overlaps Project area;
6. Temporal scope: resident mammal species are present in Project area; and
7. Interaction with Project/potential effects (areas of disturbance associated with the Project components and activities including the Ajax pit, processing plant, tailings storage facilities, mine rock storage facilities, and transmission line) – a potential interaction is anticipated.

Based on this information an interaction between mammals and Project/potential effects are expected.

6.17.1.2 Selection of Indicators

Mule deer (*Odocoileus hemionus*), white-tailed deer (*O. virginianus*) and moose (*Alces americanus*) are known to commonly occur south of Kamloops, in the vicinity of the Project. North American porcupine (*Erethizon dorsatum*), American beaver (*Castor Canadensis*), snowshoe hare (*Lepus*

americanus), and a variety of smaller rodents, such as yellow-bellied marmot (*Marmota flaviventris*), yellow-pine chipmunk (*Neotamias amoenus*), bushy-tailed woodrat (*Neotoma cinerea*), northern pocket gopher (*Thomomys talpoides*), common muskrat (*Ondatra zibethicus*), North American deermouse (*Peromyscus maniculatus*), and red squirrel (*Tamiasciurus hudsonicus*) are also known to be present. There are historical records of Great Basin pocket mouse (*Perognathus parvus*) from the Kamloops vicinity (David Nagorsen, pers. comm.). Carnivores in the Kamloops area include American black bear (*Ursus americanus*), coyote (*Canus latrans*), grey wolf (*Canis lupus*), red fox (*Vulpes vulpes*), cougar (*Puma concolor*), Canada lynx (*Lynx canadensis*), bobcat (*Lynx rufus*), American badger (*Taxidea taxus*), American marten (*Martes americana*), American mink (*Neovison vison*), ermine (*Mustela erminea*), striped skunk (*Mephitis mephitis*), and long-tailed weasel (*Mustela frenata*). As many as five bat species which are of conservation concern may be found in the area (Table 6.17-1).

Table 6.17-1. Mammal Species Present in the Area

English Name	Scientific Name	Provincial List	COSEWIC Status	SARA Schedule/ Status[1]	Identified Wildlife	Selected as Indicator?
American badger	*Taxidea taxus*	Red	Endangered	1-E	Yes	Yes
American beaver	*Castor canadensis*	Yellow	-	-	No	No
American black bear	*Ursus americanus*	Yellow	Not At Risk	-	No	No
American marten	*Martes americana*	Yellow	-	-	No	No
American mink	*Neovison vison*	Yellow	-	-	No	No
Bobcat	*Lynx rufus*	Yellow	-	-	No	No
Bushy-tailed woodrat	*Neotoma cinerea*	Yellow	-	-	No	No
Canada lynx	*Lynx canadensis*	Yellow	Not At Risk	-	No	No
Common muskrat	*Ondatra zibethicus*	Yellow	-	-	No	No
Cougar	*Puma concolor*	Yellow	-	-	No	No
Coyote	*Canus latrans*	Yellow	-	-	No	No
Ermine	*Mustela erminea*	Yellow	-	-	No	No
Great Basin pocket mouse	*Perognathus parvus*	Red	-	-	No	Yes
Grey wolf	*Canis lupus*	Yellow	Not At Risk	-	No	No
Moose	*Alces americanus*	Yellow	-	-	No	Yes
Mule deer	*Odocoileus hemionus*	Yellow	-	-	No	Yes
Fringed myotis	*Myotis thysanodes*	Blue	Data Deficient	3[3]	Yes	Yes
Little brown myotis[2]	*Myotis lucifugus*	Yellow	Endangered	1-E	No	Yes
Long-tailed weasel	*Mustela frenata*	Yellow	-	-	No	No
North American deermouse	*Peromyscus maniculatus*	Yellow	-	-	No	No
North American porcupine	*Erethizon dorsatum*	Yellow	-	-	No	No
Northern pocket gopher	*Thomomys talpoides*	Yellow	-	-	No	No
Red fox	*Vulpes vulpes*	Yellow	-	-	No	No
Red squirrel	*Tamiasciurus hudsonicus*	Yellow	-	-	No	No
Snowshoe hare	*Lepus americanus*	Yellow	-	-	No	No

(continued)

Table 6.17-1. Mammal Species Present in the Area (completed)

English Name	Scientific Name	Provincial List	COSEWIC Status	SARA Schedule/ Status[1]	Identified Wildlife	Selected as Indicator?
Spotted bat	*Euderma maculatum*	Blue	Special Concern	1-SC	Yes	Yes
Striped Skunk	*Mephitis mephitis*	Yellow	-	-	No	No
Townsend's big-eared bat	*Corynorhinus townsendii*	Blue	-	-	No	Yes
Western small-footed myotis	*Myotis ciliolabrum*	Blue	-	-	No	Yes
White-tailed deer	*Odocoileus virginianus*	Yellow	-	-	No	No
Yellow-bellied marmot	*Marmota flaviventris*	Yellow	-	-	No	No
Yellow-pine chipmunk	*Neotamias amoenus*	Yellow	-	-	No	No

[1] *E = Endangered, SC = Special Concern*

[2] *Little brown myotis was added after the AIR due to an elevation in federal status.*

[3] *Schedule 3 species are those which have been designated Special Concern by COSEWIC, but are not on the first legal list (Schedule 1) under the* Species at Risk Act. *These species are to be reassessed, with the appropriate listing to be determined.*

Some mammals are more likely to be effected by the Project because they are linked to discrete habitat types (e.g., American badger and Great Basin pocket mouse are linked to grasslands). Other mammals are susceptible to water-borne contaminants or are highly susceptible to vehicular mortalities as they travel through their home ranges.

A preliminary list of indicator species was prepared (Table 6.17-1) based on the presence of suitable/ capable habitat, the availability of sufficient species knowledge to produce a meaningful assessment, feedback from stakeholders, and likely interactions with the Project (geographically and ecologically).

No suitable habitat for Bighorn Sheep, Fisher, Grizzly Bear, and Wolverine was found in the Project Area. Potential effects to White-tailed deer (*Odocoileus virginianus*) are adequately covered by mule deer indicator.

By definition, yellow-listed species are considered secure and widespread and effects of the Project to these species are not anticipated to have an adverse effect. As such, indicator species were generally at-risk species as these populations are more likely to experience an adverse effect.

American marten are typically in dense deciduous, mixed, or coniferous upland and lowland forest (BC Conservation Data Centre 2014a). They are ranked S4S5 (apparently secure to demonstrably widespread, abundant, and secure). Coarse woody debris and sufficient overhead vegetation are necessary habitat structures for marten (Hatler et al. 2003b). Martens have been used by Aboriginal peoples for story and trade (Ignace 2014). American marten do not occur regularly in open habitats, such as grasslands, agricultural areas, or recent clear-cuts (Hatler et al. 2003b), and for these reasons, were not selected as an indicator species.

American mink, ermine, long-tailed weasel, and striped skunk can be found throughout the province, in a variety of habitat types. Ermines, long-tailed weasels, and skunks can all be found in in open woodlands, brushlands, grasslands, and rocky outcrops, and are often found near water (BC Conservation Data Centre 2014a). American mink favour forests or wetlands with abundant cover (*ibid*.). Striped skunks, long-tailed weasels, and mink have been used by First Nations and

Aboriginal Groups for story, trade, clothing, and ceremonial purposes (Ignace 2014). All four of these species are ranked S5 (demonstrably widespread, abundant, and secure) in BC, and were not selected as indicator species for this reason.

Beavers, black bears, and red foxes are common in the region. Habitats in the Project area, such as sagebrush steppe grasslands and agriculture fields, receive only occasional use by black bears and are not used by beavers (BC Conservation Data Centre 2014a). Foxes can be found in almost every habitat type in the province, and are relatively resistant to loss of habitat (Hatler et al. 2003d). Beavers have traditionally been used by First Nations and Aboriginal Groups for story, trade, food, clothing, or ceremonial purposes; black bears have traditional uses in story, trade, food, medicine, and clothing; and red foxes have been traditionally used for story and trade (Ignace 2014). Provincially, beaver, black bear, and red fox are ranked S5 (demonstrably widespread, abundant, and secure). As all three of these species have widespread healthy populations, and are not anticipated to occur throughout the majority of the Project area, they were not selected as indicator species.

Coyotes are habitat generalists, being found in almost every habitat type in BC (BC Conservation Data Centre 2014a). Yellow-bellied marmots can be found in alpine, subalpine, and montane habitats, as well as foothills and canyons (BC Conservation Data Centre 2014a). Coyotes and marmots are both very resilient to human disturbance, being found in urban centres across the province (BC Conservation Data Centre 2014a; Gonzaga University 2014). Coyotes and yellow-bellied marmots have been traditionally used by First Nations and Aboriginal Groups for story, trade, and ceremonial purposes, while the marmot has also been used for food and clothing (Ignace 2014). Coyotes and marmots in BC are ranked S5 (demonstrably widespread, abundant, and secure). As both coyote and yellow-bellied marmot populations in BC are healthy, and these species are resilient to human disturbance, they were not selected as indicators for mammals.

Grey wolves can be found in a variety of habitat types in BC, but typically more abundant in areas with low road density (BC Conservation Data Centre 2014a). Grey wolves can be found throughout BC, with the central and northern portions of the province home to the highest densities (Hatler et al. 2003c). First Nations and Aboriginal Groups have traditionally used grey wolves for story, trade, and ceremonial purposes (Ignace 2014). Grey wolves are ranked S4 (apparently secure) in BC. Although there was one sighting of a grey wolf based on anecdotal evidence (B. Ciancone, pers. comm.), no confirmed cases of grey wolf observations in proximity to the Project could be located. For these reasons, grey wolf was not selected as an indicator species.

Cougars are widely distributed across the southern half of the province and are generally associated with mountainous or remote, undisturbed areas (BC Conservation Data Centre 2014a). Canada lynx are widespread and relatively abundant in the province, generally occurring in boreal and montane regions dominated by coniferous or mixed forest; other habitats, such as open forest or rocky areas may be used if prey availability is abundant (*ibid*.). Bobcats are found throughout the southern portion of BC, and are associated with various habitats including deciduous-coniferous woodlands and forest edge, swamps, brushlands, desert, mountains, and other areas with thick undergrowth (*ibid*.). Cougars, bobcats, and lynx have traditional First Nation and Aboriginal significance for story and trade (Ignace 2014). In BC, cougars, Canada lynx, and bobcats are ranked S4 (apparently secure). Cougars are particularity sensitive to human disturbance and are known to avoid heavily urbanized areas (Minnesota Department of Natural Resources 2015). Lynx and bobcats both rely on snowshoe

hare for a large portion of their diet, and the best hunting for this prey species typically occurs in young forests regenerating after wildfires, high elevation riparian thickets, and older coniferous forest with open areas to support thick undergrowth (Hatler et al. 2003a). For these reasons cougars, Canada lynx, and bobcats were not selected as an indicator species for the Mammals VC.

North American porcupines and snowshoe hares both prefer coniferous and mixed forests (BC Conservation Data Centre 2014a). Fallen logs and/or debris are both special habitat factors for these species (NatureServe 2014). Snowshoe hare have traditional importance to Aboriginal Groups for story, food, clothing, ceremony, and as ecological indicators; porcupines have traditionally been used for story, trade, food, and for technological purposes (Ignace 2014). North American porcupines are ranked S4 (apparently secure) and snowshoe hare are ranked S5 (secure) in the province. As both of these species have widespread, healthy populations across BC, neither were selected as indicators.

Bushy-tailed woodrat, common muskrat, North American deermouse, northern pocket gopher, red squirrel, and yellow-pine chipmunk are all rodents that are found throughout the province, in a variety of habitat types. Chipmunks and squirrels are found in forested areas, deermice in forested areas as well as open habitats and brushland, muskrats are found in wetlands, pocket gophers are found in meadows or grasslands/cultivated fields, and woodrats are typically located in rocky habitats (BC Conservation Data Centre 2014a; NatureServe 2014). Bushy-tailed woodrats, common muskrats, North American deermice, northern pocket gophers, and yellow-pine chipmunks all have traditional story value for local Aboriginal peoples (Ignace 2014). Red squirrels have traditional value of story, trade, and food (*ibid*.). All six of these rodent species are ranked S5 (secure) in BC, and were not selected as indicators for this reason.

Nine indicator species for the Mammals VC were selected based on recorded observations in the Project area during baseline studies, incidental observations, stakeholder concern, reported historical presence or based on the presence of suitable habitat (Table 6.17-2).

Table 6.17-2. Summary of Indicator Species Selection Rationale and Stakeholder Issues Raised

Indicator Species	Feedback by*				Issues Raised	Rationale
	AG	G	P/S	S/P		
American Badger	✓	✓		✓	Loss of denning (grassland) habitat, Provincial Badger Recovery Strategy in place.	Species at risk; Confirmed in LSA; vulnerable to Project effects
Great Basin pocket mouse		✓		✓	Loss of suitable habitat, little known about current Great Basin pocket mouse abundance and distribution in the Project area.	Species at risk; Potentially suitable habitat present ; unsurveyed
Moose	✓	✓	✓		Loss of habitat, increased disturbance, displacement and mortality of moose.	Aboriginal Groups and public concern
Mule deer	✓	✓	✓		Loss of habitat, increased disturbance, displacement and mortality of deer.	Aboriginal Groups and public concern; designated winter range present

(continued)

Table 6.17-2. Summary of Indicator Species Selection Rationale and Stakeholder Issues Raised (completed)

Indicator Species	Feedback by*				Issues Raised	Rationale
	AG	G	P/S	S/P		
Fringed myotis		✓		✓	Loss of habitat and disturbance of fringed myotis.	Species at risk; known present
Little brown myotis		✓		✓	Loss of habitat and disturbance of little brown myotis.	Species at risk; known present
Spotted bat		✓		✓	Loss of habitat and disturbance of spotted bat.	Species at risk; Potentially suitable habitat present
Townsend's big-eared bat		✓		✓	Loss of habitat and disturbance of Townsend's big-eared myotis.	Species at risk; Potentially suitable habitat present
Western small-footed myotis		✓		✓	Loss of habitat and disturbance of western small-footed myotis	Species at risk; known present

**AG = Aboriginal Group (Stk'emlupsemc te Secwepemc Nation (SSN) and Nlaka'pamux Nation); G = Government; P/S = Public/Stakeholder (e.g., LRMP); S/P = Scientific/Professional Knowledge.*

6.17.2 Assessment Boundaries

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

6.17.2.1 Spatial Boundaries

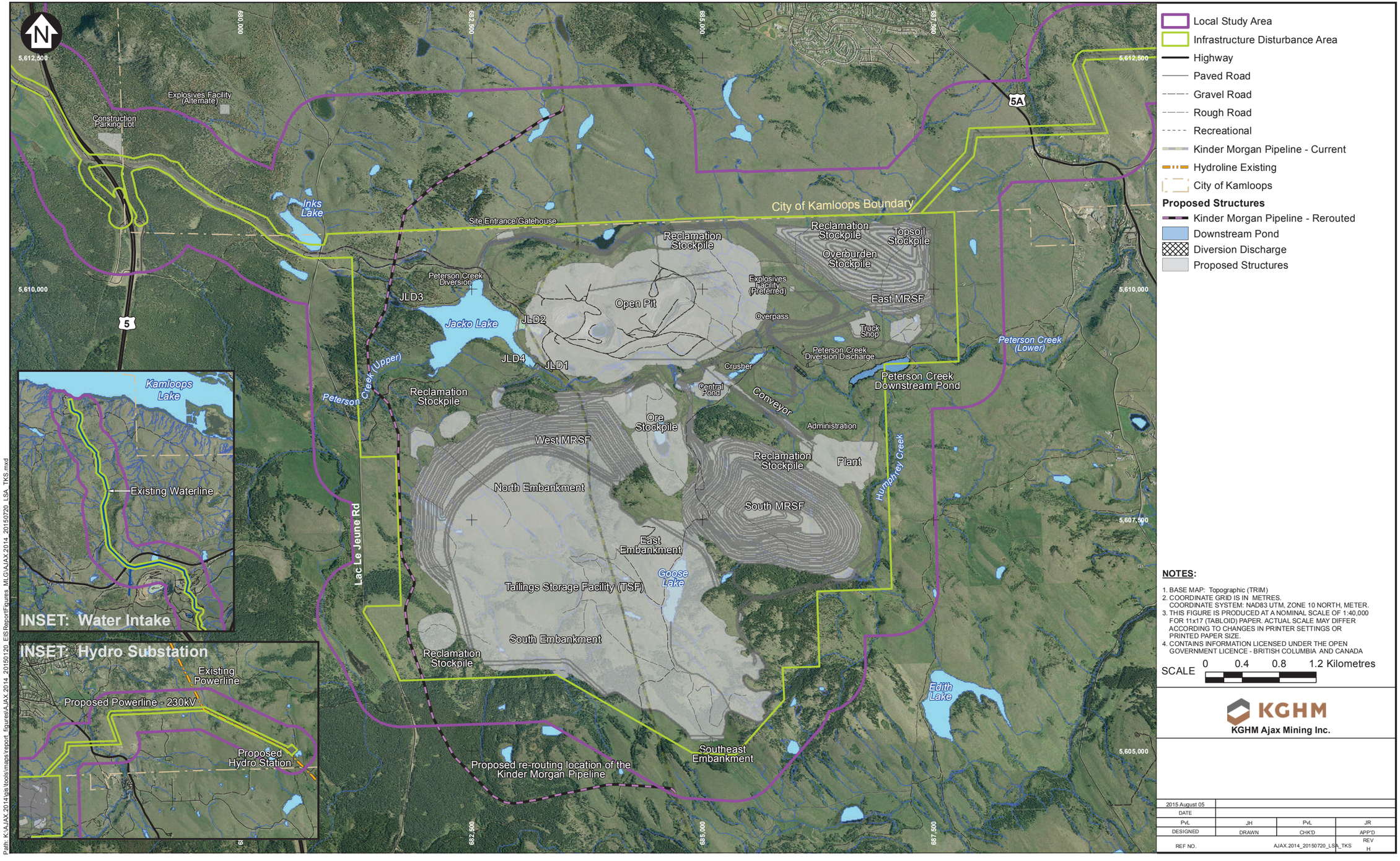
Infrastructure Footprints

The Project infrastructure footprints (IF) include the Open Pit, ancillary buildings and facilities, roads, truck shop, Tailings Storage Facility (TSF), Water Management Ponds, Mine Rock Storage Facilities (MRSFs), and stockpiles (Figure 6.17-2). The Project infrastructure footprints are 1,705 ha in size.

Infrastructure Disturbance Area

The Project infrastructure footprints and linear features (transmission line and water line) were buffered by at least 50 m (Henderson 2011) to determine the Project Infrastructure Disturbance Area (IDA). The 3,185 ha IDA will be used to assess maximum direct Project effects (e.g., mortality, habitat loss, habitat alteration, etc.). The IDA includes the Project IF (1,705 ha) used to calculate direct loss of habitat, plus a 1,480 ha buffer around the Project IF that represents a zone of influence for potential disturbance associated with habitat alteration resulting from effects pathways such as contaminants, silt or dust, noxious weeds, and changes in drainage pattern (Figure 6.17-2).

Figure 6.17-2
Local Study Area, Infrastructure Disturbance Area and Project Infrastructure



NOTES:

1. BASE MAP: Topographic (TRIM)
2. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD83 UTM, ZONE 10 NORTH, METER.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:40,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
4. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENCE - BRITISH COLUMBIA AND CANADA

SCALE 0 0.4 0.8 1.2 Kilometres

KGHM Ajax Mining Inc.

2015 August 05			
DATE			
PvL	JH	PvL	JR
DESIGNED	DRAWN	CHK'D	APP'D
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The use of a buffered polygon area rather than individual infrastructure footprints will provide an overestimate of the direct effects of the Project for the assessment. The advantage of this approach is that it enables individual footprints to be moved and/or resized without changing the results of the effects assessment.

The IDA was modified from the General Arrangement Polygon to follow a section of the Kamloops city boundary to more accurately represent the current Project IF.

Habitat alteration by dust and water quantity is accounted for under potential habitat loss within the IDA. Areas outside of the IF that are not lost will be subject to potential alteration effects. However as wildlife species present in the area are adapted to the dry, dusty environmental conditions, these effects were considered mitigable.

Local Study Area

In accordance with the AIR the General Arrangement Polygon was buffered by 500 m to determine the Local Study Area (LSA). This area is the expected area of potential disturbance associated with all Project facilities (BC Environmental Assessment Office 2015). The LSA is 7,167 ha and will be used to assess indirect Project effects (e.g., disturbance) and provide context on the amount of habitat available adjacent to the Project (Figure 6.17-2).

Regional Study Area

The Regional Study Area (RSA) is the area for which cumulative effects will be assessed. The RSA includes portions of the Campbell Landscape Unit and the South Kamloops Landscape Unit, including areas south of the Thompson River and west of Highway 97 (Figure 6.17-3). Landscape units were selected for the RSA as they are the geographical framework within which sustainable forest management regimes to maintain biodiversity are implemented. The RSA includes local watershed basins and is 158,415 ha in size.

6.17.2.2 Temporal Boundaries

The temporal boundaries of the assessment will include the short-term (e.g., initial construction and build-out), operations-related or the life of the mine, and decommissioning and reclamation activities. The temporal phases of the Project are:

- **Construction**: 2 years (Year -2 to 1);
- **Operation**: 23 years (Year 1 to 23);
- **Decommissioning and Closure**: 5 years (Year 24 to 29; includes Project decommissioning, abandonment and reclamation activities, as well as temporary closure, and care and maintenance); and
- **Post-Closure**: 5+ years (includes ongoing reclamation activities and post-closure monitoring).

6.17.2.3 Administrative Boundaries

Critical moose winter range is present in the RSA, southwest and southeast of the LSA. Critical deer winter range is present along the western edge of the LSA and draft mule deer planning cells are present in the LSA and overlap Project IF.

6.17.2.4 Technical Boundaries

Terrestrial Ecosystem Mapping (TEM) was completed within the IF as this is the area expected to interact with the Project, and thus requires detailed mapping. The pipeline utility corridor (northwest arm) will follow an existing road, and was not mapped in its entirety using TEM as a result of this previous disturbance. The transmission line (northeast arm of LSA) was not mapped using TEM as it runs through previously disturbed grassland, and will not remove any habitat. Areas outside of the LSA were quantified using VRI and other broad mapping sources that identified forested habitat, wetland habitat and grassland habitat within the RSA.

American badgers dens can be difficult to locate, and are often encountered by chance during surveys for other taxa. Targeted badger den surveys can be refined to focus on areas of suitable habitat, but den entrances are often not readily apparent (i.e., collapsed entrances, vegetation obscuring entrances). Also, as this is a nocturnal, mostly solitary species with a relatively large home range that occurs at low densities and spends a large portion of its time underground (Paige and Darling 2010), observations of individuals are rare. The small sample size for badger dens limits the analysis for this indicator species, resulting in the use of professional judgement for some components of this assessment.

Acoustic sampling for bats is used to provide information on species presence in the area and to confirm activity at specific sites thought to be suitable for feeding, roosting or hibernation.

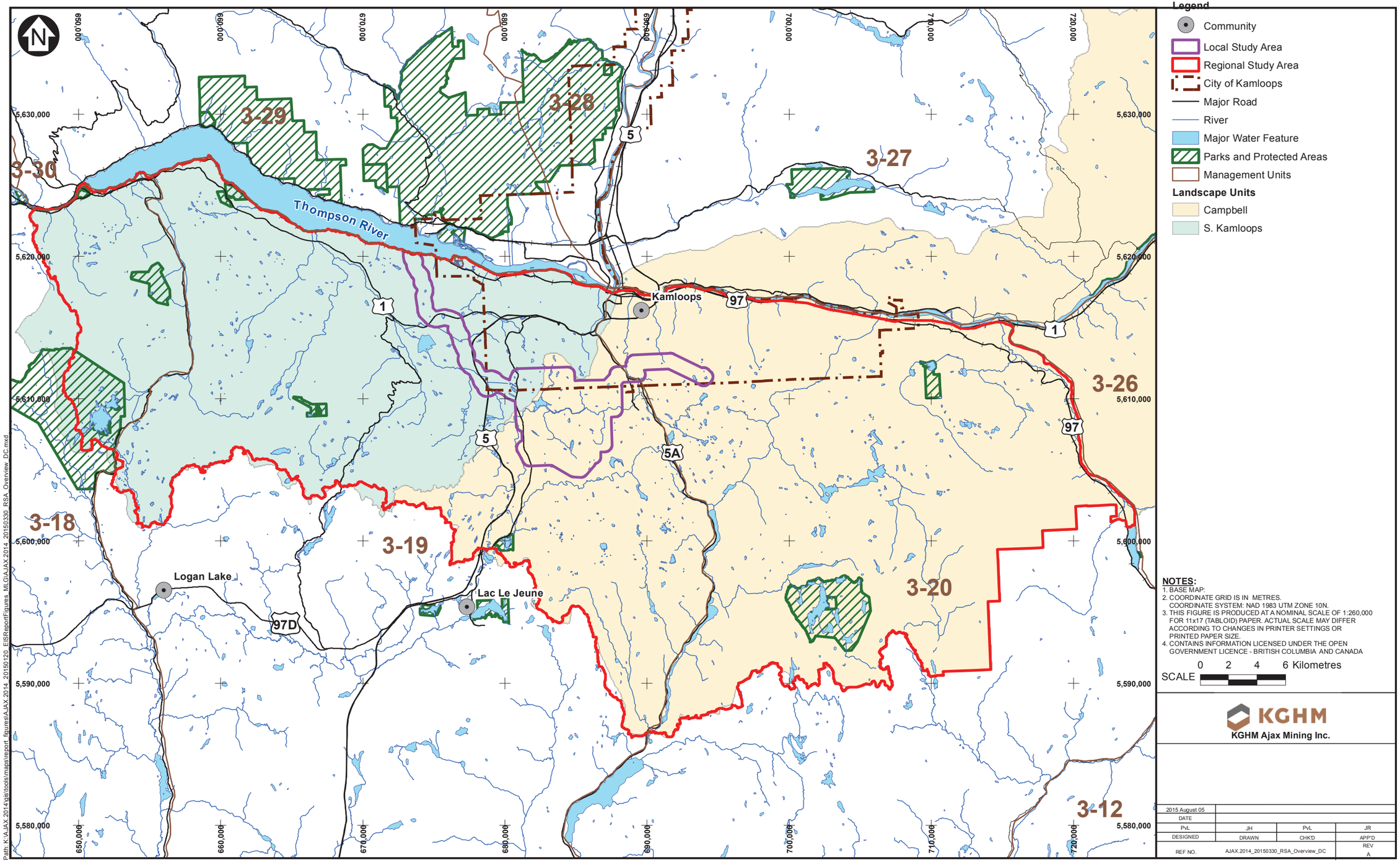
6.17.3 Background

6.17.3.1 Regulatory and Policy Framework

The Kamloops Land and Resources Management Plan (LRMP) (1995) outlines objectives of maintaining bat hibernacula and maintaining and enhancing critical deer and moose winter ranges by managing forests to ensure diversity, as well as to ensure critical habitat is managed appropriately through local level planning, and by conducting habitat improvement projects where appropriate. The LRMP identifies critical deer winter range in the Project area, while critical moose winter range is present in the RSA, but not in the LSA.

The Nicola Thompson Fraser Sustainable Forest Management Plan (SFMP) (2015) aims to conserve species diversity by ensuring that habitats for a particular species are maintained, including habitats for known occurrences of species at risk. Species of regional importance (e.g., mule deer) are to be managed to ensure that hunting opportunities are maintained and winter range is to be maintained or enhanced. The Nicola Thompson Fraser SFMP has set a target of 120 ha of spotted bat habitat and 35 ha of badger habitat to be conserved or managed within the Kamloops TSA (*ibid.*).

Figure 6.17-3
Regional Study Area



Legend

- Community
- Local Study Area
- Regional Study Area
- City of Kamloops
- Major Road
- River
- Major Water Feature
- Parks and Protected Areas
- Management Units

Landscape Units

- Campbell
- S. Kamloops

NOTES:

1. BASE MAP:
2. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD 1983 UTM ZONE 10N.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:260,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
4. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENCE - BRITISH COLUMBIA AND CANADA

SCALE 0 2 4 6 Kilometres

KGHM Ajax Mining Inc.

