13. Assessment of Potential Surface Water Quality Effects

13.1 INTRODUCTION

Water quality 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., Metal Mining Effluent Regulations [MMER; SOR/2002-2222] under the *Fisheries Act* [1985b]) legislation. Further, surface water quality of the Brucejack Gold Mine Project (the Project) has international transboundary implications, as the proposed mine location is situated within the Sulphurets Creek watershed, a tributary of the Unuk River which transverses Alaska and drains into the Pacific Ocean at Burroughs Bay. Water quality constitutes the physical, chemical, biological, and aesthetic characteristics of water which are, in turn, determined by a variety of regional and local factors including rock weathering, surface transport, biological activity, and anthropogenic influences. The chemical compositions of water and sediment will co-vary, with factors such as pH and temperature driving a dynamic and reversible exchange of elements and molecules between the water column and underlying sedimentary materials. Water quality is thus linked to important identified receptor Valued Components (VCs) including aquatic resources, fish and fish habitat, wildlife and wildlife habitat, and human health. As such, water quality in Project area lakes and streams is highly valued by Skii km Lax Ha, Nisg̱a'a Nation, Tahltan Nation, the Métis, local people, as well as the provincial and federal governments.

This chapter examines the potential effects of the Project on surface water quality due to the establishment of the mine and associated activities. A pre-development surface water quality baseline was conducted to allow for the prediction, assessment, mitigation and management of potential Project-related effects and was incorporated into mine and mine waste management planning. The baseline study report and water quality data (1987 to 2001, 2008 to 2013) are located in Appendix 13-A, Cumulative Surface Water Quality Baseline Report.

Alteration of surface water quality could potentially affect receptor VCs that have linkages with surface water quality. Effects of the Project on these receptor VCs are assessed in:

- Chapter 14, Assessment of Potential Aquatic Resources Effects;
- Chapter 15, Assessment of Potential Fish and Fish Habitat Effects;
- Chapter 17, Assessment of Potential Wetlands Effects; and
- Chapter 21, Assessment of Potential Health Effects.

13.2 REGULATORY AND POLICY FRAMEWORK

This section provides an overview of the relevant provincial and federal statutory framework, guidance documents, and policies related to potential Project-related surface water quality effects (summarized in Table 13.2-1).

Table 13.2-1. Summary of Applicable Statutes and Regulations for Potential Surface Water Quality Effects, Brucejack Gold Mine Project

Name	Level of Government	Description
Waste Discharge Regulation (BC Reg. 320/2004) under the *Environmental Management Act* (EMA; 2004)	Provincial (MOE)	The EMA provides the authorization framework to protect human health and the quality of water, land, and air in BC. Mine activities requiring authorization or registration under EMA include discharge of effluents to the aquatic receiving environment and the production, storage, treatment and discharge of prescribed quantities of hazardous waste.
British Columbia Approved and Working Water Quality Guidelines (BC MOE 2013a)	Provincial (MOE)	Water quality criteria are defined as maximum or minimum physical, chemical, or biological characteristics of water, biota or sediment; and are applicable province-wide. The guidelines are intended to prevent detrimental effects on water quality or aquatic life, under specified environmental conditions.
Mines Act (1996)	Provincial (MEM)	The BC *Mines Act* and its associated Health, Safety and Reclamation Code for Mines in BC require mines to have programs for the environmental protection of land and watercourses throughout mine life, including plans for prediction and prevention of metal leaching and acid rock drainage, and prevention of erosion and sediment release. Watercourses are required to be reclaimed, and the Ministry of Energy and Mines has the authority to require monitoring and/or remediation programs to protect watercourses and water quality.
British Columbia *Water Act*	Provincial (MMFLNRO)	Under the BC *Water Act*, the ownership of water is vested in the Crown; the Act provides statutes governing the allocation of water licences and controls the use of freshwater in the province of British Columbia. The Act also includes explicit environmental protection for waters flowing in a stream, lake, or other surface body of water.
Canadian Council of Ministers of the Environment (CCME) Sediment Quality Guidelines for the Protection of Aquatic Life (2013)	National	Environmental Quality Guidelines (EQGs) are intended to protect, sustain, and enhance the quality of the Canadian environment. Each jurisdiction determines the degree to which it will adopt CCME recommendations and EQGs should not be regarded as blanket values for national environmental quality; users of EQGs consider local conditions and other supporting information (e.g., site-specific background concentrations of naturally occurring substances) during the implementation. Science-based site-specific criteria, guidelines, objectives, or standards may, therefore, differ from the Canadian EQGs.
Metal Mining Effluent Regulations (SOR/2002-2222; under the *Fisheries Act*; 1985b)	National (DFO)	The MMER (SOR/2002-222) regulate the deposition of mine effluent if it is not within a defined pH range, if the concentrations of the MMER deleterious substances in the effluent do not exceed authorized limits, and if the effluent is demonstrated to be non-acutely lethal to rainbow trout. These discharge limits were established to be minimum national standards based on best available technology economically achievable at the time. To assess the adequacy of the effluent regulations for protecting the aquatic environment, the MMER include EEM requirements to evaluate the potential effects of effluent on fish, fish habitat, and the use of fisheries resources.
Other Guidance Documents and Regulations	Provincial and Federal	• Policy for Metal Leaching and Acid Rock Drainage at Minesites in British Columbia (BC MEM and BC MELP 1998) • Guidelines for Metal Leaching and Acid Rock Drainage at Mine sites 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) • *Canada Water Act* (1985)

13.3 BASELINE CHARACTERIZATION

13.3.1 Regional Overview

The Project area (56°28'20" N, 130°11'31" W) is located in the Boundary Ranges of the Coast Mountains of northwest British Columbia (BC), approximately 950 kilometres (km) northwest of Vancouver, 65 km north-northwest of Stewart, and 21 km south-southeast of the closed Eskay Creek Mine. Existing and proposed mine facilities are situated in the Brucejack Creek watershed (11.7 km^2), a small headwater sub-basin in the Sulphurets Creek watershed (299 km^2), a tributary of the Unuk River. Ancillary Project infrastructure is located within the watersheds of Knipple Lake, Bowser River, and Wildfire Creek/Scott Creek/Todedada watersheds (Off-site areas, Figure 13.3-1).

The Brucejack Lake watershed (mine site area) and downstream watercourses (Plate 13.3-1) constitute the primary focus of the Project water quality assessment and management strategy as Brucejack Lake will be used as a permanent disposal site for tailings and waste rock, as well as a source of process water. It is a deep glacial lake with an area of 81 hectares (ha), a maximum depth greater than 85 metres (m), and a short ice-free season between June and September (Friesen and Candy 2013). Brucejack Lake and its outflow, Brucejack Creek, are located at high elevation (~1,370 m above sea level) in the headwaters of Sulphurets Creek. Brucejack Lake occasionally receives outflow from East Lake, located east of Brucejack Lake and adjacent to Knipple Glacier, approximately 500 m from the eastern shores of Brucejack Lake. The outflow of East Lake has been observed to flow into Brucejack Lake on some occasions and underneath Knipple Glacier on others (Newhawk 1989). However, the predominant condition is for East Lake to discharge east, below the Knipple Glacier (Newhawk 1989).

a) Brucejack Lake (BJ)

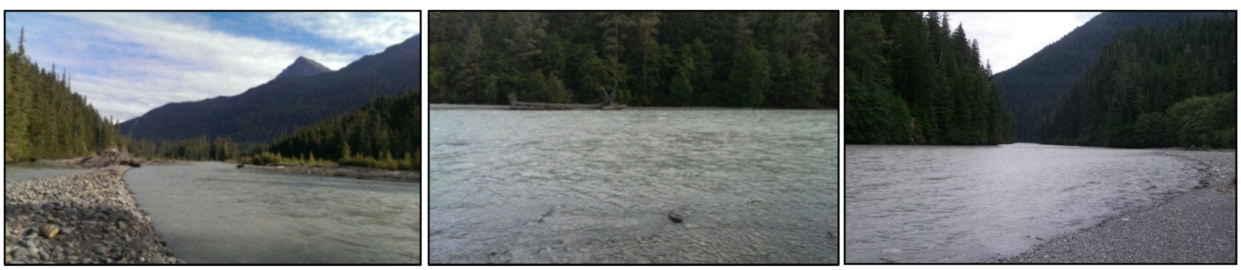
b) Brucejack Creek, upstream of Sulphurets Glacier (BJ U/S, BJ 2, BJ 3)

(continued)

Plate 13.3-1. Streams and lakes within the mine site area (Brucejack Watershed) and downstream receiving environment: a) Brucejack Lake, b) Brucejack Creek, c) Sulphurets Lake, d) Sulphurets Creek, e) Unuk River.

c) Sulphurets Lake (SUL)

d) Sulphurets Creek, downstream of Sulphurets Lake (aerial; SC1, SC3)

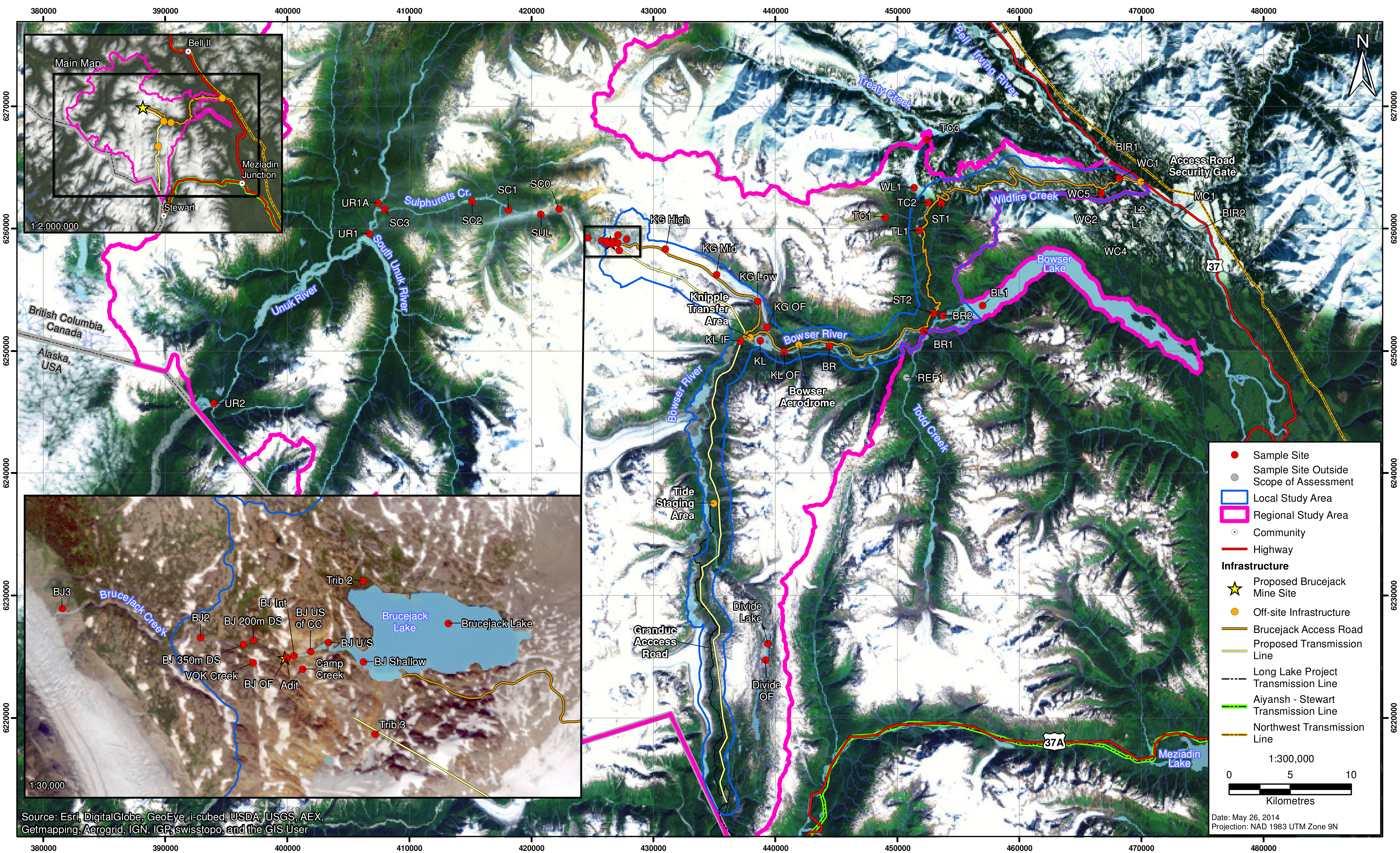


e) Unuk River (UR1A, UR1, UR2)

Plate 13.3-1. Streams and lakes within the mine site area (Brucejack Watershed) and downstream receiving environment: a) Brucejack Lake, b) Brucejack Creek, c) Sulphurets Lake, d) Sulphurets Creek, e) Unuk River (completed).

The outlet of Brucejack Lake is at the west end of the lake, where the lake discharges to Brucejack Creek (Figure 13.3-1; Plate 13.3-1). Brucejack Creek flows west in a braided channel in alluvial deposits for approximately 1 km, then pours through a bedrock-confined canyon containing several waterfalls, chutes and rapids before plunging beneath Sulphurets Glacier, joining the sub-glacial drainage channel of Sulphurets Creek for a further 4 km (Newhawk 1989). Sulphurets Creek emerges from the toe of the Sulphurets Glacier, flows into Sulphurets Lake (drainage area 84 km^2), and then extends from the outlet of Sulphurets Lake to the creek's confluence with the Unuk River (drainage area 400 km^2), eventually discharging into the Pacific Ocean northeast of Ketchikan, Alaska (drainage area 2,577 km^2 at mouth). Along its flow path to its confluence with the Unuk River, Sulphurets Creek flows receive inputs from several tributaries, the largest being Mitchell Creek.

Figure 13.3-1
Water Quality Baseline Study Area, Brucejack Gold Mine Project



Project infrastructure in off-site areas includes the Knipple Transfer Area, Bowser Aerodrome, Tide Staging Area as well as the access and transmission-line corridors (ancillary Project infrastructure, Figure 13.3-1). The Bowser Aerodrome and Knipple Transfer Area are both located within the Bowser River watershed, with the transfer area located very near to the terminus of the Knipple Glacier (Figure 13.3-1). Knipple Glacier flows in a southeastern direction and terminates at Knipple Lake, which feeds the Bowser River (Plate 13.3-2). The Bowser River originates southwest of Knipple Lake at Berendon Glacier Lake and Betty Creek, and flows through several lake sections, including the glacier terminus lake for the Frank Mackie Glacier, before reaching Knipple Lake. Downstream of Knipple Lake, the Bowser River flows east to Bowser Lake; the Bowser River confluence with the southerly flowing Scott Creek is just west of Bowser Lake. Bowser Lake has a length of 23 km and a surface area of 3,610 ha (Coombs 1988).

a) Knipple Lake (KL)

b) Bowser River (BR1)

c) Scott Creek (ST 2)

d) Todedada Lake

e) Todedada Creek (TC2)

f) Wildfire Creek (WC1)

Plate 13.3-2. Streams and lakes, from upstream to downstream, within the Bowser, Scott Creek, Todedada Creek, and Wildfire Creek Area, sampled as part of the 2008 to 2013 surface water quality baseline study for the Brucejack Gold Mine Project.

The existing exploration access road between Highway 37 and the proposed mine site area traverses the Wildfire Creek (tributary of Bell-Irving River), Todedada Creek (tributary of Treaty Creek), Scott Creek (tributary of Bowser River) and Bowser River watersheds (Figure 3.1-1). Wildfire Creek, Bowser River, and Treaty Creek drain into the Bell-Irving River (drainage area 5,330 km^2) which eventually flows into the Nass River (21,483 km^2 at mouth) which drains into the Pacific Ocean at Portland Inlet. The Knipple Glacier, on which ~11 km of the existing exploration access road is routed, also drains to the Bowser River. West of the Knipple Glacier, the exploration access road enters the Brucejack Lake watershed and extends a final 3 km to the Project's mine site area at elevation ~1400 m above sea level.

A transmission line will connect the mine site to the provincial power grid. Two potential alignments were considered, a south option and an east option, with the south option being preferred. The south transmission line option was selected in late 2013 as the only viable option based on feasibility and other studies; this route follows the Bowser River south, crossing over into the watershed of the Salmon River which flows into the Pacific Ocean at Hyder, Alaska (Figure 13.3-1).

13.3.2 Historical Activities

Several historical and current human activities occur both within and in proximity to the proposed Project Area. These include mining exploration and production, hydroelectric power generation, forestry, as well as road construction and use. Historical activities with likely interactions with current surface water quality conditions within the mine site area are summarized in Table 13.3-1. The mine site area (Brucejack watershed) itself is an advanced exploration site with a long history of mineral exploration that included underground exploration (5 km of underground workings developed) and excavation of a bulk sample by Newhawk Gold Mines Ltd. (Newhawk; 1986 to1990).

Table 13.3-1. Summary of Exploration and Mining Activities within the Brucejack Watershed, 1935 to 2013

Period	Activity
1935	Discovery of Cu-Mo mineralization on the Sulphurets Property, ~6 km northwest of Brucejack Lake; these claims were staked in 1960.
1935-1959	Project area inactive with respect to prospecting.
1960-1979	Granduc exploration, lithogeochemical sampling, trenching and diamond drilling north and northwest of Brucejack Lake.
1980	Esso Minerals Canada Ltd. (Esso) optioned the Property from Granduc; completed an extensive program consisting of mapping, trenching, and geochemical sampling.
1982-1983	Exploration and drilling activities confined to Au- and Ag-bearing vein systems in the Brucejack Lake area at the southern end of the property, including the Near Shore and West zones, located 800 m apart near Brucejack Lake. Drilling started on the Shore Zone.
1982-1985	Small-scale mining of the Catear (Goldwedge) area (Catear Creek a tributary of Brucejack Lake); included on-land and lake disposal of an un-quantified volume of waste rock and approximately 4,000 t of tailings from a small underground mine.
1986-1999	Various operators explored the Sulphurets Property; an underground program was completed on the West Zone of the Brucejack Property by the Newcana JV.; waste rock placed as shallow pad along the southern boundary of Brucejack Creek (~124,000 t).
1986-1989	Adit excavation and active de-watering of underground water.
1990	Project halted due to economic constraints, underground workings allowed to flood.
1990- May 2011	Adit passively draining into Brucejack Creek.
July 27 to Aug. 27, 1999	Waste rock and lime deposition in Brucejack Lake (~124,000 t).
2009-2010	Silver Standard Exploration
May 1, 2011 to present	Current exploration and drilling program (Pretivm).
Nov. 6 to Dec. 5, 2011	Underground dewatering test, discharge to Brucejack Creek.
Sept. 1 to Dec. 31, 2012	Waste rock deposition into Brucejack Lake.
January 2013	Water treatment plant commissioning, followed by operations through 2013.

Newhawk's Sulphurets Project was an advanced underground exploration project located at the currently proposed mine site area; it received a Certificate approving mine development through the Mine Development Assessment Process that preceded the current BC *Environmental Assessment Act* (2002). Underground workings were commenced in the fall of 1986 and continued until late 1990 as part of an advanced exploration and bulk sampling program (Newhawk 1989; Price 2005). Discharge from the existing adit (Plate 13.3-3) began in the late 1980s following the initial underground development of this program (Price 2005). Underground workings were excavated between 1986 and 1990 as part of an advanced exploration and bulk sampling program. The waste rock generated from the underground workings was used as a shallow pad for the foundation for camp facilities along the southern boundary of Brucejack Creek, just downstream of Brucejack Lake. Two small piles of ore were placed at the back of the pad and two small streams, Camp and Little Camp Creek, were piped under the pad. Reclamation efforts following Newhawk's advanced exploration work included deposition of waste rock and ore within Brucejack Lake. Roughly 60,000 m^3 of waste rock was removed from the pads along lower Brucejack Creek and deposited in Brucejack Lake during July and August of 1999 (Price 2005).

Plate 13.3-3. Photograph of adit area
(2009, post-Newhawk reclamation activities)

To support its advanced exploration program, Newhawk completed the construction of a 1,050 m (3,500 ft.) long industrial airstrip in the upper Bowser River Valley, approximately 1,500 m east of Knipple Lake (Newhawk 1989). An all-weather road was also constructed between Knipple Glacier and the west end of Bowser Lake in 1988. The historical access road in the Bowser Valley is about 23 km long and connects the western-most landing on Bowser Lake with Knipple Glacier near the current onramp to Knipple Glacier (Newhawk 1989).

The exploration phase of the proposed Brucejack Gold Mine Project commenced in 2011 and has included a drilling program, bulk sampling program, construction of an exploration access road from Highway 37 to the west end of Bowser Lake, as well as the rehabilitation of an existing access road from the west end of Bowser Lake to Brucejack Mine Site.

Areas outside of the immediate Project area that have been historically impacted include the Granduc Mine, concentrator site, and access road. The Granduc Mine was a copper mine located approximately 25 km south of the Project which operated from 1970 to 1978 and 1980 to 1984. The mine included underground workings and a mill site near Summit Lake, connected by a 17-km tunnel. Historical tailings disposal was to the upper Bowser River. In addition, a 51-km all-weather access road was built from the communities of Stewart, BC and Hyder, Alaska to the former mill site near Summit Lake. The area in the vicinity of the former mill site near Summit Lake is currently used as staging for several mineral exploration projects in the region. The terminus of the Granduc Access Road is 25 km south of the proposed Brucejack Mine Site and is currently used by mineral exploration traffic and tourists accessing the Salmon Glacier viewpoint. Summit Lake is within the Salmon River watershed.

In 2010, construction began on the Long Lake Hydroelectric Project which is located approximately 42 km south of the Project (CEA Agency 2012). It included redevelopment of a 20-m-high rockfill dam located at the head of Long Lake, and a new 10-km-long 138-kV transmission line. This project has recently (November 2013) begun operations. Activities associated with the Long Lake Hydroelectric Project will not affect baseline water quality characterization for the Brucejack Gold Mine Project.