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Fringed myotis, spotted bat and American badger are all Identified Wildlife under the *Forest and Range Practices Act* (FRPA) (Government of British Columbia 2002). General wildlife measures for the bats includes: providing adequate representation of foraging and roosting habitat on the landscape, maintaining known roots sites, maintaining a variety of seral stages to ensure long-term provisions of foraging and roost requirements, minimizing disturbance during critical times (May 1 to August 31), maintaining riparian areas, and maintaining hibernacula (if discovered). General wildlife measures for badger include (but are not limited to): maintaining important habitat features such as grasslands in a range of seral stages, friable soils, and prey; control forest encroachment and in-growth; manage livestock grazing to maintain suitable habitat for prey species; and, minimize disturbance during the breeding season (May 1 to August 15).

All species are protected from being killed, collected, or held in captivity without a permit under the BC *Wildlife Act* (Government of British Columbia 1996). However, with an authorized general wildlife permit, badgers and other predators deemed to be a menace to domestic animals or birds may be killed by the property owner. The *Species at Risk Act* (Government of Canada 2002) requires a recovery strategy or management plan for species within a specific timeframe depending on the species status and schedule. A Provincial recovery plan is available for American badger while a provincial management plan is available for spotted bat (Table 6.17-3).

Table 6.17-3. Recovery Planning Documents for SARA-listed Mammals

English Name	SARA Schedule - Status[1]	BC	SARA
American Badger	1-E	RS- 2008	RS-2006 (proposed)
Fringed Myotis	3[2]	-	-
Little Brown Myotis	1-E	-	-
Spotted Bat	1-SC	MP - 2013	-

[1] *E = Endangered, SC = Special Concern*

[2] *Schedule 3 species are those which have been designated Special Concern by COSEWIC, but are not on the first legal list (Schedule 1) under the* Species at Risk Act. *These species are to be reassessed, with the appropriate listing to be determined.*

The BC conservation framework ranks the Townsend's Big-eared bat and the Spotted Bat as priority 2 under goal 2 (prevent species from becoming at risk). The badger (priority 1), pocket mouse (priority 2), fringed myotis (priority 3), western small-footed myotis (priority 3), little brown myotis (priority 5) are all prioritized under goal 3 (maintain the diversity of native species).

The Project lies within "Region 3 – Thompson" of the Hunting and Trapping Regulations Synopsis. Three Management Unit (MU) boundaries (3-18, 3-19, and 3-20; Figure 6.17-3) divide up the region (Ministry of Forests, Lands and Natural Resource Operations 2014).

6.17.3.2 Regional Overview

The presence of grassland and forested habitats has impacted the diversity and distribution of mammals throughout the RSA. Species, unique to grasslands such as American badger and Great Basin pocket mouse, occur in the region. Moose and mule deer, which require forested areas for shelter, forage, and reproducing/rearing opportunities, can be found throughout the area. These game species are also important traditional food sources for the Stk'emlupsemc te Secwepemc

Nation (SSN, Chapter 12). Bats rely on the scattered forest areas and rocky outcrops for shelter, as well as grasslands and open water for foraging. Little undisturbed old-growth remains in the RSA due to a history of logging, agriculture, forest fire and pine beetle. However, old snags can still be found throughout the study area, and are important features for bat roosting, particularly if in proximity to wetland areas, where bats often forage.

The hunting or trapping of ungulates, furbearers, and large carnivores takes place throughout the RSA (Ministry of Forests, Lands and Natural Resource Operations 2014).

Indicator Species

American Badgers are closely associated with open, dry grasslands with deep, friable soils that are suitable for excavating burrows (Rahme et al. 1995). They also use open, dry forests, such as those composed of Douglas-fir mixed with ponderosa pine (Stevens and Lofts 1988). Badgers have traditional Aboriginal significance for story, trade and food (Ignace 2014). Recent estimates of badger numbers in BC are between 228 and 340 individuals (*jeffersonii* Badger Recovery Team 2005; *jeffersonii* Badger Recovery Team 2006; *jeffersonii* Badger Recovery Team 2008). The Thompson badger population unit (366,537 ha) has an estimated 35 to 50 individuals (COSEWIC 2012; BC Conservation Data Centre 2014a). Badger populations in the Thompson region, as well as across the province, are believed to be in decline (Weir et al. 2003; *jeffersonii* Badger Recovery Team 2008).

Badgers have relatively large home ranges in the Thompson region (Hoodicoff 2003), with males averaging 32.7 km^2 and females averaging 15.6 km^2 (95% fixed kernel estimates; Weir et al. 2003). Badger movement is greater in the summer than winter (Hoodicoff 2003). Weir et al. (2003) found average movement rates in the Thompson region to be 964 m/day during the summer and 217 m/day during the winter. Badgers are relatively tolerant of humans and will use anthropogenically modified landscapes, provided there is sufficient prey (Hoodicoff 2003; Weir et al. 2003), however, roadsides present a high risk for mortality (BC Ministry of Water, Land and Air Protection 2004). Weir et al. (2003) found badgers were most commonly found in the PPxh2, IDFxh2, BGxh2, IDFdk1, and BGxw1 Biogeoclimatic (BGC) units. Four of these units (BGxh2, BGxw1, IDFxh2, and PPxh2) make up 100% of the LSA (Appendix 6.8-A). The same study found 24% of all recorded observations occurred in cultivated fields. Badgers have been recorded in the RSA and LSA (Weir et al. 2003), and incidentally in the RSA by the local community (Cummins 2014). Badgers have significance to local Aboriginal communities, being used for story and trade (SIB pers. comm., 2013, as cited in Chapter 12; Ignace 2014). In British Columbia, American badgers are ranked S1 (critically imperilled).

The Great Basin pocket mouse is a small rodent that occupies sagebrush or antelope brush grassland habitats in the BG and IDF BGC zones. The pocket mouse forages for seeds, buds and vegetation (Cannings et al. 1999), with Cheatgrass (*Bromus tectorum*), sagebrush (*Artemisia* spp.), and Indian ricegrass (*Oryzopsis hymenoides*) being particularly important forage species (Howard 1996). The BC population is threatened by conversion of native grasslands to agricultural fields and urban development. The last known record from the Thompson River valley was a museum specimen taken in 1949 near the northeast edge of the RSA (Nagorsen 2004). In British Columbia, Great Basin pocket mice are ranked S2 (imperilled).

Mule deer and white-tailed deer are found in a variety of habitats within the LSA, including forest, shrublands, riparian areas and the grassland-forest interface. Moose also use the forested areas throughout the RSA, and populations in the Thompson Okanagan region appear to be stable (BC Ministry of Forests, Lands and Natural Resource Operations 2014). White-tailed deer have traditionally been used for food and medicine by local Aboriginal groups; mule deer have a variety of traditional uses, including story, trade, food, medicine, clothing, and ceremonial purposes; and moose have been traditionally used for food, clothing, and ceremonies (Ignace 2014). All three species are important to Aboriginal Groups as a traditional food source (University of Northern British Columbia, et al. 2011; Ignace 2014) and are species of public interest. Traditional moose hunts occur in the vicinity of Goose Lake and Peterson Creek (SIB, SSN, pers. comm., 2014, as cited in Chapter 12). In British Columbia, white-tailed deer, mule deer, and moose are ranked S5 (demonstrably widespread, abundant, and secure). As the two deer species are very similar in habitat requirements, only mule deer was selected as an indicator species.

Few data are available on specific habitat requirements for fringed myotis. Maternal colonies have been located in agricultural areas, and bats have been captured near watercourses and in open grassland habitats (BC Ministry of Water, Land and Air Protection 2004; BC Conservation Data Centre 2014a). Roost and maternity sites have been found in rock crevices, caves, buildings, and mine shafts as well as under loose bark of ponderosa pine snags (BC Ministry of Water, Land and Air Protection 2004). Foraging habitat probably includes arid grasslands and dry ponderosa pine and Douglas-fir forests (Rasheed et al. 1995). Fringed bats have been observed just north (in the Lac du Bois Grasslands) and east of the RSA (BC Conservation Data Centre 2014a; Klinkenberg 2014). In British Columbia, fringed myotis are ranked S3 (special concern, vulnerable to extirpation or extinction).

Little brown myotis are known to occur throughout the province, including the Thompson region (Nagorsen and Brigham 1993; BC Conservation Data Centre 2014f). This species persists in a wide range of habitats, including arid habitats such as grassland and Ponderosa pine forests, humid coastal forests, and northern boreal forests (Nagorsen and Brigham 1993). The little brown myotis has the greatest altitudinal range of any bat species in BC, found from sea level to over 2,200 metres (*ibid.*). Summer roosts can be found in buildings and large diameter trees (Nagorsen and Brigham 1993; COSEWIC 2013). The winter months are spent hibernating in caves and mines (*ibid.*). Little brown myotis may migrate between 50 and 200 kilometres from hibernacula to summer roost, and may return to the same site annually if left undisturbed (Nagorsen and Brigham 1993). The diet of little brown myotis consists largely of aerial insects, with foraging usually taking place over water or along the shorelines of lakes and streams (BC Conservation Data Centre 2014f). The little brown was recently upgrade by COSEWIC to "Endangered" status based on the prevalence of white-nose syndrome in eastern Canada (COSEWIC 2013). Little brown myotis have been observed just north (in the Lac du Bois Grasslands) and east of the RSA (BC Conservation Data Centre 2014a; Klinkenberg 2014). In British Columbia, little brown myotis are ranked S4 (apparently secure).

In BC, spotted bats have been found in grasslands, shrub-steppe, and open Douglas-fir and ponderosa pine forests (COSEWIC 2004a). The species is distributed across the southern interior from Williams Lake south (BC Ministry of Environment 2008a), and has been previously recorded on the northeast edge of the RSA (BC Conservation Data Centre 2007; BC Conservation Data Centre 2014c; Klinkenberg 2014). Urbanization, disturbance at cliff roosts from rock climbing and roads,

and habitat loss from hydroelectric development have been listed as potential threats to the species (BC Ministry of Water, Land and Air Protection 2004). In British Columbia, spotted bats are ranked S3S4 (special concern, vulnerable to extirpation or extinction, or apparently secure).

Townsend's big-eared bat is found throughout much of the southern portion of the province, from William's Lake south (Nagorsen and Brigham 1993; Firman 2000; BC Ministry of Environment 2008b). Most records occur at low elevations (*ibid*.), and the species' distribution at the local level is correlated with the availability of caves or cave-like roosts (Cannings et al. 1999). The species is Blue-listed in the province (BC Conservation Data Centre 2014a). Townsend's big-eared bat is known to use a wide variety of habitats, from coastal forests to arid interior grasslands, and has been recorded in the region, outside of the RSA (BC Conservation Data Centre 2014b; Klinkenberg 2014). Summer roosting occurs in caves, old mines and buildings (Maser et al. 1981; Nagorsen and Brigham 1993). Disturbance of summer roosts can also decrease reproductive success (*ibid*.). When aroused by disturbances at winter hibernacula, bats may move to another area of the hibernaculum or leave to find a new (undisturbed) hibernaculum, which can be extremely draining on the stored energy reserves of a bat. In British Columbia, Townsend's big-eared bats are ranked S3 (special concern, vulnerable to extirpation or extinction).

The western small-footed myotis is found in the southern interior of BC south of Williams Lake with recorded observations just west of the RSA (BC Ministry of Environment 2008c; Klinkenberg 2014). Maternity roost sites are not well known in BC, but are believed to include rock crevices, vertical banks, talus, and rocky outcrops (Nagorsen and Brigham 1993). Those same habitats, as well as loose bark on large-diameter trees, are also thought to be used as day roosts. Determination of threats to the species is difficult due to the general lack of knowledge regarding its biology, but habitat loss due to urbanization and agriculture, and disturbance at roosts and hibernacula, are listed as potential threats (Cannings et al. 1999). In British Columbia, western small-footed myotis are ranked S2S3 (imperiled or special concern, vulnerable to extirpation or extinction).

Potential roosting and hibernating habitat for various bat species is present at the cliffs on Sugarloaf Hill, an area north of the Inks Lake interchange, immediately adjacent to the LSA (M. Sarell, pers. comm.).

6.17.3.3 Historical Activities

The region surrounding the Project has a long history of human activity that contributes to the current 'baseline' condition, which is defined more specifically in the following section of this assessment. Historical activities considered in the region include mining, milling, pipelines, rail lines, agriculture/ranching, forestry, urban sprawl, water treatment, recreation/tourism and hunting/ fishing. Only those activities expected to interact with mammals will be discussed here.

Mining, agriculture/ranching, forestry and urban sprawl have resulted in habitat loss for ungulates, badgers, pocket mice and bats. Deer and moose are also hunted in the region. Badgers may be exterminated from agricultural and urban areas where they interact with people. Badgers and ungulates also have an increased risk of mortality from roadways. Fur trading has taken place in the area since the early 1800s. The fur trading posts were located in various locations in what is now Kamloops.

The Trans-Canada Highway to the west of the Project area was completed in 1962, and the Yellowhead Highway in 1970. Since the 1950s, the City has been continually and much of the land that was formerly used for farming in the valley has been used for residential development. Ranching (including cattle grazing) also developed, and is currently ongoing immediately within and adjacent to the Project.

The Project is located within the Kamloops Forest District, which is part of the Kamloops Timber Supply Area (TSA). Tree-killing bark beetles (including mountain pine beetle, spruce beetle, and Douglas-fir beetle) continue to pose a threat to the forests. The Project is located in the Greenstone Beetle Management Unit, where more than 30% of the area is identified as susceptible to the mountain pine beetle. In response to the pine beetle, in 2008, the Annual Allowable Cut for the TSA was determined to be 4 million cubic metres; this harvest level (and priority for beetle management) will remain in place until 2018 unless otherwise altered.

Mining activity in the Project area can be traced back over 100 years with exploration in the Project area beginning in the 1880s and continuing intermittently to present. Copper, gold, and iron mineralization was discovered at the Iron Mask Mine near Kamloops in 1896. Nearby properties including the Wheal Tamar, Ajax, and Monte Carlo claims, were explored in the following years.

The Afton Mine went into operation in 1977. Mining operations were initiated on the Ajax East and Ajax West pits in 1989 and subsequently suspended in 1991 due to depressed metal prices. A second period of production began in 1994 and was again suspended in 1997. The raw ore from the Ajax pits was trucked approximately 10 km west to the processing plant adjacent to the Afton pit. During these periods of production, it is estimated that 17 Mt of ore was mined and 13 Mt of ore was milled. In the late 1990s, the tailings facility and project components were decommissioned and reclaimed by the Afton Mine in accordance with their closure plan. At the Ajax site, this includes reclaimed mine rock dumps adjacent to Peterson Creek in the location of the proposed Ore Stockpiles.

The New Afton Mine occupies the site of the historic Afton Mine infrastructure. New Afton began underground mining immediately beneath the historic Afton Mine open pit in June 2012. This mine is able to produce up to 11,000 tonnes per day of raw ore though the processing plant. Currently the mine is licenced to draws up to approximately 7,000 m^3/d from Kamloops Lake for water supply to the processing plant. An application to withdraw an additional approximately 5,000 m^3/d is currently in review.

6.17.3.4 Baseline Studies

Baseline studies were conducted for mammals from 2007 to 2014. Surveys were conducted as described in the Application Information Requirements/Environmental Impact Statement Guidelines (AIR/EIS-G) (BC Environmental Assessment Office 2015) according to Resource Inventory Standards Committee (RISC) standards. A detailed account of these surveys is available in Appendix 6.8-A.

Surveys for badger dens, small mammals, and bats were undertaken in and around the LSA to: a) establish presence of target species and key habitat features within the LSA, b) collect data on the location and timing of use of the LSA by target species, c) confirm habitat ratings used to develop

wildlife habitat suitability models, and d) provide information to KAM to use during the Project design phase to avoid or minimize impacts to target species.

Habitat mapping based on species models was completed for American badger and Great Basin pocket mouse. Habitat associations were used to identify areas of potential bat roosting habitat. Ungulate winter range (UWR) areas were reviewed to identify critical habitat for moose and deer in the LSA and RSA.

Data Sources

General information on species status and distribution was drawn from on-line sources such as the BC Ministry of Environment's Species Explorer and NatureServe (BC Conservation Data Centre 2014a; NatureServe 2014). Occurrence records of mammals in the region were obtained from the BC Conservation Data Centre (BC Conservation Data Centre 2014d) and from the provincial Species Inventory Database (BC Ministry of Environment 2014b). Additional information on indicator species included the following reports:

- Badger (Newhouse and Davis 2002);
- Status of the Badger in British Columbia (Rahme et al. 1995);
- Badger studies in the Thompson region (Hoodicoff 2003; Weir et al. 2003);
- Badger recovery strategies were also reviewed (Badger Recovery Team 2005; Badger Recovery Team 2006; Badger Recovery Team 2008);
- COSEWIC assessment and status report on the American Badger (*Taxidea taxus*) in Canada (COSEWIC 2012);
- Status of the Great Basin Pocket Mouse (*Perognathus parvus*) in British Columbia (Nagorsen 2004);
- Mule and Black-tailed Deer in British Columbia: Ecology, Conservation and Management (Blood 2000b);
- Feeding habits of mule deer on fall, winter and spring ranges near Kamloops, British Columbia (Willms et al. 1976);
- Moose in British Columbia: Ecology, Conservation and Management (Blood 2000a);
- Status of the Western Small-footed Myotis in British Columbia (Garcia et al. 1995b);
- Status of the Fringed Myotis in British Columbia (Rasheed et al. 1995);
- COSEWIC Assessment and Update Status Report on the fringed bat *Myotis thysanodes* in Canada (COSEWIC 2004b);
- Townsend's Big-eared Bat (Blood 1998);
- Status of the Spotted Bat in British Columbia (Garcia et al. 1995a);
- COSEWIC Assessment and Status Report on the Spotted Bat (*Euderma maculatum*) in Canada (COSEWIC 2004a); and

- COSEWIC Assessment and Status Report on the Little Brown Myotis (*Myotis lucifugus*), Northern Myotis (*Myotis septentrionalis*), and Tri-colored Bat (*Perimyotis subflavus*) in Canada (COSEWIC 2013).

Information regarding Aboriginal harvest of moose and deer in the LSA was taken from Chapter 12, *Background and Aboriginal Group Settings*. The SSN, Nlaka'pamux Nation, and Métis Nation of British Columbia (MNBC) are all known to hunt ungulates. Additional traditional Aboriginal use of various mammal species was taken from the report *SSN Cultural Heritage Study - Final Report* (Ignace 2014). Species such as moose, deer, and badger have various uses, including food, trade, story, clothing, or ceremonial purposes (*ibid*.).

Methods

Habitat Mapping

Habitat suitability mapping based on the TEM was completed for American Badger and Great Basin pocket mouse (Appendix 6.8-A). Habitat suitability for American badger and Great Basin pocket mouse was modeled for living habitat, based on the ability for the LSA to meet various life requisites (e.g., feeding, security/thermal cover), in all seasons. Highly suitable American badger habitat was defined as native grasslands, structural stage 2 or 3, with friable soils, in proximity to a wetland or waterbody. As the Great Basin pocket mouse has not been recorded in the Kamloops area, highly suitable habitat for this species was determined to be absent from the LSA; a maximum rating of moderate was given to fescue/bunchgrass grasslands, structural stage 2 or 3, in the BG and PP BGC zones.

Habitat Associations

Standard suitability mapping was not done for the bat species. Habitat associations and regional habitat attributes are defined as mature and old (structural stage 6/7) forests were used to identify potential roosting habitat. These forest types were selected based on their potential to have the suitable habitat features (large snags with loose bark) roosting bats require. Maternal bat roosts can be located in caves, rock crevices or trees. Bats often use old-growth conifer forests or large diameter riparian deciduous stands that are typically adjacent to natural openings or wetlands for forage opportunities. Hibernacula are mainly located in caves.

American Badger Field Surveys

Incidental observations of badger digs were noted during field surveys targeting other taxa occurring prior to 2010. In 2011, a selection of these badger dig sites was visited by an experienced badger biologist, who evaluated the diggings and estimated their age (Appendix 6.8-A). Hair-snagging following the *Inventory Methods for Medium-sized Territorial Carnivores: Badger* (Resources Information Standards Committee 2007) and was conducted at badger digs in 2014 to collect data on the number and sex of badgers using the LSA, through DNA analysis. A total of 15 hair capture stations were set up around the LSA on July 24 and 25, 2014, and were collected on October 1, 2014.

Great Basin Pocket Mouse Field Surveys

Small mammal trapping was conducted for the Great Basin pocket mouse in August 2008 following the Inventory Methods for Small Mammals: Shrews, Voles, Mice & Rats (Resources Inventory Committee (RIC) 1998b). Sampling for small mammals occurred at the presence-not detected level and were conducted under provincial Wildlife Act permit KA08-44016. Six straight-line transects with 20 stations were conducted in potentially suitable habitat (dry grassland with fine-textured soils and big sage (*Artemisia tridentata*). These surveys were conducted before the Project footprints were changed to their current arrangement. As the surveys completed were conducted in areas most likely to support Great Basin pocket mouse (i.e., the highest rated mapped habitat), additional surveys in areas of lesser quality habitat were not deemed necessary. More detailed information on survey effort is available in Appendix 6.8-A.

Ungulate Winter Ranges

Ungulate winter ranges delineated by the Kamloops LRMP (Kamloops Interagency Management Committee 1995), and draft mule deer winter range (DWR) planning cells were obtained from the Province and spatially overlain with the LSA to determine the amount of overlap. Ungulate winter ranges are areas that meet specific winter habitat requirements (i.e., multi-storied Douglas-fir forests) for ungulate species (BC Ministry of Forests 1999). Strategies from the LRMP are to maintain at least 25% of forested area in thermal cover and to link thermal cover units together with suitable travel corridors, especially mature Douglas fir vets on ridges (Kamloops Interagency Management Committee 1995).

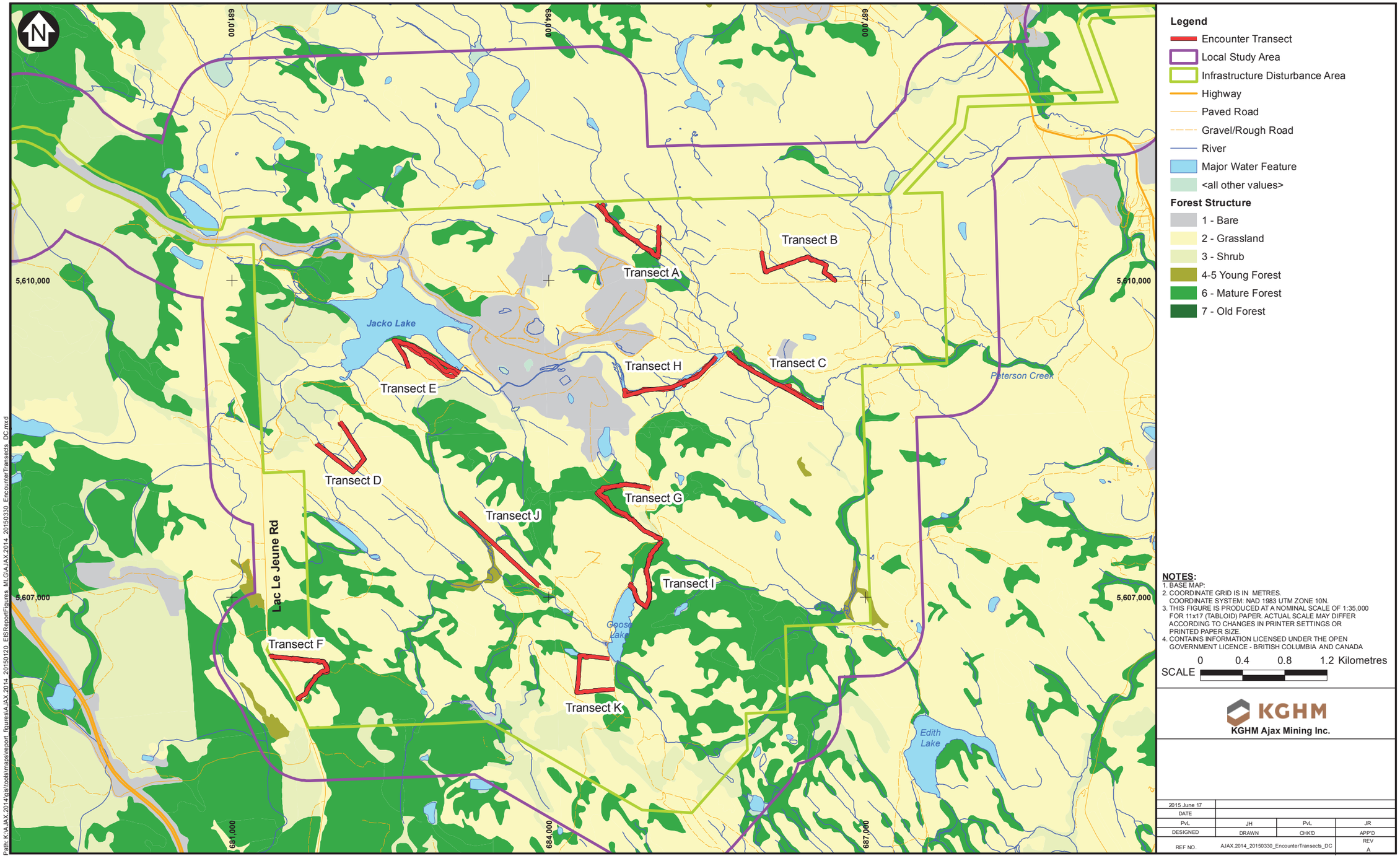
Encounter Transects Field Surveys

Encounter transects for wildlife were completed during the winter of 2014. Surveys were based on methods for pre-selected, line (transect) surveys described by Hatler (1991) and Rudran et al. (1996), and were intended to document any sign from terrestrial mammals. Each winter encounter transect was approximately one kilometre in length (Figure 6.17-4) and was representative of a general habitat types (e.g., grassland, dry forest, wetland) within the LSA. Eleven transects were laid out, with each transect surveyed by foot two times.

Bat Field Surveys

Acoustic detection surveys for bats were conducted in 2007, 2008, 2010 and 2014 using bat detectors (Mini-3 detector, Ultra Sound Advice; Petterson D230, Anabat and Songmeter SM2). Surveys were conducted according to the provincial *Inventory Methods for Bats* (Resources Inventory Committee (RIC) 1998a). Tuneable detectors (Mini-3, Petterson) cannot be used to distinguish between certain bat species that call at similar frequencies, but they can be used to establish presence/not detected of bat activity in a particular area. Bat survey stations were located in potential foraging or roosting areas (e.g., wetlands, lakes, cliffs, older forest; Figure 6.17-5). Remote detectors (Anabat and Songmeter) contain enough information that identification of the bat species or species group is often possible. The detectors were installed on trees, abandoned buildings or fence posts, between late April (when bats are coming out of winter torpor/migrating back to the region) and August (summer months are breeding/rearing season).

Figure 6.17-4
Encounter Transect Survey Location



NOTES:
1. BASE MAP:
2. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD 1983 UTM ZONE 10N.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:35,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
4. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENCE - BRITISH COLUMBIA AND CANADA

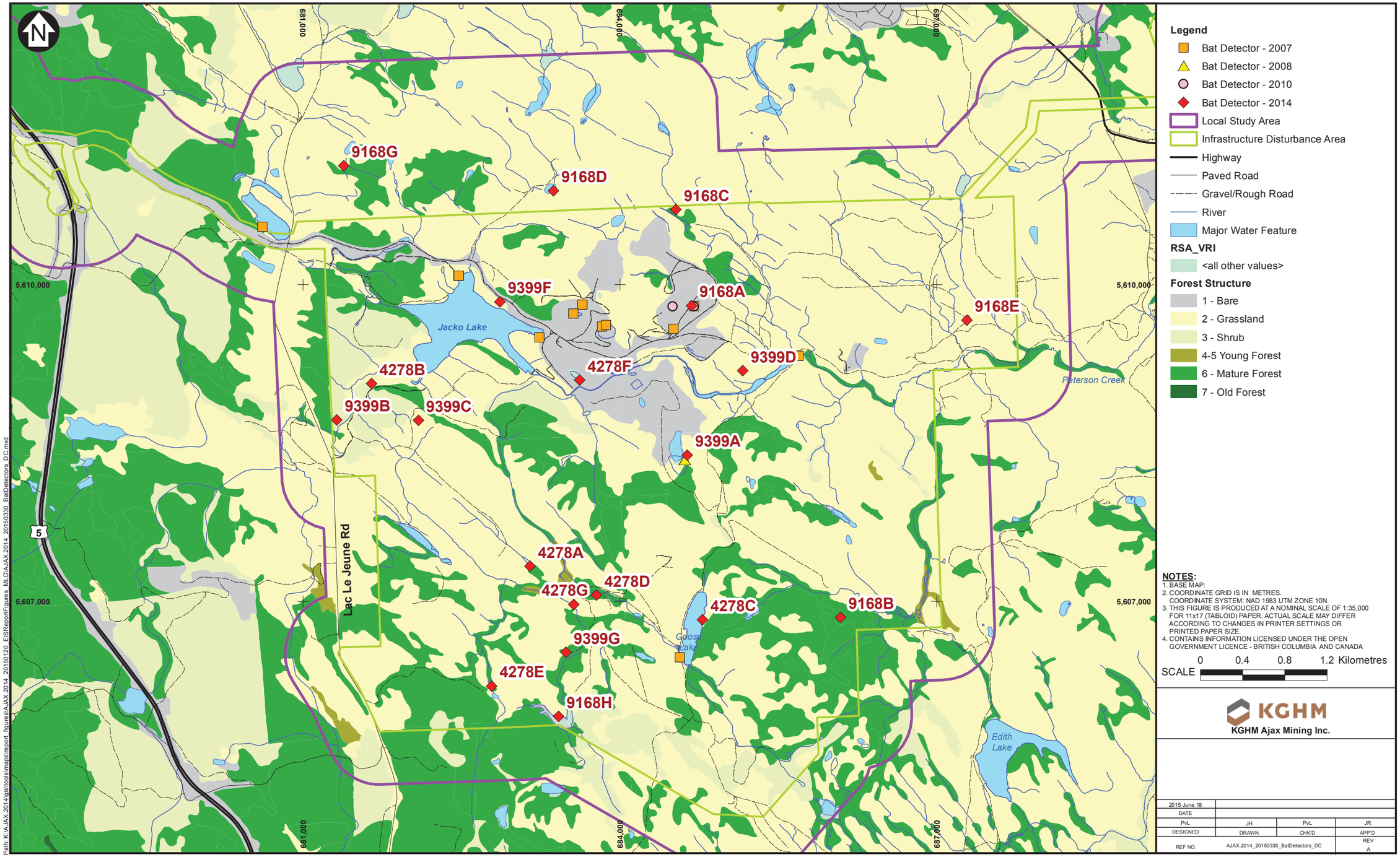
SCALE 0 0.4 0.8 1.2 Kilometres

KGHM Ajax Mining Inc.

2015 June 17			
DATE			
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Figure 6.17-5
Bat Detector Locations



Tuneable detectors were used in 2007 (48 locations, 4 hours survey effort), 2008 (2 locations, 10 minutes survey effort), and 2010 (4 locations, 20 minutes survey effort). Remote detectors were used in 2014 (22 locations, 353 sampling nights) at various locations throughout the LSA (Figure 6.17-5).

Mist netting is also recommended to assist in determining presence/not detected of different bat species. Areas of high bat activity are recommended for mist net setup to get the best results for this type of inventory method. Results from the acoustic detections were to be used to determine areas of high bat volume. These efforts, which are described in the next section, resulted in no observations of areas with high bat concentrations (e.g., hibernacula). As all listed bat species potentially occurring in the LSA can be differentiated by vocalization, and as no areas with high concentrations of bats were detected, mist netting was not deemed necessary for baseline data collection.

Water Quality

Baseline water quality was measured and modelled throughout the LSA (Surface Water Quality – Section 6.3). This included portions of Peterson Creek and Humphrey Creek as well as several other areas such as the seepage ponds and south catchment.

Characterization of Mammals Baseline Condition

Habitat Mapping

Over 4,229 ha of high and moderate-suitability American badger living habitat was mapped in the LSA (Table 6.17-4, Figure 6.17-6). High and moderate suitability mapped habitat were merged together to indicate overall Suitable habitat for American badger.

Table 6.17-4. Habitat Suitability within the LSA for American Badger and Great Basin Pocket Mouse in All Seasons

Species	Moderate Suitability (ha)	High Suitability (ha)	Total (ha)
American Badger	1,501.3	2,728.0	4,229.3
Great Basin Pocket Mouse	488.6	--	488.6

Over 488 ha of moderate-suitability Great Basin pocket mouse living habitat was mapped in the LSA. The majority of the suitable habitat is located around the northwestern end of the study area, near the New Gold New Afton mine site, and in the eastern section of the IDA, in the Bunchgrass (BG) Biogeoclimatic zone (Table 6.17-4, Figure 6.17-7).

American Badger

In total, 31 badger dig sites (some with multiple entrances) were located during field surveys conducted between 2008 and 2014 (Figure 6.17-6). Fourteen dig sites were located within the Project IF, five were located in the IDA, seven were located in the LSA, and five were located in the RSA (Figure 6.17-6). Eleven of the dig sites were noted as 'collapsed and unused' during 2014 surveys. Fifteen DNA hair capture stations were installed throughout the LSA in July 2014 (Figure 6.17-6). Six hairs were collected from three separate locations (all within the IDA) in October 2014. The hair

samples were sent to Wildlife Genetics International (Nelson, BC) for genetic analysis. Three hair samples were confirmed as badger, but insufficient material was present to obtain individual identification. Two badger observations were recorded by KAM staff in 2014 (Figure 6.17-6).

Great Basin Pocket Mouse

A total effort of 480-trapnights resulted in the capture of 77 small mammals, of which 76 were deer mice and one was a yellow-pine chipmunk (Figure 6.17-7). The Great Basin pocket mouse has not been recorded in the Thompson valley near Kamloops since 1949 (Nagorsen 2004).

Ungulates

The Kamloops LRMP identifies 859.6 ha of critical DWR within the LSA (Kamloops Interagency Management Committee 1995; Figure 6.17-8). In a more recent ungulate winter range designation the Ministry of Environment identified 896.3 ha of mule deer winter range in the LSA (Figure 6.17-8). These have been incorporated into draft winter range planning cells. No critical moose winter range (MWR) was identified in the LSA. Critical DWR from the LRMP in the RSA is 37,255 ha in size while 35,912 ha of MOE planning cells exist in the RSA.

Encounter Transects

Survey effort for the 11 transects conducted in 2014, totalled 21.6 km and 11 hours and 51 minutes. Sign from deer and coyote was observed on most transects (Table 6.17-5), with the highest density of deer pellets observed on Transect I. In April, groups of 11 to 15 deer were sighted on the open grasslands, which are the first to green up in the spring. Moose sign was limited to five pellet groups and one site with apparent moose browse recorded on three transects.

Table 6.17-5. Summary of Mammal Observations During Encounter Transect Surveys

Species	Location of Observation (Transects)	Observation Sign Type*	Number of Observations Recorded
Black Bear	F	EX	1
Coyote	A,B,C,D,E,F,G,H,I,J,K	CR,EX,TX	46
Moose	F,G,K	EX,FD	6
Porcupine	A	VI	1
Unclassified Deer	A,B,C,D,E,F,G,I,J,K	EX,TX	230
Unclassified Small Mammal	A,E,D,F,H,I	CR,TX	6
Unclassified Weasel	A,F,G,H,I	TX	11

** CR = Carcass; EX = Excrement; FD = Feeding; TX = Tracks; VI = Visual Observation of Individual*

Bats

At-risk bat species recorded on remote detectors in the LSA include fringed myotis, western small-footed myotis, and little brown myotis. Fringed myotis was detected foraging at Goose Lake (4278B) and southwest of Jacko lake (9399B and 9399C; Figure 6.17-5). Western small-footed myotis was recorded at four sites (4278A, 4278B, 4278C and 9168C) where it was likely foraging over wetlands, alkaline ponds or lakes (Figure 6.17-5). Little brown myotis was recorded at all sites surveyed.

Figure 6.17-6
Badger Habitat Suitability, Observations and Burrows

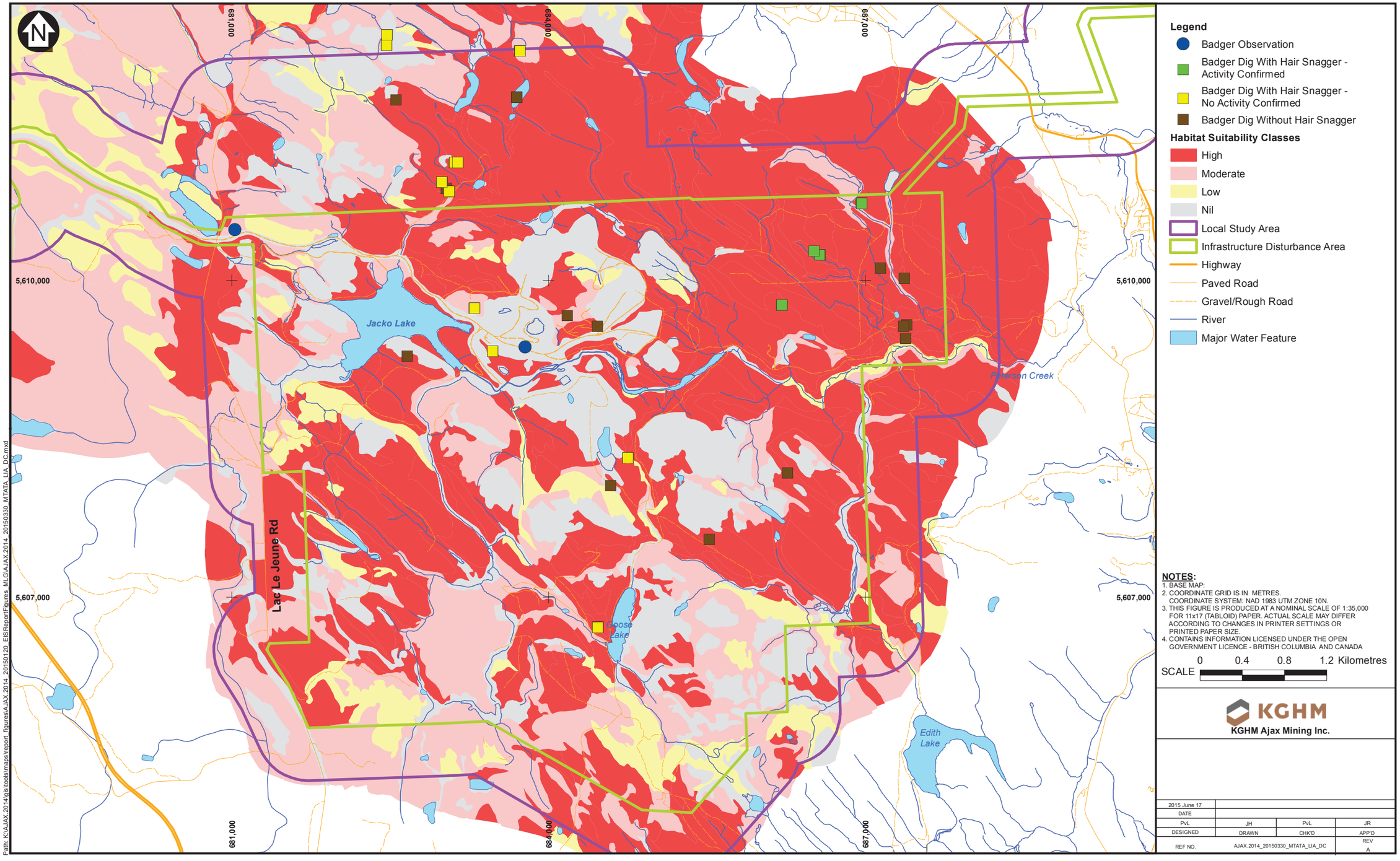


Figure 6.17-7
Pocket Mouse Habitat Suitability and Trap Locations

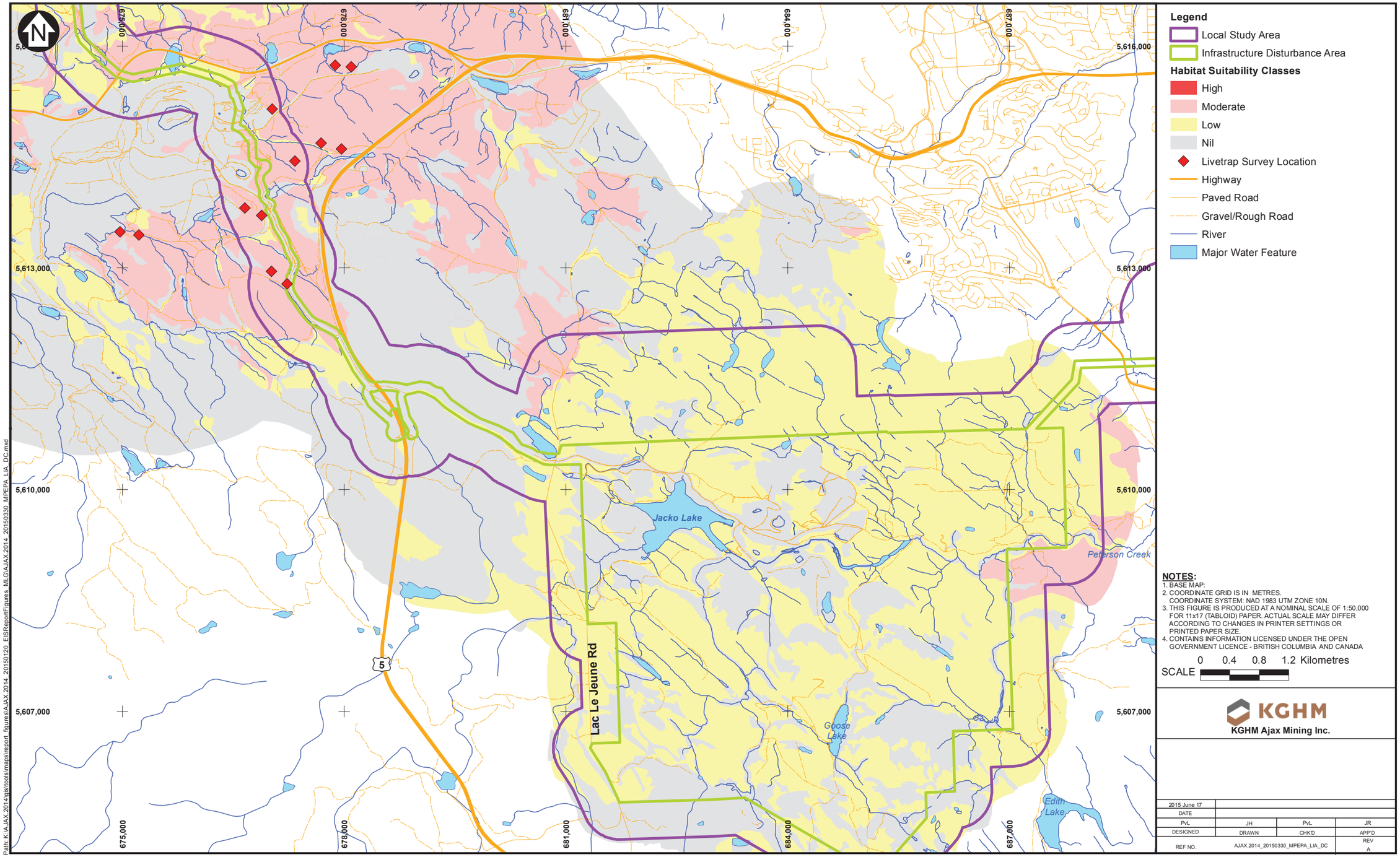
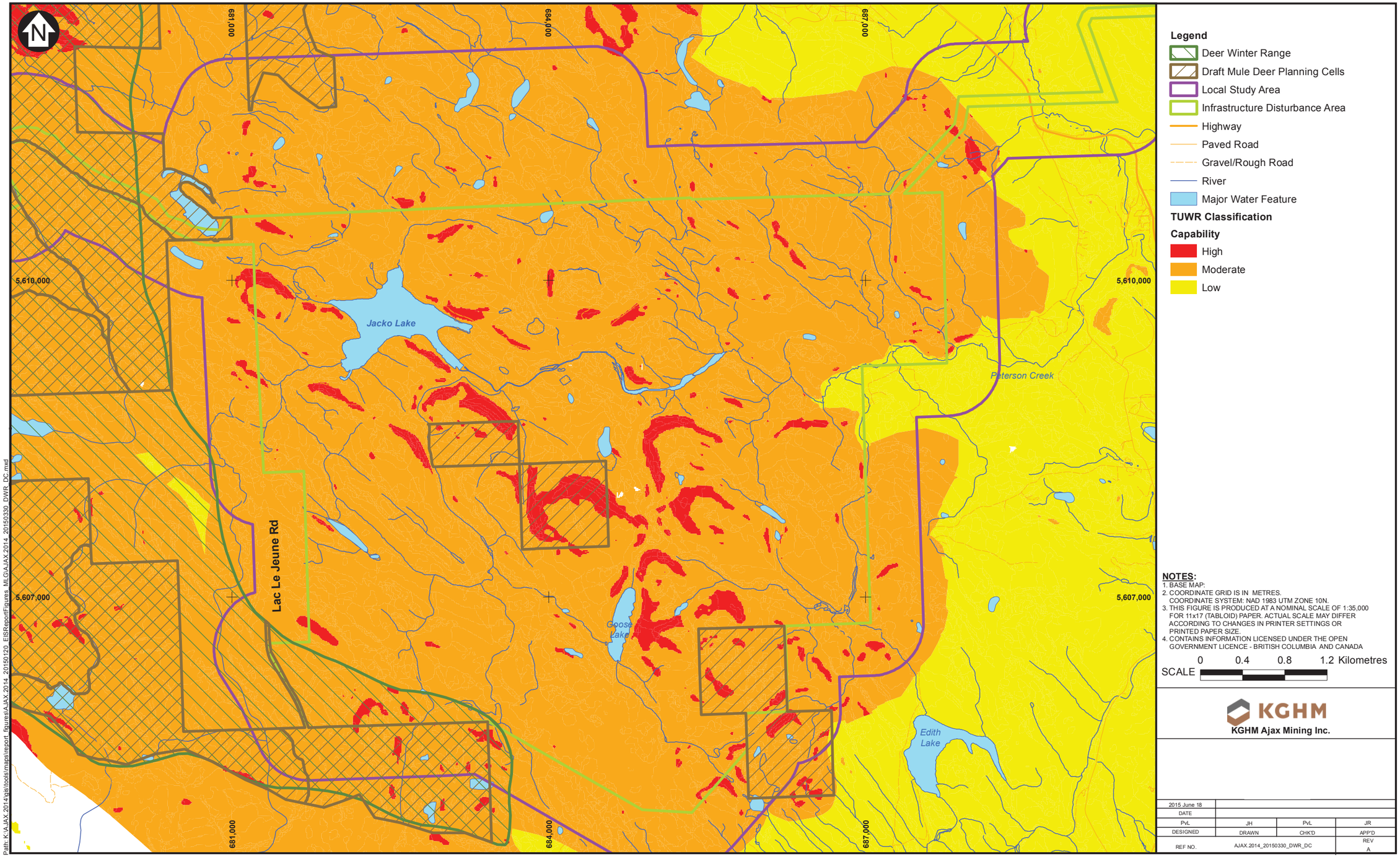


Figure 6.17-8
Deer Winter Ranges



Other bat species confirmed in the LSA are provincially Yellow-listed. These include the silver-haired bat (*Lasionycteris noctivagans*) and long-legged myotis (*Myotis volans*). The common and wide-spread big brown bat (*Eptesicus fuscus*) is likely also present but recordings cannot be reliably distinguished from those of the silver-haired bat. Townsend's big-eared bat and spotted bat were not detected during any baseline surveys.

All potential hibernacula located in the LSA were assessed to determine bat activity. Two potential hibernacula were surveyed in the LSA in 2008: an old mine adit in the east wall of the Ajax East Pit and a rock outcrop. Site-specific bat survey results include:

- Rock outcrop adjacent to a pond near the eastern edge of the Ajax South Mine Rockpile (9399A) - Confirmed roost site and potential hibernacula;
- Existing adit in the east wall of the Ajax East Pit (9168A) – no activity suggestive of roosting was observed;
- A roosting myotis was detected incidentally under a boulder on the slope between the haul road and Jacko Lake;
- Bat activity was detected at Goose Lake (one big brown bat (*Eptesicus fuscus*) or silver-haired bat (*Lasionycteris noctivagans*);
- Crescent-Afton pit - bat activity was detected over the pond; and
- Rescan (2006) reported detections of little brown myotis (*Myotis lucifugus*) near the Historic Afton tailings pond (Hughes Lake).

Incidental Observations

A number of other mammal species were incidentally observed in the study area. These species include, but are not limited to, black bear, coyote, porcupine, red fox, American beaver, and muskrat. Cougar sign was also recorded, as was the observation of one cougar by an Ajax employee. The cougar and cougar sign observations occurred outside of the LSA, near Sugarloaf Hill. A list of all mammalian species detected by observation and/or sign is available in Appendix 6.8-A.

Water Quality

Selenium and Molybdenum were predicted to exceed wildlife water quality guidelines in several sites throughout the LSA (Surface Water Quality - Section 6.3). This included downstream portions of Peterson Creek and Humphrey Creek.

Summary

Field surveys were able to: 1) confirm the presence of six of the nine indicator species within the LSA, 2) confirm the presence of suitable habitat for American badger, and 3) confirm the scarcity of suitable Great Basin pocket mouse habitat within the LSA.

The majority of the LSA contains low suitability pocket mouse habitat (8% of the LSA is considered suitable). The scarcity of suitable habitat in the LSA and the absence of pocket mouse detections within the region for the past 60 years (including these baseline surveys), suggest that this species is not present in the LSA. Based on this information the Great Basin pocket mouse is not expected to have an interaction with the Project.

Moose sign was detected occasionally during encounter transect surveys, as well as incidentally during surveys for other taxa, between 2007 and 2014, suggesting that moose pass through but do not reside in the LSA. As moose require water bodies for foraging and hard-wood conifer forest for winter cover (BC Conservation Data Centre 2014e), use of grasslands in and around the LSA is expected to be limited. Since suitable habitat within the LSA is limited to small patches of forested and riparian areas, moose are not expected to have an interaction with the Project.

The absence of historical observations in the vicinity of the Project combined with the lack of any detections during field surveys, suggest that the Project will not have an interaction with Townsend's big-eared bat and spotted bat. While effects are not anticipated for these two bat species, the potential of the Project to interact with other bat species will still be considered. Since all species in the area use similar structures for roosting and hibernating there will be some overlap in mitigation measures that will benefit Townsend's big-eared bat and spotted bat, should they reside within the LSA.

As a result of these findings, effects of the Project on moose, Great Basin pocket mouse, Townsend's big-eared bat, and spotted bat are not anticipated. The potential effects of the Project will be assessed for American badger, mule deer, fringed bat, western small-footed bat, and little brown myotis.

6.17.4 Potential Effects of the Project and Proposed Mitigation for Mammals

6.17.4.1 Identifying Potential Effects on Mammals

The AIR/EIS-G identified potential effects as habitat alteration and loss, disturbance and displacement and mortality. These effects were further subdivided into: habitat loss; habitat alteration; sensory disturbance; disruption of movement; direct mortality; indirect mortality; wildlife attractants; and chemical attractants. An interaction matrix (Table 6.17-6) is used to help scope potential effects by considering potential interactions with Project activities/components, consistent with the approach outlined in the assessment methodology (Section 5.2.4.1.). Further rationale for the scoping of potential effects is provided below. For those activities identified in Table 6.17-6 that do not include a ranking of "L", "M" or "H", but rather specific species have been identified (as per footnote on Table 6.17-6) and color coded, these interactions have been color coded to represent the potential degree of interaction. Yellow and red highlighted cells indicate "M" and "H" respectively.

<u>Habitat Loss</u>

For the purposes of this assessment habitat loss is defined as the process by which suitable habitat is rendered functionally unable to support the indicator species. Habitat loss will commence during the construction phase of the Project, specifically during vegetation clearing, land excavation, dams for water management and any other changes to the physical landscape. Permanent loss results from the replacement of habitat by Project infrastructure footprints (IF) and is considered the minimum effect. All habitat occurring within the Project IF is assumed to be lost. Habitat outside, but in close proximity to the Project IF, may not be permanently lost but is functionally compromised due to interactions with the Project IF. The IDA defines this area and is considered the maximum effect for habitat lost during Project Construction and Operation. Additional Project effects will not be considered for the Project IF where habitat has been permanently removed (i.e., a species cannot be displaced from habitat that has already been permanently lost).

Table 6.17-6. Identifying Potential Project Interactions and Effects on Mammals

Project Activities		Potential Effects on Mammals*							
		Habitat Loss	Habitat Alteration	Sensory Disturbance	Disruption of Movement	Direct Mortality	Indirect Mortality	Wildlife Attractants	Chemical Hazards
Construction	Clearing and Grubbing	H	O	O	A (frag)	A,B	O	O	O
	Earthworks	B	O	O	A (frag)	A,B	O	O	O
	Overburden/Topsoil Stockpile	O	O	O	O	O	O	O	O
	Laydown Areas and Storage Yards	O	O	O	O	O	O	B (materials may be confused for water body)	O
	Project Lighting	O	O	A B (light)	O	O	O	O	O
	Site Security and Fencing	O	O	O	D	O	O	O	O
	Fuel Storage and Filling Area	O	O	O	O	O	O	O	L
	Hazardous Wastes Transport, Storage, and Disposal	O	O	O	O	O	O	O	L
	Construction Wastes Transport, Storage, and Disposal	O	O	O	O	O	O	L	O
	Sewage Infrastructure and Disposal	O	O	O	O	O	O	O	L
	Public Road Realignment, Use, and Maintenance	O	A (invasive plant)	L	D	A D	D	O	L
	Site Road Construction, Use and Maintenance	O	A (invasive plant)	B(noise)	O	A D	O	O	O
	Haul Road Overpass Construction, Use, and Maintenance	O	O	O	O	O	O	O	O
	Site Buildings and Process Plant	O	O	O	O	O	O	O	O
	Explosives Magazine and Storage Facilities	O	O	O	O	O	O	O	O
	Open Pit Development	O	O	O	O	O	O	O	O
	Drilling and Blasting	O	L	B (noise) D (moderate - noise in UWR) A (vibration)	O	O	O	O	O
	Crushing Mine Rock	O	L	B (noise)	O	O	O	O	O

(continued)

Table 6.17-6. Identifying Potential Project Interactions and Effects on Mammals (continued)

Project Activities		Potential Effects on Mammals*							
		Habitat Loss	Habitat Alteration	Sensory Disturbance	Disruption of Movement	Direct Mortality	Indirect Mortality	Wildlife Attractants	Chemical Hazards
Construction (*cont'd*)	Loading, Hauling, and Deposition of Mine Rock	O	O	B (noise)	O	O	O	O	O
	Temporary Ore Stockpile	O	O	O	O	O	O	O	O
	Tailing Storage Facility Development	O	O	O	O	O	O	O	O
	Power Transmission, Distribution	O	A (invasive plant)	O	O	B	D	O	O
	Natural Gas Line	O	A (invasive plant)	O	O	O	D	O	O
	Pipeline Utility Corridor (Potable Water, Sewage, and Site Water)	O	A (invasive plant)	O	O	O	D	O	L
	Water Intake from Kamloops Lake	O	O	O	O	O	O	O	O
	Fire Suppression Infrastructure	O	O	O	O	O	O	O	L
	Contact Water	O	O	O	O	O	O	L	B (contaminated water)
	Non-contact Water	O	O	O	O	O	O	L	O
	Haul Road Overpass	O	O	O	O	O	O	O	O
	Water Management Dams	M	O	O	O	O	O	O	O
	Mine Staffing (Direct Employment)	O	O	O	O	D	O	A D	O
	Contracted Employment	O	O	O	O	D	O	A D	O
	Taxation	O	O	O	O	O	O	O	O
Operation	Open Pit Development	O	O	O	O	O	O	O	O
	Drilling and Blasting	O	L	B (noise) A (vibrat)	O	O	O	O	O
	Hauling Mine Rock and Ore from Pit	O	O	O	O	O	O	O	O
	Crushing and Conveying Ore	O	L	B (noise)	O	O	O	O	O
	Temporary Ore Stockpile	O	O	O	O	O	O	O	O
	Development of Mine Rock Management Facilities	O	O	O	O	O	O	O	O
	Stripping, Loading, Hauling, Deposition, and Contouring of Topsoil and Overburden	O	O	L	O	O	O	O	O

(continued)

Table 6.17-6. Identifying Potential Project Interactions and Effects on Mammals (continued)