Historical forestry activities occurred within the immediate Project area between Highway 37 and Bowser Lake, south of the Wildfire Creek and Bell-Irving River confluence. Additional details regarding historical and current human activities near the Project are included in Section 1.4, Project Location, Access, and History. These activities will not affect baseline water quality characterization for the Project.

13.3.3 Approach and Methodology

No pre-disturbance water quality data are available for the Brucejack watershed. Water quality monitoring commenced in 1987 to support a Stage 1 Impact Assessment for the Sulphurets Project proposed by Newhawk, whereas underground development began in autumn 1986. From that time onward, Brucejack Creek was affected by passive drainage from the adit, and various watercourses within the Brucejack watershed (Brucejack Lake, Brucejack Creek, Camp Creek) were periodically affected by drainage from areas disturbed through surface activities, active (dewatering) or passive drainage from the adit, as well as reclamation activities (Newhawk 1989; Price 2005). Newhawk's active mining and exploration ceased in 1990. Surface water quality data from 1987 to 2001 (Price 2005; Newhawk 1989) have been included in Appendix 13-A, Cumulative Surface Water Quality Baseline Report, both to define effects of the historical activities on water quality, and because data from the historical periods of relative inactivity provide the best available approximation of baseline conditions (see Section 13.3.3.2).

Surface water quality monitoring for the proposed Project was conducted from 2008 to 2013. The surface water quality program aimed to provide sufficient data for the Water Management Plan (Section 29.19), the Aquatic Effects Monitoring Plan (Section 29.3), predictive water quality modelling (Section 13.6) and environmental effects assessment (Sections 13.5, 13.6, 13.7). The objectives of the baseline program varied slightly from year to year to reflect updates to the proposed Project design; however, the primary objectives were the following.

1. Identification of waterbodies that could be directly or indirectly affected by the Project.
2. Collection of physical limnology and water quality data from selected stream/river and lake sites of potentially affected waterbodies.
3. Compilation and presentation of physical limnology and surface water quality data from sampled waterbodies within the study area.

13.3.3.1 Data Sources

This report describes background surface water quality conditions relevant to the Project based on both historical information collected by the previous property owners, Newhawk, from 1987 to 1999 and Silver Standard Resources Inc. from late 1999 to 2001, as well as recent Project-specific water quality data collected from 2008 to 2013.

Historical data (1987 to 2001) was accessed from the *Environmental and Socioeconomic Impact Assessment for the Sulphurets Property* (Newhawk 1989) as well as MEND Report 9.1c (Price 2005; *Case Studies of ML/ARD Assessment and Mitigation: Placement of the Sulphurets Waste Rock in Brucejack Lake*), collected during the Newcana Joint Venture exploration and reclamation work. Studies focused on the downstream pathway flowing west from Brucejack Lake into Brucejack Creek, Sulphurets Creek, and eventually into the Unuk River (Newhawk 1989; Price 2005). Historical surface water quality data were not available for the Bowser River, Scott Creek, Todedada Creek, and Wildfire Creek watersheds.

Pretium Resources Inc. (Pretivm) has a data sharing agreement with Seabridge Gold Inc. for their neighbouring proposed KSM Project; this report includes shared water quality data for sites along Sulphurets Creek and the Unuk River (2008 to 2013). This report also includes data collected by BGC Engineering Inc. in the Brucejack area during 2011 and 2012 (sites along Brucejack Creek, including tributaries).

13.3.3.2 Methods

Baseline Study Area

The current surface water quality study assessed the watercourses that could potentially be affected by mine development and operation and were further selected to coincide with the survey locations of the water quantity (Chapter 10, Surface Water Hydrology Predictive Study*)* and aquatic resources (Chapter 14, Assessment of Potential Aquatic Resources Effects); spatial boundaries for assessment of fish and fish habitat (Chapter 15, Assessment of Potential Fish and Fish Habitat Effects) differ as there are no fish or fish habitat present within the Brucejack and upper Sulphurets watersheds, based upon baseline and historical data (Rescan 2013b). Streams and lakes assessed as part of the water quality characterization program are shown in Figure 13.3-1.

The baseline study area included watercourses within four general areas:

- Brucejack watershed;
- Sulphurets/Unuk watershed;
- Bowser River/Knipple Lake watershed; and
- Wildfire Creek/Scott/Todedada watersheds

The Brucejack Lake watershed (mine site area) and far-field downstream receiving environment (Sulphurets/Unuk watersheds) are the primary focus of the Project surface water quality assessment and management strategy as Brucejack Lake will be used as a permanent disposal site for tailings and waste rock, and as a minor source of process make-up water (primary source is groundwater from the underground mine). Water quality sampling was also conducted for the Bowser Aerodrome facility (Bowser River/Knipple Lake), access road corridor (Bowser River/Wildfire Creek/Scott/Todedada watershed), far-field monitoring sites on Unuk and Bell-Irving rivers, as well as potential references sites (Figure 13.3-1). No interactions between the freshwater environment of the Salmon River and the transmission line (off-site ancillary Project infrastructure) are expected, so the Salmon River is not considered further in the effects assessment for surface water quality.

Detailed results of the surface water quality monitoring program (2008 to 2013) for lakes and streams within the study area are included in Appendix 13-A, Cumulative Surface Water Quality Baseline

Report. The surface water quality characterization and monitoring program meets or exceeds the expectations of the *Water and Air Baseline Monitoring Guidance Document for Mine Proponents and Operators* (BC MOE 2012).

Surface Water Quality Sampling Methodology

The sampling program has varied from year to year as the proposed Project design developed; details on sampling efforts are provided in Appendix 13-A, Cumulative Surface Water Quality Baseline Report). In 2008, data were collected for the KSM Project, including sites in Sulphurets Lake, Sulphurets Creek and the Unuk River. Comprehensive field programs across the entire geographic extent of the project began in 2009, and extensive programs were conducted from 2010 to 2013 to support the proposed Project design, predictive surface water quality modelling, and environmental effects assessment. Beginning in 2011, increased monitoring was conducted on Brucejack and Sulphurets lakes and Unuk River. Overall, nine lakes and 36 stream sampling sites were investigated, and include areas upstream and downstream of proposed discharges and seepage points as well as far field monitoring for potential downstream and cumulative effects.

During the five-year water quality baseline study (2008 to 2013), over 700 water quality samples were analyzed using industry-standard techniques at ALS Environmental Laboratories in Burnaby, BC, which is an accredited environmental laboratory. Sampling procedures, data analysis, and QA/QC followed the principles and procedures outlined in the *British Columbia Field Sampling Manual* (Clark 2003a). Water quality samples were analyzed for physicochemical parameters (dissolved oxygen, pH, hardness, turbidity), major anions, nutrients, cyanides (total and weak acid dissociable), total organic carbon (TOC), and total and dissolved metals at the lowest feasible method detection limit (MDL) by ALS.

Where applicable, water quality parameters were compared to approved and working BC guidelines (BC MOE 2006) for the protection of aquatic life (Table 13.3-2). In absence of an applicable BC MOE guideline, guideline criteria issued by CCME for the Protection of Aquatic Life (CCME 2013) were used (Table 13.3-2). Water quality parameters were also compared to Canadian Drinking Water Qualities, to support environmental impact assessment for human health VCs (Chapter 21, Assessment of Potential Health Effects).

Definition of Brucejack Representative Baseline Data Periods

As described in Section 13.3.2, historical mining and mineral exploration activities have affected lake and stream water quality within the Brucejack watershed; no pre-disturbance baseline water quality data are available. A summary of the approach to baseline definition for the Brucejack watershed sis provided below. For complete details of approach to baseline characterization, please refer to Appendix 13-A, Cumulative Surface Water Quality Baseline Report.

Historical datasets (see Section 13.3.3.1) were used to supplement the ongoing Project-specific lake and stream water quality monitoring program completed by Pretivm beginning in 2011. The objective was to curate the existing water quality data for the Project area to minimize the influence of both historical and ongoing mining and mineral exploration activities in the definition of baseline conditions, to support an environmental effects assessment of potential Project-related water quality effects. The construction of the curated baseline database involved the following.

1. Assessment and analyses of available historical water quality data (1987 to 2010) and site activity records to determine the best available approximation of pre-disturbance water quality conditions.
2. Use of the data identified in (i) as the base/reference case to provide a conservative means of identifying and removing affected data (Iglewicz and Hoaglin 1993) in the more recent database (2011 to 2013).

3. Use of curated baseline dataset as a basis for describing baseline or background conditions of the Brucejack watershed.

Table 13.3-2. Provincial and Federal Water Quality Guidelines for the Protection of Freshwater Aquatic Life

Parameter	BC Water Quality Guidelines[a]	CCME Guideline for the Protection of Freshwater Aquatic Life[b]
Physical Tests		
pH	6.5 to 9.0	6.5 to 9.0
Total Suspended Solids	Dependent on background levels[k]	Dependent on background levels[c]
Turbidity (NTU)	Dependent on background levels[l]	Dependent on background levels[d]
Anions		
Chloride (Cl)	600 maximum; 150 for 30-day period	640 short-term; 120 long-term
Fluoride (F)	Hardness dependent[m]	0.12[e]
Sulfate (SO_4)	100	
Nutrients		
Ammonia, Total (as N)		pH- and temperature-dependent
Nitrate (as N)	32.8 maximum; 3.0 for 30-day period	550 short-term; 13 long-term
Nitrite (as N)	0.06 maximum; 0.02 for 30-day period	0.06
Phosphorus (P)-Total		Trigger ranges[f]
Cyanides		
Cyanide, Weak Acid Diss	0.01 maximum; 0.005 for 30-day period	
Cyanide, Total		0.005
Organic / Inorganic Carbon		
Total Organic Carbon	Dependent on background levels[n]	
Total Metals		
Aluminum (Al)		0.005 if pH < 6.5; 0.1 if pH ≥ 6.5
Arsenic (As)	0.005	0.005
Boron (B)	1.2	29 short-term; 1.5 long-term
Cadmium (Cd)	Hardness dependent[e,g]	Hardness dependent[z]
Chromium (Cr)		0.001 (Cr(VI)); 0.0089 (Cr(III))
Cobalt (Co)	0.11 maximum; 0.004 for 30-day period	
Copper (Cu)	Hardness dependent[o]	Hardness dependent[h]
Iron (Fe)	1	0.3
Lead (Pb)	Hardness dependent[p]	Hardness dependent[i]
Manganese (Mn)	Hardness dependent[q]	
Mercury (Hg)	0.00002 when MeHg = 0.5% THg	0.000026
Molybdenum (Mo)	2 maximum; ≤1 for 30-day period	0.073[e]
Nickel (Ni)	Hardness-dependent[r,s]	Hardness dependent[j]
Selenium (Se)	0.002	0.001
Silver (Ag)	Hardness dependent[t]	0.0001
Thallium (Tl)	0.0003[r]	0.0008
Uranium (U)	0.3[r]	0.033 short-term; 0.015 long-term
Zinc (Zn)	Hardness dependent[u]	0.03

(continued)

Table 13.3-2. Provincial and Federal Water Quality Guidelines for the Protection of Freshwater Aquatic Life (completed)

Parameter	BC Water Quality Guidelines[a]	CCME Guideline for the Protection of Freshwater Aquatic Life[b]
Dissolved Metals		
Aluminum (Al)	pH-dependent[v]	
Iron (Fe)	0.35	

[a] British Columbia Guidelines for the Protection of Freshwater Aquatic Life (accessed March 2013).
[b] Canadian Water Quality Guidelines for the Protection of Freshwater Aquatic life, Canadian Council of Ministers of the Environment (accessed March 2013); all units are in mg/L unless otherwise noted.
[c] Total Suspended Solids (TSS) - in clear flow, maximum increase of 25 mg/L from background levels for short-term exposure (e.g., 24-h period). Maximum average increase of 5 mg/L from background levels for long-term exposure. In high flow, maximum increase of 25 mg/L from background levels between 25-250 mg/L. If background is ≥ 250 mg/L, then it should not increase more than 10% of background levels.
[d] Turbidity - in clear flow maximum increase of 8 NTUs from background levels for short-term exposure (e.g., 24-h period). Maximum average increase of 2 NTUs from background levels for a longer term exposure (e.g., 30-d period). In high flow maximum increase of 8 NTUs from background levels (8 to 80 NTUs); when background is > 80 NTUs, turbidity should not increase more than 10%.
[e] Interim guideline.
[f] Phosphorus trigger ranges: < 0.004 mg/L ultra-oligotrophic; 0.004-0.01 mg/L oligotrophic; 0.01-0.02 mg/L mesotrophic; 0.02-0.035 mg/L meso-eutrophic; 0.035-0.1 mg/L eutrophic; > 0.1 mg/L hyper-eutrophic.
[g] Cadmium - cadmium concentration = 10 $0.86^{[log10(hardness)]-3.2}$ / 1,000 mg/L. There is no minimum guideline.
[z] Cadmium - cadmium concentration(short term) = 10 $1.016^{[log10(hardness)]-1.71}$; (long term) = $10^{0.83[log10(hardness)]-2.46}$.
*[h] Copper - copper concentration = e $0.8545^{[ln(hardness)]-1.465}$ * 0.0002 mg/L. Copper guideline is a minimum of 0.002 mg/L regardless of water hardness.*
[i] Lead - lead concentration = e 1.273[ln(hardness)]-4.705 / 1,000 mg/L. Lead guideline is a minimum of 0.001 mg/L regardless of water hardness.
[j] Nickel - nickel concentration = $e^{0.76[ln(hardness)]+1.06}$ / 1,000 mg/L. Nickel guideline is a minimum of 0.025 mg/L regardless of water hardness.
[k] TSS - change from background for 24-h period is 25 mg/L and 5mg/L for 30-day period; if background is 25-100 mg/L then change from background of 10 mg/L; if background > 100 mg/L then change from background of 10%.
[l] Turbidity - change from background for 24-h period is 8 NTU and 2 NTU for 30-day period; if background is 8-50 NTU then change from background is 5 NTU; if background > 50 NTU then change from background of 10%.
*[m] Fluoride - if hardness (as $CaCO_3$) is 10 mg/L the maximum concentration is 0.4 mg/L; otherwise LC_{50} = -51.73 + 92.57 log_{10} (hardness) * 0.01 mg/L.*
[n] Total organic carbon - the 30-day median ± 20% of the median background concentration.
[o] Copper - if average water hardness (as $CaCO_3$) is ≤ 50 mg/L the maximum concentration is 0.094(hardness)+2 / 1,000 mg/L and the 30-day mean is ≤ 0.002 mg/L; if average water hardness is > 50 mg/L the maximum concentration is 0.094(hardness)+2 / 1,000 mg/L and the 30-day mean is ≤ 0.00004 mg/L.
[p] Lead - if hardness (as $CaCO_3$) is ≤ 8 mg/L the maximum concentration is 0.003 mg/L; if hardness is > 8 mg/L the maximum concentration is $e^{1.273ln(hardness)-1.460}$ / 1,000 mg/L and the 30-day mean is 3.31+$e^{1.273ln(mean[hardness])-4.704}$ / 1,000 mg/L.
[q] Manganese - manganese concentration maximum = 0.01102(hardness)+0.54 mg/L and the 30-day mean concentration = 0.0044(hardness)+0.605 mg/L.
[r] Working guideline.
[s] Nickel - if hardness (as $CaCO_3$) is 0-60 mg/L the maximum concentration is 0.025 mg/L; if hardness 60-120 mg/L maximum concentration of 0.065 mg/L; if hardness 120-180 mg/L maximum concentration of 0.110 mg/L; if hardness >180 mg/L maximum concentration of 0.150 mg/L.
[t] Silver - if hardness is ≤ 100 mg/L the maximum concentration is 0.0001 mg/L and the 30-day mean is 0.00005 mg/L; if hardness > 100 mg/L the maximum concentration is 0.003 mg/L and the 30-day mean is 0.0015 mg/L.
[u] Zinc - 30-day mean concentration = 7.5 + 0.75(hardness - 90) / 1,000 mg/L; maximum zinc concentration = 33 + 0.75(hardness - 90) / 1,000 mg/L.
[v] Dissolved aluminum - if pH ≥ 6.5 the maximum concentration is 0.1 mg/L and the 30-day mean is 0.05 mg/L; if pH < 6.5 the maximum concentration is $e^{(1.209 - 2.426pH + 0.286 K)}$ mg/L where K = (pH)2 and the 30-day mean is $e^{1.6 - 3.327 (median pH) + 0.402 K)}$ mg/L where K = $(median pH)^2$.

Assessment of data and activity records indicates that water quality data collected from 1991 to 1999 (period of relative inactivity following Newhawk mining), as well as during 2000/2001 (post-Newhawk site reclamation) and 2009/2010 (surface exploration only) are the best available approximation of pre-disturbance water quality conditions. This dataset was used as the base/reference case and compared to the overall 2011 to 2013 database to provide a conservative means of identifying and removing affected data in the more recent database. Removal of affected data yields a more conservative and accurate approximation of baseline conditions within the Brucejack watershed, with lower mean values for total and dissolved metals and other water quality parameters (e.g., total suspended solids [TSS]) as well as lower overall variability in the dataset. Although data from the entire period of water quality monitoring (1987 to 2013) are included within the baseline report for the Project, only those data determined to best characterize background conditions, constituting the curated baseline database, were used for the calculation of means and related statistics and as a basis for describing baseline or background conditions. The entire baseline dataset for Brucejack, Sulphurets and Unuk watersheds is presented in Appendices 1, 2, and 4 of Appendix 13-A, Cumulative Surface Water Quality Baseline Report.

There is slight ambiguity on the sampling location of the historically monitored "lower Brucejack Creek" (Appendix 13-A, Cumulative Surface Water Quality Baseline Report) with respect to current monitoring sites, BJ 200m D/S and BJ2. Therefore, composite data (historical lower Brucejack Creek, BJ 200m D/S, BJ2) have been used to inform and describe background conditions for these monitoring locations (Lower Brucejack Creek [LBJ]).

13.3.4 Characterization of Surface Water Quality Baseline Condition

Results of the surface water quality characterization and monitoring study have been separated according to the watershed groupings described in Section 13.3.3.2 due to both the differing aquatic environment characteristics as well as potential effects of Project facilities. Sections 13.3.4.1 and 13.3.4.2 present the results of the Brucejack watershed (mine site area), and Sulphurets and Unuk watersheds (mid and far-field downstream receiving environments), respectively. Section 13.3.4.3 presents the results of the Bowser/Scott/Todedada/Wildfire watersheds (off-site Project infrastructure and existing access road).

The hydrological regime is an especially important determinant of surface water quality in the Project area, affecting water quality at study area sites in two ways.

1. Increased discharge during freshet, glacial melt, and heavy rainfall events dilutes concentrations of major ions and total dissolved solids.
2. Increased sediment load and transport during high flow periods leads to increased concentrations of total suspended solids (TSS) and particle-associated metals.

Study area streams typically experience a low flow period between November and May, and higher flows between June and October associated with freshet, summer glacial melt, and fall heavy rain events.

13.3.4.1 Mine Site Area: Brucejack Watershed

<u>Brucejack Lake</u>

Brucejack Lake is ice-covered part of the year (usually October to June), and mixes twice per year in the spring and fall (i.e., dimictic). In its baseline condition, the waters of Brucejack Lake are oxygenated, ultra-oligotrophic (mean phosphorous < 0.004 mg/l), soft (mean hardness: 21.7 to 29.1 mg/L), of circumneutral pH (mean: 7.21 to 7.44), intermediate conductivity (mean: 45.3 to 58.7 µS/cm) with low total alkalinity and moderate sensitivity to acidic inputs (mean total alkalinity:

15.0 to 16.0 mg/L; Table 13.3-3). Concentrations of total and dissolved metals in Brucejack Lake are low and were generally less than or close to detection limits and exhibit no significant differences with depth or between open and ice-cover sampling events. However, total aluminum, cadmium, molybdenum, zinc and silver were higher during open water sampling (Table 13.3-3), although maxima of these parameters (0.0949 mg/L, 0.0010 mg/L, 0.006 mg/L, 0.0050 mg/L, and 0.170 mg/L, respectively) were not consistently associated with a particular sampling year or sampling depth. Guideline exceedances were restricted to maxima and 95th percentile concentrations for cadmium, silver, and zinc.

Upper Brucejack Creek

Baseline conditions of upper Brucejack Creek monitoring locations (BJ U/S and BJ U/S of CC) are of similar chemistry to Brucejack Lake (Table 13.3-3). During both high and low flow seasons, the waters of upper Brucejack Creek are ultra-oligotrophic (mean phosphorus <0.004 mg/L), soft (mean hardness: 22.4 to 23.5 mg/L), of circumneutral pH (mean: 7.50 to 7.71), with low total alkalinity (mean: 15.4 mg/L to 15.9 mg/L) and intermediate conductivity (mean 50.5 to 52.6 µS/cm. Total and dissolved concentrations of most metals remained below the detection limits and/or guidelines during both low and high flow periods (Table 13.3-3). In general, concentrations of total chromium, cobalt, mercury, nickel, selenium, mercury, and iron, and dissolved aluminum and cadmium consistently remained near or below detection limits. In contrast, concentrations of total aluminum, cadmium, copper, iron, lead, manganese, silver, and zinc were consistently above detection limits and exhibited distinct seasonality, with highest concentrations corresponding to highest concentrations of TSS in high flow periods (TSS high flow range: 0.50 to 14.0 mg/L; Table 13.3-3). Exceedances were generally restricted to maxima concentrations associated with high flow periods and were observed for total aluminum, arsenic, cadmium, copper, silver, and zinc (Table 13.3-3).

Camp Creek

Camp Creek drains the West Zone deposit area, and flows through the current camp area into Brucejack Creek, upstream of the adit, and downstream of upper Brucejack Creek. Current (2009 to 2013) and historical (1989 to 2001) monitoring data presented here represent sites located upstream of the historical waste rock pad site. It should be noted that a number of water quality parameters were not available in the historical data for this site and baseline data available are restricted to high flow periods (June to October, Table 13.3-3).