Project Activities		Potential Effects on Mammals*							
		Habitat Loss	Habitat Alteration	Sensory Disturbance	Disruption of Movement	Direct Mortality	Indirect Mortality	Wildlife Attractants	Chemical Hazards
Operation (*cont'd*)	Revegetation through Progressive Reclamation	O	O	O	O	O	O	A D	O
	Process Plant Operation	O	O	L	O	O	O	O	O
	Deposition to Tailing Storage Facility	O	O	O	O	O	O	O	L
	Site Road Use and Maintenance (Materials, Personnel, Supplies)	O	A (invasive plant)	L	O	A D	O	O	L
	Concentrate Transport and Storage	O	O	O	O	L	O	O	L
	Explosives Magazine and Storage Facilities	O	O	O	O	O	O	O	O
	Fire Suppression Infrastructure	O	O	O	O	O	O	O	L
	Fuel Storage and Filling Area	O	O	O	O	O	O	O	L
	Hazardous Wastes Transport, Storage, and Disposal	O	O	O	O	O	O	O	L
	General Wastes Transport, Storage, and Disposal	O	O	O	O	O	O	L	O
	Sewage Infrastructure and Disposal	O	O	O	O	O	O	O	L
	Laydown Areas and Storage Yards	O	O	O	O	O	O	O	O
	Power Transmission, Distribution	O	A (invasive plant)	O	O	O	D	O	O
	Project Lighting	O	O	A B (light)	O	O	O	O	O
	Site Access, Security and Fencing	O	O	O	D	O	O	O	O
	Water Intake from Kamloops Lake	O	O	O	O	O	O	O	O
	Contact Water	O	O	O	O	O	O	L	B (contaminated water)
	Non-contact Water	O	O	O	O	O	O	L	O
	Potable Water Treatment and Use	O	O	O	O	O	O	L	O
	Haul Road Overpass	O	O	O	O	O	O	O	O
	Mine Staffing (Direct Employment)	O	O	O	O	D	O	A D	O
	Contracted Employment	O	O	O	O	D	O	A D	O
	Taxation	O	O	O	O	O	O	O	O

(continued)

Table 6.17-6. Identifying Potential Project Interactions and Effects on Mammals (continued)

Project Activities		Potential Effects on Mammals*							
		Habitat Loss	Habitat Alteration	Sensory Disturbance	Disruption of Movement	Direct Mortality	Indirect Mortality	Wildlife Attractants	Chemical Hazards
Decommissioning and Closure	Dismantling of Ancillary Buildings	O	O	B (noise)	O	O	O	O	O
	Pit Lake Planning	O	O	O	O	O	O	O	O
	Site Road Decommissioning	O	O	B (noise)	O	O	O	O	O
	Tailing Storage Facility Decommissioning and Reclamation	O	O	B (noise)	O	O	O	O	L
	Mine Rock Management Facilities Reclamation	O	O	B (noise)	O	O	O	O	O
	Fuel Storage and Filling Area	O	O	O	O	O	O	L	L
	Hazardous Wastes Transport, Storage, and Disposal	O	O	O	O	O	O	O	L
	General Wastes Transport, Storage, and Disposal	O	O	O	O	O	O	L	O
	Sewage Infrastructure and Disposal	O	O	O	O	O	O	O	L
	Laydown Areas and Storage Yards	O	O	O	O	O	O	O	O
	Power Transmission, Distribution	O	A (invasive plant)	O	O	O	D	O	O
	Project Lighting	O	O	A B (light)	O	O	O	O	O
	Site Access, Security and Fencing	O	O	O	D	O	O	O	O
	Contact Water	O	O	O	O	O	O	L	B (contaminated water)
	Non-contact Water	O	O	O	O	O	O	L	O
	Potable Water Treatment and Use	O	O	O	O	O	O	L	O
	Haul Road Overpass	O	O	O	O	O	O	O	O
	Road use to the Project (Materials, Personnel, Supplies)	O	O	B (noise)	O	A D	O	O	L
	Mine Staffing (Direct Employment)	O	O	O	O	D	O	A D	O
	Contracted Employment	O	O	O	O	D	O	A D	O
	Taxation	O	O	O	O	O	O	O	O

(continued)

Table 6.17-6. Identifying Potential Project Interactions and Effects on Mammals (completed)

Project Activities		Potential Effects on Mammals*							
		Habitat Loss	Habitat Alteration	Sensory Disturbance	Disruption of Movement	Direct Mortality	Indirect Mortality	Wildlife Attractants	Chemical Hazards
Post-Closure	General Site Inspections and Maintenance	O	O	O	O	O	O	O	O
	Contact Water	O	O	O	O	O	O	L	B (contaminated water)
	Non-contact Water	O	O	O	O	O	O	L	O
	Road use to the Project (Materials, Personnel, Supplies)	O	O	O	O	A D	O	O	L
	Mine Staffing (Direct Employment)	O	O	O	O	D	O	A D	O
	Contracted Employment	O	O	O	O	D	O	A D	O

Notes:

** A = American Badger; B = Bats; D = Mule Deer; "O," "L," "M," and "H" indicate interaction is anticipated for all Indicator Species.*

O	*No interaction anticipated.*
L	*Negligible to minor interaction expected; implementation of best practices, standard mitigation and management measures; no monitoring required, no further consideration warranted.*
M	*Potential moderate interaction requiring unique active management/monitoring/mitigation; warrants further consideration.*
H	*Key interaction; warrants further consideration.*

Although multiple Project activities will result in habitat loss, for the purpose of this assessment habitat loss will result from clearing and/or grubbing, earthworks and water management dams during construction. It is assumed that all Project IF will be cleared and/or grubbed prior to construction. Suitable habitat is present in the LSA for badger, mule deer and bat species and an interaction with the Project is anticipated. A ranking of "low" to "high" was assigned for Project activities (Table 6.17-6) that will remove grassland, forests, wetland, or rocky areas, and warrants further analysis as described in Section 6.17.4.2.

Habitat Alteration

Habitat alteration is defined as a reduction in habitat suitability. Activities that affect the physical characteristics or accessibility of an area, either permanently or temporarily can result in a change in habitat suitability.

Habitat alteration will occur throughout the construction and operation phases of the Project, specifically as a result of drilling, blasting, crushing and road use (fugitive dust deposition), soil compaction, linear feature use and maintenance (invasive species introduction, vegetation maintenance) and changes in drainage and water quantity. Invasive plant species may degrade grassland habitat for badger and decrease forage opportunities for deer. Included within the IDA is a minimum 50-metre buffer between the edge of the Project IF and the IDA. This buffer incorporates habitat alteration resulting from edge effects into the maximum habitat loss effect (Gieselman et al. 2013). As all suitable habitat within the Project IF will be permanently lost during initial Project construction activities (minimum effect), habitat alteration will be considered in the IDA and LSA. For the maximum habitat loss effect, habitat alteration will only be considered in the LSA.

Construction and operations Project activities that will lead to habitat alteration include dust generating activities (e.g., road realignment, use and maintenance, drilling and blasting, crushing mine rock) and activities that may promote the spread of invasive plant species (e.g., linear features such as power transmission, natural gas and pipeline corridor). Suitable habitat is present for badgers, deer and bats in the LSA and an interaction with the Project is anticipated. A ranking of "low" to "moderate" was assigned for Project activities (Table 6.17-6) that will potentially alter grassland, forests, wetland, or rocky areas, and warrants further analysis as described in Section 6.17.4.2.

Habitat fragmentation can be associated with corridors of unsuitable habitat (e.g., open roads) that may function as filters or barriers for some wildlife populations (Jalkotzy et al. 1997). The loss of vegetative cover can restrict road crossings to a few individuals (filter) or no individuals (barrier). The degree of loss of connectivity will vary with the width of the corridor, the frequency of vehicular traffic, the habitat on either side of the corridor and the species being considered. The resulting fragmentation and obstruction can limit the ability of species to disperse, breed and survive if it cannot access critical habitats or travel corridors. Project activities that can lead to habitat fragmentation will be considered under disruption of movement.

Sensory Disturbance

Sensory disturbance refers to a Project related activity (e.g., noise, light, human presence) that causes individuals to change their behaviour or avoid certain habitats that would otherwise be suitable. Disturbance can interrupt normal activity (e.g., foraging, courting, tending young) and cause an animal to move away from the source of disturbance, resulting in increased energy expenditures or utilization of sub-optimal habitats (Ward et al. 1999; Gill and Sutherland 2000; Gibeau et al. 2002; Bautista et al. 2004; Blanc et al. 2006). Disturbance during critical periods (e.g., birthing season or hibernation) may be lethal to some species. For some VCs, noise can mask the sounds that individuals use to find prey, mates, and avoid predators (Barber et al. 2010). Masking can reduce fitness (breeding success), especially for species that are highly reliant on their acoustic environment. In some cases, habituation and adaptation can allow wildlife to accommodate the presence of noise in their environment. Some species, including, but not limited to, coyotes and deer, will tolerate a considerable amount of human presence, providing there is no perceived risk (Price et al. 2014; Environmental Advisory Council 2001).

Roads are often cited as having the greatest effects of disturbance on wildlife (Jalkotzy et al. 1997). Repeated disturbances from traffic may cause some species to avoid the area around active roads, resulting in a net decrease in available habitat, as well as changes in daily and seasonal movement patterns.

Project activities expected to cause noise-sensory disturbance to mammals during construction include public and site road construction, use and maintenance; drilling and blasting; crushing mine rock; loading hauling and deposition of mine rock. During operation drilling and blasting; crushing and conveying ore; stripping, loading, hauling, deposition, and contouring of topsoil and overburden; process plant operation; and site road use and maintenance will cause noise-sensory disturbance to mammals. The source, duration, and intensity of noise will influence how an animal will respond, whether it is disturbed, displaced, or becomes habituated. Badgers, bats and deer are all known to be disturbed by noise and an interaction is anticipated. A ranking of “low” to “high” was assigned for Project activities causing noise disturbance (Table 6.17-6) and further analysis is included in Section 6.17.4.2.

Potential effects of artificial lighting at night include increased predation risk, and disruption of circadian rhythms governing behaviours such as foraging, hibernation and reproduction, although there are few studies actually measuring the effects of artificial light on mammals outside of laboratory conditions. Beier (2006) reviewed a number of studies indicating that many nocturnal mammals decrease activity and time spent foraging in open areas during nights with increased moonlight. Animals in areas where artificial lighting is constant do not have the option of concentrating their activities during darker periods, and must either suffer increased risk of predation or abandon the habitat.

Project activities expected to cause light-sensory disturbance to nocturnal indicator species (i.e, badgers and bats) include Project lighting during Construction, Operation, and Decommissioning and Closure phases. A ranking of “low” was assigned for this Project activity (Table 6.17 6).

Disruption of Movement

A wildlife movement corridor is a linear habitat that connects two significant habitat areas (Beier and Loe 1992). Disruption of movement refers to Project related activities that may cause an interruption to animal movements or migration, or may cause complete avoidance of certain habitats that would otherwise be suitable. Wildlife movement may be affected directly as a result of Project related activities, such as excavation of the mine (movement barrier), road construction (corridors) and site security and fencing.

Public road use and site fencing during Construction, Operation, and Decommissioning and Closure phases of the Project may dissuade mammals from moving between areas of suitable habitat. Habitat fragmentation resulting from habitat loss during construction can also prevent mammals from moving through their home range. A ranking of "low" to "moderate" was assigned for disruption of movement and further discussion is included in Section 6.17.4.2.

Direct Mortality

Direct mortality is defined as the death of an individual resulting directly from a Project related activity. Direct mortality can result from any number of project activities, but are typically associated with vehicle/machinery use on roads, removal of a habitat feature while they are occupied, and interactions with anthropogenic structures (e.g., flying into transmission lines or windows in buildings).

Project activities expected to cause mortality include clearing/grubbing; earthworks; public and site road use; power transmission; natural gas line; mining staff; and contracted employment during Construction, Operation, and Decommissioning and Closure. A ranking of "low" to "high" was assigned for direct mortality and further discussion is included in Section 6.17.4.2.

Indirect Mortality

Indirect mortality is defined as the death of an individual resulting indirectly from a Project related activity. Wildlife mortality may be caused indirectly from increased access for hunting or poaching, from range shifts leading to increased resource competition between individuals, or from increased hunting pressure by natural predators.

Project activities expected to cause indirect mortality include public road use; and linear features (power transmission, natural gas line, pipeline utility corridor) during Construction, Operation, and Decommissioning and Closure. A ranking of "low" was assigned for indirect mortality and further discussion is included in Section 6.17.4.2

Wildlife Attractants

Wildlife attractants are defined as features or materials that may attract wildlife away from their natural environments, to areas that are superficially superior. Odours, food waste, sewage, garbage, and stored chemicals from construction crews and camps are examples of attractants that may entice individuals, but that ultimately will have a detrimental effect on the species. Regenerating vegetation on road sides and road salt used in winter may attract some mammals to roads resulting in an increased risk of vehicular mortality.

Project activities which may result in a wildlife attractant include laydown areas and storage yards; construction waste transport, storage and disposal; contact and non-contact water; mine staff and contracted employment; potable treatment and use; and fuel storage and filing area during Construction, Operation, and Decommissioning and Closure. A ranking of "low" was assigned for wildlife attractants and no further discussion is included in Section 6.17.4.2

The LSA is not expected to harbour a high density of the wildlife species that are most likely to become pests (e.g., black bears, raccoons). However, coyotes, red foxes, and even deer can cause problems if they become habituated to people and associate human presence with food. Animals that lose their fear of humans can cause property damage and injuries to people. Animals that are fed by people or that become used to feeding on garbage may become aggressive or raid storage areas. Problem animals are often subject to control actions and end up being killed.

Chemical Hazards

Chemical hazards are defined as chemicals that result from Project related activities that have the potential to cause an adverse health effect on wildlife. Wildlife may ingest, inhale, or absorb chemicals (e.g., metals, dust, organic anthropogenic substances, etc.) from improperly stored substances, dust on soil or vegetation, or bioaccumulation from prey.

Lead accumulation generally increases in proportion to the amount of lead in the environment and the duration of exposure (animal age), however, environmental characteristics of temperature, pH and salinity conditions also influence the rate of uptake of lead by aquatic organisms (World Health Organization 1989). Lead concentrates in bottom sediments, with only a minor fraction present dissolved in the water column (World Health Organization 1989).

Roberts et al. (1978) documented increased lead levels in tissues of small mammals captured on metalliferous mine spoils as compared to those trapped on control areas, and suggested that clinical symptoms of lead intoxication could occur in small mammals from specific tailings sites. Tolerance to lead ingestion varies widely between species and is dependent on the form of lead involved (i.e., metallic lead, tetravalent organic lead, lead salts).

Evaluation of potential toxic effects of metals on wildlife and ecosystems is hampered by a wide array of environmental factors operating both independently and synergistically, which are known to affect toxicity and bioaccumulation. Metals bioavailability varies greatly with environmental factors such as temperature, pH, water velocity, season, and salinity. The potential effects of metal contamination may be complicated due to interactions between different metals. Small mammals feeding on invertebrates (i.e., shrews) ingest more metals than do small mammals feeding on vegetation (i.e., voles; Hunter et al. 1987).

The fuel storage and filling area has the potential to result in a chemical hazard to mammals. Hazardous waste transport and sewage infrastructure, as well as oil, fuel, other petroleum-based fluids and antifreeze from machinery can cause direct mortality and habitat contamination if they are allowed to escape into the environment. Petroleum compounds can affect organisms physically (smothering, reduced light), via habitat modification (alterations in pH or diminished food availability) or via toxic action (Albers 2003). As a chemical hazard from any of these activities would

have to be the result of an accident or malfunction, the expected interaction of these activities on mammals was given a ranking of "low" and no further discussion in Section 6.17.4.2 will be included.

Contact water, which is any water that may have come in contact with potentially toxic materials, may have a negative effect on mammals. Heavy metals such as copper, cadmium, lead, chromium and mercury are known to be persistent and mobile in the environment, and to be potentially toxic to many forms of life. Potential sources of metal contamination within the LSA include terrestrial (e.g., Mine Rock Storage Facilities) and aquatic (e.g., Tailings Storage Facilities (TSF), water management ponds) components. The water quality in the pit depends on the interaction of the water with the rock in the pit walls, and with the pH of the water. Contact water interactions have been assigned a ranking of "M" and will be discussed further in Section 6.17.4.2.

6.17.4.2 Effects on Mammals

For effects ranked as "L" no further consideration of this interaction is warranted. For effects ranked "M" or "H" in Section 6.17.4.1 (Table 6.17-6), further analysis was undertaken, and is described below to quantify the potential effects of Project activities on mammals.

Habitat Loss

Methods to Predict Impacts of Project Activities on Mammals

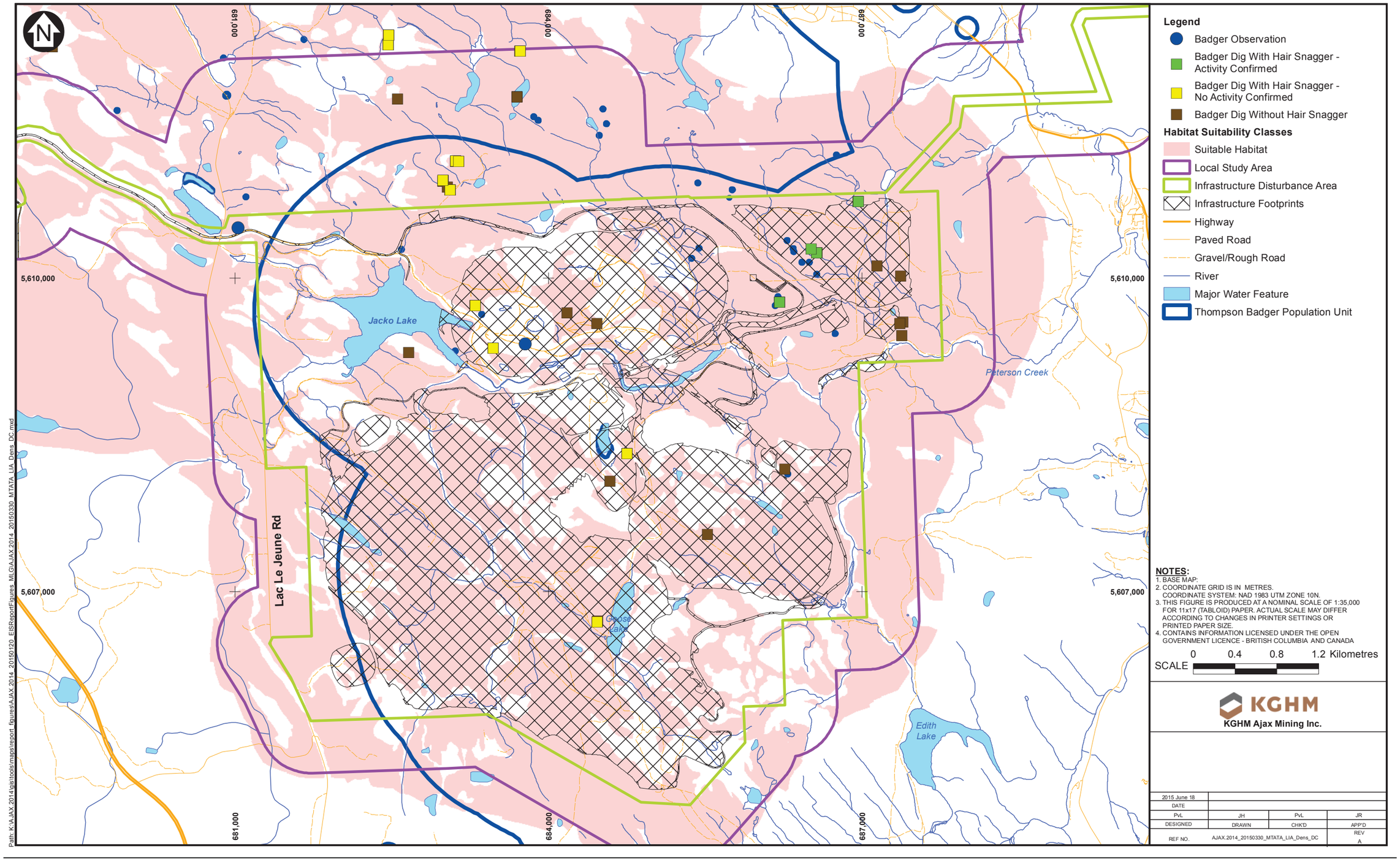
The amount of suitable habitat lost for mammals was calculated by determining the maximum and minimum potential effects. The maximum effect was calculated by overlaying the IDA footprint on the badger habitat suitability mapping, badger population unit, ungulate winter ranges, and bat roosting habitat associations (vegetation mapping), while the minimum effect was determined by overlying the Project IF. Potential roosting habitat for bats was defined as mature and old (structural stages 6 and 7) forest since old forests are more likely to have microhabitat (loose bark, snags) features used for roosting. The potential exists for an adverse effect on an indicator species if high or moderately suitability (Suitable) habitat is present within the IDA or IF. The amount of Suitable habitat lost within the IDA or IF was compared to the total amount of Suitable habitat within the LSA to calculate the percent of suitable habitat lost within the LSA.

Loss of habitat features was also considered. All badger dig sites and bat roosting sites were considered in relation to Project assessment boundaries. Hibernation and roosting sites are limiting features for bats on the landscape (COSEWIC 2004a; COSEWIC 2013; US Fish and Wildlife Service (USFWS) 2007; Dixon 2010; Salata 2012). Habitat features (rock outcrops) that provide potential hibernating and roosting sites were assessed in the field.

Predicted Impacts of Project Activities on Mammals

Habitat loss is expected to have the greatest impact on badgers, with up to 49% of suitable habitat in the LSA being affected by the Project (Table 6.17-7, Figure 6.17-9). A similar proportion (up t56%) of the Thompson Badger Population Unit within the LSA will also be lost. The majority (up to 73%) of known badger digs sites identified in the LSA will also be removed. Simulation models developed by Jager et al. (2006) determined that the number of habitat-related deaths increased with habitat loss, while age-related and orphan mortality decreased. Based on the proportion of habitat lost and the confirmation of badger activity in the LSA, the potential effect of habitat loss on badgers is anticipated to be moderate.

Figure 6.17-9
Badger Habitat Loss (Dens and Suitable Habitat)



Deer winter range occurs within the LSA, and up to 18% of critical DWR (as identified by the Kamloops LRMP) that is located within the LSA may be affected by the Project. Draft mule deer winter range planning cells identified by the Ministry of Environment are also present in the LSA, with up to 26% affected by the Project. (Table 6.17-7, Figure 6.17-10). There is a significant amount of overlap (~60%) between the critical DWR (LRMP) and the Draft DWR (MOE), meaning habitat loss is not cumulative. Deer winter range management prescriptions are to maintain 25% as forested cover so the impact may be less. The project LSA overlaps with ~2% of the mapped DWR in the RSA (both LRMP and MOE), and the Project will affect less than 1% of DWR throughout the RSA (Table 6.17-7). The potential effect of habitat loss on deer is anticipated to be low.

Table 6.17-7. Summary of Habitat Loss by Indicator Species

	Suitable Habitat and Habitat Features Available					
Species and Life Requisite	RSA (ha)	LSA (ha)	Max Area Lost - IDA (ha)	Min Area Lost - IF (ha)	% Range of Loss (LSA)	% Range of Loss (RSA)
American Badger (TEM modeled habitat)	N/A	4,229.3	2,070.7	1,163.2	28 – 49%	N/A
American Badger (Thompson Badger Population Unit)	56,585	5,347.4	2,922.9	1,656.8	31 – 56%	3 – 5%
Badger Dig sites	N/A	26	19	14	54 – 73%	N/A
Critical DWR (LRMP)	37,255	859.6	154.4	32.8	4 – 18%	< 1%
Draft DWR (MoE)	35,912	896.3	234.4	90.7	10 – 26%	< 1%
Bats (TEM – mature and old forest)	N/A	254.7	89.3	37.1	15 - 35%	N/A
Bats (VRI – mature and old forest)	78,474	1,394	592	309	22 – 42%	< 1%

Hibernacula are typically found in crevices, caves, or historical mines. One confirmed roost and one potential roost occur in the Project IF. Roosting habitat in mature and old forests occurs in the LSA and up to 26% of this habitat may be affected by the Project (Table 6.17-7, Figure 6.17-11). Bat activity was confirmed throughout the LSA with at-risk species detected in the Project IF. The potential effect of habitat loss on bats is anticipated to be moderate. No hibernacula were located in the LSA, but Sugarloaf Hill was identified as an area that may have suitable bat roosting and hibernating habitat.

Habitat Alteration

Methods to Predict Impacts of Project Activities on Mammals

Linear features (roads, pipelines, transmission lines) were buffered by 100 metres to determine the area where habitat alteration effects resulting from invasive plant species could occur. The 100 m buffer was determined based on literature review and the prominence of grassland habitat (Tyser and Worley 1992; Hansen and Clevenger 2005). This buffer was overlaid on badger habitat suitability mapping for the indicator species to determine the amount of suitable habitat affected. Habitat alteration cannot occur in areas where habitat has been lost, including the IF (minimum habitat loss effect) and the IDA (maximum habitat loss effect). The amount of suitable habitat altered is reported excluding the IF and the IDA.

The maximum dust fall (see Air Quality - Section 10.1) is not expected to exceed 1.12 mg/dm^3/day, which is well below the MOE Ambient Air Quality Objectives lower range (applying to sensitive environmental situations) of 1.7 mg/dm^3/day (British Columbia Ministry of Environment 2014). As such, habitat alteration resulting from dust fall is not expected to occur.

Predicted Impacts of Project Activities on Mammals

The introduction of invasive plant species may have an interaction with badgers. Invasive plants may lead to a reduction of badger prey species (COSEWIC 2012); these introduced species may also change the soil composition (Gordon 1998; Wolfe and Klironomos 2005; Batten et al. 2006; Jordan et al. 2008), potentially reducing the ability to efficiently burrow. The construction of new roads, transmission lines, and pipeline utility corridors has the potential for invasive species introduction and spread. Habitat alteration resulting from the spread of invasive plants is anticipated to impact 2 to 12% of Suitable American badger habitat (Table 6.17-8, Figure 6.17-12). However, as badgers have been observed throughout the LSA, an area with invasive plant presence, the potential effect of habitat alteration on badgers is anticipated to be low.

Table 6.17-8. Summary of Habitat Altered by Indicator Species

Species and Life Requisite	Suitable Habitat (high and moderate class) Available			
	LSA (ha)	Altered Area (ha) – (exclude IF)	Altered Area (ha) – (excluding IF & IDA)	% Range of Altered
American Badger	4,229.3	500.2	93.1	2 - 12%

Habitat alteration is not expected to affect deer as this species is resilient and known to use disturbed habitats (roadsides). Bats are unlikely to be affected by invasive species and dust because they forage and roost in tree canopy, habitat which will not be affected by these potential Project impacts.

Sensory Disturbance

Methods to Predict Impacts of Project Activities on Mammals

Sensory disturbance was determined for mammals using noise contours modelled for the Noise Effects Assessment (Section 10.5). Species are expected to avoid habitats if noise levels exceed 120 dB, as this is the typical level that causes pain in humans (Chepesiuk 2005; SCENIHR (Scientific Committee on Emerging and Newly-Identified Health Risks) 2008). Noise levels that may elicit a behavioural response in mammals can vary, depending on the species. Noise levels of 108 dB have been documented to be loud enough to elicit a response in mammals (Harding and Bohne 2004).

Luo et al. (2014) found that roosting (torpid) bats showed a weak response to traffic noise, and were able to rapidly habituate to repeated and prolonged noise exposure. Speakman and Racey (1991) tested a range of disturbance stimuli on torpid bats, and found that sounds exceeding 90 dB had no noticeable effect. Based on a lack of critical habitat features (known hibernacula) present in the disturbance area, and bats' ability to habituate to various types of noise disturbance, a quantitative analysis was not completed. Professional judgement was used to determine possible interactions with foraging bats.

Figure 6.17-10
Habitat Loss of Deer Winter Ranges

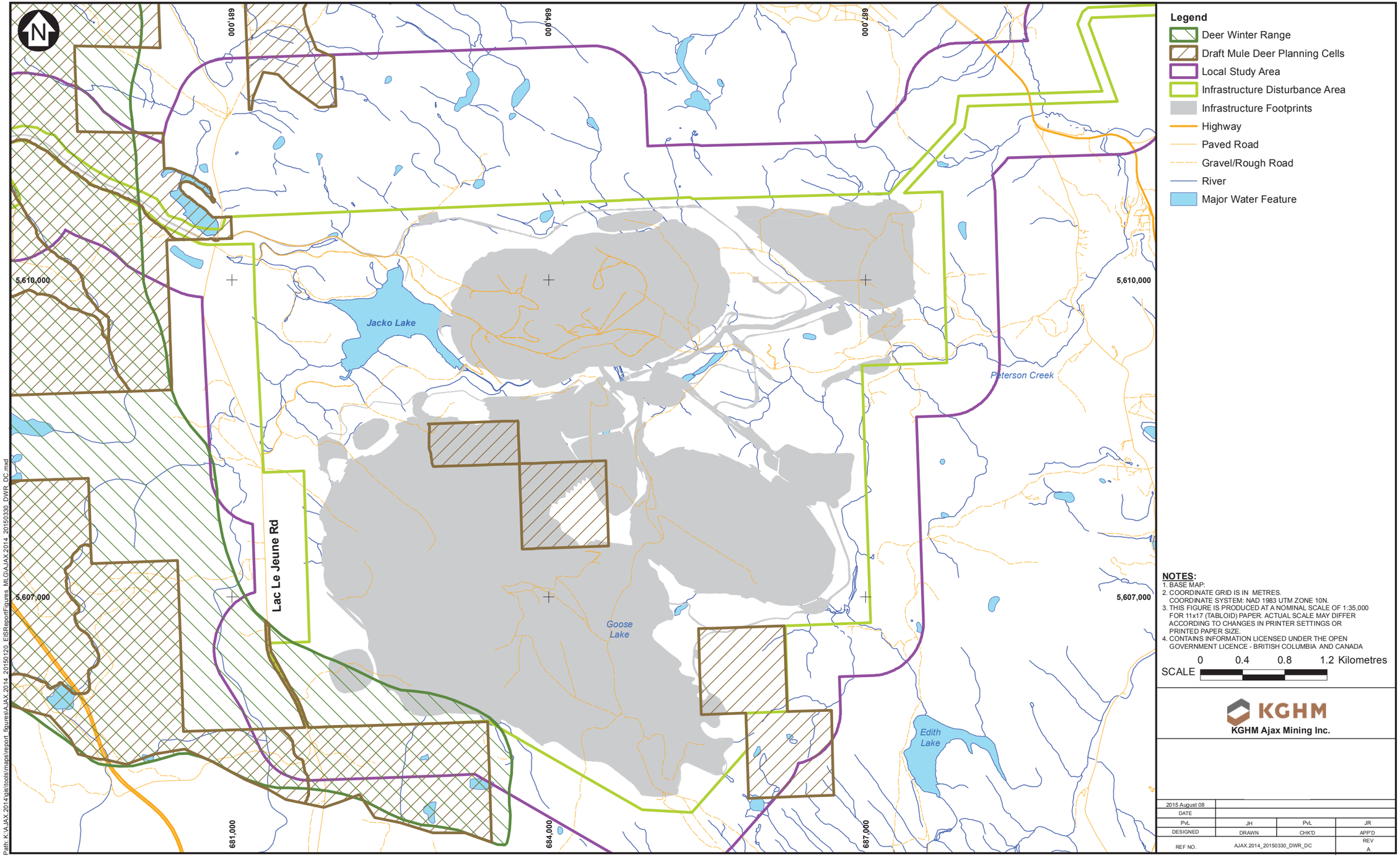


Figure 6.17-11
Bat Habitat Loss

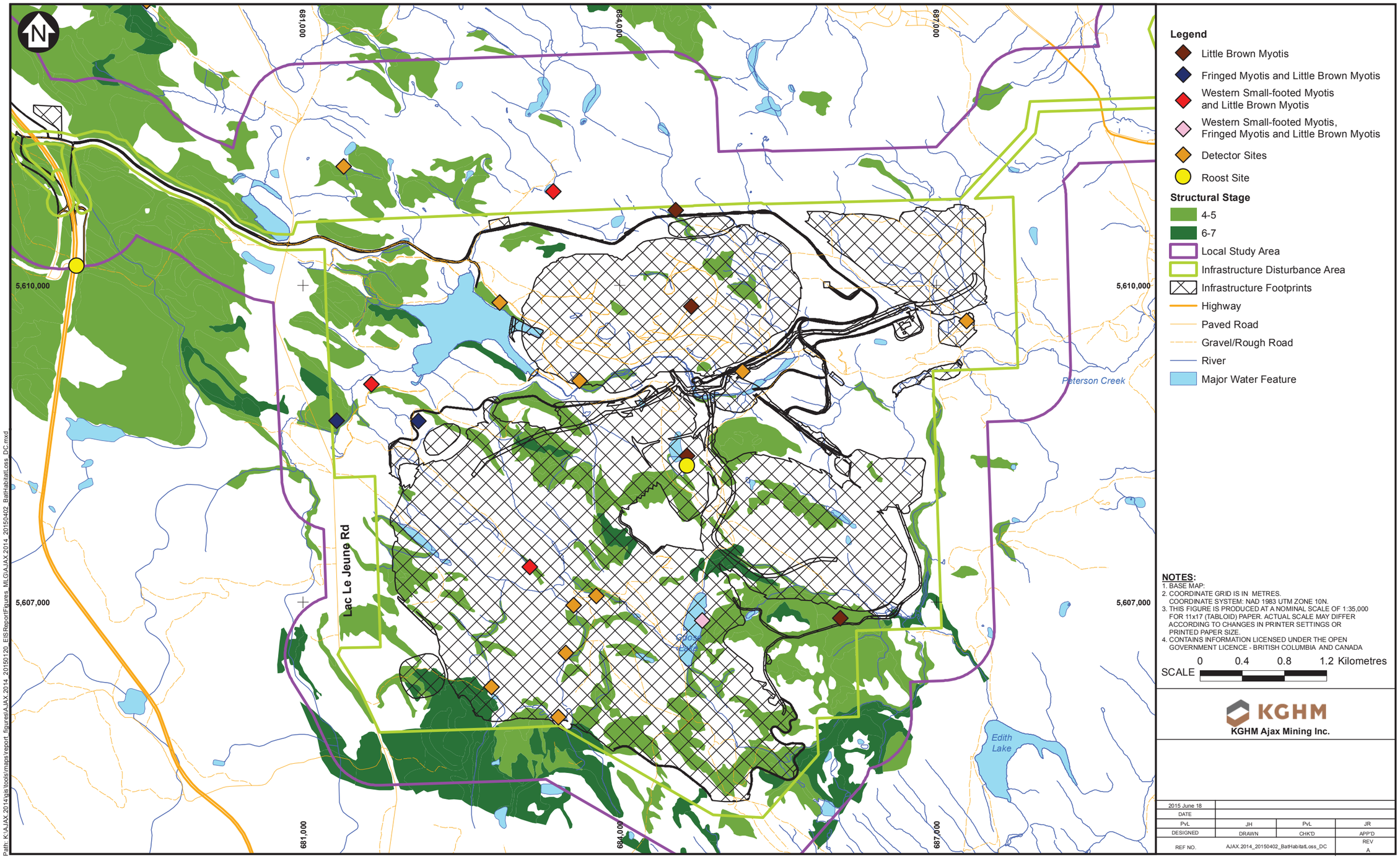
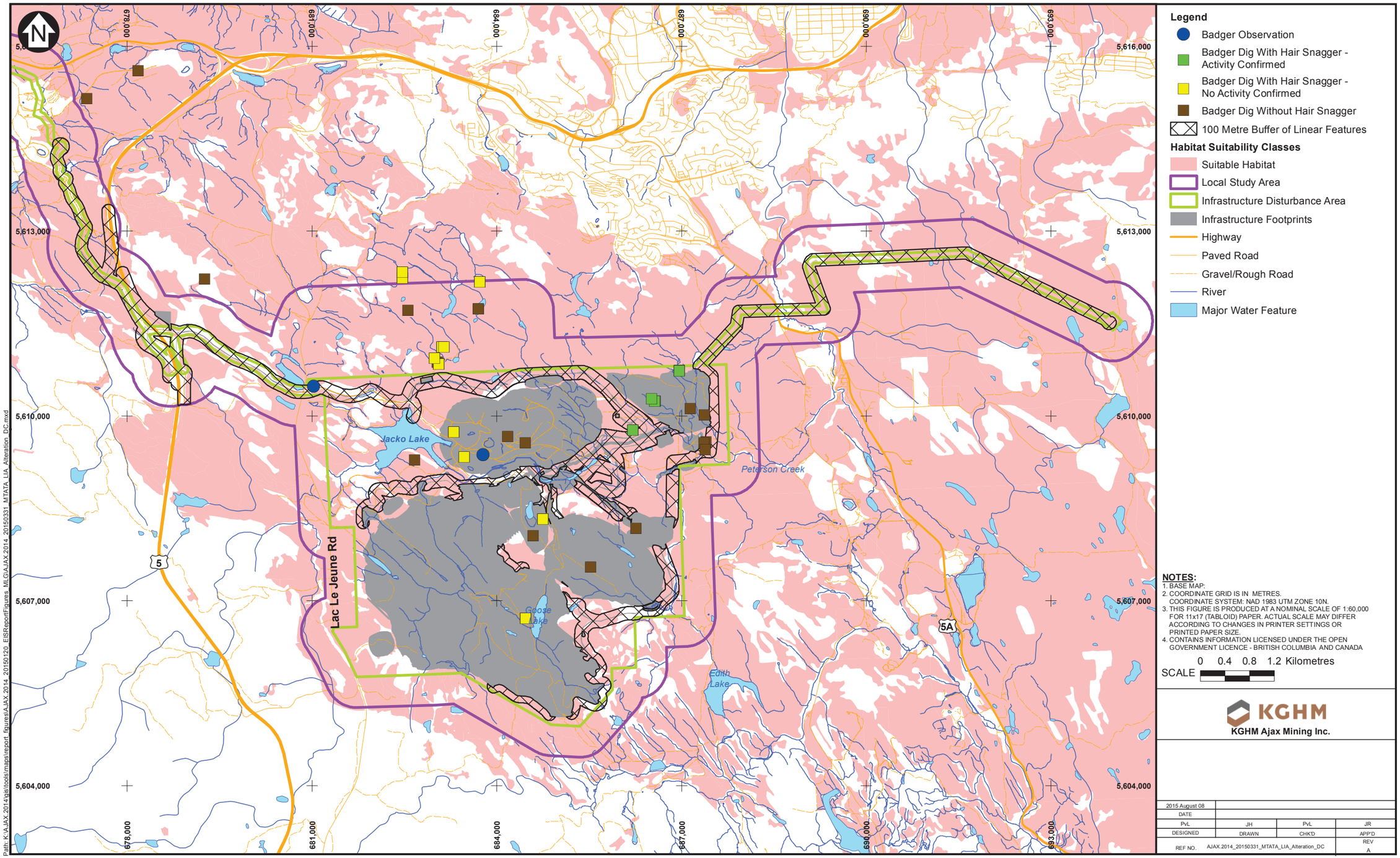


Figure 6.17-12
Badger Habitat Alteration



Noise levels exceeding 106 dB have been observed to cause a behavioural response in ungulates shortly after the calving season, but little response during most other times of year (Reimers and Colman 2006). Belant et al. (1996) found that white-tailed deer habituated to systematically exploding propane tanks, but motion-detection activated explosions were successful as a deer repellent. Various studies have also shown that deer habituate to aircraft noise, and can often be found foraging adjacent to airstrips (Seamans 2001). Deer are anticipated to habituate to both continuous and instantaneous noise generated from the Project.

Fossorial mammals (those which are adapted to digging and life underground) may be sensitive to seismic/substrate vibrations (Mason and Narins 2001; Narins et al. 1997). Badgers may be disturbed from ground vibrations generated from blasting activity, as they have acute pressure sensors in their feet (Minta and Marsh 1988). Badgers are sensitive to sound (anthropogenic or other individual badgers) and will often move around within their burrows if a disturbance is detected (Minta and Marsh 1988).

Noise contours were overlaid on badger habitat suitability maps to determine the amount of Suitable habitat affected by noise. Both the 120 dB and 108 dB thresholds reflect the instantaneous and attenuated noises from blasting activities. Sensory disturbance cannot occur in areas were habitat has been lost (i.e., Project IF – minimum habitat loss effect; IDA – maximum habitat loss effect). The amount of suitable habitat disturbed is reported excluding the IF and IDA. Critical habitat features occurring in these areas (known active badger digs) were also considered. As badgers are known to be resilient to continuous noise disturbances (i.e., they dig burrows in highway and railroad berms; Hoodicoff 2003), continuous Project noise was not considered for sensory disturbance on badgers.

Little is known about the impacts of artificial lighting on mammals, professional judgement based on sensitivity of the species, proximity of habitat and likelihood of interaction (i.e., time of activity) was used to determine if there will be an interaction.

Predicted Impacts of Project Activities on Mammals

Sensory disturbance will occur for American badger as a result of Project blasting noise. Habitat avoidance (120 dB) resulting from noise may affect 5 to 14% of suitable habitat in the LSA (Table 6.17-9). Energetic costs may be experienced (108 dB) in 28 to 42% of the Suitable habitat in the LSA (Table 6.17-9, Figure 6.17-13). Three of the 26 badger digs are within the 120 dB blasting radius and 12 additional digs are within the 108 dB radius in the LSA. The effects of ground vibrations on badgers are not well understood, making a prediction of the impact of this activity on this species difficult. The potential effect of noise sensory disturbance on badgers is anticipated to be minor.

Two additional badger dig sites located outside of the LSA but within the RSA are also located within the 108 dB blast radius.

Table 6.17-9. Summary of Sensory Disturbance to Badgers

Species and Life Requisite	LSA Total	Suitable Habitat (High and Moderate Class) and Features Available				
		Total Remaining after Habitat Loss (min. effect)	Disturbed Area – 108 dB (excluding IF)	Disturbed Area – 108 dB (excluding IF and IDA)	Disturbed Area – 120 dB (excluding IF)	Disturbed Area – 120 dB (excluding IF and IDA)
American Badger habitat (ha)	4,229.3 (100%)	3,066.1 (72%) 3	1,290.7 (42%)	866.6 (28%)	431.3 (14%)	141.8 (5%)
Badger Digs	26 (100%)	12 (46%)	12 (100%)	9 (75%)	3 (25%)	1 (8%)

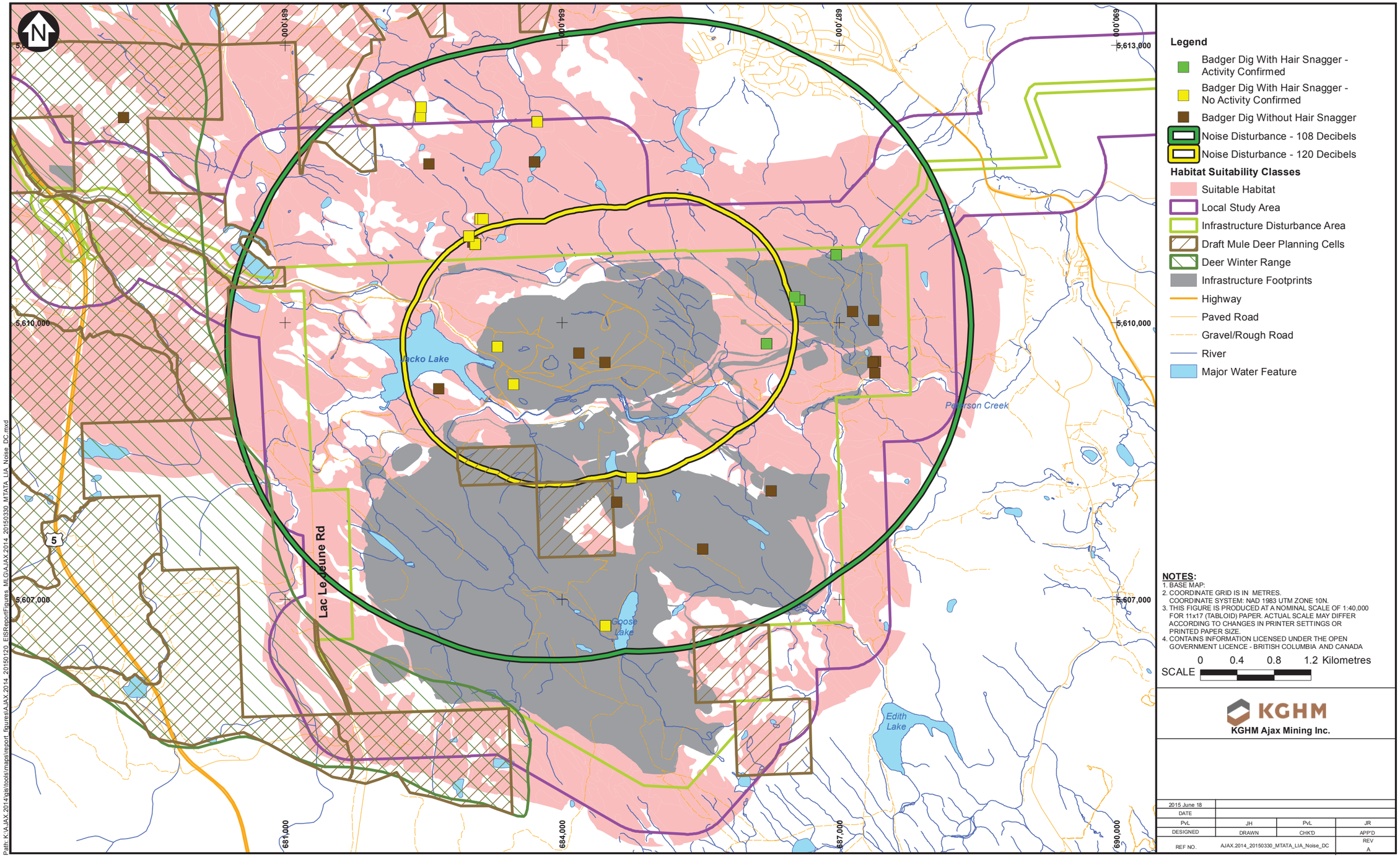
Project noise may affect bats by reducing their ability to efficiently locate prey (Schaub et al. 2008; Siemers and Schaub 2010). Bats are sensitive to road noise as traffic may mask the sounds of both prey and predators (Siemers and Schaub 2010; Berthinussen and Altringham 2012). Anthropogenic noise (e.g., road traffic) may mask the cues emitted by prey species, resulting in a decrease in echolocation efficiency (Jones 2008; Bunkley et al. 2015). Disturbance of bats during hibernation can cause them to expend their stored fat too quickly, leaving them with insufficient resources to last the rest of the winter (Nagorsen and Brigham 1993). Thomas (1995) found that human presence inside of a bat hibernaculum caused a relatively small number of individuals to arouse from torpor, but that the effect did not propagate throughout the entire population.

Bats response to anthropogenic noise varies among species (Thomas 1995), with some species being observed to habituate to repeated and prolonged anthropogenic noise (Luo et al. 2014). Bats in the IDA may experience a decrease in foraging success if feeding occurs within noise disturbance buffers. However, as bats are nocturnal and the majority of high intensity noise disturbances are anticipated to occur during daylight hours, the potential for sensory disturbance on bats is anticipated to be low. Since no hibernacula were confirmed and only two potential sites were identified in the LSA, the potential effect of noise disturbance on hibernating bats is anticipated to be low.

Dorrance et al. (1975) observed that deer were disturbed by anthropogenic noise and Sawyer et al. (2006; Sawyer et al. 2009) found that mule deer moved from highly suitable winter habitat to poor habitat in response to natural gas development, but this may have been in response to human presence. Loud, short duration noises resulting from drilling activities in natural gas production have a greater impact on mule deer than production and maintenance activities (Lutz et al. 2011). Deer that avoid critical winter range may have increased energy expenditures, which can impact critical activities such as foraging, resting, or reproducing (*ibid*.).

Deer present in any DWR may be affected by Project related noise. Mule deer may experience energetic costs (108 dB) in 7.7 ha (1% of total DWR in LSA, 0.02% of total DWR in the RSA; LRMP) to 15.7 ha (2% of total DWR in LSA, 0.04% of total DWR in the RSA; MOE) of DWR within the LSA. Based on the limited area impacted, the potential effect of noise disturbance on deer is anticipated to be low.

Figure 6.17-13
Mammal Noise Disturbance (Badger and Deer)



Badgers and bats are nocturnal and the potential for these species to be affected by artificial light exists (Beier 2006). As the eyes of nocturnal animals such as badgers are well adapted to foraging in low-light conditions (International Dark-Sky Association 2009), slight changes in the illumination of the environment may impact the badger's ability to hunt successfully. The European badger (*Meles meles*) exhibit similar characteristics to the American badger in that both species are nocturnal, spending much of their days in excavated dens. Studies of European badgers indicated that given the choice of using lit and un-lit areas, un-lit areas were preferentially chosen, even if the lit areas had a larger abundance of food (Institute of Ecology and Environmental Management 2008). Also, some bat species evaluate light levels before emerging from their roosts, waiting for a specific intensity after sunset (Swift 1980). Artificial light near roost sites may delay emergence, decreasing foraging time. As the majority of artificial light is expected to be focused in the Project infrastructure footprints the potential effect of light sensory disturbance on badgers and bats is anticipated to be low. Further discussion on the potential impacts of artificial light can be found in the Wildlife Attractants section below.

Disruption of Movement

Methods to Predict Impacts of Project Activities on Mammals

Baseline studies were not conducted to specifically identify movement corridors. Disruption of movement for mammals was determined using professional judgement. Mammals with extensive ranges, such as American badger and mule deer, were the focus of this effect.

Predicted Impacts of Project Activities on Mammals

Disruption of movement is anticipated to impact American badger by inhibiting the ability to move between areas of suitable habitat. Ramey and Bourassa (2005) found that after an initial disturbance, home ranges shifted away from the disturbance. The inability to travel unhindered between areas of suitable habitat may result in increased energy expenditure and reduced fitness for an individual. Reduced fitness may result in decreased reproductive success (Efroymson et al. 2004). Habitat fragmentation makes it difficult for individuals to form high-quality territories, find a mate and results in more energy on movement and aggression-related mortality (Jager et al. 2006).

Weir et al. (2003) reported male home range sizes of 21 to 53 km^2 (95% fixed kernel estimates) in the Thompson region. Only one female was included for home range analysis in this study, and resulted in a home range estimate of approximately 16 km^2 (*ibid*.). Based on these estimates the 42 km^2 LSA could support one or two male badgers, or two, or possibly three, female badgers. Models used by Jager et al. (2006) determined that habitat fragmentation affecting ≥10% of the total habitat resulted in a decrease in badger population size and persistence, as well as a female's ability to find a mate. Hoodicoff (2003) found that badgers in the Thompson region appear to be confined to small, isolated pockets of habitat amid a human-dominated landscape. Project activities could restrict movements of badgers present in the LSA. The potential effect of disruption to movement on badgers is anticipated to be moderate due to the amount of suitable habitat that will be fragmented by Project footprints.

As the majority of the habitat within the IDA is grassland (low suitability winter deer habitat), and deer have been observed to move between areas of suitable habitat to the west of the LSA (Bonar

1987), the potential effect of disruption to movement on deer is anticipated to be low and is therefore not discussed as a key effect.

The potential effect of disruption to movement on bats is negligible as bats can fly over barriers to areas of suitable habitat.

Direct Mortality

Methods to Predict Impacts of Project Activities on Mammals

Direct mortality for mammals could not be measured directly. A qualitative approach based on number of roads present, number of vehicles expected to use these roads, timing of road use and the timing of habitat removal (clearing/grubbing, earthworks) was used to address this potential effect.

Predicted Impacts of Project Activities on Mammals

Weir et al. (2003) found the primary cause of death for badgers within Thompson region was road mortality. Large home ranges that overlap major transportation corridors, such as highways and railways, result in increased mortality risk for these animals. Seventy-one percent (71%) of deaths documented by Hoodicoff (2003) were from vehicular collision. Badger roadkills in other studies have been found to be around 59% of total mortalities (Messick and Hornocker 1981; Hoodicoff 2003). The *Wildlife Accident Monitoring and Mitigation in British Columbia* (Sielecki 2010b) report indicates that deer are the most commonly killed wildlife species in the region as a result of vehicle collisions. Between 1988 and 2007, there were 3,197 deer/vehicle collisions and 4 badger/vehicle collisions in the Thompson-Nicola district (*ibid*.).

Increased traffic on Project roads during Construction and Operation will result in an increase in wildlife-vehicle collisions. A peak of 467 vehicle trips/day has been projected for Project roads during Operation. Traffic levels on public roads are also expected to increase as a result of the Project due to the labour force required. The potential effect of vehicular mortality on badgers is moderate due to the amount of suitable habitat adjacent to Project roads and the known vulnerability of this species to this type of mortality. The potential effect of vehicular mortality on deer is anticipated to be low during critical times of year (winter months) due to the limited interaction between the Project roads and suitable DWR. Deer mortality as a result of vehicular collisions during the rest of the year is anticipated to be low. Direct mortality may occur during transport of concentrate from the Project to the Port of Vancouver; however, the incremental effect of Project-related vehicles to existing highway traffic is considered negligible.

Roosting or hibernating bats may be vulnerable to mortality if bat habitat (e.g., trees, talus, rock outcrops) is disturbed or removed when bats are present. Roosting adult bats may be roused and escape during forest clearing but non-volant juveniles would be killed if maternity roost trees are felled during the breeding season (June - September). Bats in the vicinity of Project activities may also suffer mortality as a result of the energetic expenditure associated being roused from torpor. American badger juveniles may also suffer mortality if construction activities disturb their den. Bats can detect large landscape features up to 100 m away (Griffin 1970) and prey-sized objects at less than 10 m. Bats almost never collide with transmission lines, masts, or other non-turbine (static) structures. Mortality effects due to collisions with transmission lines are not anticipated.

The potential effect of direct mortality from construction activities for badger is anticipated to be moderate based on the amount of suitable habitat that will be removed and the presence of badger dens in the IDA. The potential effect of direct mortality from construction activities on bats is anticipated to be low based on the limited roosting habitat that will be removed.

Indirect Mortality

Deer are a commonly harvested species and increased access can result in increased hunting pressure. Linear corridors (right-of-ways) can also increase hunter access. Mine staff (direct employment) and contractors (indirect employment) may also increase the number of hunters active in the area. The potential effect of indirect mortality from hunting is anticipated to be low since hunters are already active in the area and access to the mine site and surrounding private lands will continue to be restricted.

Wildlife Attractants

Methods to Predict Impacts of Project Activities on Mammals

The impacts of wildlife attractants on mammals were not measured directly. A qualitative approach based on presence of suitable habitat, potential attractants expected to occur, and professional judgement was employed.

Predicted Impacts of Project Activities on Mammals

The presence of non-contact and treated potable water (potential sources of drinking water) throughout the LSA may attract bats, badgers, and deer away from otherwise superior habitat. Contact water may have a similar interaction, however, for the purpose of this assessment; contact water was assessed under chemical hazards. Mine staff (direct employment) and contractors (indirect employment) may leave out attractants, such as food and garbage, which may attract badgers throughout all phases of the Project. As the occurrence of contact and non-contact water, as well as direct and contracted employees, will be limited to the IDA, the anticipated interaction between wildlife attractants and any mammal indicator species is anticipated to be low since most suitable habitat will have been removed.

Artificial night lighting has been observed to attract invertebrates to the locations they are illuminating (Bruce-White and Shardlow 2011). As invertebrates make up the majority of the diet of all species of bats within the LSA (BC Conservation Data Centre 2014a), an increase in prey abundance may result in an increase in bats at these artificial light locations. However, this is not considered a negative interaction.

Bats have been observed attempting to drink from smooth man-made structures (e.g., sheets of metal, plastic, or wood) that have similar characteristics to waterbodies (Greif and Siemers 2010; Goerlitz et al. 2012). Some species of bats were observed to repeatedly (>100 attempts) mistake materials with water-like signatures (Greif and Siemers 2010). The presence of these materials in laydown areas and storage yards may have energetic costs to bats and may lead to a reduction in overall bat fitness (dehydration).

The potential effect of attractants on badger and deer is anticipated to be low since effects will be limited to the IDA where suitable habitat is limited. Effects to bats may be moderate based on the potential energetic costs associated with smooth structures.

Chemical Hazards

Methods to Predict Impacts of Project Activities on Mammals

To determine the potential effect of hazardous chemicals a qualitative approach was taken considering the presence of mammals or suitable habitat, potential for exposure (e.g., method of uptake such as ingestion or dermal exposure), likelihood of toxicity and likelihood of bioaccumulation. Hazardous chemicals were examined based on BC water quality guidelines for wildlife (BC Ministry of Environment 2014a). If any elements did not have a wildlife water quality guideline, the livestock water quality guideline was used instead. The concentrations of potentially hazardous chemicals were modelled at five locations: Jacko Lake, the Peterson Creek Diversion Pond and Humphrey Creek in the Project IF; and Peterson Creek node 2.3 and 2.0 in the LSA. Seven Project infrastructure sites were also modelled, including three sites on Tailing Storage Facility (TSF, TSF S WMP, and TSF SE WMP) and four sites on the Mine Rock Storage Facility (WMRSF 1, WMRSF 2, SMRSF, and EMRSF). Modelling considered year 1 (start of construction) to year 124 (100 years post closure), with major ions, nutrients and dissolved metals modelled for each month. Only those elements that exceed wildlife guidelines will be discussed (BC Ministry of Environment 2014a). Wildlife guidelines are the maximum recommended concentration of elements to protect wildlife from potentially adverse health effects. Wildlife guidelines have not been developed for the majority of elements due to a lack of sufficient research in the area. Exceeding water quality guidelines does not imply that unacceptable risks exist, but rather that the potential for adverse effects may be increased and additional investigation may be required. Details of the modelling are provided in Section 6.3. An ecological risk assessment (ERA) was conducted to determine risk quotients (RQs) for various mammal species. Details for this assessment can be seen in Appendix 10.4-A.