Baseline waters of Camp Creek were slightly acidic (mean pH: 6.31), soft (mean hardness: 36.3 mg/L), with low suspended solids (mean: 10.5 mg/L), alkalinity (mean: 3.54 mg/L) and moderate sulphate concentrations (mean: 37.9 mg/L). However, concentrations of nutrients, anions and metals were generally elevated in Camp Creek relative to upper Brucejack Creek and Brucejack Lake (Table 13.3-3). Exceedances of mean and/or median concentrations were observed for: total aluminum, cadmium, copper, silver, and zinc (Table 13.3-3). Further, although mean and median pH during remained circumneutral, pH was highly variable and at times acidic (pH = 4.40 to 7.90). Moderate sulphate, variable pH and elevated metal concentrations observed in Camp Creek from 1991 to 1998 and 2000 to 2010 were the result of a natural source of dissolved metals and sulphate upstream of the historical waste rock pad location (Price 2005).

Lower Brucejack Creek

Lower Brucejack Creek drains the VOK zone as well as areas between the West Zone deposit and Gossan Hill Zone. The waters of lower Brucejack Creek monitoring locations (BJ OF, LBJ (composite data: BJ 200m D/S, BJ2) and BJ3) are downstream of Camp Creek and the existing adit and have similar chemistries and exhibit greater seasonal variation than their upstream counterparts.

Table 13.3-3. Baseline Water Quality of the Brucejack Watershed (Mine Site Area), Brucejack Gold Mine Project

Project Area		Mine Site Area and Downstream Receiving Environment																			
Site		Brucejack Lake										Brucejack Creek, Upstream of Camp Creek (2 sites)									
		Under Ice (n=8)					Open Water (n=22)					Low Flow (n=31)					High Flow (n=55)				
	Units	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P
Physical Tests																					
Colour	CU	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Conductivity	µS/cm	5.10	56.0	50.1	45.3	55.1	44.0	149	49.1	58.7	121	41.0	64.9	53.8	52.6	60.5	32.0	84.0	50.0	50.5	61.8
Hardness (as $CaCO_3$)	mg/L	10.8	24.7	23.0	21.7	24.5	21.6	88.0	22.5	29.1	84.0	15.3	29.9	23.9	23.5	25.2	14.0	31.6	22.5	22.4	25.8
pH	pH	6.50	7.53	7.38	7.21	7.53	6.80	8.00	7.40	7.44	7.80	6.80	8.16	7.78	7.71	8.07	6.40	8.08	7.53	7.50	7.99
Total Suspended Solids	mg/L	0.500	3.00	1.50	1.75	3.0	0.500	15.6	1.50	4.17	14.9	0.500	8.90	1.50	2.22	5.50	0.500	14.0	1.50	3.79	10.4
Total Dissolved Solids	mg/L	5.0	40.0	28.0	26.6	37.9	21.0	123	30.0	39.3	94.0	23.0	46.0	36.0	34.5	41.0	8.00	66.0	32.0	33.2	51.6
Turbidity	NTU	0.180	0.320	0.260	0.258	0.318	0.260	2.45	0.630	0.851	2.0	0.220	14.9	0.470	1.15	1.02	0.500	11.8	2.55	3.67	11.1
Acidity	mg/L	1.40	1.70	1.50	1.52	1.66	2.30	5.20	3.60	3.37	4.60	0.500	3.40	2.00	2.12	2.90	1.40	5.10	2.00	2.36	4.60
Alkalinity, Bicarbonate (as $CaCO_3$)	mg/L	2.90	15.7	15.1	12.8	15.7	14.4	14.9	14.7	14.7	14.9	6.50	18.4	15.9	15.9	18.1	12.1	16.4	14.1	14.2	15.9
Alkalinity, Carbonate (as $CaCO_3$)	mg/L	1.00	1.00	1.00	1.00	1.00	0.500	1.00	0.500	0.722	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Alkalinity, Hydroxide (as $CaCO_3$)	mg/L	1.00	1.00	1.00	1.00	1.00	0.500	1.00	0.500	0.722	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Alkalinity, Total (as $CaCO_3$)	mg/L	2.90	20.0	15.7	15.0	19.7	12.0	34.0	14.9	16.9	27.4	6.50	19.0	15.9	15.9	18.3	11.9	21.0	15.4	15.7	21.0
Anions and Nutrients																					
Ammonia, Total (as N)	mg/L	0.00250	0.00250	0.00250	0.00250	0.00250	0.00250	0.00550	0.00250	0.00309	0.00546	0.00250	0.02990	0.00250	0.00426	0.00973	0.00250	0.0571	0.00250	0.00487	0.00250
Bromide (Br)	mg/L	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250
Chloride (Cl)	mg/L	0.250	1.00	0.250	0.344	0.738	0.250	1.00	0.250	0.393	1.00	0.250	15.00	0.250	0.758	0.750	0.150	6.00	0.250	0.418	1.00
Fluoride (F)	mg/L	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0260	0.0100	0.0113	0.0217
Nitrate (as N)	mg/L	0.00250	0.0198	0.00650	0.00786	0.0174	0.00250	0.00250	0.00250	0.00250	0.00250	0.00250	0.07200	0.00250	0.00685	0.0169	0.00250	0.0349	0.00610	0.0105	0.0329
Nitrite (as N)	mg/L	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0012	0.000500	0.0005	0.000500	0.0005	0.00180	0.000500	0.000578	0.000950
Total Kjeldahl Nitrogen	mg/L	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0500	0.0250	0.0278	0.0400	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0840	0.0250	0.0278	0.0250
Total Nitrogen	mg/L	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0500	0.0250	0.0278	0.0400	0.00125	0.0600	0.0250	0.0175	0.0250	0.00125	0.0550	0.0250	0.0246	0.0290
Orthophosphate-Dissolved (as P)	mg/L	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.00110	0.000500	0.000529	0.000500
Phosphorus (P)-Total	mg/L	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00290	0.00100	0.00121	0.00214	0.00100	0.02050	0.00100	0.00242	0.00643	0.00100	0.0171	0.00300	0.00452	0.0159
Sulphate (SO_4)	mg/L	0.680	10.2	8.83	7.10	10.1	4.00	33.0	8.11	9.65	23.0	5.00	11.6	9.29	8.66	10.7	2.00	17.7	8.61	7.93	11.0
Cyanides																					
Cyanide, Total	mg/L	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.00250	0.000500	0.00132	0.00250	0.000500	0.00250	0.000500	0.000595	0.000500
Cyanide, WAD	mg/L	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.00250	0.000500	0.00132	0.00250	0.000500	0.00250	0.000500	0.000595	0.000500
Organic Carbon																					
Total Organic Carbon	mg/L	0.250	0.250	0.250	0.250	0.250	0.250	2.06	1.81	1.18	2.02	0.250	0.770	0.250	0.302	0.606	0.250	0.640	0.250	0.311	0.600
Total Metals																					
Aluminum (Al)	mg/L	0.00400	0.0105	0.00600	0.00694	0.0102	0.0164	0.095	0.0279	0.0372	0.080	0.00650	*0.887*	0.0163	0.0546	0.028	0.0189	*0.475*	0.0617	*0.145*	*0.417*
Antimony (Sb)	mg/L	0.000050	0.000280	0.000250	0.000218	0.000276	0.000230	0.000300	0.000250	0.000252	0.000291	0.000210	0.000440	0.000235	0.000244	0.000250	0.000160	0.000420	0.000240	0.000249	0.000368
Arsenic (As)	mg/L	0.000200	0.0020	0.000610	0.000918	0.0019	0.000500	0.00240	0.00097	0.00114	0.00230	0.000500	0.00412	0.000590	0.00100	0.00220	0.000490	0.0150	0.00136	0.00169	0.00257
Barium (Ba)[2]	mg/L	0.0177	0.0339	0.0326	0.0301	0.0339	0.0325	0.0363	0.0347	0.0344	0.0359	0.0320	0.0410	0.0341	0.0345	0.0373	0.0295	0.0452	0.0358	0.0365	0.0436
Beryllium (Be)[2]	mg/L	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000250	0.000250	0.000170	0.000250	0.000050	0.000500	0.000050	0.000234	0.000500	0.000050	0.000500	0.000050	0.000087	0.000250
Bismuth (Bi)	mg/L	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.1000	0.000250	0.0411	0.1000	0.000250	0.100	0.000250	0.0046	0.000250
Boron (B)	mg/L	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.05000	0.00500	0.02341	0.05000	0.00500	0.0500	0.00500	0.00696	0.00500
Cadmium (Cd)[2]	mg/L	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000100	0.000005	0.000032	0.000100	0.000005	0.000100	0.000005	0.000011	0.000017	0.000005	0.00100	0.000017	0.000091	0.000480
Calcium (Ca)	mg/L	2.67	9.30	8.55	7.58	9.21	7.97	35.3	9.04	12.7	34.5	5.78	11.0	9.09	8.93	9.78	4.80	13.5	8.55	8.60	10.4
Chromium (Cr)	mg/L	0.000050	0.000110	0.000050	0.000062	0.000098	0.000100	0.000250	0.000120	0.000133	0.000205	0.000050	0.000600	0.000150	0.000268	0.000500	0.000050	0.000500	0.000120	0.000131	0.000250
Cobalt (Co)	mg/L	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000350	0.000050	0.000105	0.000150	0.000050	0.000410	0.000050	0.000096	0.000218
Copper (Cu)	mg/L	0.000250	0.00100	0.000250	0.000406	0.000825	0.000140	0.000500	0.000250	0.000342	0.000500	0.000250	0.00413	0.000500	0.000551	0.000905	0.000110	**0.0700**	0.00050	0.00204	0.00215
Iron (Fe)	mg/L	0.0150	0.120	0.0150	0.0300	0.0885	0.0150	0.390	0.0500	0.0922	0.295	0.0150	**1.89**	0.0150	0.0822	0.0950	0.0005	0.720	0.0900	0.137	0.424
Lead (Pb)	mg/L	0.000025	0.000500	0.000040	0.000207	0.000500	0.000025	0.00100	0.000250	0.000329	0.00098	0.000025	0.00129	0.000250	0.000258	0.000500	0.000025	0.00300	0.0005	0.0005	0.00145
Lithium (Li)[2]	mg/L	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.00250	0.00250	0.00160	0.00250	0.000250	0.00250	0.000250	0.00120	0.00250	0.000250	0.00250	0.000250	0.000819	0.00250
Magnesium (Mg)	mg/L	0.139	0.316	0.286	0.265	0.313	0.270	0.780	0.297	0.360	0.774	0.260	0.380	0.300	0.300	0.315	0.260	0.920	0.300	0.335	0.526
Manganese (Mn)	mg/L	0.000710	0.00300	0.00140	0.00171	0.00291	0.00241	0.00892	0.00396	0.00422	0.00704	0.00137	0.0408	0.00274	0.00552	0.0141	0.00262	0.0644	0.0093	0.0155	0.0459
Mercury (Hg)	mg/L	0.000005	0.000250	0.000005	0.000043	0.000183	0.0000050	0.00120	0.0000050	0.0000832	0.000210	0.00001	0.00003	0.000005	0.000007	0.000020	0.000003	0.000080	0.000005	0.000008	0.000025
Molybdenum (Mo)	mg/L	0.000005	0.000500	0.000362	0.000323	0.000500	0.000337	0.00600	0.000500	0.000700	0.000500	0.000265	0.00250	0.000500	0.000636	0.002250	0.000255	0.01300	0.000500	0.000896	0.00270
Nickel (Ni)[2]	mg/L	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000500	0.000250	0.000352	0.000500	0.000250	0.000500	0.000250	0.000261	0.000250
Phosphorus (P)	mg/L	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
Potassium (K)	mg/L	0.0250	0.0800	0.0700	0.0634	0.0784	0.0750	0.106	0.0870	0.0869	0.102	0.0710	1.00	0.122	0.477	1.00	0.0630	1.00	0.132	0.171	0.264
Selenium (Se)	mg/L	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000130	0.000100	0.000083	0.000117	0.000050	0.000500	0.000075	0.000240	0.000500	0.000050	0.000500	0.000050	0.000077	0.000109
Silicon (Si)	mg/L	0.210	0.600	0.560	0.502	0.596	0.555	0.719	0.598	0.608	0.682	0.493	1.62	0.548	0.608	0.685	0.508	1.32	0.740	0.799	1.27

(continued)

Table 13.3-3. Baseline Water Quality of the Brucejack Watershed (Mine Site Area), Brucejack Gold Mine Project (continued)

Project Area		Mine Site Area and Downstream Receiving Environment																			
Site		Brucejack Lake										Brucejack Creek, Upstream of Camp Creek (2 sites)									
		Under Ice (n=8)					Open Water (n=22)					Low Flow (n=31)					High Flow (n=55)				
	Units	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P
Total Metals ***(cont'd)***																					
Silver (Ag)	mg/L	0.000005	**0.000200**	0.000005	0.000041	**0.000148**	0.000005	**0.00500**	0.000050	**0.000268**	0.000085	0.000005	**0.00250**	0.000010	**0.000105**	**0.000126**	0.000005	**0.00110**	0.000050	0.000084	**0.000350**
Sodium (Na)	mg/L	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Strontium (Sr)	mg/L	0.0226	0.0577	0.0535	0.0486	0.0573	0.0525	0.0575	0.0558	0.0555	0.0572	0.0363	0.0713	0.0588	0.0577	0.0628	0.0472	0.0805	0.0557	0.0564	0.0643
Thallium (Tl)	mg/L	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000050	0.000050	0.000032	0.000050	0.000005	0.000100	0.000005	0.000046	0.000100	0.000005	0.000100	0.000005	0.000016	0.000050
Tin (Sn)	mg/L	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000250	0.000050	0.000132	0.000250	0.000050	0.000250	0.000050	0.000059	0.000050
Titanium (Ti)	mg/L	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.01900	0.00500	0.00564	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500
Uranium (U)	mg/L	0.000005	0.000025	0.000023	0.000020	0.000025	0.00003	0.00004	0.00003	0.00003	0.00004	0.0000	0.0001	0.000028	0.000055	0.000100	0.000019	0.000100	0.000029	0.000032	0.000044
Vanadium (V)	mg/L	0.0005	0.0005	0.0005	0.0005	0.0005	0.00050	0.00050	0.00050	0.00050	0.00050	0.0005	0.0017	0.000500	0.000555	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500
Zinc (Zn)	mg/L	0.00150	0.0110	0.00150	0.00325	0.00890	0.00025	0.170	0.00250	0.0111	0.0241	0.00150	0.0210	0.00250	0.00277	0.00350	0.000250	0.0250	0.00250	0.00348	0.0109
Dissolved Metals																					
Aluminum (Al)	mg/L	0.00150	0.00500	0.00150	0.00256	0.00466	0.00340	0.0179	0.00445	0.00602	0.0131	0.00150	0.0179	0.00250	0.00305	0.00504	0.00380	0.0233	0.00980	0.00928	0.0164
Antimony (Sb)	mg/L	0.00005	0.00025	0.00022	0.00019	0.00024	0.00021	0.00025	0.00023	0.00023	0.00025	0.00010	0.00025	0.00022	0.00022	0.00025	0.00014	0.000360	0.000200	0.000222	0.000347
Arsenic (As)	mg/L	0.00022	0.00100	0.00053	0.00059	0.00100	0.00050	0.00230	0.00070	0.00095	0.00180	0.00005	0.00220	0.00055	0.00075	0.00190	0.00005	0.008000	0.000900	0.00120	0.00296
Barium (Ba)	mg/L	0.0204	0.0339	0.0319	0.0301	0.0336	0.0318	0.0348	0.0321	0.0323	0.0338	0.0188	0.0400	0.0340	0.0337	0.0364	0.0275	0.0368	0.0331	0.0328	0.0365
Beryllium (Be)	mg/L	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00025	0.00025	0.00017	0.00025	0.00005	0.00050	0.00005	0.00023	0.00050	0.00005	0.000500	0.000050	0.000087	0.000250
Bismuth (Bi)	mg/L	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.100	0.000250	0.0411	0.100	0.000250	0.100000	0.000250	0.00459	0.000250
Boron (B)	mg/L	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.05000	0.00500	0.0234	0.05000	0.00500	0.0500	0.00500	0.00696	0.00500
Cadmium (Cd)	mg/L	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000100	0.000005	0.000032	0.000100	0.000005	0.000100	0.000005	0.000011	0.000009	0.000005	0.001000	0.000038	0.000092	0.000480
Calcium (Ca)	mg/L	4.02	9.36	8.53	7.84	9.26	8.21	34.0	8.55	11.8	33.0	5.73	11.3	9.07	8.97	9.63	4.30	12.0	8.56	8.41	9.55
Chromium (Cr)	mg/L	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000250	0.000100	0.000095	0.000183	0.000050	0.000500	0.000080	0.000245	0.000500	0.000050	0.000500	0.000050	0.000092	0.000250
Cobalt (Co)	mg/L	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000150	0.000050	0.000091	0.000150	0.000050	0.000370	0.000050	0.000075	0.000204
Copper (Cu)	mg/L	0.000250	0.001000	0.000250	0.000406	0.000825	0.000050	0.000500	0.000250	0.000295	0.000500	0.000250	0.000500	0.000500	0.000392	0.000500	0.000050	0.0150	0.000500	0.000804	0.002500
Iron (Fe)	mg/L	0.0150	0.0300	0.0150	0.0169	0.0248	0.0100	0.0150	0.0150	0.0148	0.0150	0.0150	0.0150	0.0150	0.0150	0.0150	0.00050	0.0800	0.0150	0.0216	0.0635
Lead (Pb)	mg/L	0.00003	0.00050	0.00003	0.00020	0.00050	0.000025	0.004000	0.000250	0.000417	0.000500	0.00003	0.00050	0.00025	0.00021	0.00050	0.00003	0.00300	0.000500	0.000451	0.002500
Lithium (Li)	mg/L	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.00250	0.00250	0.00160	0.00250	0.000250	0.00250	0.000250	0.00118	0.00250	0.000250	0.00250	0.000250	0.000729	0.002500
Magnesium (Mg)	mg/L	0.176	0.310	0.284	0.266	0.305	0.265	0.720	0.276	0.338	0.713	0.228	0.380	0.298	0.294	0.310	0.000500	0.520	0.288	0.287	0.330
Manganese (Mn)	mg/L	0.000050	0.00148	0.000488	0.000688	0.00141	0.000060	0.000872	0.000182	0.000377	0.000843	0.000150	0.01590	0.00100	0.00320	0.0111	0.00023	0.0615	0.00421	0.00849	0.0395
Mercury (Hg)	mg/L	0.000005	0.000250	0.000005	0.000043	0.000183	0.000005	0.001200	0.000005	0.000100	0.000485	0.000005	0.000025	0.000005	0.000007	0.000021	0.000005	0.002500	0.000005	0.000102	0.000022
Molybdenum (Mo)	mg/L	0.000142	0.000500	0.000349	0.000377	0.000500	0.000328	0.001000	0.000439	0.000449	0.000525	0.00003	0.00250	0.000500	0.000526	0.00100	0.000234	0.0120	0.000500	0.000776	0.002500
Nickel (Ni)[2]	mg/L	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000500	0.000250	0.000352	0.000500	0.000250	0.000500	0.000250	0.000261	0.000250
Phosphorus (P)	mg/L	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
Potassium (K)	mg/L	0.0250	0.0830	0.0740	0.0664	0.0822	0.0700	0.0880	0.0755	0.0775	0.0867	0.0750	1.00	0.110	0.46	1.00	0.0520	1.00	0.0850	0.128	0.156
Selenium (Se)	mg/L	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000100	0.000075	0.000075	0.000100	0.000050	0.000500	0.000050	0.000234	0.000500	0.000050	0.000500	0.000050	0.000070	0.000050
Silicon (Si)	mg/L	0.274	0.590	0.560	0.509	0.586	0.528	0.579	0.545	0.549	0.573	0.418	0.692	0.549	0.539	0.598	0.446	0.861	0.527	0.552	0.733
Silver (Ag)	mg/L	0.000005	0.000500	0.000005	0.000191	0.000500	0.000005	0.000500	0.000050	0.000243	0.000500	0.000005	0.000250	0.000010	0.000026	0.000050	0.000005	0.000800	0.000050	0.000071	0.000310
Sodium (Na)	mg/L	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Strontium (Sr)	mg/L	0.0327	0.0588	0.0519	0.0495	0.0576	0.0490	0.0554	0.0521	0.0526	0.0551	0.0352	0.0708	0.0582	0.0572	0.0628	0.0416	0.0784	0.0541	0.0545	0.0613
Thallium (Tl)	mg/L	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000050	0.000050	0.000032	0.000050	0.000005	0.000100	0.000005	0.000044	0.000100	0.000005	0.000100	0.000005	0.000013	0.000050
Tin (Sn)	mg/L	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000250	0.000050	0.000132	0.000250	0.000050	0.000250	0.000050	0.000059	0.000050
Titanium (Ti)	mg/L	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.005000	0.005000	0.005000
Uranium (U)	mg/L	0.000005	0.000023	0.000022	0.000019	0.000023	0.000020	0.000034	0.000027	0.000026	0.000032	0.000005	0.000100	0.000024	0.000053	0.000100	0.000005	0.000100	0.000021	0.000024	0.000033
Vanadium (V)	mg/L	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500
Zinc (Zn)	mg/L	0.000250	0.00700	0.00150	0.00247	0.00630	0.0001	0.0250	0.00170	0.00399	0.0170	0.00150	0.01100	0.00250	0.00241	0.00285	0.000500	0.0250	0.00250	0.003507	0.0117

(continued)

Table 13.3-3. Baseline Water Quality of the Brucejack Watershed (Mine Site Area), Brucejack Gold Mine Project (continued)