Predicted Impacts of Project Activities on Mammals

Water quality within Jacko Lake and in the Peterson Creek Diversion Pond is not expected to exceed wildlife water quality guidelines for any dissolved metals (Section 6.3).

At Peterson Creek downstream node 2.3, sulphate is anticipated to exceed wildlife guidelines in May of year 1 of Operation (Table 6.17-10).

Table 6.17-10. Modelled Median Water Quality for Peterson Creek 2.3

Dissolved Metals	Wildlife Guideline (mg/L)	No. of Months Guidelines Exceeded	Max Modelled Value (mg/L)
Sulphate (SO_4^{2-})	429	1	667

At Peterson Creek downstream node 2.0, selenium and sulphate will exceed wildlife water quality guidelines (Table 6.17-11). Baseline selenium levels at this node exceeded the wildlife water quality guideline of 0.002 mg/L in April of 2011 and 2013, with a maximum level of 0.004 mg/L. Selenium levels at this node are expected to be above this baseline maximum starting in April and May of year 1

and every April and May thereafter until year 124. Sulphate levels are anticipated to exceed wildlife guidelines in January, February, and September through December of Construction, January through April and September through December of Operation from year 1 to year 24, and January through May and September through December in all subsequent years.

Table 6.17-11. Modelled Median Water Quality for Peterson Creek 2.0

Dissolved Metals	Wildlife Guideline (mg/L)	No. of Months Guidelines Exceeded	Max Modelled Value (mg/L)
Selenium (Se)	0.002	249	0.0034
Sulphate (SO_4^{2-})	429	1,098	989

At Humphrey Creek, mercury, molybdenum, selenium, and sulphate are expected to exceed wildlife water quality guidelines (Table 6.17-12). Mercury will exceed wildlife water quality guidelines in May, August, September, and November in Construction and for the first 29 years of Operation. Molybdenum will exceed wildlife guidelines in April, May, and June of year 26, April and May in years 27 & 28, and April of year 29; molybdenum will again exceed guidelines from December through February, beginning in year 37 & 38, and November through February from year 39 to 55, and again from years 84 to 106. Selenium will exceed wildlife guidelines from January to May, and December of Construction and throughout all of Operations. Sulphate will exceed guidelines in December of year 37, December of through February starting in year 38 and ending in year 50, once in December of year 80, and again from February through December, from year 84 to year 105.

Table 6.17-12. Modelled Median Water Quality for Humphrey Creek

Dissolved Metals	Wildlife Guideline (mg/L)	No. of Months Guidelines Exceeded	Max Modelled Value (mg/L)
Mercury (Hg)	0.00002	120	0.000082
Molybdenum (Mo)	0.05	165	0.0964
Selenium (Se)	0.002	775	0.0065
Sulphate (SO_4^{2-})	429	104	493

Fluoride, mercury, molybdenum, selenium, and sulphate are expected to exceed wildlife water quality guidelines in the TSF (Table 6.17-13). Fluoride is expected to exceed guidelines from November of year 2 of until year 24. Mercury will exceed guidelines from May of year 4 to the end of year 24. Molybdenum will exceed wildlife water quality guidelines throughout Construction and all of Operation, excluding May to December of year 1. Selenium will exceed guidelines throughout Construction and all of Operation, beginning in April of year 2. Sulphate will exceed wildlife guidelines throughout Construction (excluding April), and throughout Operation, beginning in December of year 1.

Table 6.17-13. Modelled Median Water Quality for the TSF

Dissolved Metals	Wildlife Guideline (mg/L)	No. of Months Guidelines Exceeded	Max Modelled Value (mg/L)
Fluoride (F^-)	1	266	1,420
Mercury (Hg)	0.00002	275	0.00025
Molybdenum (Mo)	0.05	292	2.20
Selenium (Se)	0.002	285	0.017
Sulphate (SO_4^{2-})	429	288	7,250

The TSF South and Southeast Embankment water management ponds (WMPs) will exceed wildlife water guidelines for mercury, molybdenum, selenium, and sulphate (Tables 6.17-14 and 6.17-15). In addition to these four exceedances, the southeast embankment will also exceed fluoride and chloride levels (Table 6.17-15). Mercury will exceed wildlife water quality guidelines in the south embankment from year 37 through year 124, and in the southeast embankment from year 35 to 124. Molybdenum will exceed guidelines in the south embankment starting in April of year 24 and in the southeast embankment in September of year 22 and will continue to exceed at both sites through to year 124. Selenium will exceed guidelines in the south embankment starting in July of year 13 and will continue to exceed through to year 124, whereas the southeast embankment will exceed in June of year 16 to year 124. Sulphate will exceed guidelines at both sites, starting in December of year 41 in the south embankment and in September of year 76 in the southeast embankment. Both sites will continue to exceed sulphate guidelines until year 124, with the exception of a few sporadic months when levels will drop down to just below guideline standards.

Table 6.17-14. Modelled Median Water Quality for the TSF South Embankment WMP

Dissolved Metals	Wildlife Guideline (mg/L)	No. of Months Guidelines Exceeded	Max Modelled Value (mg/L)
Mercury (Hg)	0.00002	1,049	0.000052
Molybdenum (Mo)	0.05	1,209	0.50
Selenium (Se)	0.002	1,338	0.014
Sulphate (SO_4^{2-})	429	993	920

Table 6.17-15. Modelled Median Water Quality for the TSF Southeast Embankment WMP

Dissolved Metals	Wildlife Guideline (mg/L)	No. of Months Guidelines Exceeded	Max Modelled Value (mg/L)
Chloride (Cl^-)	600	195	714
Fluoride (F^-)	1	748	1.4
Mercury (Hg)	0.00002	1,061	718
Molybdenum (Mo)	0.05	1,228	0.000068
Selenium (Se)	0.002	1,303	0.0095
Sulphate (SO_4^{2-})	429	565	718

Chloride will exceed wildlife water quality guidelines from year 106 to year 124. Starting in year 106, guidelines will be exceeded for about half the year, increasing by approximately one month per year until year 112, when levels will remain in exceedance until year 124. Fluoride will exceed wildlife guidelines starting in year 61, when levels will be exceeded for approximately half the year. Levels will increase approximately one month per year until year 65, when levels will exceed guidelines until the end of year 124.

The West Mine Rock Storage Facilities (WMRSF) water management ponds (WMP1 and WMP2) will exceed wildlife guidelines for mercury, molybdenum, selenium, and sulphate (Tables 6.17-16 and 6.7-17). Mercury will exceed wildlife water quality guidelines in the WMP1 from May of year 4 until March of year 27. In the WMP2, mercury will exceed guidelines between years 4 and 32 and from year 86 until year 124; between year 32 and 60, mercury levels will remain just below the acceptable wildlife level, while from year 60 to 86, mercury levels will fluctuate between just above and just below acceptable levels. Molybdenum will exceed guidelines starting in June of year 3 in the WMP1 and starting in May of year 4 in the WMP2, and will continue to exceed at both sites until year 124. Selenium will exceed wildlife guidelines in both the WMP1 and WMP2 starting in April of year 3 and continuing through until year 124. Sulphate will exceed wildlife guidelines in WMP1 from August of year 5 until April of year 25, and in WMP2 from August of year 5 until March of year 28.

Table 6.17-16. Modelled Median Water Quality for the West Mine Rock Storage Facility North WMP 1

Dissolved Metals	Wildlife Guideline (mg/L)	No. of Months Guidelines Exceeded	Max Modelled Value (mg/L)
Mercury (Hg)	0.00002	272	0.000053
Molybdenum (Mo)	0.05	1,459	0.64
Selenium (Se)	0.002	1,461	0.035
Sulphate (SO_4^{2-})	429	236	784

Table 6.17-17. Modelled Median Water Quality for the West Mine Rock Storage Facility North WMP 2

Dissolved Metals	Wildlife Guideline (mg/L)	No. of Months Guidelines Exceeded	Max Modelled Value (mg/L)
Mercury (Hg)	0.00002	896	0.000064
Molybdenum (Mo)	0.05	1,450	0.74
Selenium (Se)	0.002	1,461	0.044
Sulphate (SO_4^{2-})	429	270	963

The South Mine Rock Storage Facility (SMRSF) WMP will exceed wildlife water quality guidelines for fluoride, mercury, molybdenum, selenium, and sulphate (Table 6.17-18). Fluoride will exceed wildlife guidelines in most months between years 5 and 25, with the exception of late spring/early summer for a number of these years. Mercury will exceed guidelines beginning in May of Construction and will continue to exceed until the end of year 124; twenty months will see mercury levels drop below guidelines, but only marginally so. Molybdenum and selenium will both exceed

wildlife guidelines from April of Construction until the end of year 124 of Operation. Sulphate will exceed guidelines beginning in August of Construction and will continue until February of year 28; Levels will be below guidelines between March and May in year 1 of Operation and again between May and July of year 27.

Table 6.17-18. Modelled Median Water Quality for the South Mine Rock Storage Facility WMP

Dissolved Metals	Wildlife Guideline (mg/L)	No. of Months Guidelines Exceeded	Max Modelled Value (mg/L)
Fluoride (F^-)	1	180	1.4
Mercury (Hg)	0.00002	1,476	0.00048
Molybdenum (Mo)	0.05	1,497	2.54
Selenium (Se)	0.002	1,497	0.086
Sulphate (SO_4^{2-})	429	326	5,606

The East Mine Rock Storage Facility (EMRSF) WMP will exceed wildlife water quality guidelines for mercury, molybdenum, selenium, and sulphate (Table 6.17-19). Mercury will exceed guidelines between May of year 6 and March of year 25. Molybdenum will exceed wildlife guidelines from September of year 9 to February of year 10, and again from July of year 10 through April of year 25. Selenium will exceed wildlife guidelines from April of year 2 though to April of year 25. Sulphate will exceed guidelines from July of year 11 through February of year 25.

Table 6.17-19. Modelled Median Water Quality for the East Mine Rock Storage Facility WMP

Dissolved Metals	Wildlife Guideline (mg/L)	No. of Months Guidelines Exceeded	Max Modelled Value (mg/L)
Mercury (Hg)	0.00002	227	0.000049
Molybdenum (Mo)	0.05	184	0.15
Selenium (Se)	0.002	277	0.024
Sulphate (SO_4^{2-})	429	164	634

The presence of contact water throughout the IDA is anticipated to be used by bats as a source of drinking water. The degree to which bats will use the contact water as a source of drinking water is unknown. Ciechanowski (2002) found that bat species whose foraging activities were strongly associated with water seemed to avoid small, isolated ponds during nightly activity. Foraging bats may also be exposed to metal ingestion through consumption of insects that have fed on plants in mining areas or insects that have developed in contaminated water (O'Shea et al. 2000). Bats are long-lived in general, which makes them more susceptible to long-term metal accumulation (O'Shea et al. 2000).

Mercury, either in elemental from or as methylmercury, can affect the movement and motor skills in some mammals (Evans et al. 1975; Wolfe et al. 1998; Yates et al. 2014). Increased mercury levels can lead to problems with the central nervous system, reduced fertility, slower growth and development, and even death, depending on levels of exposure (Hagan 2014; Wolfe et al. 1998; Yates et al. 2014).

Molybdenum effects on mammals are complex and poorly understood (Eisler 1989). The toxicological properties of Mo depend on interactions with other elements, such as copper (Cu) and sulfur (S) (*ibid*.). Evidence suggests that, aside from cows and sheep, mammals are comparatively tolerant of high dietary intakes of molybdenum (*ibid*.).

The full effect of selenium on mammals has not been well documented, with potential positive and negative effects associated with this element (Eisler 1985). Selenium may protect mammals from the toxic effects of mercury (Hg), cadmium (Ca), arsenic (As), and thallium (Tl) (*ibid*.). Mammals are less susceptible to selenium toxicity than birds (King et al. 2001; Eisler 1985). Selenium may negatively impact mammals by increasing reproductive abnormalities, delaying growth, and increasing infertility occurrences (Eisler 1985). Rats have a recommended dietary level of 1,000 ppb (parts per billion) of selenium (Eisler 1985). King et al. (2001) found that selenium concentrations of 4.75 µg/g of body weight in Yuma myotis (*Myotis yumanensis*) did not appear to be a contaminant of concern.

Information from the ecological risk assessment (Appendix 10.4-A) shows that selenium is anticipated to have a slightly elevated risk quotient (RQ) for American mink at Peterson Creek. American mink have a strict diet of freshwater fish (dietary restrictions which no other mammals in the area share), which is why they were examined for effects of selenium. Because the Baseline risk already exceeds the risk threshold for mink, and as the difference in risk between Baseline and Future cases is small, selenium exposure is not expected to manifest into adverse effects for this species.

Ecological risk was also quantified for other mammalian receptor species', including black bear, moose, mule deer, meadow vole, muskrat, red fox, and snowshoe hare, based on the total exposure to chemicals of potential concern (COPCs) from the environment relative to benchmark toxicological reference values. The change in potential risk to these species' as a result of the Project was deemed to be negligible.

Contact water is expected to be contained in the Project IF so the effect on deer and badger is anticipated to be low. The potential effect of contact water on bats is anticipated to be moderate since bats may drink from open water in the Project IF. Bats may also be attracted to these areas due to increase foraging opportunities if insects congregate at Project lights. Water present in the TSF may have limited exposure to contaminants in the top few centimetres. If this is the case, then the impact of contact water on bats will be low.

6.17.4.3 Mitigation Measures for Mammals

Mitigation measures proposed to address potential effects during all phases of the Project are discussed below.

Habitat Loss

Habitat loss will occur throughout the entire IDA. To reduce the impacts of habitat removal on reproducing individuals, habitat loss will be avoided during sensitive windows (rutting season, September and October). The following will be considered to mitigate for critical mule deer winter habitat loss:

- sensitive sites (DWR planning cells) will be avoided if at all possible and whenever practical.

The Recovery strategy for the badger in British Columbia (*jeffersonii* Badger Recovery Team 2006) recommends the following strategies to address habitat loss threats:

- increase grassland and open forest restoration;
- support and encourage conservation land acquisition;
  - KAM owned lands that are conducive to suitable badger habitat will be enhanced to provide better forage opportunities to badgers;
  - grassland habitat known to be used by badgers will be fenced off and livestock grazing will be controlled/minimized on KAM owned lands during sensitive times (birthing and rearing; March through August);
- initiate priority research and monitoring projects; and
- increase the consideration given to badger habitat conservation during strategic planning.

The Management Plan for the spotted bat (BC Ministry of Environment 2013) provides valuable suggestions for protection and management. Recommendations within this plan also benefit little brown myotis and other bat species found in this study area. The following was suggested to for habitat protection:

- sensitive sites (e.g., large veteran trees) should be avoided if at all possible and whenever practical;
- if roosting habitat or hibernation sites are identified, they will be avoided if possible;
  - if these sites cannot be avoided, clearing activities will be undertaken outside of the sensitive breeding/rearing season (June through September);
- suitable foraging sites, in particular wetlands and riparian areas, will be maintained; and
- monitoring of strategically selected locations will be required to assess the effectiveness of mitigation measures.

Additional habitat loss compensation for bats will include the installation of bat boxes near foraging sites. Bat boxes will be installed on free-standing poles or on facility walls where their presence will not interfere with facility operations. They will be situated where they will get at least ten hours of sun to provide warm conditions for maternity roosts. Bat boxes will be installed at other locations on KAM lands away from the mine site, and as an enhancement feature at conservation sites elsewhere in region such as the Lac du Bois Grasslands. Further details will be provided in the *Wildlife and Vegetation Monitoring Plan* (Section 11.27).

Habitat Alteration

Fugitive Dust Mitigation

Dust mitigation measures will be addressed under several management and monitoring plans. Mitigation measures (i.e. dust suppression for site roads and access roads, control of fugitive dust from drop points and conveyors and control of fugitive dust from the TSF) to protect air quality are described in Section 10.1 and in the *Air Quality Monitoring and Dust Control Plan* (Section 11.6).

Reducing traffic by implementing the *Transportation Management Plan* and the *Access Management Plan* (Sections 11.20 and 11.21 respectively), which limits the amount of traffic on site and the speed limits associated with site roads, will also reduce the potential for negative effects of dust.

Invasive Species Mitigation

Development and implementation of an invasive plant species plan is integral to reducing invasive species introduction. Avoiding the introduction of invasive species is central to circumventing costly measures required for their eradication. Reducing traffic by implementing the *Access Management Plan* (Section 11.21) on site is also a key measure to help reduce the introduction of invasive plant species.

The plan for invasive species will manage for the priority species throughout the Project area. A site-specific plan will be developed by the Project's Environmental Manager through discussion (as needed) with the Invasive Plant Council, environmental scientists, and local governing agencies. The plan will draw upon the *Invasive Alien Plant Program: Reference Guide* (BC MOFR 2010) and *Invasive Plant Pest Management Plan for the Southern Interior of British Columbia* (BC Ministry of Forests and Range 2010), which outline an Integrated Pest Management approach for invasive alien plants, under the authority of several partnering ministries.

Reclamation to restore affected areas after Project activities have ceased will reduce the establishment of invasive species, which prefer disturbed sites. The reclamation plan will prioritize the rapid re-vegetation of all temporarily disturbed areas and will use appropriate seed mixes that minimize the spread of invasive plants. The *Invasive Plant Management Plan* (Section 11.17) will also include objectives for limiting invasive species, monitoring the presence and possible spread of invasive plants in temporarily disturbed areas, and monitoring the success of re-vegetation programs. Mitigation measures to reduce the spread of invasive species will include:

- prior to work commencing, surveys will be conducted to identify invasive species populations. Treatment will be initiated as required;
- all vehicles entering and leaving work sites will be inspected;
- vehicles will be cleaned thoroughly with special attention to wheel wells, tire treads, and tracks where mud and seeds of noxious weeds may be lodged; and
- vehicles must be washed before being allowed on site.

Water Quality

Water quality mitigation will be addressed under several management and monitoring plans: the *Surface Water Quality Management and Monitoring Plan* (Section 11.23), the *Groundwater Quality Management and Monitoring Plan* (Section 11.24), and the *Water Management and Hydrometric Monitoring Plan* (Section 11.7). The measures specified in these plans are expected to mitigate the potential effects of water quality on mammals.

Sensory Disturbance

Noise is anticipated to have a negative effect on mammals, specifically on American badgers and the various bat species present. Noise may come from roads or Project specific activities, such as drilling and blasting. A *Noise Management Plan* (Section 11.22) will be developed with the objective to ensure that noise levels during all phases of the Project are acceptably low for human and wildlife receptors, as per human health guidelines (Health Canada 2011).

Noise mitigation measures relevant to American badger and all bat species include:

- ensuring impulse events, such as blasting, will be limited to certain times of the day (avoiding crepuscular (sunrise and sunset) and overnight work, during spring, summer, and fall (non-torpor seasons), if possible);
- considering noise ratings when selecting equipment;
- adjusting blasting configurations to minimise simultaneous blasting effects;
- optimizing the operation of equipment to minimize noise (e.g., reduced speed limits);
- optimizing the site layout to minimize noise impacts (e.g., through use of natural screens such as buildings, facing away from relevant receptors, minimizing the need for mobile equipment to use their backup alarms);
- applying noise dampening measures where possible, including conducting loud procedures indoors, where practical; and
- minimizing traffic noise during critical times of day (sunrise/sunset) along roads by providing a vehicle parking lot for staff and shuttling mine personnel from this site to the mine.

While an interaction between mammals and artificial lighting is expected to be low, using low-pressure sodium lamps, fitting lamps with ultraviolet filters, or using directional lighting will further reduce the potential for any effect on mammals, especially bats.

Disruption of Movement

Disruption of movement is anticipated for badgers as a result of construction related activities. The Recovery strategy for the Badger in British Columbia (*jeffersonii* Badger Recovery Team 2006) recommends the following strategies to address habitat connectivity:

- facilitate movement among populations by maintaining habitat across the landscape; and
- confirm movements of individuals among populations via monitoring.

Additional hair snagging efforts will help to determine where individuals are located across the landscape, the composition of the badger population in the LSA, and how they respond to the mine.

Direct Mortality

Direct mortality is anticipated for all species of bats present during construction of the Project, as well as for badgers during Construction and Operation of the Project.

Vehicular mortalities may occur throughout all phases of the Project, especially during Construction and Operation when road use will be higher than in later stages. These collisions will be reduced through the implementation of speed limits and minimizing the number of vehicles using sites roads (*Transportation Management Plan*; Section 11.20).

Measures to mitigate mortality of mammals include:

- clearing of vegetation during breeding/rearing periods (March to August for badgers, June to September for bats) should be avoided;
  - if these windows cannot be avoided, pre-clearing surveys will be undertaken by a qualified individual to ensure no mortalities occur and work will be within timing windows limited when possible (BC *Wildlife Act* Government of British Columbia 1996);
- vehicles will yield to wildlife observed along Project roads and the locations of observed wildlife will be communicate these observations to the environmental manager;
- traffic will be minimized along roads by providing a vehicle parking lot for staff, and mine personnel will be shuttled from this site to the mine;
- speed limits and wildlife signage will be implemented to alert drivers of potential collisions (*jeffersonii* Badger Recovery Team 2006);
- a specific height for roadside vegetation will be maintained to improve drivers' sight lines;
- habitat near roads be modified to decrease suitability for badgers and their prey (*jeffersonii* Badger Recovery Team 2006), as well as deer;
- continued monitoring and wildlife sighting observations to identify key movement corridors;
- training and education programs will be initiated to inform staff of sensitive sites to ensure they avoid accidental destruction of key areas (*jeffersonii* Badger Recovery Team 2006); and
- guns and hunting activities will be banned on sites by any mine employees or contractors.

No listed-indicator species were considered nuisance wildlife. Measures used to control wildlife attractants are intended to minimize or eliminate problem wildlife situations. However, if a problem wildlife situation does arise, the environmental coordinator will initiate the appropriate response actions. Any direct intervention with problem wildlife will be done by authorized personnel in consultation with, and as approved or directed by, the British Columbia (BC) Conservation Officer Service. KAM will opt for non-lethal solutions (e.g., aversive conditioning, relocation) whenever appropriate and safe to do so.

Wildlife Attractants

Bats are attracted to laydown areas and storage yards because they associate smooth surfaces with sources of open water. Large pieces of smooth metal, plastic, or wood have similar properties to water when a bat is using echolocation to identify its surroundings. This can be mitigated by placing objects (e.g., rocks, cones, nets) on top of any large, smooth materials, allowing bats to differentiate between a smooth surface and one with foreign objects on it.

Chemical Hazards

Chemical hazards from various Project activities (e.g., fuel storage and filling area, deposition to the TSF, contact water, vehicle/machinery leaks) are expected to be low in all phases of the Project. Monitoring Plans that will be in place to further reduce these effects include:

- a *Construction Waste Management Plan* (Section 11.4);
- a *Metal Leaching and Acid Rock Drainage Management and Monitoring Plan* (Section 11.5);
- a *Water Management and Hydrometric Monitoring Plan* (Section 11.7);
- a *Contaminated Sites Management Plan* (Section 11.8);
- a *Solid Waste Management Plan* (Section 11.9).
- a *Hazardous Waste Management Plan* (Section 11.10);
- a *Risk Management Plan (Accidents and Malfunctions)* (Section 11.12);
- a *Natural Hazards Management Plan* (Section 11.13);
- an *Emergency Response Plan* (Section 11.14);
- a *Surface Water Quality Management and Monitoring Plan* (Section 11.23); and
- a *Groundwater Quality Management and Monitoring Plan* (Section 11.24).

Chemical hazards resulting from the presence of contact water are not expected to interact with any indicator species other than bats. Very little data is available on metal accumulation in bats; however, long-lived species (>30 years for some species) are often more susceptible to bioaccumulation of contaminants.

Monitoring of bat activity around the TSF will be undertaken, and mitigation measures implemented on the basis of monitoring results. Boonman et al. (1998) found that the presence of duckweed (*Lemnaceae*) on the surface of the waterbodies caused bats to avoid ponded areas by interfering with their echolocation. If levels of specific elements known to have a detrimental effect on bats are found to be of concern, the addition of duckweed, or other foreign objects (e.g., buoys, nets), to the TSF may dissuade bats from identifying it as a waterbody (i.e., if the surface water is not placid, then bat echolocation may not result in it being recognized as water), thereby reducing the potential interaction with the toxic water. Nets have been used to dissuade some species from using contaminated sites, and may also be a mitigation measure that is effective, providing the netting is maintained (Eisler and Wiemeyer 2004; New Mexico Department of Game and Fish 2004).

6.17.5 Residual Effects and Their Significance

6.17.5.1 Summary of Residual Effects

Habitat loss, specifically DWR, bat foraging areas and suitable badger habitat, may not be avoidable. Over the long-term, some habitat may be restored through reclamation and revegetation processes. Reclamation and revegetation of areas will occur during Operation, Closure, and Post-Closure. Shrub/grassland habitat may be created on mine rock areas, but this will not necessarily equate to

suitable badger habitat as soils will not have the same friability as before the Project. Reclaimed aspen groves may also provide feeding and security habitat for deer, once an appropriate structural stage is reached. Badgers, bats, and deer will each be subjected to loss of habitat as a result of Project construction activities and a residual effect is anticipated to occur.

After the implementation of mitigation measures for fugitive dust, invasive species and water quality habitat alteration is expected to have a negligible to low impact on mammals, no residual effects are expected for any indicator species.

A residual effect may occur as a result of Project related blasting noise on badgers. A residual effect for sensory disturbance of bats is not anticipated due to their ability to adapt to anthropogenic noise, and limited anticipated noise during crepuscular times.

Project activities are anticipated to prevent badgers from moving between areas of suitable habitat. These activities cannot be avoided, and the effects from them will last through the Operation phase of the Project. A residual effect associated with disruption of movement is anticipated for American badger.

Vehicular mortalities may occur throughout all phases of the Project; however, after the implementation of mitigation processes, the anticipated interaction is low for all mammal indicator species, and therefore, no residual effects for mortality are anticipated.

Bats are attracted to laydown areas and storage yards because they associate smooth surfaces with sources of open water. The attraction of mammals to sub-optimal habitat for all other activities and phases of the Project is expected to be low. With the implementation of mitigation measures, wildlife attractants are expected to have a negligible to low impact on bats. No residual effects are expected for mammals.

The likelihood of contact water, as well as the efficacy of mitigation measures, is not well understood. As chemical hazards may have a moderate impact on bats, a residual effect is expected for this species group.

After the implementation of mitigation measures, four residual effects are anticipated to occur (Table 6.17-20). The loss of American badger, bat, and mule deer habitat cannot be fully mitigated. Sensory disturbance on badgers from Project activities such as drilling, blasting, and rock crushing may be minimized by limiting these activities to specific windows; however, these activities may still have an interaction with badgers in dens. Disruption of badger movement through the LSA will not be avoidable, and a residual effect is anticipated. Chemical hazards may be present in contact water that may be consumed by various bat species.

6.17.5.2 Criteria for Characterization of Residual Effects

Specific criteria used to characterize residual effects are outline below (Table 6.17-21). For habitat loss/alteration, magnitude was assigned thresholds based on literature and professional knowledge (Andren 1994). Negligible is a 0-5% change to available habitat in the LSA, Minor was a 5-30% change, Medium was a 30-50% change and Major is a change greater than 50%.

Table 6.17-20. Summary of Residual Effects on Mammals

Valued Component	Project Phase (timing of effect)	Project Component/ Physical Activity	Description of Cause-Effect[1]	Description of Mitigation Measure(s)	Description of Residual Effect
Mammals (American Badger, Bats, Mule Deer)	Construction	Clearing/ Grubbing, Earthworks	Removal of vegetation and habitat features – Habitat Loss	Reclamation/ revegetation, avoid sensitive sites, install bat boxes	Reduction in available habitat
Mammals (American Badger)	Construction, Operation	Drilling and blasting/loud Project activities	Displacement from dens, increase in stress hormones – Sensory Disturbance	Limit noise to certain windows (avoid sunrise/ sunset)	Uncertain, but stress levels may increase and forage efficiency may decrease
Mammals (American Badger)	Construction, Operation, Closure	Clearing/ Grubbing, Earthworks	Inability to travel between areas of suitable habitat – Disruption of Movement	Maintain habitat across landscape, where possible; continued monitoring	Increased energy expenditure/ reduced fitness/ decrease in reproductive success
Mammals (Bats)	Construction, Operation, Closure	Contact water	Ingestion of toxic water – Chemical Hazard	Continued monitoring of water quality, netting/buoys/ duckweed addition to TSF	Increased reproductive abnormalities, delayed growth, increased infertility occurrences

[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 VC.*

6.17.5.3 Characterization of Residual Effects

Four residual effects are anticipated on mammals as a result of the Project (Table 6.17-22). Habitat loss will occur for American badger (28 to 49% of suitable habitat removed), bats (15 to 35% of habitat associations removed) and mule deer (4 to 18% of critical DWR removed). The magnitude of this effect is medium for badgers as less than 50% of suitable habitat is being removed; the magnitude of this effect is minor for bats as an estimated 15% of habitat associations will be lost, and also for deer, as no more than 18% of habitat is being removed. The duration will be long term for all indicators as the habitat will be lost for at least the duration of the Project; reclamation efforts during Decommissioning and Closure may re-establish suitable habitat. The effect will occur sporadically, during the Construction and Operation phases when suitable habitat will be removed, and will be limited locally to within the Project IF. This effect may be reversible in the long-term, upon closure of the mine. Badgers, bats, and mule deer have a low resiliency to lost habitat, with this being one of the major threats to each species (*jeffersonii* Badger Recovery Team 2006; Nelson et al. 2008; Cox et al. 2009; BC Ministry of Environment 2013; The Pallid Bat Recovery Team 2008). Where the open pit mine exists, habitat for badgers will not be reclaimed. A medium habitat effect is expected for badger and a minor long term habitat effect is expected for bats and deer.

Table 6.17-21. Definitions of Characterization Criteria for Residual Effects on Mammals

Magnitude	Duration	Frequency	Geographic Extent (Physical/Biophysical)	Reversibility	Resiliency	Ecological Context	Likelihood of Effects	
							Probability	Confidence Level
How severe will the effect be?	*How long will the effect last?*	*How often will the effect occur?*	*How far will the effect reach?*	*To what degree is the effect reversible?*	*How resilient is the receiving environment or population?*	*What is the current condition of the ecosystem and how commonly is it represented in the LSA?*	*How likely is the effect to occur?*	*How certain is this analysis?*
Negligible: No or very little detectable change from baseline conditions. (< 5% of available habitat in LSA)	**Short-term:** Effect lasts 1 to 5 years.	**Once:** Effect is confined to one discrete period in time during the life of the Project.	**Local:** Effect extends less than 500 m from infrastructure or activity.	**Reversible Short-term:** Effect can be reversed relatively quickly.	**Low:** The receiving environment or population has a low resilience to imposed stresses, and will not easily adapt to the effect.	**Low:** The receptor is considered to have little to no unique attributes or provision of functions is severely degraded.	**High:** It is highly likely that this effect will occur.	**High:** > 80% confidence. There is a good understanding of the cause-effect relationship and all necessary data are available for the Project area. There is a low degree of uncertainty and variation from the predicted effect is expected to be low.
Minor: Differs from the average value for baseline conditions to a small degree. (5-30%)	**Medium-term:** Effect lasts 6 to 25 years.	**Sporadic:** Effect an effect that occurs at sporadic or intermittent intervals during any phase of the Project.	**Landscape:** Effect is limited to the LSA or one watershed (i.e., Sub-area).	**Reversible Long-term:** Effect can be reversed within 20 years of Post-Closure.	**Neutral:** The receiving environment or population has a neutral resilience to imposed stresses and may be able to respond and adapt to the effect.	**Neutral:** The receiving environment considered to have some unique attributes and provides most functions that an undisturbed environment would provide.	**Medium:** This effect is likely, but may not occur.	**Medium:** 50 to 80% confidence. The cause-effect relationships are not fully understood, there are a number of unknown external variables, or data for the Project area are incomplete. There is a moderate degree of uncertainty; while results may vary, predictions are relatively confident.
Medium: Differs substantially from the average value for baseline conditions and approaches the limits of natural variation. (30-50%)	**Long-term:** Effect lasts between 26 and 50 years.	**Regular:** Effect occurs on a regular basis during the life span of the Project.	**Regional:** Effect extends across the broader region (e.g., RSA, multiple watersheds, etc.).	**Irreversible:** Effect cannot be reversed (i.e., is permanent).	**High:** The receiving environment or population has a high natural resilience to imposed stresses, and can respond and adapt to the effect.	**High:** The receiving environment or population is uncommon and occurs in a natural state and provides functions at a maximum capacity.	**Low:** This effect is unlikely but could occur.	**Low:** < 50% confidence. The cause-effect relationships are poorly understood, there are a number of unknown external variables, and data for the Project area are incomplete. High degree of uncertainty and final results may vary considerably.
Major: Differs substantially from baseline conditions, resulting in a detectable change beyond the range of natural variation. (> 50%)	**Far Future:** Effect lasts more than 50 years.	**Continuous:** Effect occurs constantly during the life of the Project.	**Beyond Regional:** Effect extends beyond the regional scale, and may extend across or beyond the province.					

Table 6.17-22. Characterization of Residual Effects, Significance, Likelihood and Confidence on Mammals

Residual Effect	Residual Effects Characterization Criteria							Significance of Adverse Residual Effects	Likelihood and Confidence	
	Magnitude	Duration	Frequency	Geographic Extent	Reversibility	Resiliency	Context		Probability	Confidence
Habitat Loss (American Badger, Bats, Mule Deer)	Medium	Long-term	Sporadic	Local	Reversible Long-term	Low	Neutral	Not Significant (moderate)	High	Medium
Sensory Disturbance (American Badger)	Minor	Medium-term	Regular	Landscape	Reversible Short-term	Neutral	Neutral	Not Significant (minor)	Medium	Low
Disruption of Movement (American Badger)	Minor	Long-term	Continuous	Landscape	Reversible Long-term	Neutral	Neutral	Not Significant (minor)	Medium	Medium
Chemical Hazards (Bats)	Medium	Long-term	Continuous	Local	Reversible Long-term	Low	Neutral	Not Significant (minor)	Medium	Low

Sensory disturbance is anticipated for badgers. Drilling and blasting noise may cause an increase in stress hormones in denning individuals. Sensory disturbance will be of minor magnitude, occurring over the medium-term (activity causing noise disturbance is anticipated to decrease as the Project progresses). Activities will occur regularly on the landscape (within the LSA). This effect is reversible in the short-term as cessation of the activity will result in cessation of the disturbance. Badgers are known to burrow into, and persist alongside railroad berms (Hoodicoff 2003), indicating a high resiliency to sensory (noise) disturbance.

Some Project activities and components (e.g., open pit, TSF) will prevent badgers from moving freely within areas of suitable habitat (potentially within a single home range). The potential for disruption of movement to an individual or individuals within their home range(s) will have a minor magnitude since habitat in the vicinity of the Project is already fragmented, and individuals are known to persist in the area. This will be a long-term effect as it will occur for at least the length of the Project. This disruption will be continuous, but will be a landscape extent. Disruption of movement may be reversible over the long-term, after mining activities have stopped. Badgers are known to shift home ranges in response to a disturbance (Ramey and Bourassa 2005), suggesting some resilience to fragmented habitat.

The presence of open contact water in the tailings storage facility may have an interaction with the various bat species in the LSA. The presence of contaminated (contact) water in the IDA will differ substantially from that of baseline conditions, equating to a medium magnitude. The potential for interaction will last for as long as contact water (TSF) remains present, which will be long-term. Contact water will be present continuously throughout the life of the Project and beyond. The chemical hazard will be limited to the Project IF, and is reversible in the long-term. As contaminants are thought to be a major factor contributing to decreases in bat populations (Bayat et al. 2014), bat resiliency to chemical hazards was ranked low.

6.17.5.4 Significance of Residual Effects

Habitat loss is anticipated to have a not significant (moderate) effect on American badger within the LSA. The loss of between 28 and 49% of suitable over the long-term equates to a medium magnitude effect. This species is not known to be resilient to anthropogenic change, and loss of habitat (specifically resulting from urban development) is one of the main threats to badgers (*jeffersonii* Badger Recovery Team 2006; Nixon et al. 2008; Ontario American Badger Recovery Team 2010).

Habitat loss is anticipated to have a not significant (minor) effect on bats within the LSA. The loss of between 15 and 35% of potentially suitable roosting habitat within the LSA equates to a minor to medium magnitude effect. A magnitude of minor was chosen as hibernating habitat is considered to be a limiting habitat feature for bats (COSEWIC 2004a; COSEWIC 2013; US Fish and Wildlife Service (USFWS) 2007; Dixon 2010; Salata 2012), and no hibernacula were located in the LSA. As bats can often be found roosting in man-made structures (Agosta 2002; Lučan and Hanák 2011), and are known to be resilient to human disturbance, local bat populations are not anticipated to be affected in a noticeable way from habitat loss.

Habitat loss is anticipated to have a not significant (minor) effect on mule deer within the LSA. The loss of between 4 and 18% of critical DWR within the LSA equates to a negligible to minor

magnitude effect. While deer have specific habitat requirements in winter, the loss of DWR will occur only in the most eastern portion of the range. As at least 82% of this critical area will remain undisturbed, and as deer are resilient to human disturbance, the local populations are not anticipated to be affected in a noticeable way from habitat loss.

Sensory disturbance of denning badgers is anticipated to have a not significant (minor) effect within the LSA. The potential disturbance to individuals in their dens will have a minor magnitude in that the conditions are anticipated to vary from baseline only slightly (blasting to occur only once per day).

Disruption of movement of badgers within the LSA is anticipated to have a not significant (minor) effect. Badger habitat within the area is already fragmented from past activities (mines, roads) and the area is at the edge of the Thompson Badger Population Unit. While disruption of movement may decrease use in the area, habitat loss is anticipated to have the greatest impact on the badger's ability to meet its life requisites.

Chemical hazards for bats are anticipated to have a not significant effect within the LSA. Occasional ingestion of this water may not cause any negative effects in bats, however, long-term, repeated exposure has the potential to negatively impact populations in the area.

6.17.5.5 Characterization of Likelihood and Confidence

In the characterization of residual effects, significance, likelihood and confidence on mammals (Table 6.17-22), the greatest potential adverse effects on any indicator species were selected for each of the parameters. The specific characterization of likelihood and confidence for each indicator will be discussed below.

The probability and confidence of habitat loss on American badger were ranked high and medium, respectively. Probability was ranked high as suitable badger habitat within the Project IF will be removed, and removed habitat equates to habitat loss. Confidence was ranked medium as the amount of habitat loss is known, but the amount of suitable habitat required to meet all American badger life requisites is unknown.

The probability and confidence of habitat loss on bats were ranked medium and low, respectively. Probability was ranked medium as foraging bat habitat is located throughout the IDA, and most of this habitat will likely not actually be removed, only the habitat within Project IF. Confidence was ranked low as the distribution of other critical habitat features that may be more limiting to bats (e.g., hibernacula) in the LSA and RSA are unknown.

The probability and confidence of habitat loss on mule deer were ranked medium and high, respectively. Probability was ranked medium as critical DWR is located on the western edge of the IDA, and most of this habitat will likely not actually be removed, only the habitat within Project IF. Confidence was ranked high as deer are a resilient species to anthropogenic activities, and the amount of potentially removed habitat will not be so great as to have a noticeable effect on this species.

The probability and confidence of sensory disturbance on American badgers was ranked medium and low, respectively. Probability was ranked medium as the activities that will cause noise will

occur, but the distribution of individuals in these disturbed areas is unknown. Confidence was ranked low as effects of anthropogenic noise on this species is not well understood. Studies suggest that badgers may be sensitive to human disturbance, but also that they are able to habituate relatively quickly. The effect, therefore, is likely, but may not occur.

The probability and confidence of disruption of movement for American badger were both ranked medium. Probability was ranked medium as the location of badger home range in the LSA are not well understood, making it difficult to determine if movements will be impeded. Confidence was ranked medium as data concerning badger home range in the LSA is incomplete, so the full extent of this effect cannot be fully understood.

The probability and confidence of chemical hazards for bats were ranked medium and low, respectively. Probability was given this ranking as potentially toxic water will be present in the IDA, but bat distribution in this area is not well understood. Confidence was ranked low as the likelihood of bats using contact water as source of drinking water remains unknown, as do the long term implications of the ingestion of said water.

6.17.5.6 Summary of Residual Effects Assessment and Significance

Four residual effects are anticipated to occur on the VC "Mammals" as a result of various Project activities and after the implementation of mitigation measures (Table 6.17-23). Habitat loss is anticipated to have a not significant (moderate) effect on American badger and a not significant (minor) effect on bats and deer within the LSA. Sensory disturbance is anticipated to have a not significant (minor) effect on denning American badger within the LSA. Disruption of movement is anticipated to have a not significant (minor) effect on badgers traveling throughout their home range in the LSA. Chemical hazards are anticipated to have a not significant (minor) effect on bats who may consume contact water in the IDA within the LSA.

Table 6.17-23. Summary of Residual Effects, Mitigation, and Significance on Mammals

Residual Effects	Project Phase	Mitigation Measures	Significance
Habitat Loss (American Badger, Bats, Mule Deer)	Construction	Reclamation/revegetation / installation of bat boxes	Not Significant (moderate)
Sensory Disturbance (American Badger)	Construction, Operation	Limit noise to certain windows (avoid sunrise/sunset)	Not Significant (minor)
Disruption of Movement (American Badger)	Construction, Operation, Closure	Maintain habitat across landscape, where possible; continued monitoring of local population	Not Significant (minor)
Chemical Hazards (Bats)	Construction, Operation, Closure	Continued monitoring of water quality, buoys/netting/duckweed added to TSF	Not Significant (minor)

These residual effects will be carried forward into the cumulative effects assessment section, and discussed in relation to other projects within the RSA (Section 6.17.6).

6.17.6 Cumulative Effects Assessment

6.17.6.1 Introduction

The cumulative effects assessment (CEA) considers the effects on wildlife and wildlife habitat that are likely to result from the residual environmental effects of the Project in combination with the effects of other projects and activities (past, present, or future) within the RSA. The CEA methodology is based on the framework outlined by the *Canadian Environmental Assessment Act* (1992) guidelines (Hegmann et al. 1999) with additional guidance provided in the AIR.

Past land use (e.g., agriculture, forestry, urban development) has shaped much of the region's current wildlife habitat abundance and distribution, and, in turn, has shaped how wildlife uses the landscape. Many past, present and future projects have, and will continue to contribute to the amount of various mammal habitat types in the RSA. Several projects have been identified as occurring in the region, and could potentially interact with the Project. Each of these projects will be considered in combination with the result of our residual effects assessment to determine if there is an interaction, and consequently, if there is the potential for a cumulative residual effect to occur. These interactions can include direct, indirect, additive and synergistic effects. To be included in the CEA projects must occur within the RSA, must have a residual effect, and must have the potential to act cumulatively with the residual effects for mammals described in Section 6.17.5.

6.17.6.2 Identification of Other Actions That May Affect Mammals

A list of past, present, and anticipated future projects and activities known to occur in the region were provided (Table 6.17-24, Figure 6.17-14). Projects/activities were initially scoped out if there was no perceived spatial interaction (i.e., the project/activity occurs outside of the RSA). Other projects/activities were scoped into the CEA on a VC by VC basis. If a residual effect from the Project was determined, the likelihood of other projects/activities resulting in the same effect were assessed using reports generated from those projects/activities; in the absence of any data indicating specific effects, professional judgement was used. Other projects/activities considered for cumulative effects on mammals are listed below.

6.17.6.3 Project Effects and Other Project or Activity Effects

Habitat loss, sensory disturbance, disruption of movement, and chemical hazards are all potential effects that may be compounded by other projects/activities in the region. Habitat loss associated with past, present and future project activities cannot be quantified. In the majority of cases, no information is available on total habitat loss. Consequently, a qualitative analysis was conducted to determine potential interactions based on professional judgement, location of these projects/ activities, and the sensitivity of specific mammals to habitat loss. Sensory disturbance is not anticipated to be compounded by other projects/activities in the region as there are no other known high intensity, short duration noise (blasting) events expected to occur.

Table 6.17-24. Ranking Potential for Residual Effects to Interact Cumulatively with Effects of Other Human Actions on Mammals

Residual Effect	Industrial Projects/Activities													Natural Resources & Land Use			Tourism and Commercial Recreation Activities					Community Infrastructure			Transportation					
	Vidette Lake Mine	Afton Mine (Historical)	Iron Mask Mine	Bonaparte Mine	New Afton Mine (New Gold)	Highland Valley Copper Mine (Teck)	Domtar Kamloops Pulp Mill	Tolko-Hefley Creek Plywood and Veneer	LaFarge Cement Plant	Trans Mountain Pipeline System (Kinder Morgan)	Trans Mountain Pipeline System - Expansion (Kinder Morgan)	Harper Creek	Highland Valley Copper – Bethlehem Expansion	Kamloops Forest District	Agriculture	Ranching	Tranquille on the Lake	Lac Le Jeune Resort	Tobiano Golf Course	Recreational Hunting, Fishing, Foraging	Recreational Trails	City of Kamloops Wastewater Management	Water Treatment Centre	City Expansion and Growth	Lac le Jeune Road	Highway 1	Highway 5A	Highway 5 (Coquihalla Highway)	Kamloops Airport	Rail Yards and Lines (CP and CN)
Habitat Loss	-	O	O	-	O	-	O	-	-	O	L	-	-	L	M	M	-	-	O	O	O	-	-	M	O	O	O	O	-	O
Vibration	-	O	O	-	O	-	O	-	-	O	O	-	-	O	O	O	-	-	O	O	O	-	-	O	O	O	O	O	-	O
Movement	-	O	O	-	O	-	O	-	-	O	O	-	-	O	O	O	-	-	O	O	O	-	-	O	O	O	L	O	-	O
Chemical Hazards	-	O	O	-	L	-	O	-	-	O	O	-	-	O	O	O	-	-	O	O	O	-	-	O	O	O	O	O	-	O

Notes:

O *No interaction anticipated.*

L *Negligible to minor interaction expected; implementation of best practices, standard mitigation and management measures; no monitoring required, no further consideration warranted.*

M *Potential moderate interaction requiring unique active management/monitoring/mitigation; warrants further consideration.*

H *Key interaction; warrants further consideration.*

Existing mine pits in the area (e.g., Afton, Crescent-Afton, Pothook and Ajax, Iron Mask) would have likely removed suitable habitat for badgers as they occur within grassland areas. These projects, however, were considered as baseline conditions for the purpose of this assessment. Construction of Lac le Jeune Road, Highway 5A, and the TransCanada Highway occurred previous to 1950, while the Coquihalla Highway was built in the early 1980s. The construction of these roadways, as well as other existing projects (e.g., Domtar), were also considered as part of baseline conditions.

The New Afton Mine, an underground copper-gold mine on the site at the former Afton open pit mine, may be a risk of a chemical hazard for bats. The tailings facility for this project may be used by bats as a source of drinking water. Potential mitigation measures taken by this mine to avoid this interaction are unknown, so the potential for an interaction was assumed to occur.

Agriculture and forestry have occurred in the region since the 1800s. Habitat loss associated with both of these activities is assumed to have occurred, although it cannot be quantified. Agriculture is assumed to have removed grassland habitat for badger, while forestry is assumed to have removed areas of suitable winter habitat for mule deer and some general habitat for bats (Table 6.17-24).

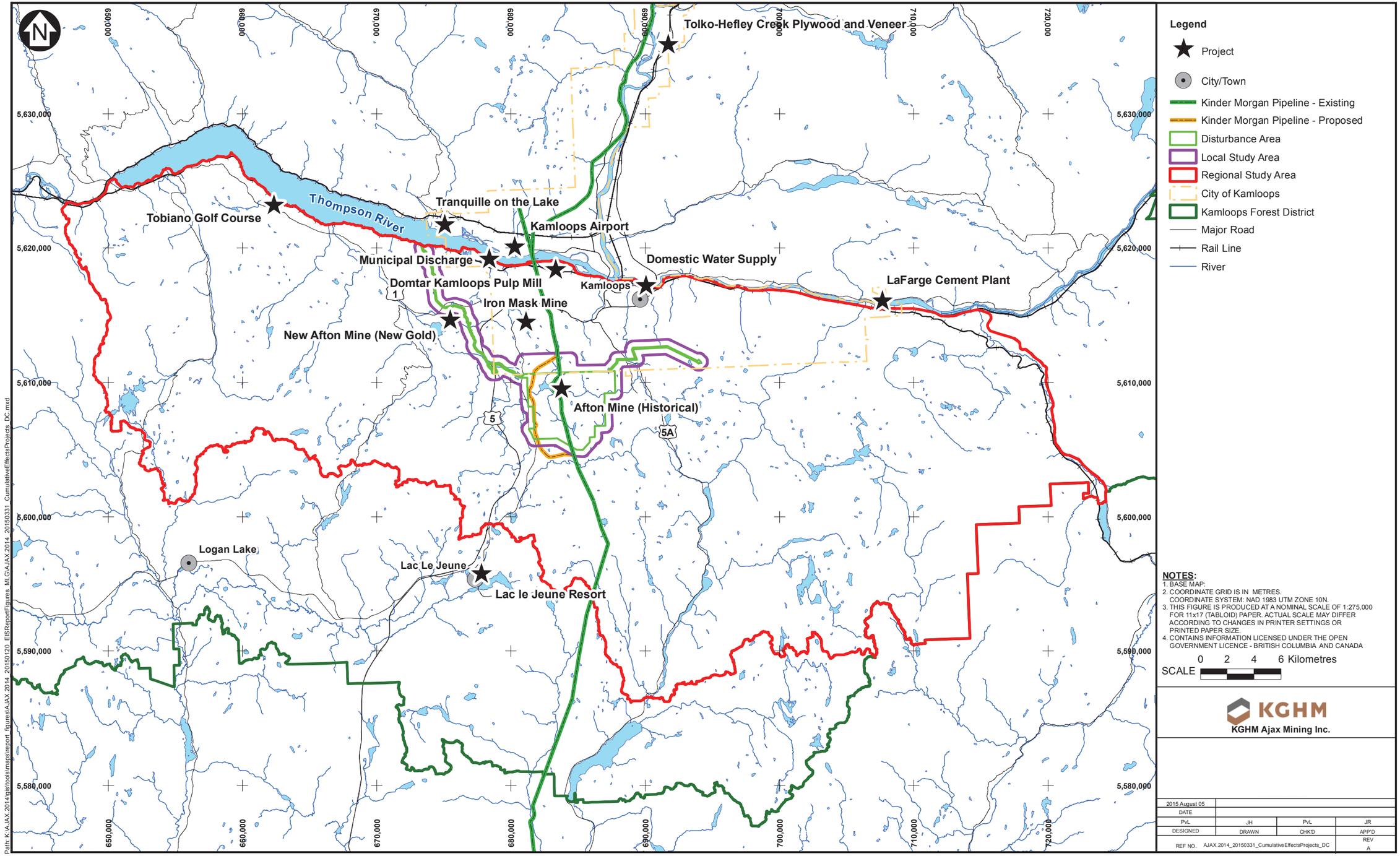
Construction of Lac le Jeune Road occurred previous to 1950, and the Coquihalla Highway was built in the early 1980's. American badger and mule deer all have areas of suitable habitat on both sides of the Coquihalla. As both Lac le Jeune Road and the Coquihalla Highway bisect areas of known suitable habitat, it is anticipated that badgers and deer lost some amount of habitat as a result of the construction of both of these roadways (Table 6.17-24). Quantification of this loss, however, is not possible based on the information available. Disruption of badger movement between areas of suitable habitat may also have occurred as a result of the construction of these roads.

Future projects/activities, such as the expansion of the City of Kamloops, specifically the growth of Aberdeen (neighbourhood adjacent to LSA) and the Southwest Industrial Area, as well construction of Kinder Morgan's TransMountain pipeline, will likely result in additional habitat loss of both badgers and bats (Table 6.17-24). Aberdeen is expected to continue expanding, from an approximate population of 10,000 people in 2011 to over 16,000 by 2036 years (TRUE Consulting Group 2008; City of Kamloops 2012). If approved, construction of the TransMountain pipeline twinning is anticipated to commence as early as 2016. Construction of this project would likely result in badger and deer habitat loss. The amount of habitat lost as a result of this project will likely be relatively small within the region.

6.17.6.4 Proposed Mitigation Measures

As KAM has limited authority to guide regional initiatives to support the diversity and persistence of habitat, this would be better guided by the provincial government.

Figure 6.17-14
Cumulative Effects Regional Study Area



Habitat Loss

Habitat loss is anticipated for badgers, bats and mule deer. Mitigation for the impacts of the Project on habitat loss consisted of avoiding sensitive sites, mine site reclamation, installing bat boxes, and enhancing suitable badger habitat on KAM owned lands, outside of the LSA. This was not sufficient to reduce the total loss of habitat. Additional habitat loss mitigation will be required to compensate for the cumulative loss of habitat in the RSA. KAM will partner with the *Grassland Conservation Council* (GCC) *of British Columbia* as well as the *Nature Conservancy of Canada* (NCC) to enhance existing grassland habitat within the RSA. Discussions with the provincial government will be initiated in an effort to develop Wildlife Habitat Areas (WHAs) on KAM owned land. The provincial *Recovery Strategy for the American Badger, jeffersonii Subspecies in Canada* (*jeffersonii* Badger Recovery Team 2008) as well as the *National Recovery Strategy for American Badger, jeffersonii Subspecies* (*jeffersonii* Badger Recovery Team 2005) provide a list of existing and recommended approaches to habitat protection that should be followed. Habitat loss cannot fully be mitigated, and therefore will be carried forward and evaluated in Section 6.17.6.5.

Sensory Disturbance

Mitigation to reduce sensory disturbance to badgers and bats consisted of ensuring the timing of blasting does not correspond to times of day when foraging may occur, and optimizing and adjusting equipment and site layout to minimize noise. Traffic noise cannot be fully mitigated, only minimized. Traffic noise throughout the RSA cannot be controlled by KAM, and therefore, cannot be mitigated. Any mitigation measures taken will not be sufficient to fully reduce the potential impact of noise on badgers and bats. As a result, any habitat compensation or offsets should be located in areas situated away from known or anticipated anthropogenic disturbance to minimize the potential for further sensory disturbance to mammals. Sensory Disturbance cannot fully be mitigated, and therefore will be carried forward and evaluated in Section 6.17.6.5.

Disruption of Movement

Disruption of movement is anticipated for badgers as a result of the Project and cannot be mitigated. The construction and continued use of both Lac le Jeune Road and the Coquihalla Highway have likely caused a disruption of badger movement. The Coquihalla is much wider and has a much larger daily volume of traffic traveling it. This highway was therefore considered a greater barrier to movement than Lac le Jeune Road. Wildlife crossing areas are present along the Coquihalla (Sielecki 2010a), and may offset the disruption of movement of badgers throughout their home ranges. Additional crossing structures may be installed in areas where badgers are likely to encounter a barrier. Further surveys to determine badger home range and distribution in the Project area will help identify areas where these structures may be beneficial.

Disruption of movement cannot fully be mitigated, and therefore will be carried forward and evaluated in Section 6.17.6.5.

Chemical Hazards

Mitigation to reduce the effects of chemical hazards to bats consisted of continued monitoring of water quality within the LSA, with the addition of foreign objects (e.g., duckweed, buoys, nets) to

the TSF to dissuade bats from using it as a source of drinking water if levels of chemicals were determined to be cause for concern. The tailings storage of the New Afton Mine, as well as from existing mine sites, may increase the likelihood of bats ingesting contaminated water in the region. Contaminant levels from these projects are unknown. Similar mitigation measures as are in place for the Ajax Project could also be implemented for the other tailings areas in the RSA.

Chemical hazards cannot fully be mitigated, and therefore will be carried forward and evaluated in Section 6.17.6.5.