Project Area		Mine Site Area and Downstream Receiving Environment																			
Site		Camp Creek					Brucejack Outflow (BJ OF)										Lower Brucejack Creek (2 sites)				
		High Flow (n=22)					Low Flow (n=4)					High Flow (n=9)					Low Flow (n=16)				
	Units	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P
Physical Tests																					
Colour	CU	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Conductivity	µS/cm	32.1	230	77.0	95.6	170	53.8	79.8	55.3	61.0	76.3	46.4	102	57.0	67.5	96.9	56.7	150	107	110	149
Hardness (as $CaCO_3$)	mg/L	12.7	65.0	33.7	36.3	59.9	22.4	27.4	23.8	24.4	26.9	18.4	40.4	25.0	27.8	38.2	25.2	42.2	32.7	34.3	41.9
pH	pH	4.40	7.90	6.20	6.31	7.76	7.72	7.82	7.78	7.78	7.82	7.35	8.34	7.72	7.73	8.15	6.60	7.97	7.87	7.78	7.97
Total Suspended Solids	mg/L	0.500	67.0	5.00	10.5	29.5	1.50	18.2	1.50	5.675	15.7	1.50	17.3	1.50	7.36	17.22	0.500	8.50	3.55	3.55	6.48
Total Dissolved Solids	mg/L	23.0	162	60.5	65.6	108	27.0	46.0	34.0	35.3	44.7	27.0	63.0	37.0	40.4	57.8	37.0	99.0	65.0	69.3	99.0
Turbidity	NTU	20.5	31.2	25.9	25.9	30.7	0.890	7.13	1.73	2.87	6.43	0.95	16.4	3.79	6.19	15.3	0.690	5.16	3.56	3.15	5.07
Acidity	mg/L	1.80	3.70	2.75	2.75	3.61	1.80	2.80	2.10	2.20	2.71	0.500	3.70	2.10	2.23	3.60	1.60	3.10	2.40	2.26	3.03
Alkalinity, Bicarbonate (as $CaCO_3$)	mg/L	0.500	2.70	1.60	1.60	2.59	15.1	21.8	16.2	17.3	21.1	11.3	24.7	14.8	17.3	24.6	17.2	36.4	27.0	27.8	35.1
Alkalinity, Carbonate (as $CaCO_3$)	mg/L	0.500	1.00	0.750	0.750	0.975	1.00	1.00	1.00	1.00	1.00	0.500	1.00	1.00	0.813	1.00	1.00	1.00	1.00	1.00	1.00
Alkalinity, Hydroxide (as $CaCO_3$)	mg/L	0.500	1.00	0.750	0.750	0.975	1.00	1.00	1.00	1.00	1.00	0.500	1.00	1.00	0.813	1.00	1.00	1.00	1.00	1.00	1.00
Alkalinity, Total (as $CaCO_3$)	mg/L	0.500	14.0	2.00	3.54	10.4	15.1	21.8	16.2	17.3	21.1	11.3	24.7	14.8	17.3	24.6	12.0	36.4	27.0	26.8	35.0
Anions and Nutrients																					
Ammonia, Total (as N)	mg/L	0.00250	0.0289	0.0025	0.0113	0.0263	0.00250	0.0652	0.0123	0.0231	0.0576	0.00250	0.145	0.00610	0.0233	0.0964	0.0140	0.225	0.0732	0.107	0.224
Bromide (Br)	mg/L	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250
Chloride (Cl)	mg/L	0.150	1.00	0.250	0.460	1.00	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	1.00	0.250	0.406	0.693
Fluoride (F)	mg/L	0.0100	0.0330	0.0100	0.0177	0.0307	0.0100	0.0300	0.0100	0.0150	0.0270	0.0100	0.0470	0.0100	0.0213	0.0430	0.0100	0.0820	0.0490	0.0536	0.0820
Nitrate (as N)	mg/L	0.00250	0.0199	0.0123	0.0116	0.0191	0.00250	0.00750	0.00250	0.00417	0.00700	0.00250	0.00250	0.00250	0.00250	0.00250	0.0117	-	-	-	-
Nitrite (as N)	mg/L	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	-	-	-	-
Total Kjeldahl Nitrogen	mg/L	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0710	0.0250	0.0365	0.0641	0.0250	0.219	0.0250	0.0580	0.167	0.0250	0.240	0.110	0.121	0.240
Total Nitrogen	mg/L	0.0250	0.0570	0.0410	0.0410	0.0554	0.0250	0.174	0.0250	0.0623	0.152	0.0250	0.289	0.0605	0.0991	0.240	0.0250	0.675	0.257	0.347	0.6596
Orthophosphate-Dissolved (as P)	mg/L	0.00200	0.00200	0.00200	0.00200	0.00200	0.000500	0.00360	0.00210	0.00207	0.00345	0.000500	0.00810	0.000500	0.0024	0.00696	0.0005	0.00240	0.00140	0.00145	0.00233
Phosphorus (P)-Total	mg/L	0.0143	0.0229	0.0186	0.0186	0.0225	0.00100	0.0402	0.00440	0.0125	0.035085	0.00100	0.0278	0.00820	0.0117	0.0265	0.00230	0.00760	0.00620	0.00581	0.00729
Sulphate (SO_4)	mg/L	9.86	104	30.0	37.9	62.0	9.58	16.0	9.86	11.3	15.1	1.83	23.6	11.8	13.7	22.5	10.0	36.4	23.8	25.3	36.0
Cyanides																					
Cyanide, Total	mg/L	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500
Cyanide, WAD	mg/L	0.000500	0.00130	0.000900	0.000900	0.00126	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500
Organic Carbon																					
Total Organic Carbon	mg/L	0.250	2.19	1.22	1.22	2.09	0.250	1.04	0.250	0.448	0.922	0.250	2.14	0.855	0.976	1.90	0.250	0.250	0.250	0.250	0.250
Total Metals																					
Aluminum (Al)	mg/L	*0.0503*	*0.903*	*0.881*	*0.611*	*0.901*	0.0191	*0.254*	0.0464	0.0915	*0.223*	0.0398	*0.875*	0.0735	*0.320*	*0.803*	0.0258	*0.110*	0.0733	0.0717	*0.103*
Antimony (Sb)	mg/L	0.000130	0.000200	0.000180	0.000170	0.000198	0.000210	0.000560	0.000380	0.000383	0.000556	0.000220	0.00114	0.000420	0.000537	0.00103	0.000270	0.00268	0.00151	0.00138	0.00241
Arsenic (As)	mg/L	0.000050	0.00700	0.000555	0.00140	0.00587	0.0007	0.00207	0.00098	0.00118	0.00195	0.000640	0.0063	0.00185	0.00230	0.00519	0.000880	0.00384	0.00217	0.00230	0.00384
Barium (Ba)[2]	mg/L	0.0380	0.0550	0.0433	0.0454	0.0538	0.0340	0.0402	0.0350	0.0361	0.0395	0.0310	0.0616	0.0383	0.0422	0.05812	0.0351	0.0412	0.0363	0.0367	0.0395
Beryllium (Be)[2]	mg/L	0.000050	0.000250	0.000250	0.000183	0.000250	0.000050	0.000250	0.000050	0.000100	0.000220	0.000050	0.000250	0.000250	0.000161	0.000250	0.000050	0.000050	0.000050	0.000050	0.000050
Bismuth (Bi)	mg/L	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250
Boron (B)	mg/L	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.0160	0.00500	0.00744	0.016	0.00500	0.0240	0.0130	0.0144	0.0240
Cadmium (Cd)[2]	mg/L	0.000005	0.00500	0.000400	0.000741	0.00479	0.000005	0.000040	0.000008	0.000015	0.000036	0.000005	0.000078	0.000033	0.00004	0.00007	0.000005	0.000100	0.000005	0.000018	0.000073
Calcium (Ca)	mg/L	3.70	24.2	12.5	13.3	21.8	8.97	10.1	9.21	9.37	9.98	6.96	15.0	10.2	10.6	14.1	9.28	47.7	12.3	15.0	23.3
Chromium (Cr)	mg/L	0.000100	0.000250	0.000160	0.000170	0.000241	0.000050	0.000130	0.000085	0.000088	0.000129	0.000100	0.000300	0.000190	0.000183	0.000280	0.000050	0.000160	0.000100	0.000087	0.000153
Cobalt (Co)	mg/L	0.000050	0.001900	0.000660	0.000870	0.001776	0.000050	0.000200	0.000050	0.000088	0.000178	0.000050	0.000440	0.000150	0.000228	0.000440	0.000050	0.000490	0.000050	0.000087	0.000266
Copper (Cu)	mg/L	0.000230	**0.0390**	0.00300	**0.00576**	**0.0147**	0.000250	0.00156	0.000430	0.000668	0.00142	0.000250	0.00182	0.000750	0.00089	0.00167	0.000250	**0.00700**	0.000250	0.000748	0.00239
Iron (Fe)	mg/L	0.0150	**1.96**	0.230	0.365	**1.09**	0.015	0.492	0.0255	0.140	0.424	0.0150	0.936	0.135	0.275	0.748	0.0150	0.440	0.0565	0.0784	0.195
Lead (Pb)	mg/L	0.0001	0.0070	0.000500	0.0013	0.0025	0.000095	0.0022	0.000161	0.000647	0.00187	0.000066	0.0033	0.000250	0.000810	0.0025	0.000062	0.00300	0.000290	0.000484	0.00128
Lithium (Li)[2]	mg/L	0.001130	0.00250	0.00250	0.00204	0.00250	0.000250	0.00806	0.00151	0.00283	0.007226	0.00131	0.0182	0.00250	0.006723333	0.0179	0.00025	0.0411	0.0210	0.0235	0.0411
Magnesium (Mg)	mg/L	0.190	1.26	0.684	0.681	1.18	0.305	0.444	0.330	0.352	0.428	0.326	0.894	0.414	0.521	0.820	0.327	1.13	0.676	0.749	1.12
Manganese (Mn)	mg/L	0.0087	0.259	0.124	0.131	0.246	0.0057	0.0198	0.0089	0.0108	0.0185	0.0074	0.1020	0.0310	0.0437	0.0876	0.00855	0.1350	0.0262	0.0328	0.0834
Mercury (Hg)	mg/L	0.000005	0.000010	0.000005	0.000005	0.000007	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005
Molybdenum (Mo)	mg/L	0.000066	0.0170	0.000500	0.00200	0.01500	0.000340	0.000466	0.000352	0.000378	0.0004489	0.000300	0.00135	0.000382	0.000547	0.001098	0.000373	0.000938	0.000654	0.000690	0.000938
Nickel (Ni)[2]	mg/L	0.000250	0.000790	0.000250	0.000430	0.000736	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250
Phosphorus (P)	mg/L	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
Potassium (K)	mg/L	0.149	0.305	0.272	0.242	0.302	0.087	0.284	0.137	0.161	0.268	0.096	0.682	0.279	0.348	0.68	0.160	1.17	0.627	0.663	1.08
Selenium (Se)	mg/L	0.000050	0.000100	0.000050	0.000067	0.000095	0.000050	0.000100	0.000075	0.000075	0.0001	0.00005	0.00012	0.0001	0.000089	0.00012	0.000050	0.000140	0.000115	0.000102	0.000133
Silicon (Si)	mg/L	0.505	3.44	1.41	1.79	3.24	0.599	0.984	0.651	0.721	0.940	0.596	1.98	0.869	1.19	1.972	0.733	1.22	0.893	0.972	1.22

(continued)

Table 13.3-3. Baseline Water Quality of the Brucejack Watershed (Mine Site Area), Brucejack Gold Mine Project (continued)

Project Area		Mine Site Area and Downstream Receiving Environment																			
Site		Camp Creek					Brucejack Outflow (BJ OF)										Lower Brucejack Creek (2 sites)				
		High Flow (n=22)					Low Flow (n=4)					High Flow (n=9)					Low Flow (n=16)				
	Units	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P
Total Metals *(cont'd)*																					
Silver (Ag)	mg/L	0.000005	**0.00750**	0.000050	**0.000474**	**0.000975**	0.000005	**0.000281**	0.000011	0.000077	**0.00024**	0.00001	**0.00013**	0.00003	0.00006	**0.00012**	0.000005	0.000056	0.000019	0.000027	0.000052
Sodium (Na)	mg/L	1.00	1.00	1.00	1.00	1.00	1.00	3.10	1.00	1.53	2.79	1.00	6.40	1.00	2.44	6.12	1.00	13.7	7.20	8.12	13.6
Strontium (Sr)	mg/L	0.0259	0.184	0.0517	0.0872	0.171	0.0561	0.0972	0.0583	0.0675	0.0915	0.0527	0.184	0.0775	0.103	0.172	0.0625	0.268	0.167	0.180	0.268
Thallium (Tl)	mg/L	0.000016	0.000050	0.000050	0.000039	0.000050	0.000005	0.000050	0.000010	0.000019	0.000045	0.000014	0.000050	0.000050	0.000041	0.000050	0.000005	0.000041	0.000021	0.000018	0.000032
Tin (Sn)	mg/L	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050
Titanium (Ti)	mg/L	0.00500	0.0400	0.00500	0.0167	0.0365	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.015	0.00500	0.00711	0.0146	0.00500	0.00500	0.00500	0.00500	0.00500
Uranium (U)	mg/L	0.000039	0.000081	0.000054	0.000058	0.000078	0.000025	0.000042	0.000033	0.000033	0.000041	0.000025	0.000115	0.000052	0.000058	0.000104	0.000030	0.000240	0.000105	0.000094	0.000161
Vanadium (V)	mg/L	0.000500	0.00120	0.000500	0.000733	0.00113	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.00150	0.000500	0.000800	0.00146	0.000500	0.000500	0.000500	0.000500	0.000500
Zinc (Zn)	mg/L	0.00160	**0.186**	0.0240	**0.0348**	**0.0690**	0.00150	0.00450	0.00150	0.00225	0.00405	0.00150	0.0103	0.00370	0.00488	0.00946	0.00150	0.0250	0.00150	0.00330	0.00888
Dissolved Metals																					
Aluminum (Al)	mg/L	0.0070	0.0251	0.0180	0.0167	0.0244	0.00150	0.00780	0.00585	0.00525	0.0077	0.00710	0.0292	0.0120	0.0149	0.0282	0.00310	0.0223	0.00480	0.00639	0.0133
Antimony (Sb)	mg/L	0.000050	0.000130	0.000050	0.000077	0.000122	0.0002	0.00051	0.000215	0.000285	0.000468	0.0002	0.00102	0.00022	0.000457	0.000952	0.000210	0.00265	0.00155	0.00134	0.00233
Arsenic (As)	mg/L	0.000050	0.00500	0.000200	0.000871	0.00400	0.00035	0.0011	0.00054	0.0006325	0.00103	0.00029	0.00137	0.0006	0.000679	0.00118	0.000050	0.00358	0.00149	0.00186	0.00358
Barium (Ba)	mg/L	0.0170	0.0525	0.0281	0.0325	0.0501	0.0324	0.0351	0.0332	0.0335	0.03486	0.0263	0.0439	0.0321	0.0331	0.0409	0.0322	0.0374	0.0339	0.0341	0.0365
Beryllium (Be)	mg/L	0.000050	0.000250	0.000250	0.000183	0.000250	0.000050	0.000250	0.000050	0.000100	0.000220	0.00005	0.00025	0.00025	0.000161	0.000250	0.000050	0.000050	0.000050	0.000050	0.000050
Bismuth (Bi)	mg/L	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.00025	0.00025	0.00025	0.00025	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250
Boron (B)	mg/L	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.005	0.005	0.0140	0.0050	0.00689	0.0136	0.00500	0.0240	0.0140	0.0150	0.0240
Cadmium (Cd)	mg/L	0.000005	0.005000	0.000400	0.000551	0.000700	0.000005	0.000014	0.000005	0.000007	0.000013	0.000005	0.000036	0.000023	0.000022	0.000034	0.000005	0.000400	0.000005	0.000034	0.000144
Calcium (Ca)	mg/L	4.73	24.2	13.9	13.5	22.3	8.50	10.3	9.01	9.21	10.12	6.93	14.7	9.41	10.3	13.98	9.50	15.1	12.0	12.5	15.0
Chromium (Cr)	mg/L	0.000050	0.000250	0.000100	0.000133	0.000235	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000250	0.000050	0.000083	0.000190	0.000050	0.000110	0.000050	0.000054	0.000068
Cobalt (Co)	mg/L	0.000050	0.001460	0.000320	0.000610	0.00135	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000170	0.000050	0.000079	0.000158	0.000050	0.000450	0.000050	0.000083	0.000233
Copper (Cu)	mg/L	0.000100	0.022000	0.00200	0.00375	0.00900	0.000250	0.000250	0.000250	0.000250	0.000250	0.000100	0.000520	0.000250	0.000249	0.000412	0.000250	0.003000	0.000250	0.000422	0.000938
Iron (Fe)	mg/L	0.00100	0.230	0.0150	0.0541	0.2100	0.0150	0.0150	0.0150	0.0150	0.0150	0.0150	0.0150	0.0150	0.0150	0.0150	0.0150	0.0500	0.0150	0.0172	0.0238
Lead (Pb)	mg/L	0.000025	0.00700	0.000500	0.00103	0.00250	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000500	0.000025	0.000055	0.000144
Lithium (Li)	mg/L	0.000250	0.00250	0.00250	0.00175	0.00250	0.00025	0.00791	0.00138	0.00273	0.00710	0.00071	0.0173	0.0025	0.00650	0.0166	0.000250	0.0405	0.0213	0.0236	0.0405
Magnesium (Mg)	mg/L	0.212	1.25	0.570	0.663	1.18	0.285	0.429	0.312	0.335	0.412	0.265	0.886	0.374	0.469	0.784	0.307	1.13	0.683	0.745	1.12
Manganese (Mn)	mg/L	0.00422	0.229	0.109	0.114	0.217	0.00416	0.00904	0.00521	0.00590	0.008587	0.00177	0.0512	0.0209	0.0218	0.0460	0.0056	0.127	0.0242	0.0306	0.0779
Mercury (Hg)	mg/L	0.000005	0.000200	0.000005	0.000054	0.000171	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005
Molybdenum (Mo)	mg/L	0.000025	0.0150	0.000500	0.002140	0.0130	0.000323	0.000453	0.000347	0.000367	0.000438	0.000258	0.00122	0.000344	0.000517	0.001012	0.000347	0.000899	0.000664	0.000673	0.000889
Nickel (Ni)[2]	mg/L	0.000250	0.000710	0.000250	0.000403	0.000664	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000510	0.000250	0.000267	0.000328
Phosphorus (P)	mg/L	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
Potassium (K)	mg/L	0.095	0.133	0.121	0.116	0.132	0.0820	0.258	0.0910	0.131	0.233	0.084	0.487	0.116	0.234	0.469	0.092	1.12	0.635	0.637	1.03
Selenium (Se)	mg/L	0.000050	0.000100	0.000050	0.000067	0.000095	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000100	0.000050	0.000072	0.000100	0.000050	0.000120	0.000100	0.000084	0.000120
Silicon (Si)	mg/L	0.268	0.671	0.425	0.455	0.646	0.555	0.618	0.575	0.581	0.613	0.447	0.843	0.651	0.647	0.830	0.571	1.01	0.801	0.841	1.01
Silver (Ag)	mg/L	0.000005	0.007500	0.000050	0.000446	0.000500	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000050	0.000005	0.000008	0.000016
Sodium (Na)	mg/L	1.00	1.00	1.00	1.00	1.00	1.00	2.90	1.00	1.48	2.62	1.00	6.10	1.00	2.36	5.78	1.00	12.9	7.10	7.82	12.9
Strontium (Sr)	mg/L	0.0234	0.175	0.0490	0.0825	0.162	0.0537	0.0934	0.0549	0.0642	0.0877	0.0505	0.179	0.0711	0.100	0.168	0.0615	0.259	0.163	0.175	0.258
Thallium (Tl)	mg/L	0.000005	0.000050	0.000050	0.000035	0.000050	0.000005	0.00005	0.000005	0.000016	0.00004325	0.000005	0.00005	0.00005	0.00003	0.00005	0.000005	0.000032	0.000016	0.000014	0.000026
Tin (Sn)	mg/L	0.000050	0.000050	0.000050	0.000050	0.000050	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.000050	0.000050	0.000050	0.000050	0.000050
Titanium (Ti)	mg/L	0.005000	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500
Uranium (U)	mg/L	0.000005	0.000045	0.000015	0.000022	0.000042	0.000015	0.000034	0.000023	0.000024	0.0000325	0.000011	0.000068	0.000027	0.00004	0.000064	0.000023	0.000213	0.000101	0.000084	0.000139
Vanadium (V)	mg/L	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500
Zinc (Zn)	mg/L	0.000500	0.0700	0.0200	0.0279	0.0600	0.00150	0.00150	0.00150	0.00150	0.00150	0.00150	0.003	0.00150	0.00184	0.00276	0.00150	0.0250	0.00150	0.00316	0.00963

(continued)

Table 13.3-3. Baseline Water Quality of the Brucejack Watershed (Mine Site Area), Brucejack Gold Mine Project (continued)

Project Area		Mine Site Area and Downstream Receiving Environment														
Site		Lower Brucejack Creek (2 sites)					Brucejack Creek, Upstream Adjacent Sulphurets Glacier (BJ3)									
		High Flow (n=39)					Low Flow (n=4)					High Flow (n=3)[1]				
	Units	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P
Physical Tests																
Colour	CU	2.50	2.50	2.50	2.50	2.50	2.50	21.0	2.50	7.13	18.2	2.50	2.50	-	2.50	-
Conductivity	µS/cm	46.0	107	59.9	61.2	87.2	90.9	150	112	116	147	50.3	67.4	-	61.4	-
Hardness (as $CaCO_3$)	mg/L	17.0	46.0	24.4	25.3	33.2	31.9	43.4	36.7	37.2	43.0	19.4	26.5	-	23.6	-
pH	pH	6.50	8.13	7.59	7.48	8.10	7.87	8.00	7.97	7.95	8.00	7.63	8.30	-	7.91	-
Total Suspended Solids	mg/L	1.00	34.0	6.00	9.01	22.9	1.50	3.20	1.50	1.93	2.95	3.30	21.5	-	11.4	-
Total Dissolved Solids	mg/L	27.0	86.0	37.5	39.1	59.8	53.0	96.0	66.5	70.5	92.9	26.0	44.0	-	35.0	-
Turbidity	NTU	0.360	14.4	6.00	7.17	13.6	0.410	1.89	1.32	1.23	1.86	3.73	12.3	-	6.87	-
Acidity	mg/L	0.500	4.70	2.40	2.46	4.48	1.60	2.60	2.20	2.15	2.59	1.20	2.30	-	1.63	-
Alkalinity, Bicarbonate (as $CaCO_3$)	mg/L	11.0	22.5	15.4	14.8	19.1	23.8	34.6	28.7	29.0	34.3	12.0	21.3	-	16.7	-
Alkalinity, Carbonate (as $CaCO_3$)	mg/L	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.500	1.00	-	0.833	-
Alkalinity, Hydroxide (as $CaCO_3$)	mg/L	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.500	1.00	-	0.833	-
Alkalinity, Total (as $CaCO_3$)	mg/L	11.0	31.0	15.6	15.8	20.4	23.8	34.6	28.7	29.0	34.3	12.0	21.3	-	16.7	-
Anions and Nutrients																
Ammonia, Total (as N)	mg/L	0.0025	0.0570	0.00390	0.00879	0.0305	0.0372	0.231	0.0587	0.0964	0.208	0.00250	0.00250	-	0.00250	-
Bromide (Br)	mg/L	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	-	0.0250	-
Chloride (Cl)	mg/L	0.150	1.00	0.250	0.324	1.00	0.250	0.250	0.250	0.250	0.250	0.250	0.250	-	0.250	-
Fluoride (F)	mg/L	0.0100	0.0370	0.0220	0.0201	0.0325	0.0340	0.0730	0.0470	0.0503	0.0708	0.0100	0.0280	-	0.0210	-
Nitrate (as N)	mg/L	0.00250	0.00900	0.00250	0.00458	0.00888	-	-	-	-	-	-	-	-	-	-
Nitrite (as N)	mg/L	0.000500	0.000500	0.000500	0.000500	0.000500	-	-	-	-	-	-	-	-	-	-
Total Kjeldahl Nitrogen	mg/L	0.0250	0.122	0.0250	0.0556	0.121	0.0435	0.260	0.0525	0.102	0.229	0.0250	0.0600	-	0.0367	-
Total Nitrogen	mg/L	0.0250	0.157	0.0685	0.0688	0.137	0.138	0.834	0.295	0.3905	0.7743	0.0250	0.0600	-	0.0367	-
Orthophosphate-Dissolved (as P)	mg/L	0.0005	0.002	0.0005	0.000594	0.000875	0.0005	0.00180	0.00150	0.00133	0.00179	0.000500	0.000500	-	0.000500	-
Phosphorus (P)-Total	mg/L	0.00100	0.0377	0.0118	0.0160	0.0346	0.00280	0.00410	0.00375	0.00360	0.00410	0.0054	0.0280	-	0.0146	-
Sulphate (SO_4)	mg/L	5.00	38.0	12.2	12.5	20.9	19.4	35.9	24.9	26.3	35.1	10.7	14.5	-	12.9	-
Cyanides																
Cyanide, Total	mg/L	0.000500	0.00100	0.000500	0.000534	0.000663	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	-	0.000500	-
Cyanide, WAD	mg/L	0.000500	0.00110	0.000500	0.000544	0.000688	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	-	0.000500	-
Organic Carbon																
Total Organic Carbon	mg/L	0.250	0.800	0.250	0.330	0.665	0.250	0.250	0.250	0.250	0.250	0.250	1.10	-	0.667	-
Total Metals																
Aluminum (Al)	mg/L	0.0358	*1.05*	*0.260*	*0.352*	*0.866*	0.0109	0.0634	0.0422	0.0397	0.0627	*0.390*	*0.951*	-	*0.646*	-
Antimony (Sb)	mg/L	0.000170	0.000680	0.000350	0.000389	0.000658	0.00055	0.00223	0.00135	0.00137	0.00221	0.000460	0.000720	-	0.000600	-
Arsenic (As)	mg/L	0.000300	0.00458	0.0017	0.00182	0.00353	0.00141	0.00298	0.00167	0.00193	0.00281	0.00236	0.00490	-	0.00363	-
Barium (Ba)[2]	mg/L	0.0313	0.0541	0.0398	0.0400	0.0522	0.0350	0.0419	0.0376	0.0380	0.0413	0.0417	0.0602	-	0.0480	-
Beryllium (Be)[2]	mg/L	0.000050	0.000250	0.000050	0.000063	0.000100	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	-	0.000050	-
Bismuth (Bi)	mg/L	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	-	0.000250	-
Boron (B)	mg/L	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.0220	0.0130	0.0133	0.0211	0.00500	0.00500	-	0.00500	-
Cadmium (Cd)[2]	mg/L	0.000005	0.0110	0.000100	0.000411	0.000500	0.000005	0.000024	0.000005	0.000010	0.000021	0.000022	0.000097	-	0.000064	-
Calcium (Ca)	mg/L	6.50	12.9	9.73	9.51	12.0	11.9	16.1	13.3	13.7	15.9	7.06	10.2	-	8.86	-
Chromium (Cr)	mg/L	0.000050	0.000590	0.000195	0.000204	0.000358	0.000050	0.000120	0.000050	0.000068	0.000110	0.000150	0.000280	-	0.000217	-
Cobalt (Co)	mg/L	0.000050	0.000640	0.000320	0.000314	0.000520	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000520	-	0.000290	-
Copper (Cu)	mg/L	0.000250	**0.0120**	0.00122	0.00181	0.00400	0.000250	0.000250	0.000250	0.000250	0.000250	0.00076	0.00190	-	0.00132	-
Iron (Fe)	mg/L	0.0150	**1.15**	0.216	0.268	0.577	0.0150	0.0330	0.0235	0.0238	0.0329	0.151	0.936	-	0.529	-
Lead (Pb)	mg/L	0.000249	**0.0210**	0.0006	0.00153	0.00275	0.0001	0.0002	0.0002	0.0002	0.0002	0.0004	0.0018	-	0.00109	-
Lithium (Li)[2]	mg/L	0.000250	0.0100	0.00211	0.00288	0.00768	0.0122	0.0351	0.0188	0.0212	0.0335	0.00233	0.00507	-	0.00408	-
Magnesium (Mg)	mg/L	0.000500	0.820	0.384	0.399	0.606	0.607	1.17	0.819	0.854	1.1475	0.437	0.579	-	0.491	-
Manganese (Mn)	mg/L	0.0195	0.0812	0.0443	0.0475	0.0781	0.0104	0.0169	0.0141	0.0139	0.0165	0.0165	0.0722	-	0.0443	-
Mercury (Hg)	mg/L	0.000005	0.000010	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	-	0.000005	-
Molybdenum (Mo)	mg/L	0.000260	0.0240	0.000500	0.00143	0.00211	0.000511	0.000846	0.000687	0.000683	0.000839	0.000283	0.000476	-	0.000407	-
Nickel (Ni)[2]	mg/L	0.000250	0.000570	0.000250	0.000290	0.000570	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	-	0.000250	-
Phosphorus (P)	mg/L	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	-	0.150	-
Potassium (K)	mg/L	0.092	0.523	0.268	0.274	0.491	0.327	0.920	0.607	0.615	0.911	0.311	0.638	-	0.456	-
Selenium (Se)	mg/L	0.000050	0.000110	0.000050	0.000071	0.000110	0.000110	0.000130	0.000115	0.000118	0.000129	0.000110	0.000130	-	0.000120	-
Silicon (Si)	mg/L	0.768	2.21	1.04	1.21	2.05	0.877	1.05	0.955	0.959	1.04	0.929	2.38	-	1.58	-

(continued)

Table 13.3-3. Baseline Water Quality of the Brucejack Watershed (Mine Site Area), Brucejack Gold Mine Project (completed)

Project Area		Mine Site Area and Downstream Receiving Environment														
Site		Lower Brucejack Creek (2 sites)					Brucejack Creek, Upstream Adjacent Sulphurets Glacier (BJ3)									
		High Flow (n=39)					Low Flow (n=4)					High Flow (n=3)[1]				
	Units	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P
Total Metals *(cont'd)*																
Silver (Ag)	mg/L	0.000005	**0.00750**	0.000050	**0.000282**	**0.000430**	0.000005	0.000014	0.000009	0.000009	0.000014	0.000019	**0.000171**	-	0.000089	-
Sodium (Na)	mg/L	1.00	3.90	1.00	1.34	2.85	4.40	12.8	6.95	7.78	12.3	1.00	2.30	-	1.43	-
Strontium (Sr)	mg/L	0.0490	0.142	0.0695	0.07265	0.105	0.129	0.256	0.182	0.187	0.250	0.0506	0.0889	-	0.0758	-
Thallium (Tl)	mg/L	0.000005	0.000050	0.000014	0.000019	0.000040	0.000005	0.000023	0.000012	0.000013	0.000022	0.000018	0.000045	-	0.000029	-
Tin (Sn)	mg/L	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	-	0.00005	-
Titanium (Ti)	mg/L	0.00500	0.0160	0.00500	0.00719	0.0160	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.0130	-	0.00967	-
Uranium (U)	mg/L	0.000027	0.000073	0.000044	0.000048	0.000069	0.000043	0.000148	0.000081	0.000088	0.000142	0.000046	0.000072	-	0.00006	-
Vanadium (V)	mg/L	0.000500	0.0016	0.000500	0.000700	0.00138	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.0019	-	0.000967	-
Zinc (Zn)	mg/L	0.00250	0.0250	0.00700	0.00910	0.0205	0.00150	0.0015	0.00150	0.00150	0.00150	0.00320	0.0097	-	0.00667	-
Dissolved Metals																
Aluminum (Al)	mg/L	0.00710	0.0620	0.0279	0.0286	0.0513	0.00430	0.00620	0.00470	0.00498	0.00602	0.0183	0.0251	-	0.0216	-
Antimony (Sb)	mg/L	0.000160	0.000610	0.000240	0.000309	0.000610	0.000500	0.00209	0.00133	0.00131	0.00208	0.000250	0.000570	-	0.000460	-
Arsenic (As)	mg/L	0.000280	0.00160	0.000700	0.000782	0.00150	0.00128	0.00289	0.00139	0.00174	0.00268	0.000720	0.00139	-	0.00107	-
Barium (Ba)	mg/L	0.0269	0.0354	0.0310	0.0308	0.0340	0.0340	0.0407	0.0362	0.0368	0.0403	0.0267	0.0325	-	0.0300	-
Beryllium (Be)	mg/L	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	-	0.000050	-
Bismuth (Bi)	mg/L	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	-	0.000250	-
Boron (B)	mg/L	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.0220	0.0135	0.0135	0.0213	0.00500	0.00500	-	0.00500	-
Cadmium (Cd)	mg/L	0.000005	0.00500	0.000100	0.000248	0.000500	0.000005	0.000005	0.000005	0.000005	0.000005	0.000014	0.000060	-	0.000041	-
Calcium (Ca)	mg/L	5.80	16.6	9.30	9.50	12.2	11.8	15.5	13.4	13.5	15.4	7.23	9.88	-	8.80	-
Chromium (Cr)	mg/L	0.000050	0.000170	0.000050	0.000058	0.000080	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	-	0.000050	-
Cobalt (Co)	mg/L	0.000050	0.000290	0.000170	0.000168	0.000290	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000180	-	0.000120	-
Copper (Cu)	mg/L	0.000250	0.004	0.000500	0.000967	0.003000	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	-	0.000250	-
Iron (Fe)	mg/L	0.0100	0.136	0.0150	0.0331	0.0920	0.0150	0.0150	0.0150	0.0150	0.0150	0.0150	0.0150	-	0.0150	-
Lead (Pb)	mg/L	0.000025	0.004	0.000500	0.000562	0.0025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	-	0.000025	-
Lithium (Li)	mg/L	0.00025	0.0101	0.00157	0.00242	0.00735	0.0124	0.0337	0.0186	0.0208	0.0323	0.00188	0.00583	-	0.00381	-
Magnesium (Mg)	mg/L	0.0005	1.10	0.362	0.387	0.6408	0.596	1.13	0.805	0.834	1.11	0.326	0.449	-	0.402	-
Manganese (Mn)	mg/L	0.00750	0.0637	0.0358	0.0342	0.0574	0.00862	0.015	0.0113	0.0116	0.0145	0.00454	0.0402	-	0.02448	-
Mercury (Hg)	mg/L	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	-	0.000005	-
Molybdenum (Mo)	mg/L	0.000221	0.018	0.000500	0.00125	0.00206	0.000495	0.000799	0.000645	0.000646	0.000797	0.000237	0.000496	-	0.000381	-
Nickel (Ni)	mg/L	0.000250	0.000550	0.000250	0.000269	0.000325	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	-	0.000250	-
Phosphorus (P)	mg/L	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	-	0.150	-
Potassium (K)	mg/L	0.0940	0.307	0.155	0.161	0.266	0.293	0.905	0.591	0.595	0.898	0.118	0.277	-	0.211	-
Selenium (Se)	mg/L	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000120	0.000110	0.000098	0.000119	0.000050	0.000050	-	0.000050	-
Silicon (Si)	mg/L	0.378	0.814	0.669	0.625	0.800	0.772	0.995	0.8475	0.866	0.982	0.305	0.554	-	0.465	-
Silver (Ag)	mg/L	0.000005	0.007500	0.000050	0.000261	0.000450	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	-	0.000005	-
Sodium (Na)	mg/L	1.00	3.80	1.00	1.26	2.75	4.40	12.1	6.90	7.58	11.6	1.00	2.20	-	1.40	-
Strontium (Sr)	mg/L	0.0449	0.139	0.0677	0.0699	0.0998	0.131	0.245	0.176	0.182	0.240	0.0519	0.0889	-	0.0753	-
Thallium (Tl)	mg/L	0.000005	0.000016	0.000005	0.000006	0.000008	0.000005	0.000025	0.000016	0.000015	0.000024	0.000005	0.000005	-	0.000005	-
Tin (Sn)	mg/L	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	-	0.000050	-
Titanium (Ti)	mg/L	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	-	0.00500	-
Uranium (U)	mg/L	0.000011	0.000060	0.000023	0.000026	0.000051	0.000045	0.000145	0.000075	0.000085	0.000138	0.000013	0.000042	-	0.000029	-
Vanadium (V)	mg/L	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	-	0.000500	-
Zinc (Zn)	mg/L	0.00150	0.0290	0.00430	0.00684	0.0196	0.00150	0.00150	0.00150	0.00150	0.00150	0.00150	0.00150	-	0.00150	-

Notes:
- Parameter not reported.
As hydrological regime is an important determinant of surface water quality in the Project Area, concentrations (predicted and baseline) assessed for both high flow (June to October) and low flow (November to May) periods.
Grey highlighted values exceed BC chronic water quality guidelines for the protection of aquatic life; bolded font values exceed BC acute (maximum) water quality guidelines.
Italicized font indicates exceedance of CCME guidelines for the protection of aquatic life, applied in the absence of an applicable BC guideline.
Orange font indicates exceedance of health-based drinking water quality guidelines.
[1] *Samples where n ≤ 3, median and 95th percentile summary statistics were not calculated.*
[2] *Working guideline.*

General water quality parameters in lower Brucejack Creek are elevated in concentration compared to Brucejack Lake and upper Brucejack Creek. Lower Brucejack Creek sites are soft (mean hardness: 24.9 to 31.1 mg/L), slightly acidic (mean pH: 7.57 to 7.92), with low total alkalinity (median: 15.0 to 23.1 mg/L) and intermediate conductivity (mean: 56.9 to 90.5 µS/cm). Overall maxima observations of general parameters in Brucejack Creek (conductivity = 150.0 µS/cm; hardness = 46.0 mg/L; pH = 8.13; total alkalinity = 36.4 mg/L) were always associated with lower Brucejack Creek sites.

Metal concentrations within lower Brucejack Creek are generally elevated compared to Brucejack Lake and upper Brucejack Creek; observed trends are element specific. In general, concentrations of total chromium, cobalt, mercury, nickel, selenium, mercury and dissolved aluminum consistently remained near or below detection limits (Table 13.3-3). In contrast, concentrations of total aluminum, arsenic, cadmium, copper, iron, lead, manganese, silver and zinc were consistently above detection limits and exhibited distinct seasonality, with highest concentrations corresponding to highest concentrations of TSS in high flow periods (Table 13.3-3). Of these, iron, lead, and manganese generally increased along Brucejack Creek, from the lake outlet to site BJ3; maxima were usually associated with lower Brucejack Creek (BJ 200m D/S, BJ2) during high flow. This may be due to inputs from the Camp Creek (for example, lead and manganese concentrations increase immediately downstream of Camp Creek Confluence, at BJ OF and BJ 200m D/S (Figures 5.1-13 to 5.15 of Appendix 13-A, Cumulative Surface Water Quality Baseline Report).

The overall factor and frequency of guideline exceedances were generally increased in lower Brucejack Creek relative to upper Brucejack Creek and Brucejack Lake. Both the Brucejack and Sulphurets catchments are highly mineralized areas with gossans and similar geological features evident on the surface, contributing to naturally elevated background metal concentrations. Further, groundwater inputs also influence the water chemistry in the tributaries into Brucejack Creek, contributing to observed increases in some metal concentrations downstream. That is, baseline groundwaters from most areas are shown to be naturally elevated with respect to several metals (total aluminum, silver, arsenic, chromium, copper, iron and zinc) at concentrations exceeding guidelines (Appendix 9-A). Exceedances of mean and/or median concentrations in Brucejack Creek were observed for: total aluminum, cadmium, lead, lithium, silver, and zinc (Table 13.3-4).

13.3.4.2 Mid- and Far-field Downstream Receiving Environment: Sulphurets/Unuk Watersheds

<u>Sulphurets Lake</u>

Sulphurets Lake is a glacial-headed lake, resulting in reduced water clarity and high total suspended solids and turbidity loads. It is a cold, circumneutral, monomictic lake; water column temperatures remain less than 4°C year-round (Appendix 13-A, Cumulative Surface Water Quality Baseline Report). Water chemistry of Sulphurets Lake exhibits pronounced variation across open water and under-ice sampling periods and with depth (Table 13.3-4). During under-ice sampling periods, the waters of Sulphurets Lake were hard (mean hardness: 121.0 mg/L), of circumneutral pH (mean: 7.81), high conductivity (mean: 251.0 µS/cm) with moderate total alkalinity and low sensitivity to acidic inputs (mean total alkalinity: 46.2 mg/L; Table 13.3-4). In contrast, concentrations of general parameters were significantly reduced during open water periods; waters were soft (mean hardness: 35.3 mg/L), of circumneutral pH (mean: 7.95), intermediate conductivity (mean: 78.6 µS/cm) with low total alkalinity and moderate sensitivity to acidic inputs (mean total alkalinity: 18.8 mg/L).

Metal concentrations in Sulphurets Lake are substantially elevated relative to Brucejack Lake. Exceedances of mean and/or median concentrations were observed for: aluminum (total and dissolved), cadmium, chromium, cobalt, copper, iron, silver, and zinc (Table 13.3-4).

Sulphurets Creek

Baseline water quality monitoring (2008-2013) was conducted downstream of the Sulphurets Glacier, upstream of Sulphurets Lake (SC0) as well as along Sulphurets creek, downstream of Sulphurets Lake (SC1, SC2, SC3; Figure 13.3-1).

Water chemistry changes substantially as Brucejack Creek passes under Sulphurets Glacier and joins the existing sub-glacial flow of Sulphurets Creek. Concentrations of TSS and total metals alkalinity, hardness and conductivity were much higher at SC0 relative to upstream monitoring sites (alkalinity = 18.3 to 86.3 mg/L as $CaCO_3$; hardness= 27.2 to 218 mg/L as $CaCO_3$; and conductivity = 58.7 to 420 µS/cm). However, elevated levels of TSS and most metal elements decrease between SC0 and SC1, suggesting that suspended particulate loads and associated bound metals settle out within the water column of Sulphurets Lake.

In general, metal concentrations are substantially elevated within the Sulphurets watershed, and show distinct seasonality, with highest observed concentrations corresponding with high flow periods. This is likely related to both its role in draining the mineralized Kerr and Sulphurets mineral deposits (plus other mineralized zones) as well as the contribution of poor water quality (i.e., elevate concentrations of total and dissolved metals, sulphate) from Mitchell Creek to Sulphurets Creek. An exception was observed for total silver concentrations, which, while showing similar seasonal trends, were generally higher within the Brucejack watershed relative to Sulphurets (in particular Camp Creek, range: 0.00001 to 0.00750 mg/L) and persisted beneath Sulphurets Glacier to SC0 (Figure 5.1-17 of Appendix 13-A, Cumulative Surface Water Quality Baseline Report). Total silver concentrations subsequently decrease between SC0 and SC1, suggesting that bound-silver settles out with suspended particulate loads within the water column of Sulphurets Lake. Silver concentrations increase again along SC1, SC2 and SC3, likely reflecting inputs from tributaries, including Mitchell Creek, to Sulphurets Creek (Table 13.3-4).

Monitoring sites within Sulphurets Creek had the greatest incidence of guideline exceedances (stream and lake sites) of those in the entire baseline study area. Thirteen of the 29 parameters had overall mean concentrations greater than guideline values within the Sulphurets Creek including dissolved aluminum, arsenic, cadmium, cobalt, copper, iron (total and dissolved), mercury, manganese, lead, selenium, silver, and zinc.

Unuk River

Water quality monitoring (2007 to 2013) was conducted upstream and downstream of the confluence of Sulphurets Creek (UR1A), as well as at the international border (UR2; Figure 13.3-1). Waters of the Unuk River were on average circumneutral to alkaline pH (6.89 to 8.55), with lower averages of total alkalinity, conductivity, and hardness compared to Sulphurets Creek (Table 13.3-4). The Unuk River had similar overall trends in metal concentrations to Sulphurets Creek. However, the influence of contributions from Mitchell/Sulphurets Creek is evident in the Unuk River: concentrations of aluminum, arsenic, cadmium, cobalt, copper, manganese, selenium, uranium, and zinc increase in the Unuk River downstream of its confluence with Sulphurets Creek compared to levels observed immediately upstream. Median concentrations higher than guidelines were observed for aluminum (total and dissolved), arsenic, cadmium, chromium, copper, iron (total), and zinc (Table 13.3-4).