6.17.6.5 Evaluation of Significance of Residual Cumulative Effects

After the implementation of mitigation measures, three cumulative residual effects are anticipated to occur. The loss of suitable bat habitat associations within the RSA as a result of the Ajax Project represents only 0.8% of the old and mature forest (up to 592 out of 78,474 ha, as mapped using VRI) identified in the RSA. The loss of critical DWR within the RSA as a result of the Project represents only 0.4% of the critical DWR (up to 154.4 out of 37,255 ha) and 0.7% of the draft mule deer winter range planning cells (up to 234.4 of 35,912 ha) identified in the RSA. As these areas are relatively small, as the majority of forested areas throughout the RSA have no proposed development on them, and as mitigation measures have been outlined to reduce this impact, a cumulative residual effect for habitat loss on bats and deer is not anticipated. The loss of higher proportions of badger habitat (28–49% of the RSA) cannot be mitigated and may result in a cumulative residual effect (Table 6.17-25).

Table 6.17-25. Summary of Cumulative Effects Mitigation Measures and Residual Effects on Mammals

Ajax Project Activity	Other Human Action Activity	Description of Potential Cumulative Effect	Description of Mitigation Measure(s)	Description of Residual Cumulative Effect
Clearing/Grubbing, Earthworks	Construction of other project infrastructure	Loss of suitable habitat	Reclamation/revegetation, Sensitive site avoidance. Partnering with GCC, NCC to enhance existing grasslands. Discuss creation of WHAs on KAM owned land with provincial government.	Reduction in available habitat (Badger)
Drilling/Blasting, Crushing/Hauling Mine Rock, Road Noise	Access to other project sites/ activities, existing motorways	Sensory disturbance due to loud, short duration noises/ Sensory disturbance associated with traffic on project and public roads	Limit noise to certain windows (avoid sunrise/sunset). Habitat creation to occur away from areas of anthropogenic disturbance.	Uncertain, may cause difficulty in locating prey/detecting predators, may disturb roosting/ hibernating individuals

(continued)

Table 6.17-25. Summary of Cumulative Effects Mitigation Measures and Residual Effects on Mammals (completed)

Ajax Project Activity	Other Human Action Activity	Description of Potential Cumulative Effect	Description of Mitigation Measure(s)	Description of Residual Cumulative Effect
Hauling, mine roads	Existing motorways	Reduced ability to travel between areas of suitable habitat	Additional Wildlife Crossing Structures in areas determined to be beneficial for badger movement.	Individuals may require more energy to travel within home range, or may have difficulty locating a mate (Badger)
Contact water	Release of hazardous materials into environment	Accumulation of toxic/hazardous materials over time	Continued monitoring of water quality, netting/buoys/ duckweed addition to TSF.	Individuals may suffer reduced fitness or illness a result of exposure to various chemicals (Bats)

Sensory disturbance on badgers and bats from Project activities may be mitigated by minimizing these activities to specific windows. However, limiting road traffic in the region is not practical, and may result in a cumulative residual effect to foraging bats (Table 6.17-25). No other loud blasting or drilling noises are known to currently occur within the RSA, nor are any expected from upcoming projects/activities. A cumulative residual effect for sensory disturbance on American badger is not anticipated.

Disruption of movement is anticipated to already occur for badgers within the RSA. As their habitat becomes fragmented, the ability to move between areas becomes increasingly difficult. The Coquihalla Highway, TransCanada Highway (#1), Highway 5A, and Lac le Jeune Road have been barriers to movement for decades. The Ajax Project may further compound this issue.

Chemical hazards are present on the landscape within the RSA. Tailings produced by the New Afton Mine may be ingested by bats, potentially resulting in an accumulation of toxic/hazardous materials in this species group. As mitigation for this effect on this species is unknown for the New Afton Mine, a cumulative residual effect may result.

Four residual cumulative effects are anticipated on mammals as a result of the Ajax Project and other projects/activities occurring throughout the region (Table 6.17-26). Habitat loss has, and will continue to occur for American badgers. Habitat loss for badgers was ranked not significant (moderate) as although this species is sensitive to habitat loss, a considerable amount of suitable habitat likely exists within the RSA to the southeast of the Project. The area southeast of the Project is composed of large patches of grassland that have not been heavily disturbed (Figure 6.17-15).

Sensory disturbance is anticipated for one mammal indicator species, American badger. Road noise and other noisy Project activities, combined with noise from roads throughout the region and noise from various other project activities, may reduce foraging abilities in bats. Sensory disturbance on foraging bats was ranked not significant (minor) as the amount of potential bat habitat that will not be located in proximity to road noise is relatively large throughout the RSA.

Table 6.17-26. Characterization of Cumulative Residual Effects, Significance, Likelihood and Confidence on Mammals

Residual Effect	Residual Effects Characterization Criteria							Significance of Adverse Residual Effects	Likelihood and Confidence	
	Magnitude	Duration	Frequency	Geographic Extent	Reversibility	Resiliency	Context		Probability	Confidence
Habitat Loss (American Badger)	Medium	Long-term	Sporadic	Regional	Irreversible	Low	Neutral	Not Significant (moderate)	High	Medium
Sensory Disturbance	Minor	Far Future	Regular	Regional	Reversible Short-term	Neutral	Neutral	Not Significant (minor)	Low	Medium
Disruption of Movement (American Badger)	Minor	Far Future	Continuous	Regional	Irreversible	Neutral	Neutral	Not Significant (minor)	Medium	Medium
Chemical Hazards (Bats)	Minor	Far Future	Continuous	Regional	Reversible Long-term	Low	Neutral	Not Significant (minor)	Medium	Low

Disruption of movement is anticipated for American badger only. The construction of motorways (Coquihalla, TransCanada, Highway 5A, and Lac le Jeune Road) in the past would have fragmented badger habitat in the region. Disruption of movement was ranked not significant (minor) as only a small portion of these roadways cut through highly suitable badger habitat (Figure 6.17-15). The majority of American badger habitat within the RSA remains relatively undisturbed by any major roads.

Chemical hazards are anticipated for bats only. The presence of contact water at the New Afton Mine may lead to health concerns for bats, if contaminated water is the main drinking source. Chemical hazards were ranked not significant (minor) as many non-contaminated waterbodies occur throughout the RSA.

6.17.7 Conclusions

Mammals were assessed as a VC to determine likely interactions with specific Project activities and how these interactions would affect this species group. All potential effects (habitat loss, habitat alteration, sensory disturbance, disruption of movement, direct mortality, indirect mortality, wildlife attractants and chemical hazards) arising from each Project activity were identified and evaluated. After the implementation of mitigation measures, four Project-related residual effects and three cumulative residual effects were determined for mammals as a result of this Project, as well as in combination with other projects/activities, past, present, and future, occurring within the region (Table 6.17-27).

Table 6.17-27. Summary of Project and Cumulative Residual Effects, Mitigation, and Significance for Mammals

Residual Effects	Project Phase	Mitigation Measures	Residual Effect Significance	Residual Cumulative Effect Significance
Habitat Loss (American Badger, Bats, Mule Deer)	Construction	Avoidance of breeding sites through re-design where possible. Progressive reclamation/revegetation.	Not Significant (moderate)	Not Significant (moderate)
Sensory Disturbance (American Badger)	Construction, Operation	Limit noise to certain windows (avoid sunrise/sunset) where possible	Not Significant (minor)	Not Significant (minor)
Disruption of Movement (American Badger)	Construction, Operation	Wildlife Crossing Structures in sensitive travel areas, if determined to be beneficial for badger movement	Not Significant (moderate)	Not Significant (minor)
Chemical Hazards (Bats)	Construction, Operation, Closure	Continued monitoring of water quality, netting/buoys/duckweed addition to TSF	Not Significant (minor)	Not Significant (minor)

Habitat loss, sensory disturbance, disruption of movement, and chemical hazards were all considered Project-related residual effects, while habitat loss, disruption of movement and chemical hazards were considered cumulative residual effects. The magnitude and geographic extent of these effects differs as the scale at which they were assessed was much smaller for the Project-related residual effects than for cumulative residual effects (i.e., LSA vs. RSA). Duration of sensory disturbance differs as Project related noise will stop upon closure of the mine, but anthropogenic noise across the region will continue. Due to these differences, the likelihood and confidence, as well as the significance of the residual effects, also differs between assessments.

The loss of American badger habitat may result in a negative impact to this species. As badgers are Red-listed (extirpated, endangered, or threatened) in BC, the loss of suitable habitat could impact populations locally and regionally. Habitat loss is considered not significant (moderate) for this species for Project-related residual effects as about 28% of suitable habitat will be removed. Habitat loss is considered not significant (minor) for cumulative residual effects as suitable habitat still exists within the region, and that habitat has very little current or anticipated disturbances (projects/activities).

The loss of bat habitat will likely have a low impact effect on bats in the area, both locally and regionally. Habitat loss is considered not significant (minor) for bats for Project-related residual effects as an estimated 15% of identified habitat associated with bat roosting to be removed by the Project. Limiting habitat features (hibernacula) were not identified in the LSA, but these features may be present at Sugarloaf Hill, an area outside of the LSA but located in in close proximity to the Project. Habitat loss was not considered for cumulative residual effects as only 0.8% of roosting habitat associations in the RSA may be removed as a result of the Project.

The loss of critical DWR will not have a noticeable effect on deer populations in the area, either locally and regionally. Habitat loss is considered not significant (minor) for deer for Project-related residual effects as between 4 and 18% of identified DWR may be removed by the Project, with the majority of this limiting habitat type remaining unaltered. Habitat loss was not considered for cumulative residual effects as only 0.4% of critical DWR in the RSA may be removed as a result of the Project (Figure 6.17-16).

Sensory disturbance may result in a reduction of use of digs by badgers. Increased stress levels and/or decreased foraging efficiency may result from Project related noise. Sensory disturbance is considered not significant (minor) for this species for Project-related residual effects as the effect is easily reversible in the short-term, and a reduction in habitat use does not necessarily mean the habitat will be abandoned long-term.

Disruption of badger movement may result in increased energy expenditures and decreased reproductive success for this species. Disruption of movement is considered not significant (moderate) for Project-related residual effects as fragmented habitats may decrease badger populations, but individuals may shift home ranges in response to a disturbance. Disruption of movement is considered not significant (minor) for this species for cumulative residual effects as an abundance of unfragmented grassland habitat exists southeast of the Project, and that habitat does not have any anticipated projects/activities.

Chemical hazards present on the landscape may have a negative effect on various bat species. An increase of toxins in the system of bats may reduce overall health. Chemical hazards are considered not significant (moderate) for Project-related residual effects as repeated exposure to high concentrations of metals and other toxins may reduce the ability for this species group to persist on the landscape, but the long-term effects are not well understood. Chemical hazards were considered not significant (minor) for this species group for cumulative residual effects as a large amount of non-contaminated water exists throughout the RSA, with few projects/activities planned that would change this.

Figure 6.17-15
Badger Cumulative Effects

Tolko-Hefley Creek Plywood and Veneer
Thompson River
Tranquille on the Lake
Tobiano Golf Course
Kamloops Airport
Municipal Discharge
Domestic Water Supply
Domtar Kamloops Pulp Mill
Kamloops
LaFarge Cement Plant
Iron Mask Mine
New Afton Mine (New Gold)
Afton Mine (Historical)
Logan Lake
Lac Le Jeune
Lac le Jeune Resort

5,630,000
5,620,000
5,610,000
5,600,000
5,590,000
5,580,000
650,000
660,000
670,000
680,000
690,000
700,000
710,000
720,000

Legend
- Project
- Populated Place
- Kinder Morgan Pipeline - Existing
- Kinder Morgan Pipeline - Proposed
- Parks and Protected Areas
- Local Study Area
- Regional Study Area
- City of Kamloops
- Major Road
- Rail Line
- River
- Grassland Habitat
- Thompson Badger Population Unit

NOTES:
1. BASE MAP:
2. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 10N.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:275,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
4. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENCE - BRITISH COLUMBIA AND CANADA

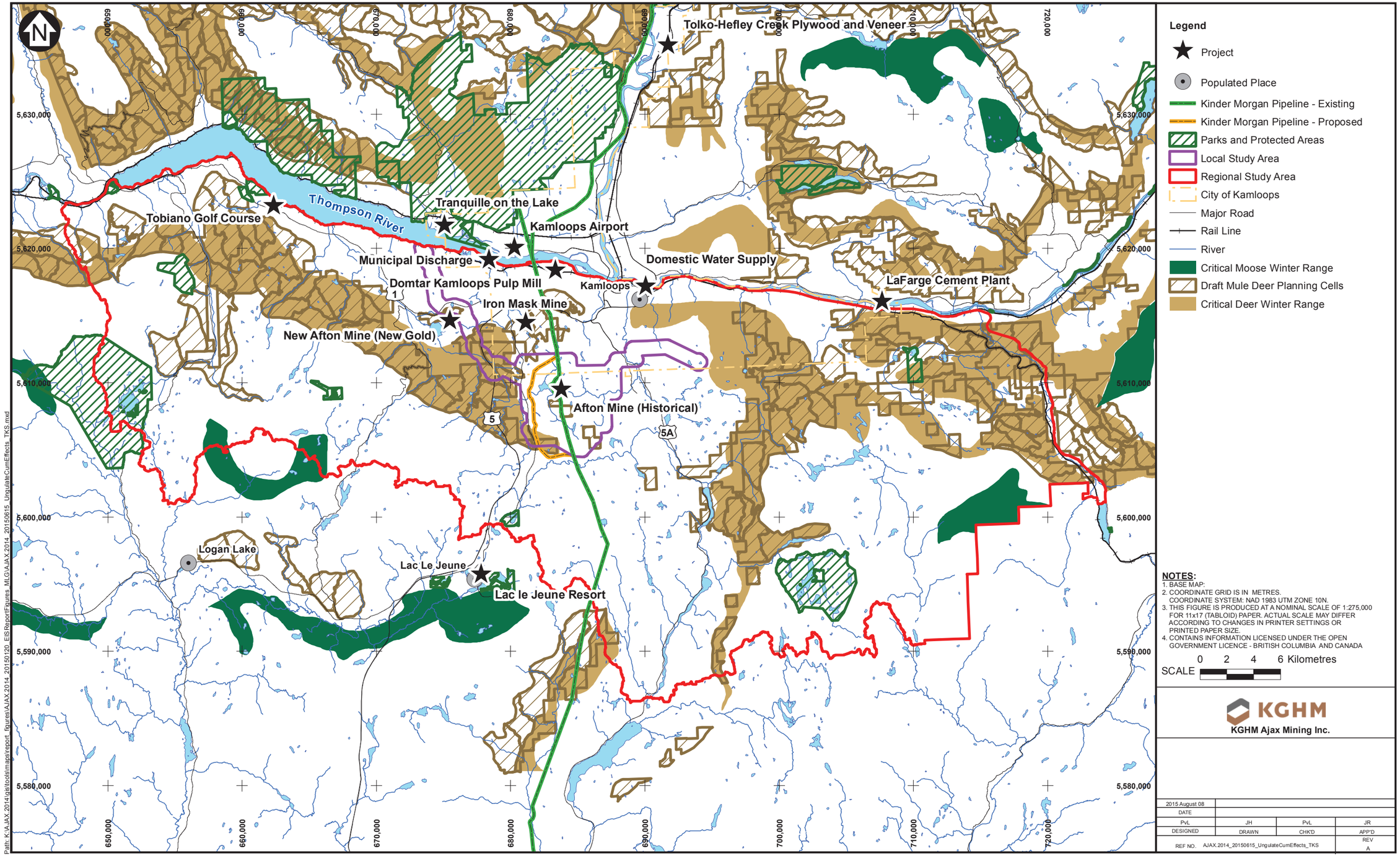
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KGHM Ajax Mining Inc.

2015 June 18			
DATE			
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Figure 6.17-16
Ungulate Cumulative Effects



NOTES:
1. BASE MAP:
2. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD 1983 UTM ZONE 10N.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:275,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
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KGHM Ajax Mining Inc.

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6.18 SUMMARY OF ASSESSMENT OF POTENTIAL ENVIRONMENTAL EFFECTS

Table 6.18-1 summarizes all residual Project and cumulative effects, significance determinations, and mitigation measures for the assessment of environmental Valued Components. Additional summary information is also provided in Chapter 18.

Table 6.18-1. Summary of Residual Project and Cumulative Effects and Mitigation Measures: Environmental

Residual Effect	Project Phase	Mitigation	Significance of Project Residual Effect	Significance of Cumulative Residual Effect
VC: Green House Gases (Section 6.1)				
Increase in atmospheric GHG of up to 123 kt CO2eq/yr during Construction and Operation due to Scope 1, 2 and 3 Emissions and Land Use Changes	Construction, Operation.	Access and haul roads designed to minimize distances. Larger trucks for ore and waste transport to minimize number of trips. Consider energy conservation in equipment procurement and selection. Consider the use of alternate fuels. Select the best achievable technology. Maintain vehicles in good operating condition. Utilize buses/multi-passenger vehicles to transport crews. Train equipment and vehicle operators to reduce GHG emissions. Operate vehicles within the posted maximum speed limits and reduce idling. Land clearing will be minimized for the Project where practical and economically achievable. Progressively re-vegetate or re-vegetate disturbed areas prior to Closure.	Not Significant (Minor)	Not Significant (Minor)
VC: Geology, Landforms and Soils (Section 6.2)				
Alteration of Baseline Landforms	Construction, Operation, Decommissioning and Closure.	Footprint minimization and re-contouring. Progressive reclamation.	Not Significant (Minor)	Not Significant (Minor)

Residual Effect	Project Phase	Mitigation	Significance of Project Residual Effect	Significance of Cumulative Residual Effect
VC: Surface Water Quality (Section 6.3)				
Humphrey Creek change in sulphate, copper, molybdenum, and selenium concentrations	All phases	Water Management Plan. SMRSF Pond – manage seepage and runoff from the southern extent of the SMRSF. Reclamation on SMRSF in Decommissioning and Closure with a low permeability till layer overlain with topsoil to reduce infiltration and maximize evapotranspiration and runoff. Dry cover on TSF to reduce infiltration into the underlying tailings solids and increase non-contact runoff. Air Quality Management Plan to reduce dust.	Not Significant (Moderate)	No residual effect
Change in sulphate concentrations in Peterson Creek at PC02.3.	All phases	Water Management Plan. Operations – interception of seepage from the EMRSF at EMRSF Pond, reclaimed to mill for Operations water demand. Reclamation of EMRSF in Decommissioning and Closure with a low permeability till layer overlain with topsoil to reduce infiltration and maximize evapotranspiration and runoff.	Not Significant (Minor)	No residual effect
Change in sulphate, chloride, and selenium concentrations in Peterson Creek at PC02.	All phases	Water Management Plan. Operations – interception of seepage from the EMRSF, reclaimed for Operations water demand. Reclamation of EMRSF in Decommissioning and Closure with a low permeability till layer overlain with topsoil to reduce infiltration and maximize evapotranspiration and runoff.	Not Significant (Moderate)	No residual effect
VC: Surface Water Quantity (Section 6.4)				
Change in surface water quantity (all metrics) in Kamloops Lake.	All phases	Water Management Plan. Maximize capture and re-use of contact water.	Not Significant (Minor)	Not Significant (Minor)

Residual Effect	Project Phase	Mitigation	Significance of Project Residual Effect	Significance of Cumulative Residual Effect
VC: Surface Water Quantity (Section 6.4) *(cont'd)*				
Change in surface water quantity (all metrics) in Peterson Creek (Lower) at PC02	Construction, Operation, Decom. and Closure	Water Management Plan. Operation of Peterson Creek Diversion System.	Not Significant .(Moderate)	Not Significant (Moderate)
Change in surface water quantity (low flow) in Peterson Creek (Lower) at PC02	Post-Closure	Water Management Plan. Re-establish Peterson Creek as natural draining.	Not Significant (Moderate)	Not Significant (Moderate)
Change in surface water quantity (annual flow volume, monthly flow distribution, peak flow) in Peterson Creek (Lower) at PC02	Post-Closure	Water Management Plan. Re-establish Peterson Creek as natural draining.	Not Significant (Minor)	Not Significant (Minor)
Change in surface water quantity (all metrics) in Jacko Lake	All phases	Water Management Plan. Operation of Peterson Creek Diversion System; Re-establish Peterson Creek as natural draining Post-Closure.	Not Significant (Minor)	Not Significant (Minor)
VC: Groundwater Quality (Section 6.5)				
Increases in Groundwater Fluoride, Sulphate, Copper, Iron, Manganese, Molybdenum, and Zinc Concentrations in RES-2 Well	Operation, Decommissioning and Closure, Post Closure.	Water Management Plan. TSF Design which includes an underdrain system in the embankment foundation, Liner system on the upstream face of the embankment overlying a low permeability glacial till basin liner. SMRSF Pond – manage seepage and runoff from the southern extent of the SMRSF. Reclamation of MRSFs in Decommissioning and Closure with a low permeability till layer overlain with topsoil to reduce infiltration and maximize evapotranspiration and runoff. Dry cover on TSF to reduce infiltration into the underlying tailings solids and increase non-contact runoff. Air Quality Management Plan to reduce dust.	Residual effects assessed in Human Health VC (Section 10.4) and Surface Water Quality VC (Section 6.3).	Residual effects assessed in Human Health VC (Section 10.4) and Surface Water Quality VC (Section 6.3).

Residual Effect	Project Phase	Mitigation	Significance of Project Residual Effect	Significance of Cumulative Residual Effect
VC: Groundwater Quantity (Section 6.6)				
Changes to magnitude or timing of groundwater recharge and discharge.	Operation, Decommissioning and Closure, Post Closure.	Water Management Plan. Water management ponds to collect seepage. Reclamation of MRSFs and TSF in Decommissioning and Closure to minimize seepage.	Not Significant (Moderate)	Not Significant (Moderate)
Changes to groundwater elevations, flow rates, or flow directions.	Operation, Decommissioning and Closure, Post Closure.	Water Management Plan. Water management ponds to collect seepage. Reclamation of MRSFs and TSF in Decommissioning and Closure to minimize seepage.	Not Significant (Moderate)	Not Significant (Moderate)
VC: Fish and Fish Habitat (Section 6.7)				
Direct loss of habitat in NE arm of Jacko Lake from Open Pit Development affecting the productivity of the fish population.	Operation, Decommissioning and Closure, Post Closure.	Offsetting Measures (proposed at Inks Lake). Fisheries and Aquatic Life Monitoring Plan.	Not Significant (Minor)	Not Significant (Minor)
Direct loss of habitat in Peterson Creek from Open Pit Development affecting the productivity of the fish population.	Operation.	Offsetting Measures (proposed at Inks Lake). Fisheries and Aquatic Life Monitoring Plan.	Not Significant (Minor)	Not Significant (Minor)
Indirect habitat loss in Peterson Creek downstream of the Project area from flow reductions associated with Project Footprint and Contact Water.	Operation, Decommissioning and Closure, Post Closure.	Water Management Plan. Fisheries and Aquatic Life Monitoring Plan. Surface Water Quality Management and Monitoring Plan.	Not Significant (Moderate)	No residual effect
Fish mortality in Jacko Lake associated with changes in pressure from blasting.	Operation	Blast Design. Fish and Aquatic Life Management Plan.	Not Significant (Minor)	No residual effect
Fish mortality in Jacko Lake associated with changes in pressure from installation of the sheet pile dam for Open Pit Development	Construction	Design in accordance with National Oceanic and Atmospheric Administration interim criteria for the onset of physical injury to fish.	Not Significant (Minor)	No residual effect

Residual Effect	Project Phase	Mitigation	Significance of Project Residual Effect	Significance of Cumulative Residual Effect
VC: Fish and Fish Habitat (Section 6.7) *(cont'd)*				
Sub-lethal effects on fish populations in Peterson Creek downstream of the Project area associated with changes in primary productivity from reduced flows resulting from Project Footprint and Contact Water.	All phases	Water Management Plan. Fisheries and Aquatic Life Monitoring Plan. Surface Water Quality Management and Monitoring Plan.	Not Significant (Minor)	Not Significant (Minor)
VC: Rare Plants (Section 6.8)				
Habitat loss.	Construction.	Avoidance through re-design where possible; Establish exclusion areas. Transplantation. Regional research on plant distribution. Invasive species management.	Not Significant (Moderate)	Not Significant (Moderate)
VC: Rare and Sensitive Ecosystems (Section 6.9)				
Habitat loss.	Construction.	Avoidance through re-design where possible. Establish exclusion areas. Erosion and sediment control. Avoid use of herbicides. Invasive species management. Wetland compensation/enhancement.	Not Significant (Moderate)	Not Significant (Minor)
VC: Grasslands (Section 6.10)				
Habitat loss.	Construction.	Limit construction footprint. Establish exclusion areas. Use appropriate reclamation seed mixes. Invasive species management. Progressive reclamation.	Not Significant (Moderate)	Not Significant (Minor)
VC: Terrestrial Invertebrates (Section 6.11)				
No residual effects				

Residual Effect	Project Phase	Mitigation	Significance of Project Residual Effect	Significance of Cumulative Residual Effect
VC: Amphibians (Section 6.12)				
Habitat Loss.	Construction.	Avoidance of breeding sites through re-design where possible. Establish exclusion areas. Erosion and sediment control. Avoid use of herbicides. Integration of amphibian habitat with wetland compensation efforts. Artificial diversion pools to attract amphibians away from the mine site infrastructure. Discuss creation of Wildlife Habitat Areas on KAM owned land with provincial government. Contribute to existing programs on spadefoots.	Not Significant (Moderate)	Not Significant (Minor)
Direct Mortality.	Construction, Operation.	Translocation of individuals to areas of suitable habitat. Work with BC Frogwatch Program to increase education of regional amphibian conservation.	Not Significant (Minor)	Not Significant (Minor)
Chemical Hazards.	All Phases	Installation of artificial 'diversion pools' to attract amphibians away from mine site infrastructure. Communicate water quality results with other projects in the RSA. Contribute to existing programs on spadefoots.	Not Significant (Minor)	Not Significant (Minor)
VC: Reptiles (Section 6.13)				
No residual effects				

Residual Effect	Project Phase	Mitigation	Significance of Project Residual Effect	Significance of Cumulative Residual Effect
VC: Migratory Birds (Section 6.14)				
Habitat Loss.	Construction.	Avoidance of breeding sites through re-design where possible. Fish offsetting and wetland compensation programs will support bird habitat.	Not Significant (Moderate)	Not Significant (Minor)
Chemical Hazards.	All Phases.	Removal of vegetation around TSF and MRSF to discourage bird nesting. Make attractive bird habitat at fish offsetting and wetland compensation areas to encourage nesting.	Not Significant (Minor)	Not Significant (Minor)
VC: Raptors (Section 6.15)				
Habitat Loss (Great Gray Owl, Rough-legged Hawk, Short-eared Owl, Swainson's Hawk).	Construction.	Avoidance of breeding sites through re-design where possible Progressive reclamation/revegetation. Artificial nest creation	Not Significant (Minor)	Not Significant (Minor)
Sensory Disturbance (Bald Eagle, Great Gray Owl, Short-eared Owl, Swainson's Hawk).	Construction, Operation.	Limit noise to certain windows (outside of breeding season, if practical)	Not Significant (Minor)	Not Significant (Minor)
VC: Non-migratory Gamebirds (Section 6.16)				
Habitat Loss (Sharp-tailed Grouse, ruffed Grouse).	Construction.	Avoidance of breeding sites through re-design where possible. Progressive reclamation/revegetation. Off-site lek enhancement or artificial lek creation.	Not Significant (Moderate)	Not Significant (Minor)
Decreased lek usage, or abandonment of nests due to sensory disturbance (Sharp-tailed Grouse - lek; Sharp-tailed Grouse and Ruffed Grouse - nest)	Construction, Operation.	Limit noise to certain windows (06:00 – 10:00, outside of breeding season, if practical).	Not Significant (Moderate)	Not Significant (Minor)

Residual Effect	Project Phase	Mitigation	Significance of Project Residual Effect	Significance of Cumulative Residual Effect
VC: Mammals (Section 6.17)				
Habitat Loss (American Badger, Bats, Mule Deer).	Construction.	Avoidance of breeding sites through re-design where possible. Progressive reclamation/revegetation.	Not Significant (Moderate)	Not Significant (Moderate)
Sensory Disturbance (American Badger).	Construction, Operations.	Limit noise to certain windows (avoid sunrise/sunset), where possible	Not Significant (Minor)	Not Significant (Minor)
Disruption of Movement (American Badger).	Construction, Operations,	Wildlife Crossing Structures in sensitive travel areas, if determined to be beneficial for badger movement.	Not Significant (Moderate)	Not Significant (Minor)
Chemical Hazards (Bats).	Construction, Operations, Decommissioning and Closure.	Continued monitoring of water quality, netting/buoys/duckweed addition to TSF.	Not Significant (Minor)	Not Significant (Minor)

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Definitions of the acronyms and abbreviations used in this reference list can be found in the Glossary and Abbreviations section.

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