Table 13.3-4. Baseline Water Quality of Sulphurets and Unuk Watersheds, Brucejack Gold Mine Project

Project Area		Mid- and Far-field Receiving Environments																			
Site		Sulphurets Creek, Upstream of Sulphurets Lake (SC0)										Sulphurets Lake (SUL)									
		Low Flow (n=5)					High Flow (n=7)					Under Ice (n=4)					Open Water (n=11)				
	Units	Min	Max.	Median	Mean	95th P	Min	Max.	Median	Mean	95th P	Min	Max.	Median	Mean	95th P	Min	Max.	Median	Mean	95th P
Physical Tests																					
Colour	CU	2.50	21.20	2.50	6.24	17.46	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Conductivity	µS/cm	281	420	355	353	412	58.7	139	72.6	90.4	137.5	131	400	251	258	395	53.3	146	78.6	88.2	145
Hardness (as $CaCO_3$)	mg/L	139	218	168	174	212	27.2	62.8	32.8	41.0	62.6	59.3	197	121	125	194	24.0	66.4	35.3	39.8	65.1
pH	pH	8.01	8.15	8.11	8.09	8.14	7.49	8.09	7.98	7.85	8.08	7.75	7.99	7.81	7.84	7.96	6.75	8.39	7.95	7.86	8.29
Total Suspended Solids	mg/L	1.50	22.0	6.30	8.12	19.5	77.1	319	197	209	316	1.50	34.7	17.8	17.9	34.6	10.0	95.1	52.7	47.6	84.8
Total Dissolved Solids	mg/L	176	290	227	234	285	46	91	49	60.4	89.2	96.0	280	181	184	276	39.0	102	54.0	59.7	98.0
Turbidity	NTU	2.23	21.5	5.63	8.43	19.2	31.5	244	193	158	244	0.660	63.1	31.4	31.6	62.9	6.74	121	48.9	50.9	104
Acidity	mg/L	2.00	3.00	2.40	2.46	2.94	0.5	9.20	1.80	2.50	7.07	1.70	3.70	2.60	2.65	3.66	0.500	5.90	2.50	2.41	4.65
Alkalinity, Bicarbonate (as $CaCO_3$)	mg/L	63.6	91.2	79.3	78.3	89.4	18.3	32.5	19.4	23.5	32.2	29.1	69.3	46.2	47.7	68.2	15.9	29.2	18.8	20.7	28.1
Alkalinity, Carbonate (as $CaCO_3$)	mg/L	1.00	1.00	1.00	1.00	1.00	0.500	1.00	1.00	0.929	1.00	1.00	1.00	1.00	1.00	1.00	0.500	1.00	1.00	0.955	1.00
Alkalinity, Hydroxide (as $CaCO_3$)	mg/L	1.00	1.00	1.00	1.00	1.00	0.500	1.00	1.00	0.929	1.00	1.00	1.00	1.00	1.00	1.00	0.500	1.00	1.00	0.955	1.00
Alkalinity, Total (as $CaCO_3$)	mg/L	63.6	91.2	79.3	78.3	89.4	18.3	32.5	19.4	23.5	32.2	29.1	69.3	46.2	47.7	68.2	15.9	29.2	18.8	20.7	28.1
Anions and Nutrients																					
Ammonia, Total (as N)	mg/L	0.00250	0.00980	0.00250	0.00396	0.00834	0.00250	0.00250	0.00250	0.00250	0.00250	0.00520	0.0107	0.00670	0.00733	0.0103	0.00250	0.00930	0.00250	0.00335	0.00720
Bromide (Br)	mg/L	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250
Chloride (Cl)	mg/L	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
Fluoride (F)	mg/L	0.0520	0.0610	0.0590	0.0584	0.0610	0.0100	0.0460	0.0220	0.0220	0.0394	0.0340	0.120	0.0575	0.0673	0.114	0.0100	0.0350	0.0100	0.0186	0.0345
Nitrate (as N)	mg/L	0.0210	0.113	0.0347	0.0475	0.0981	0.0025	0.0241	0.0149	0.0142	0.0235	0.0268	0.0320	0.0282	0.0288	0.0316	0.0080	0.0282	0.0158	0.0163	0.0281
Nitrite (as N)	mg/L	0.0005	0.0019	0.0013	0.00122	0.0019	0.000500	0.001000	0.000500	0.000571	0.000850	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500
Total Kjeldahl Nitrogen	mg/L	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250
Total Nitrogen	mg/L	0.0250	0.0920	0.0250	0.0384	0.0786	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0500	0.0250	0.0273	0.0375
Orthophosphate-Dissolved (as P)	mg/L	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.0015	0.000500	0.000900	0.00147	0.0005	0.00110	0.000500	0.000650	0.0010	0.000500	0.00140	0.000500	0.000773	0.0013
Phosphorus (P)-Total	mg/L	0.00270	0.0295	0.00680	0.0104	0.0255	0.0978	0.498	0.314	0.324	0.496	0.0010	0.0457	0.0196	0.0215	0.0446	0.00100	0.106	0.0524	0.0503	0.0917
Sulphate (SO_4)	mg/L	82.4	143	106	110	139	8.89	33.8	14.2	18.8	32.9	33.0	150	79.3	85.4	146	9.61	40.3	16.5	20.6	39.8
Cyanides																					
Cyanide, Total	mg/L	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500
Cyanide, WAD	mg/L	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500
Organic Carbon																					
Total Organic Carbon	mg/L	0.250	0.250	0.250	0.250	0.250	0.250	1.5	0.590	0.667	1.41	0.250	0.250	0.250	0.250	0.250	0.250	0.880	0.250	0.405	0.755
Total Metals																					
Aluminum (Al)	mg/L	*0.114*	*0.878*	*0.197*	*0.400*	*0.830*	*3.07*	*8.01*	*6.82*	*5.91*	*7.98*	0.0253	*3.03*	*1.06*	*1.29*	*2.87*	*1.04*	*3.75*	*2.30*	*2.35*	*3.73*
Antimony (Sb)	mg/L	0.00150	0.00200	0.00153	0.00166	0.00196	0.00214	0.00497	0.00353	0.00362	0.00490	0.00121	0.00175	0.00143	0.00146	0.00173	0.00107	0.00195	0.00140	0.00140	0.00180
Arsenic (As)	mg/L	0.000970	0.00332	0.00127	0.001668	0.002982	0.0102	0.0255	0.0171	0.0179	0.0252	0.00018	0.00442	0.00198	0.00214	0.00430	0.00176	0.00789	0.00443	0.00459	0.00717
Barium (Ba)[2]	mg/L	0.0465	0.0672	0.0500	0.0553	0.0664	0.0981	0.233	0.194	0.178	0.233	0.0424	0.0967	0.0615	0.0655	0.0939	0.0531	0.132	0.0765	0.0802	0.124
Beryllium (Be)[2]	mg/L	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000250	0.000160	0.000151	0.000244	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000250	0.000050	0.000094	0.000250
Bismuth (Bi)	mg/L	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250
Boron (B)	mg/L	0.00500	0.0150	0.00500	0.00700	0.0130	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500
Cadmium (Cd)[2]	mg/L	0.000045	0.000100	0.000065	0.000067	0.000096	0.000171	0.000403	0.000278	0.000284	0.000395	0.000086	0.000227	0.000109	0.000133	0.000211	0.000059	0.000141	0.000097	0.000097	0.000135
Calcium (Ca)	mg/L	51.5	77.1	59.9	63.6	76.0	12.1	28.6	20.0	19.3	27.0	22.8	72.4	43.2	45.4	70.9	8.81	22.2	12.6	14.0	22.2
Chromium (Cr)	mg/L	0.000050	0.000620	0.000210	0.000244	0.000540	**0.00243**	**0.00639**	**0.00490**	**0.00456**	**0.00624**	0.000050	**0.00184**	0.00077	0.000858	**0.00179**	0.000840	**0.00379**	**0.00171**	**0.00171**	**0.00313**
Cobalt (Co)	mg/L	0.000230	0.000720	0.000400	0.000420	0.000676	0.00210	0.00574	0.00397	0.00405	0.00566	0.00113	0.00307	0.00128	0.00169	0.00281	0.000680	0.00194	0.00131	0.00125	0.00181
Copper (Cu)	mg/L	0.00118	0.00701	0.00184	0.00302	0.00630	**0.0158**	**0.0415**	**0.0337**	**0.0310**	**0.0406**	**0.0135**	**0.0780**	**0.0205**	**0.0331**	**0.0694**	**0.00901**	**0.0256**	**0.0132**	**0.0159**	**0.0245**
Iron (Fe)	mg/L	0.0960	**1.13**	0.206	0.366	0.960	**4.89**	**13.9**	**9.67**	**9.76**	**13.9**	0.0150	**2.80**	**1.06**	**1.23**	**2.67**	0.874	**4.95**	**2.41**	**2.51**	**4.25**
Lead (Pb)	mg/L	0.00014	0.00107	0.00030	0.00052	0.00104	0.0055	0.0135	0.0101	0.0097	0.0133	0.00003	0.00303	0.00138	0.00145	0.00299	0.00100	0.00584	0.00285	0.00292	0.00487
Lithium (Li)[2]	mg/L	0.00247	0.00427	0.00313	0.00323	0.00414	0.00230	0.00806	0.00549	0.00550	0.00799	0.00159	0.00358	0.00258	0.00258	0.00350	0.00105	0.00258	0.00180	0.00178	0.00254
Magnesium (Mg)	mg/L	4.16	6.27	4.86	5.14	6.16	2.19	5.66	4.10	3.90	5.42	2.21	5.92	3.78	3.92	5.80	1.13	2.35	1.82	1.78	2.29
Manganese (Mn)	mg/L	0.0496	0.119	0.0637	0.0763	0.113	0.188	0.524	0.348	0.358	0.519	0.0909	0.499	0.161	0.228	0.454	0.0716	0.165	0.119	0.112	0.160
Mercury (Hg)	mg/L	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000094	0.000023	0.000036	0.000089	0.000005	0.000025	0.000011	0.000013	0.000024	0.000005	0.000027	0.000005	0.000011	0.000026
Molybdenum (Mo)	mg/L	0.00189	0.00248	0.00228	0.00225	0.00246	0.000722	0.00182	0.00115	0.00116	0.00167	0.00101	0.00189	0.00138	0.00142	0.00186	0.000413	0.000992	0.000690	0.000693	0.000986
Nickel (Ni)[2]	mg/L	0.000560	0.00101	0.000790	0.000790	0.0010	0.00202	0.00559	0.00370	0.00390	0.00549	0.00122	0.00242	0.00170	0.00176	0.00234	0.000790	0.00371	0.00134	0.00149	0.00286
Phosphorus (P)	mg/L	0.150	0.150	0.150	0.150	0.150	0.150	0.460	0.340	0.294	0.460	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
Potassium (K)	mg/L	0.639	1.04	0.724	0.770	0.990	1.15	2.27	2.13	1.79	2.24	0.60	1.27	0.809	0.871	1.23	0.537	1.60	0.865	0.96	1.55
Selenium (Se)	mg/L	0.000170	0.000360	0.000220	0.000260	0.000354	0.00017	0.00043	0.00033	0.000305714	0.000412	0.00027	0.00037	0.00035	0.00033	0.00037	0.000050	0.000280	0.000200	0.000182	0.000275
Silicon (Si)	mg/L	1.57	3.81	1.79	2.23	3.49	7.61	15.6	13.5	12.0	15.2	1.67	6.14	3.51	3.71	5.93	2.59	9.17	4.97	5.23	8.55

(continued)

Table 13.3-4. Baseline Water Quality of Sulphurets and Unuk Watersheds, Brucejack Gold Mine Project (continued)

Project Area		Mid- and Far-field Receiving Environments																			
Site		Sulphurets Creek, Upstream of Sulphurets Lake (SC0)										Sulphurets Lake (SUL)									
		Low Flow (n=5)					High Flow (n=7)					Under Ice (n=4)					Open Water (n=11)				
	Units	Min	Max.	Median	Mean	95th P	Min	Max.	Median	Mean	95th P	Min	Max.	Median	Mean	95th P	Min	Max.	Median	Mean	95th P
Total Metals *(cont'd)*																					
Silver (Ag)	mg/L	0.000005	0.000043	0.000005	0.000018	0.000041	**0.000156**	**0.000419**	**0.000261**	**0.000267**	**0.000389**	0.000005	0.000064	0.000024	0.000029	0.000061	0.000026	**0.00013**	0.00007	0.00007	**0.00013**
Sodium (Na)	mg/L	1.00	3.60	3.10	2.82	3.56	1.00	1.00	1.00	1.00	1.00	1.00	2.60	1.65	1.73	2.56	1.00	1.00	1.00	1.00	1.00
Strontium (Sr)	mg/L	0.298	0.444	0.368	0.370	0.434	0.065	0.161	0.110	0.108	0.151	0.125	0.424	0.240	0.257	0.412	0.0502	0.1300	0.0789	0.0827	0.129
Thallium (Tl)	mg/L	0.000005	0.000020	0.000005	0.000011	0.000020	0.000053	0.000129	0.000098	0.000089	0.000127	0.000005	0.000050	0.000023	0.000025	0.000049	0.000020	0.000060	0.000040	0.000040	0.000056
Tin (Sn)	mg/L	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000100	0.000050	0.000057	0.000085	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000170	0.000050	0.000061	0.000110
Titanium (Ti)	mg/L	0.005	0.0480	0.00500	0.0152	0.0410	0.113	0.259	0.223	0.198	0.250	0.00500	0.0650	0.0305	0.0328	0.0637	0.0230	0.120	0.0680	0.0705	0.113
Uranium (U)	mg/L	0.000146	0.000226	0.000164	0.000177	0.000219	0.000100	0.000258	0.000171	0.000162	0.000243	0.000064	0.000106	0.000082	0.000084	0.000103	0.000041	0.000106	0.000061	0.000064	0.000092
Vanadium (V)	mg/L	0.0005	0.00280	0.000500	0.00106	0.00244	0.0100	0.0251	0.0211	0.0186	0.0248	0.000500	0.00780	0.00290	0.00353	0.00743	0.00260	0.0104	0.00710	0.00648	0.0104
Zinc (Zn)	mg/L	0.00150	0.0067	0.00430	0.00456	0.00656	0.0230	**0.0581**	**0.0407**	**0.0418**	**0.0581**	0.0128	0.0304	0.0140	0.0178	0.0281	0.0083	0.0226	0.0157	0.0147	0.0215
Dissolved Metals																					
Aluminum (Al)	mg/L	0.0190	0.0688	0.0280	0.0379	0.0647	0.0791	**0.280**	**0.117**	**0.132**	**0.237**	0.0145	0.0830	0.0462	0.0475	0.0799	0.0345	**0.276**	0.0636	0.0942	**0.206**
Antimony (Sb)	mg/L	0.00134	0.00180	0.00152	0.00153	0.00176	0.000610	0.00171	0.000940	0.000981	0.00154	0.000910	0.00127	0.00108	0.00108	0.00125	0.000480	0.000950	0.000630	0.000665	0.000940
Arsenic (As)	mg/L	0.000620	0.000700	0.000630	0.000646	0.000692	0.000880	0.00139	0.00108	0.00111	0.00135	0.000050	0.000530	0.000360	0.000325	0.000514	0.000160	0.00117	0.000450	0.000476	0.000940
Barium (Ba)	mg/L	0.0439	0.0495	0.0467	0.0464	0.0491	0.0239	0.0475	0.0358	0.0337	0.0442	0.0305	0.0448	0.0361	0.0369	0.0443	0.0209	0.0320	0.0265	0.0264	0.0316
Beryllium (Be)	mg/L	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000250	0.000050	0.000086	0.000250
Bismuth (Bi)	mg/L	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250
Boron (B)	mg/L	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500
Cadmium (Cd)	mg/L	0.000035	0.000092	0.000045	0.000057	0.000088	0.000005	0.000024	0.000005	0.000009	0.000021	0.000025	0.000226	0.000078	0.000102	0.000211	0.000005	0.000036	0.000017	0.000020	0.000036
Calcium (Ca)	mg/L	49.1	77.1	59.6	61.5	74.9	9.95	22.4	11.7	14.7	22.3	21.1	69.5	43.1	44.2	68.6	8.67	23.7	12.7	14.1	23.2
Chromium (Cr)	mg/L	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000140	0.000050	0.000063	0.000113	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000250	0.000050	0.000106	0.000250
Cobalt (Co)	mg/L	0.000050	0.000540	0.000180	0.000246	0.000496	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.00297	0.000645	0.00108	0.002700	0.000050	0.000230	0.000050	0.000105	0.000225
Copper (Cu)	mg/L	0.000250	0.000660	0.000560	0.000464	0.000648	0.000250	0.000580	0.000250	0.000297	0.000481	0.000250	0.0481	0.00943	0.0168	0.0437	0.000250	0.00100	0.00028	0.000484	0.00100
Iron (Fe)	mg/L	0.0150	0.0150	0.0150	0.0150	0.0150	0.0150	0.0500	0.0150	0.0263	0.0467	0.0150	0.0150	0.0150	0.0150	0.0150	0.0150	0.2020	0.0150	0.0388	0.132
Lead (Pb)	mg/L	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000187	0.000052	0.000063	0.000153	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000240	0.000025	0.000056	0.000163
Lithium (Li)	mg/L	0.00237	0.00342	0.00296	0.00287	0.00335	0.00025	0.000850	0.00053	0.000501	0.000817	0.000250	0.00333	0.00177	0.00178	0.00328	0.000250	0.00250	0.000250	0.000740	0.00250
Magnesium (Mg)	mg/L	3.91	6.09	4.72	4.88	5.95	0.576	1.76	0.849	1.08	1.73	1.61	5.73	3.36	3.52	5.64	0.562	1.74	0.886	1.01	1.73
Manganese (Mn)	mg/L	0.0440	0.0933	0.0497	0.0580	0.0856	0.000547	0.00978	0.00134	0.00261	0.00784	0.0175	0.490	0.119	0.186	0.447	0.00081	0.0513	0.0170	0.0229	0.0511
Mercury (Hg)	mg/L	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000030	0.000005	0.000009	0.000023	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005
Molybdenum (Mo)	mg/L	0.0018	0.00229	0.00224	0.002154	0.00229	0.000489	0.00141	0.000726	0.000799	0.001293	0.000970	0.001960	0.001295	0.001380	0.00190	0.000371	0.00102	0.000577	0.000618	0.00101
Nickel (Ni)[2]	mg/L	0.000510	0.000850	0.000550	0.000636	0.000828	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.00235	0.000725	0.00101	0.00218	0.000250	0.000960	0.000250	0.000315	0.000605
Phosphorus (P)	mg/L	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
Potassium (K)	mg/L	0.503	0.753	0.625	0.628	0.737	0.154	0.377	0.208	0.246	0.364	0.328	0.603	0.464	0.465	0.601	0.126	0.291	0.175	0.189	0.289
Selenium (Se)	mg/L	0.000150	0.000350	0.000210	0.000234	0.000340	0.000050	0.000270	0.000160	0.000173	0.000270	0.000280	0.000360	0.000300	0.000310	0.000351	0.000050	0.000270	0.000130	0.000145	0.000265
Silicon (Si)	mg/L	1.37	1.51	1.43	1.43	1.50	0.421	1.02	0.582	0.628	0.9573	0.950	2.18	1.31	1.44	2.10	0.355	1.01	0.554	0.603	0.943
Silver (Ag)	mg/L	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005
Sodium (Na)	mg/L	1.00	3.50	3.00	2.68	3.44	1.00	1.00	1.00	1.00	1.00	1.00	2.60	1.55	1.68	2.53	1.00	1.00	1.00	1.00	1.00
Strontium (Sr)	mg/L	0.287	0.414	0.357	0.351	0.403	0.0551	0.126	0.0724	0.0837	0.126	0.119	0.429	0.241	0.258	0.418	0.0471	0.137	0.0785	0.0804	0.137
Thallium (Tl)	mg/L	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000011	0.000005	0.000006	0.000009	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000050	0.000005	0.000013	0.000050
Tin (Sn)	mg/L	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050
Titanium (Ti)	mg/L	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500
Uranium (U)	mg/L	0.000107	0.000202	0.000151	0.000154	0.000196	0.000018	0.000056	0.000034	0.000038	0.000056	0.000045	0.000106	0.000076	0.000076	0.000103	0.000005	0.000018	0.000015	0.000014	0.000018
Vanadium (V)	mg/L	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500
Zinc (Zn)	mg/L	0.00150	0.00310	0.00150	0.00182	0.00278	0.00150	0.00150	0.00150	0.00150	0.00150	0.00150	0.0293	0.00720	0.0113	0.0268	0.000500	0.00150	0.00150	0.00137	0.00150

(continued)

Table 13.3-4. Baseline Water Quality of Sulphurets and Unuk Watersheds, Brucejack Gold Mine Project (continued)

Project Area		Mid- and Far-field Receiving Environments																			
Site		Sulphurets Creek (3 sites)										Unuk River, Upstream of Sulphurets Confluence (UR1A)									
		Low Flow (n=85)					High Flow (n=105)					Low Flow (n=25)					High Flow (n=22)				
	Units	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P
Physical Tests																					
Colour	CU	2.50	95.3	2.50	3.77	2.50	2.50	94.2	2.50	5.62	2.91	2.50	8.70	2.50	3.00	5.72	2.50	6.60	2.50	3.08	5.78
Conductivity	µS/cm	2.5	473	390	364	450	2.5	360	139	152	299	90.2	237	200	189	235	84.60	159	106	110	154
Hardness (as $CaCO_3$)	mg/L	28.0	230	180	174	221	27.3	227	65.55	73.1	146.7	45.1	112	90.8	88.1	109	39.3	71.5	48.2	51.2	71.0
pH	pH	7.07	8.31	8.03	7.99	8.20	6.65	8.35	7.84	7.77	8.13	7.49	8.31	8.10	8.07	8.21	7.77	8.55	7.98	7.99	8.25
Total Suspended Solids	mg/L	1.50	280	7.80	21.3	90.6	1.50	859	97.5	136	500	1.50	47.30	1.50	3.97	8.46	1.50	415	18.30	68.50	326
Total Dissolved Solids	mg/L	42.0	326	256	243	306	25.8	234	96.5	100	192	65.0	147	116	112	142	50.00	122	74.50	75.95	109
Turbidity	NTU	0.140	212	13.3	24.1	86.3	1.48	531	78.1	107	350	0.250	31.7	0.69	2.70	13.6	3.94	380	25.9	60.4	221
Acidity	mg/L	0.500	6.30	3.00	3.16	5.88	0.500	12.1	2.65	2.98	5.9	0.500	4.70	2.60	2.51	4.26	0.500	11.90	2.35	2.90	4.85
Alkalinity, Bicarbonate (as $CaCO_3$)	mg/L	18.2	103	77.9	73.0	100	1.00	65.2	27.2	29.9	56.8	34.2	87.7	69.5	68.0	84.9	30.4	59.2	39.2	40.9	58.6
Alkalinity, Carbonate (as $CaCO_3$)	mg/L	0.500	1.00	1.00	0.988	1.00	0.500	1.00	1.00	0.884	1.00	0.500	1.00	1.00	0.980	1.00	0.500	1.00	1.00	0.864	1.00
Alkalinity, Hydroxide (as $CaCO_3$)	mg/L	0.500	1.00	1.00	0.988	1.00	0.500	1.00	1.00	0.884	1.00	0.500	1.00	1.00	0.980	1.00	0.500	1.00	1.00	0.864	1.00
Alkalinity, Total (as $CaCO_3$)	mg/L	18.2	103	77.9	73.0	100	1.00	65.2	27.1	29.7	56.2	34.2	87.7	69.5	68.0	84.9	30.4	59.2	39.2	40.9	58.6
Anions and Nutrients																					
Ammonia, Total (as N)	mg/L	0.00250	0.00800	0.00250	0.00276	0.00482	0.00250	0.0179	0.00250	0.00321	0.00760	0.00250	0.00520	0.00250	0.00261	0.00250	0.00250	0.00550	0.00250	0.00264	0.00250
Bromide (Br)	mg/L	0.0250	0.355	0.0250	0.0356	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250
Chloride (Cl)	mg/L	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.500	0.250	0.260	0.250	0.250	0.250	0.250	0.250	0.250
Fluoride (F)	mg/L	0.01000	0.208	0.123	0.117	0.189	0.0100	0.171	0.0550	0.0673	0.145	0.0200	0.0450	0.0350	0.0346	0.0450	0.0100	0.0350	0.0210	0.0196	0.0339
Nitrate (as N)	mg/L	0.01110	0.667	0.0865	0.115	0.280	0.00640	0.189	0.0224	0.0374	0.0959	0.0465	0.175	0.0840	0.0906	0.174	0.0139	0.0802	0.0275	0.0341	0.0709
Nitrite (as N)	mg/L	0.000500	0.00140	0.000500	0.000536	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.0019	0.000500	0.000564	0.000500
Total Kjeldahl Nitrogen	mg/L	0.0250	0.13300	0.0250	0.0336	0.0940	0.0250	0.131	0.0250	0.0376	0.102	0.0250	0.0950	0.0250	0.0363	0.0834	0.0250	0.132	0.0250	0.0457	0.1235
Total Nitrogen	mg/L	0.0250	0.763	0.09000	0.131	0.329	0.0250	0.280	0.0250	0.0618	0.151	0.0250	0.270	0.0850	0.105	0.245	0.025	0.170	0.0535	0.0691	0.159
Orthophosphate-Dissolved (as P)	mg/L	0.000500	0.0154	0.000500	0.00106	0.00238	0.000500	0.0123	0.000500	0.000924	0.00245	0.000500	0.00190	0.000500	0.000644	0.00136	0.000500	0.00200	0.000500	0.000819	0.00170
Phosphorus (P)-Total	mg/L	0.00100	1.46	0.0364	0.122	0.791	0.00230	1.42	0.132	0.229	0.765	0.00100	0.0797	0.00330	0.00748	0.0226	0.00570	0.675	0.0408	0.111	0.4991
Sulphate (SO_4)	mg/L	9.02	153	117	112	144	9.72	113	38.0	44.8	93.1	11.4	40.9	30.4	29.3	39.5	8.8	22.8	12.4	13.9	22.4
Cyanides																					
Cyanide, Total	mg/L	-	-	-	-	-	0.00110	0.00110	0.00110	0.00110	0.00110	-	-	-	-	-	-	-	-	-	-
Cyanide, WAD	mg/L	0.000500	0.003	0.000500	0.000630	0.001385	0.000500	0.001900	0.000500	0.000615	0.001315	0.000500	0.0022	0.000500	0.000834	0.0016	0.000500	0.0023	0.000500	0.000814	0.002085
Organic Carbon																					
Total Organic Carbon	mg/L	0.250	2.98	0.340	0.513	1.055	0.250	1.77	0.250	0.500	1.38	0.250	1.78	0.825	0.926	1.66	0.250	3.09	0.680	0.923	2.30
Total Metals																					
Aluminum (Al)	mg/L	0.0078	*7.40*	*0.419*	*0.809*	*2.564*	0.0460	*20.9*	*3.12*	*3.96*	*10.1*	0.00950	*1.78*	0.0410	*0.194*	*0.776*	*0.209*	*17.0*	*1.03*	*2.53*	*8.16*
Antimony (Sb)	mg/L	0.000050	0.00155	0.00079	0.000900	0.00144	0.00032	0.00405	0.00112	0.00126	0.00216	0.00102	0.00334	0.00198	0.00205	0.00312	0.000730	0.00407	0.00128	0.00157	0.00266
Arsenic (As)	mg/L	0.000170	0.0786	0.00251	0.00652	0.0443	0.00043	0.059	0.00607	0.00885	0.026645	0.000280	0.00132	0.000340	0.000483	0.00121	0.000510	0.0198	0.00152	0.00314	0.00896
Barium (Ba)[2]	mg/L	0.0175	0.243	0.0419	0.0493	0.09572	0.0298	0.410	0.08785	0.109	0.245	0.0226	0.0446	0.0333	0.0339	0.0423	0.0214	0.297	0.0348	0.0608	0.174
Beryllium (Be)[2]	mg/L	0.000050	0.000640	0.000250	0.000218	0.000250	0.000050	0.000840	0.000250	0.000229	0.000343	0.000050	0.000250	0.000250	0.000162	0.000250	0.000050	0.000560	0.000250	0.000182	0.000250
Bismuth (Bi)	mg/L	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000730	0.000250	0.000255	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250
Boron (B)	mg/L	0.00500	0.016	0.00500	0.00594	0.0110	0.00500	0.0120	0.00500	0.00518	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.0130	0.00500	0.00568	0.01165
Cadmium (Cd)[2]	mg/L	0.000005	0.00576	0.00147	0.00138	0.00357	0.000025	0.00559	0.000874	0.00114	0.00304	0.000014	0.000099	0.000025	0.000034	0.000077	0.000030	0.000425	0.000050	0.000084	0.000270
Calcium (Ca)	mg/L	7.52	92.5	65.5	62.0	79.2	10.3	59.8	24.7	26.4	48.3	14.3	37.7	29.4	28.8	37.2	13.0	30.5	16.3	18.1	24.8
Chromium (Cr)	mg/L	0.00005	**0.00654**	0.00025	0.000613	**0.00166**	0.00014	**0.0237**	**0.00231**	**0.00326**	**0.00862**	0.000050	**0.00368**	0.000210	0.000485	**0.00160**	0.00048	**0.0297**	**0.00193**	**0.00462**	**0.0159**
Cobalt (Co)	mg/L	0.00016	0.00948	0.00162	0.00197	0.00495	0.00034	0.0159	0.002595	0.003520577	0.007663	0.000050	0.00103	0.00005	0.000160	0.000574	0.00019	0.0110	0.00072	0.00164	0.00591
Copper (Cu)	mg/L	0.00191	**0.315**	**0.0734**	**0.0875**	**0.227**	0.00262	**0.474**	**0.0858**	**0.121**	**0.361**	0.000250	0.00440	0.000490	0.000894	0.00245	0.00104	**0.0458**	0.00326	**0.00709**	**0.0242**
Iron (Fe)	mg/L	0.0150	**18.1**	**1.85**	**2.89**	**11.6**	0.0480	**36.6**	**5.58**	**7.33**	**16.5**	0.0350	**2.49**	0.0920	0.32488	**1.08**	0.297	**23.6**	**1.41**	**3.59**	**12.9**
Lead (Pb)	mg/L	0.000025	0.00939	0.00096	0.00154	0.00652	0.0001	0.0193	0.00394	0.00491	0.0115	0.000025	0.00163	0.000066	0.000244	0.00111	0.0003	0.0105	0.00107	0.00194	0.0071
Lithium (Li)[2]	mg/L	0.001	0.00251	0.00250	0.00226	0.00250	0.00083	0.0130	0.0025	0.00284	0.00653	0.000660	0.00250	0.00250	0.00200	0.00250	0.000880	0.0124	0.00250	0.00275	0.00687
Magnesium (Mg)	mg/L	2.84	7.09	5.36	5.30	7.00	1.24	13.2	3.21	3.48	6.01	2.58	5.77	4.74	4.59	5.57	2.30	10.7	3.10	3.69	6.38
Manganese (Mn)	mg/L	0.0268	0.425	0.218	0.206	0.364	0.0462	0.973	0.212	0.242	0.501	0.00690	0.0600	0.00942	0.0149	0.0449	0.0135	0.651	0.0392	0.0982	0.374
Mercury (Hg)	mg/L	0.000005	0.000022	0.000005	0.000005	0.000005	0.000005	0.000075	0.000005	0.000013	0.000033	0.000005	0.000012	0.000005	0.000005	0.000005	0.000005	0.000067	0.000005	0.000012	0.000052
Molybdenum (Mo)	mg/L	0.000305	0.00545	0.00241	0.00232	0.00404	0.000504	0.00636	0.00154	0.00185	0.00368	0.000477	0.00127	0.00104	0.000970	0.00125	0.000545	0.00135	0.0007225	0.000788	0.00108
Nickel (Ni)[2]	mg/L	0.0006	0.00729	0.00170	0.00187	0.00340	0.0003	0.0221	0.00268	0.00352	0.00852	0.000250	0.00882	0.000250	0.000927	0.00171	0.000890	**0.0283**	0.00184	0.00448	0.0157
Phosphorus (P)	mg/L	0.150	1.32	0.150	0.215	0.780	0.150	1.41	0.150	0.290	0.789	0.150	0.150	0.150	0.150	0.150	0.150	0.770	0.150	0.203	0.529
Potassium (K)	mg/L	0.318	2.71	1.48	1.33	2.09	0.340	6.17	1.54	1.74	3.56	0.353	0.733	0.550	0.543	0.652	0.408	4.55	0.645	1.01	2.71
Selenium (Se)	mg/L	0.000200	0.00473	0.00195	0.00172	0.00331	0.000050	0.00367	0.000830	0.00103	0.00223	0.000350	0.000850	0.000670	0.000636	0.000820	0.000300	0.000970	0.000460	0.000508	0.000789
Silicon (Si)	mg/L	1.62	11.6	2.75	3.08	5.87	1.15	35.7	6.48	7.96	18.4	1.93	5.28	2.08	2.30	2.87	1.64	32.1	3.23	6.32	20.1

(continued)

Table 13.3-4. Baseline Water Quality of Sulphurets and Unuk Watersheds, Brucejack Gold Mine Project (continued)

Project Area		Mid- and Far-field Receiving Environments																			
Site		Sulphurets Creek (3 sites)										Unuk River, Upstream of Sulphurets Confluence (UR1A)									
		Low Flow (n=85)					High Flow (n=105)					Low Flow (n=25)					High Flow (n=22)				
	Units	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P
Total Metals *(cont'd)*																					
Silver (Ag)	mg/L	0.00001	**0.00018**	0.00001	0.00002	0.00008	0.00001	**0.00055**	0.00006	0.00009	**0.00025**	0.000005	0.000054	0.000005	0.000010	0.000034	0.000005	**0.000253**	0.000024	0.000044	**0.000143**
Sodium (Na)	mg/L	1.00	4.20	2.30	2.15	3.78	1.00	2.30	1.00	1.02	1.00	1.00	3.70	2.40	2.16	3.36	1.00	2.40	1.00	1.06	1.00
Strontium (Sr)	mg/L	0.0928	0.465	0.368	0.341	0.441	0.0578	0.317	0.135	0.145	0.261	0.125	0.313	0.253	0.239	0.284	0.103	0.205	0.140	0.149	0.197
Thallium (Tl)	mg/L	0.000005	0.000110	0.000050	0.000038	0.000050	0.000005	0.000266	0.000050	0.000061	0.000156	0.000005	0.000050	0.000050	0.000031	0.000050	0.000005	0.000167	0.000050	0.000044	0.000107
Tin (Sn)	mg/L	0.000050	0.000450	0.000050	0.000056	0.000050	0.000050	0.000200	0.000050	0.000077	0.000180	0.000050	0.000100	0.000050	0.000052	0.000050	0.000050	0.000140	0.000050	0.000057	0.000117
Titanium (Ti)	mg/L	0.00500	0.396	0.00500	0.0286	0.111	0.00500	1.46	0.113	0.187	0.544	0.00500	0.0610	0.00500	0.0104	0.0330	0.00500	0.666	0.0420	0.109	0.374
Uranium (U)	mg/L	0.000005	0.000791	0.000437	0.000354	0.000615	0.000032	0.000864	0.000297	0.000313	0.000681	0.000022	0.000050	0.000038	0.000038	0.000050	0.000020	0.000300	0.000038	0.000063	0.000170
Vanadium (V)	mg/L	0.0005	0.0249	0.0005	0.00222	0.00742	0.0005	0.0928	0.0096	0.0132	0.0361	0.000500	0.00630	0.000500	0.00104	0.00320	0.000500	0.0763	0.00475	0.0113	0.03887
Zinc (Zn)	mg/L	0.00340	**0.426**	**0.101**	0.09745	**0.268**	0.00440	**0.395**	**0.0718**	**0.0861**	**0.212**	0.00150	0.0128	0.00300	0.00358	0.00734	0.00320	**0.0780**	0.00700	0.0133	**0.0382**
Dissolved Metals																					
Aluminum (Al)	mg/L	0.00410	**0.255**	0.0366	0.0403	0.0821	0.00500	**0.417**	0.0415	0.0513	**0.103**	0.00150	**0.170**	0.00570	0.0151	0.0302	0.0179	**0.133**	0.0436	0.0549	**0.130**
Antimony (Sb)	mg/L	0.000050	0.00144	0.000550	0.000735	0.00132	0.000050	0.00138	0.000480	0.000561	0.00109	0.000890	0.00342	0.00198	0.00203	0.00325	0.000630	0.00420	0.00110	0.00132	0.00210
Arsenic (As)	mg/L	0.000050	0.00134	0.000150	0.000210	0.000464	0.000050	0.00096	0.000140	0.000235	0.000627	0.000210	0.000350	0.000270	0.000268	0.000298	0.000220	0.000710	0.000355	0.000381	0.000499
Barium (Ba)	mg/L	0.0110	0.0465	0.0372	0.0363	0.0425	0.0212	0.0463	0.0303	0.0311	0.0419	0.0162	0.0404	0.0316	0.0308	0.0385	0.0147	0.0271	0.0202	0.0203	0.0258
Beryllium (Be)	mg/L	0.000050	0.000250	0.000250	0.000179	0.000250	0.000050	0.000250	0.000250	0.000172	0.000250	0.000050	0.000250	0.000250	0.000162	0.000250	0.000050	0.000250	0.000250	0.000159	0.000250
Bismuth (Bi)	mg/L	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250
Boron (B)	mg/L	0.00500	0.0130	0.00500	0.00575	0.0110	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500
Cadmium (Cd)	mg/L	0.000005	0.00370	0.000687	0.000669	0.00158	0.000005	0.00485	0.000226	0.000603	0.00231	0.000013	0.000041	0.000021	0.000024	0.000041	0.000005	0.000034	0.000017	0.000018	0.000034
Calcium (Ca)	mg/L	7.07	80.7	62.8	60.2	76.5	9.96	56.2	23	24.5	47.6	14.2	36.0	28.8	28.0	35.1	12.6	22.8	16.0	16.5	22.7
Chromium (Cr)	mg/L	0.000050	0.000250	0.000100	0.000135	0.000250	0.000050	0.000250	0.000100	0.000147	0.000250	0.000050	0.000400	0.000100	0.000132	0.000250	0.000050	0.000350	0.000200	0.000192	0.000279
Cobalt (Co)	mg/L	0.000050	0.00579	0.00122	0.00134	0.00264	0.000050	0.00761	0.000380	0.00120	0.00430	0.000050	0.000110	0.000050	0.000052	0.000050	0.000050	0.000180	0.000050	0.000056	0.000050
Copper (Cu)	mg/L	0.0004	0.0335	0.00385	0.00457	0.00829	0.000150	0.257	0.00113	0.00717	0.0107	0.000250	0.000960	0.000250	0.000360	0.000860	0.000160	0.000960	0.000360	0.000457	0.000947
Iron (Fe)	mg/L	0.0150	0.264	0.0150	0.0227	0.0462	0.0150	**2.13**	0.0150	0.0622	0.0880	0.0150	0.160	0.0150	0.0241	0.0658	0.0150	0.188	0.0330	0.0494	0.120
Lead (Pb)	mg/L	0.000025	0.000385	0.000025	0.000031	0.000025	0.000025	0.000379	0.000025	0.000033	0.000078	0.000025	0.000102	0.000025	0.000030	0.000061	0.000025	0.000078	0.000025	0.000032	0.000076
Lithium (Li)	mg/L	0.000940	0.00250	0.00250	0.00222	0.00250	0.00025	0.00250	0.00250	0.00178	0.0025	0.00073	0.00250	0.00250	0.00192	0.00250	0.00025	0.00250	0.00250	0.00165	0.00250
Magnesium (Mg)	mg/L	0.975	7.19	5.14	4.97	6.60	0.593	4.83	1.71	1.90	3.73	2.33	5.50	4.43	4.42	5.39	1.76	3.56	2.26	2.45	3.43
Manganese (Mn)	mg/L	0.00390	0.344	0.187	0.170	0.317	0.000348	0.328	0.0762	0.103	0.269	0.00336	0.0126	0.00669	0.00742	0.0112	0.000412	0.0131	0.00531	0.00582	0.00990
Mercury (Hg)	mg/L	0.000005	0.000012	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000011	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005
Molybdenum (Mo)	mg/L	0.000249	0.00311	0.00205	0.00196	0.00276	0.000025	0.00266	0.00103	0.00114	0.00213	0.000447	0.00122	0.000999	0.000933	0.00119	0.000472	0.00105	0.000644	0.000687	0.000957
Nickel (Ni)[2]	mg/L	0.000250	0.00301	0.00129	0.00131	0.00215	0.00025	0.00325	0.00054	0.000858	0.00232	0.000250	0.000870	0.000250	0.000329	0.000634	0.000250	0.000650	0.000250	0.000332	0.000620
Phosphorus (P)	mg/L	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
Potassium (K)	mg/L	0.191	2.21	1.28	1.16	1.98	0.141	1.67	0.788	0.718	1.35	0.315	0.638	0.492	0.494	0.638	0.263	0.540	0.391	0.388	0.511
Selenium (Se)	mg/L	0.000100	0.00304	0.00188	0.00149	0.00243	0.000050	0.00212	0.000640	0.000736	0.00184	0.000340	0.000810	0.000630	0.000629	0.000786	0.000280	0.000590	0.000370	0.000398	0.000529
Silicon (Si)	mg/L	0.604	2.61	2.13	2.04	2.53	0.314	2.19	1.01	1.05	1.87	1.33	2.12	1.97	1.95	2.05	0.763	1.98	1.25	1.27	1.87
Silver (Ag)	mg/L	0.000005	0.000010	0.000005	0.000005	0.000005	0.000005	0.000020	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005
Sodium (Na)	mg/L	1.00	4.00	2.20	2.08	3.70	1.00	1.00	1.00	1.00	1.00	1.00	3.40	2.20	1.98	3.26	1.00	1.00	1.00	1.00	1.00
Strontium (Sr)	mg/L	0.0801	0.463	0.353	0.332	0.442	0.0517	0.3	0.123	0.131	0.254	0.126	0.294	0.242	0.233	0.282	0.0926	0.189	0.128	0.136	0.184
Thallium (Tl)	mg/L	0.000005	0.000050	0.000050	0.000039	0.000050	0.000005	0.000050	0.000050	0.000036	0.000050	0.000005	0.000050	0.000050	0.000030	0.000050	0.000005	0.000050	0.000050	0.000030	0.000050
Tin (Sn)	mg/L	0.000050	0.000190	0.000050	0.000052	0.000050	0.000050	0.000320	0.000050	0.000055	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050
Titanium (Ti)	mg/L	0.00500	0.0110	0.00500	0.00507	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500
Uranium (U)	mg/L	0.000005	0.000481	0.000298	0.000234	0.000435	0.000005	0.000317	0.000030	0.000051	0.000171	0.000014	0.000049	0.000036	0.000034	0.000048	0.000013	0.000031	0.000019	0.000020	0.000030
Vanadium (V)	mg/L	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.001200	0.000500	0.000507	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500
Zinc (Zn)	mg/L	0.000500	0.261	0.0222	0.0281	0.0678	0.000500	0.325	0.0055	0.0270	0.120	0.000500	0.00320	0.00150	0.00169	0.00300	0.0005	0.00300	0.00150	0.00123	0.00150

(continued)

Table 13.3-4. Baseline Water Quality of Sulphurets and Unuk Watersheds, Brucejack Gold Mine Project (continued)

Project Area		Mid- and Far-field Receiving Environments									
Site		Unuk River, Downstream of Sulphurets Confluence (2 sites)									
		Low Flow (n=40)					High Flow (n=49)				
	Units	Min	Max.	Median	Mean	95th P	Min	Max.	Median	Mean	95th P
Physical Tests											
Colour	CU	2.50	51.90	2.50	3.86	2.88	2.50	55.6	2.50	4.80	6.21
Conductivity	µS/cm	6.20	335	246	241	331	2.50	234	118	119	191
Hardness (as $CaCO_3$)	mg/L	57.0	160	115	115	158	37.3	138	52.5	58.4	98.9
pH	pH	6.89	8.27	8.05	7.98	8.24	7.14	8.20	7.89	7.87	8.20
Total Suspended Solids	mg/L	1.50	85.0	4.00	10.3	54.1	14.3	769	75.3	123	424
Total Dissolved Solids	mg/L	74.0	220	155	152	206	33.8	151	75.0	80.1	120
Turbidity	NTU	0.550	122	5.62	11.3	39.5	17.5	495	55.4	90.7	290
Acidity	mg/L	0.500	6.50	2.60	2.80	5.60	1.10	12.40	2.45	2.73	4.87
Alkalinity, Bicarbonate (as $CaCO_3$)	mg/L	35.0	91.8	71.3	70.2	91.1	22.7	64.8	33.0	35.2	51.9
Alkalinity, Carbonate (as $CaCO_3$)	mg/L	0.500	1.00	1.00	0.987	1.00	0.500	1.00	1.00	0.917	1.00
Alkalinity, Hydroxide (as $CaCO_3$)	mg/L	0.500	1.00	1.00	0.987	1.00	0.500	1.00	1.00	0.917	1.00
Alkalinity, Total (as $CaCO_3$)	mg/L	35.0	91.8	71.3	70.2	91.1	22.7	64.8	33.0	35.2	51.9
Anions and Nutrients											
Ammonia, Total (as N)	mg/L	0.00250	0.0218	0.00250	0.00379	0.01569	0.00250	0.0129	0.00250	0.00341	0.00920
Bromide (Br)	mg/L	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250
Chloride (Cl)	mg/L	0.250	0.790	0.250	0.335	0.736	0.250	0.250	0.250	0.250	0.250
Fluoride (F)	mg/L	0.0440	0.100	0.0660	0.0677	0.0953	0.0230	0.0820	0.0450	0.0470	0.0760
Nitrate (as N)	mg/L	0.0538	0.314	0.110	0.127	0.215	0.0133	0.143	0.0417	0.0513	0.108
Nitrite (as N)	mg/L	0.000500	0.002500	0.000500	0.000551	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500
Total Kjeldahl Nitrogen	mg/L	0.025	0.767	0.025	0.0566	0.130	0.0250	0.258	0.0250	0.0475	0.140
Total Nitrogen	mg/L	0.025	0.970	0.140	0.171	0.334	0.0250	0.200	0.0695	0.0829	0.177
Orthophosphate-Dissolved (as P)	mg/L	0.000500	0.00310	0.000500	0.000816	0.00276	0.000500	0.00330	0.000500	0.00110	0.00240
Phosphorus (P)-Total	mg/L	0.0024	0.426	0.0145	0.0440	0.168	0.0295	1.04	0.122	0.189	0.665
Sulphate (SO_4)	mg/L	23.4	85.9	55.5	54.3	80.7	11.4	52.2	22.7	25.0	45.3
Cyanides											
Cyanide, Total	mg/L	-	-	-	-	-	0.000500	0.000500	0.000500	0.000500	0.000500
Cyanide, WAD	mg/L	0.000500	0.0022	0.000500	0.000883	0.0018	0.000500	0.0027	0.000500	0.000810	0.0021
Organic Carbon											
Total Organic Carbon	mg/L	0.250	1.55	0.740	0.780	1.41	0.250	3.26	0.720	0.979	2.82
Total Metals											
Aluminum (Al)	mg/L	0.0350	*5.06*	*0.175*	*0.450*	*1.78*	*0.573*	*22.4*	*2.42*	*3.94*	*15.3*
Antimony (Sb)	mg/L	0.00049	0.00202	0.00123	0.00117	0.00199	0.00039	0.00280	0.00102	0.00113	0.00205
Arsenic (As)	mg/L	0.000410	0.0152	0.00116	0.00226	0.00920	0.00115	0.0263	0.003535	0.00549	0.0205
Barium (Ba)[2]	mg/L	0.0309	0.108	0.0394	0.0411	0.0483	0.0353	0.355	0.0655	0.0895	0.298
Beryllium (Be)[2]	mg/L	0.000050	0.000250	0.000250	0.000167	0.000250	0.000050	0.000590	0.000250	0.000213	0.000432
Bismuth (Bi)	mg/L	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250
Boron (B)	mg/L	0.00500	0.0130	0.00500	0.00578	0.0111	0.00500	0.012	0.00500	0.00538	0.00825
Cadmium (Cd)[2]	mg/L	0.000135	0.00112	0.000529	0.000504	0.000957	0.000129	0.00212	0.000471	0.000552	0.00111
Calcium (Ca)	mg/L	20.6	56.9	40.5	40.2	54.4	13.6	37.4	19.4	21.3	34.1
Chromium (Cr)	mg/L	0.00005	**0.00840**	0.00025	0.0006185	**0.00286**	0.00059	**0.0347**	**0.00300**	**0.00547**	**0.0235**
Cobalt (Co)	mg/L	0.00013	0.00446	0.000585	0.0007295	0.0018105	0.00071	0.0155	0.00177	0.00298	0.0116
Copper (Cu)	mg/L	0.00486	**0.102**	**0.0270**	**0.0333**	**0.0727**	**0.0127**	**0.174**	**0.0521**	**0.0615**	**0.145**
Iron (Fe)	mg/L	0.14	**9.50**	0.752	**1.29**	**3.10**	**1.24**	**32.6**	**3.94**	**6.44**	**26.9**
Lead (Pb)	mg/L	0.000056	0.0068	0.000353	0.000743	0.0019	0.0008	0.0190	0.0024	0.0036	0.0118
Lithium (Li)[2]	mg/L	0.000250	0.00250	0.00250	0.00189	0.00250	0.00106	0.0138	0.0025	0.00312	0.0106
Magnesium (Mg)	mg/L	2.27	5.98	4.01	4.20	5.83	1.51	13.7	3.09	3.70	10.1
Manganese (Mn)	mg/L	0.0190	0.214	0.0842	0.0732	0.124	0.0563	0.835	0.1230	0.1818	0.664
Mercury (Hg)	mg/L	0.000005	0.000096	0.000005	0.000008	0.000007	0.000005	0.000093	0.000005	0.000012	0.000040
Molybdenum (Mo)	mg/L	0.00110	0.00320	0.00182	0.00198	0.00284	0.000765	0.00291	0.00153	0.00156	0.00272
Nickel (Ni)[2]	mg/L	0.000250	0.00919	0.0009	0.00116	0.00305	0.0012	**0.0289**	0.0026	0.0051	0.0222
Phosphorus (P)	mg/L	0.150	0.390	0.150	0.156	0.150	0.150	1.150	0.150	0.243	0.936
Potassium (K)	mg/L	0.692	1.78	1.13	1.12	1.45	0.684	5.2	1.22	1.55	4.32
Selenium (Se)	mg/L	0.00061	0.00184	0.00109	0.00106	0.00142	0.000300	0.00191	0.000670	0.000759	0.001405
Silicon (Si)	mg/L	2.18	10.9	2.53	2.93	4.81	2.03	37.8	6.05	8.52	29.1

(continued)

Table 13.3-4. Baseline Water Quality of Sulphurets and Unuk Watersheds, Brucejack Gold Mine Project (completed)

Project Area		Mid- and Far-field Receiving Environments									
Site		Unuk River, Downstream of Sulphurets Confluence (2 sites)									
		Low Flow (n=40)					High Flow (n=49)				
	Units	Min	Max.	Median	Mean	95th P	Min	Max.	Median	Mean	95th P
Total Metals *(cont'd)*											
Silver (Ag)	mg/L	0.000005	**0.000116**	0.000005	0.000011	0.000037	0.000005	**0.000413**	0.000050	0.000075	**0.000280**
Sodium (Na)	mg/L	1.00	3.60	2.45	2.23	3.41	1.00	3.20	1.00	1.10	1.85
Strontium (Sr)	mg/L	0.122	0.359	0.236	0.247	0.333	0.079	0.228	0.124	0.134	0.213
Thallium (Tl)	mg/L	0.000005	0.000050	0.000050	0.000032	0.000050	0.000012	0.000224	0.000050	0.000057	0.000185
Tin (Sn)	mg/L	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000270	0.000050	0.000067	0.000163
Titanium (Ti)	mg/L	0.00500	0.243	0.00500	0.0192	0.0670	0.0210	1.60	0.132	0.222	0.836
Uranium (U)	mg/L	0.000135	0.000384	0.000231	0.000247	0.000366	0.000108	0.00112	0.000224	0.000259	0.000490
Vanadium (V)	mg/L	0.000500	0.0207	0.0005	0.00157	0.00613	0.00170	0.0859	0.0086	0.0150	0.0685
Zinc (Zn)	mg/L	0.0101	**0.0858**	0.0375	0.0371	**0.0757**	0.0141	**0.166**	**0.0402**	**0.0479**	**0.113**
Dissolved Metals											
Aluminum (Al)	mg/L	0.0160	**0.260**	0.0364	0.0459	0.0865	0.00570	**0.827**	0.0554	0.0860	**0.258**
Antimony (Sb)	mg/L	0.000460	0.00190	0.00113	0.00109	0.00180	0.000250	0.00196	0.000635	0.000738	0.00138
Arsenic (As)	mg/L	0.000050	0.00825	0.000210	0.000425	0.000453	0.000050	0.00241	0.000150	0.000244	0.000600
Barium (Ba)	mg/L	0.0210	0.0487	0.0348	0.0345	0.0459	0.0182	0.0382	0.0248	0.0254	0.0321
Beryllium (Be)	mg/L	0.000050	0.000250	0.000250	0.000165	0.000250	0.000050	0.000250	0.000250	0.000171	0.000250
Bismuth (Bi)	mg/L	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250
Boron (B)	mg/L	0.00500	0.0110	0.00500	0.00580	0.0101	0.00500	0.00500	0.00500	0.00500	0.00500
Cadmium (Cd)	mg/L	0.000117	0.000720	0.000261	0.000289	0.000480	0.000005	0.000636	0.000142	0.000185	0.000391
Calcium (Ca)	mg/L	17.7	54.8	39.8	39.0	53.9	13.2	35.5	18.1	19.0	28.9
Chromium (Cr)	mg/L	0.000050	0.000250	0.000050	0.000129	0.000250	0.000050	0.000940	0.000170	0.000186	0.000250
Cobalt (Co)	mg/L	0.000050	0.00101	0.000455	0.000406	0.000772	0.000050	0.0017	0.000250	0.000405	0.000955
Copper (Cu)	mg/L	0.00154	0.0507	0.00297	0.00447	0.00663	0.00025	0.0470	0.00169	0.00325	0.00757
Iron (Fe)	mg/L	0.0150	**2.15**	0.0150	0.0768	0.0709	0.0150	**3.5**	0.0150	0.121	0.318
Lead (Pb)	mg/L	0.000025	0.00106	0.000025	0.000058	0.000080	0.000025	0.002360	0.000025	0.000100	0.000271
Lithium (Li)	mg/L	0.00025	0.00250	0.00250	0.00184	0.00250	0.00025	0.00250	0.00250	0.00173	0.00250
Magnesium (Mg)	mg/L	1.75	5.76	3.82	3.94	5.68	0.916	3.89	1.77	1.87	3.33
Manganese (Mn)	mg/L	0.0175	0.11	0.0600	0.0562	0.0981	0.00131	0.0999	0.0340	0.0433	0.0952
Mercury (Hg)	mg/L	0.000005	0.000013	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005
Molybdenum (Mo)	mg/L	0.000807	0.003	0.001695	0.00183	0.00276	0.000765	0.00252	0.00117	0.00123	0.00172
Nickel (Ni)[2]	mg/L	0.000250	0.00119	0.000715	0.000603	0.00102	0.00025	0.00199	0.000250	0.000444	0.00114
Phosphorus (P)	mg/L	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
Potassium (K)	mg/L	0.479	1.44	1.07	1.02	1.42	0.426	1.13	0.646	0.679	1.00
Selenium (Se)	mg/L	0.000550	0.00167	0.001005	0.001028	0.0014715	0.000190	0.00109	0.000500	0.000534	0.000980
Silicon (Si)	mg/L	1.33	2.75	2.16	2.22	2.68	0.706	3.07	1.29	1.37	2.07
Silver (Ag)	mg/L	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000025	0.000005	0.000006	0.000005
Sodium (Na)	mg/L	1.00	3.40	2.35	2.11	3.21	1.00	1.00	1.00	1.00	1.00
Strontium (Sr)	mg/L	0.106	0.347	0.232	0.239	0.333	0.0697	0.226	0.115	0.118	0.189
Thallium (Tl)	mg/L	0.000005	0.000050	0.000050	0.000031	0.000050	0.000005	0.000050	0.000050	0.000032	0.000050
Tin (Sn)	mg/L	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000140	0.000050	0.000052	0.000050
Titanium (Ti)	mg/L	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.06500	0.00500	0.00665	0.01020
Uranium (U)	mg/L	0.000044	0.000362	0.000186	0.000208	0.000358	0.000005	0.000245	0.000091	0.000093	0.000166
Vanadium (V)	mg/L	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.003500	0.000500	0.000563	0.000500
Zinc (Zn)	mg/L	0.00250	0.0541	0.0119	0.0133	0.0226	0.0005	0.0292	0.00340	0.00606	0.0215

Notes:

- Parameter not reported.

As hydrological regime is an important determinant of surface water quality in the Project Area, concentrations (predicted and baseline) assessed for both high flow (June to October) and low flow (November to May) periods.

Grey highlighted values exceed BC chronic water quality guidelines for the protection of aquatic life; bolded font values exceed BC acute (maximum) water quality guidelines.

Italicized font indicates exceedance of CCME guidelines for the protection of aquatic life, applied in the absence of an applicable BC guideline.

Orange font indicates exceedance of health-based drinking water quality guidelines.

[1] Samples where n ≤ 3, median and 95th percentile summary statistics were not calculated.

[2] Working guideline.

13.3.4.3 Off-site Project Infrastructure: Bowser River and Wildfire/Scott/Todedada Creek Watersheds

Lakes

Within off-site areas, Knipple Lake, Bowser Lake and Todedada Lake constituted the baseline lake sampling program and were only sampled during open-water seasons.

Knipple Lake is a glacier fed lake and was included in the 2013 program; sampling occurred once in August 2013. Knipple Lake has similar chemistry to Sulphurets Lake; waters are soft (mean hardness = 25.4 to 25.8 mg/L), of circumneutral pH (7.58 to 7.97) with low total alkalinity (17.0 to 17.1 mg/L) and elevated TSS and turbidity (215-226 mg/L; 308-316 NTU). Further, within Knipple Lake, concentrations of total and dissolved metals were elevated, likely as a consequence of elevated TSS concentrations and glacial inputs; most metal parameters measured were at higher concentrations in Knipple Lake than any other lake within the baseline study area (Table 13.3-5). These include aluminum (total and dissolved), arsenic, cadmium, chromium, cobalt, lead, iron (total and dissolved), nickel, selenium, thallium, uranium and zinc. Exceedances were observed for aluminum (total and dissolved) arsenic, cadmium, chromium, cobalt, copper, iron, lead, mercury, silver, and zinc.

Conductivity, hardness, total alkalinity are elevated in Bowser and Todedada Lakes compared to Knipple Lake (range: conductivity= 91 to 155 µS/cm; hardness= 43 to 71 mg/L; alkalinity 35 to 62 mg/L) with lower levels of TSS and turbidity. Overall mean concentrations of chromium (0.002 mg/L) and uranium (0.000087 mg/L) were elevated in Bowser Lake, which also had relatively higher concentrations of TSS. In contrast, the majority of metals were below detection limit downstream at Todedada Lake, which was more similar in chemistry to Brucejack Lake (Tale 13.3-5).

Streams

In general, streams within off-site areas were soft to moderately hard (mean: 15.3 to 89.2 mg/L), circumneutral to slightly alkaline (mean: pH 7.52 to 8.06), with low to moderate alkalinity (mean: 9.9 to 71.3 mg/L) and wide ranging conductivities (mean: 36.5 to 184.2 µS/cm). Sites WC1 and WC5 within the Wildfire Creek watershed were the most acid-sensitive and had the lowest alkalinity, hardness, pH and conductivity of all the stream sites in off-site areas. Effects of the hydrological regime were evident in off-site areas with minima of conductivity, hardness and alkalinity generally associated with low flow periods. Nutrient concentrations were generally higher in off-site area monitoring locations than within the Brucejack/Sulphurets/Unuk watersheds. Off-site areas are at lower elevation and likely have higher allocthonous carbon and nutrient inputs.

Total and dissolved metal concentrations of stream sites within the Bowser River, Scott/Todedada and Wildfire Creek Area were low and in general remained less than or close to detection limits, particularly within Scott Creek and Wildfire Creek Areas (Table 13.3-5). These included cadmium, iron (dissolved), mercury, molybdenum, thallium, and zinc. The greatest concentrations of total metals were associated with high flow months and spring freshet in glacial-headed systems and thus decrease from east (i.e., at Knipple Glacier and Bowser River watershed) to west (Wildfire Creek watershed; Figures 5.2-4 to 5.2-20 (streams) of Appendix 13-A, Cumulative Surface Water Quality Baseline Report). This is likely reflective of corresponding higher sediment loads in Bowser watershed and associated particulate-bound metals. Within off-site areas, maxima incidence of guideline exceedances were always associated with stream and lake sites within the Bowser River watershed (KL, KL_IF, KG_OF, KL_OF, BR, BR1, BR2 and BL1; Table 13.3-5).

13.4 ESTABLISHING THE SCOPE OF THE EFFECTS ASSESSMENT FOR SURFACE WATER QUALITY

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

- *Step 1:* scoping process to select surface water quality VCs and indicators based on a consideration of the Project's potential to interact with a VC;
- *Step 2:* consideration of feedback on the results of the scoping process;
- *Step 3:* defining assessment boundaries for surface water quality VCs and indicators; and
- *Step 4:* identification of key potential effects on surface water quality VCs and/or indicators.

These steps are described in detail below.

13.4.1 Selecting Receptor Valued Components

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

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

Surface water quality was screened for inclusion as a receptor VC as a result of the scoping process, as described in Section 6.4.1.1. Surface water quality was originally screened for inclusion as an intermediate component (i.e., pathway) VC; however, through consultation and feedback with the working group for the Project, it was changed to a receptor VC. Surface water quality is a key aspect of environmental health as is linked to other important ecosystem components including fish and fish habitat, aquatic resources (primary and secondary producers, sediment quality), soil, vegetation, wildlife, and human health.

Table 13.3-5. Baseline Water Quality of Bowser River and Wildfire/Scott/Todedada Creek Watersheds (Off-site Areas), Brucejack Gold Mine Project

Project Area		Off-site Areas																					
Site		Knipple Lake Inflow/Outflow (2 sites)[1]										Knipple Lake (KL)[1]		Knipple Glacier Outflow (KG OF)[1]					Bowser River (3 sites)				
		Low Flow (n=2)					High Flow (n=4)					Open Water		High Flow (n=2)					Low Flow (n=13)				
	Units	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P	Shallow (1 m)	Deep (30 m)	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P
Physical Tests																							
Colour	CU	2.50	2.50	-	2.50	-	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	-	2.50	-	2.50	6.80	2.50	2.83	4.22
Conductivity	µS/cm	158	167	-	163	-	50.9	87.3	70.0	69.5	87.2	50.1	50.6	103	203	-	153	-	106	229	210	194	228
Hardness (as $CaCO_3$)	mg/L	74.6	83.3	-	79.0	-	23.1	41.5	32.4	32.3	41.4	25.8	25.4	51.0	91.2	-	71.1	-	51.9	125	97.4	96.1	120
pH	pH	7.97	8.14	-	8.06	-	7.73	8.06	7.86	7.88	8.05	7.48	7.97	7.83	7.91	-	7.87	-	7.47	8.13	8.01	7.97	8.12
Total Suspended Solids	mg/L	1.5	1.5	-	1.5	-	84.0	228	144	150	224	218	226	12.6	624	-	318	-	1.50	27.0	3.00	7.71	25.0
Total Dissolved Solids	mg/L	91.0	94.0	-	92.5	-	50.0	81	66.0	65.8	80.9	52.0	57.0	75.0	127	-	101	-	69.0	152	122	123	151
Turbidity	NTU	4.55	5.58	-	5.07	-	273	368	337	329	364	308	316	14.9	1,030	-	522	-	0.540	75.3	4.35	16.9	63.1
Acidity	mg/L	1.3	3.0	-	2.2	-	1.10	1.50	1.30	1.30	1.49	1.50	1.90	1.60	2.70	-	2.15	-	0.50	6.80	2.70	2.92	6.14
Alkalinity, Bicarbonate (as $CaCO_3$)	mg/L	54.8	55.4	-	55.1	-	22.1	33.0	27.5	27.5	33.0	17.1	17.0	36.0	56.1	-	46.1	-	38.7	95.7	68.7	70.7	92.6
Alkalinity, Carbonate (as $CaCO_3$)	mg/L	1.0	1.0	-	1.0	-	0.50	0.50	0.50	0.50	0.50	1.00	1.00	0.50	1.00	-	0.75	-	0.50	1.00	1.000	0.923	1.00
Alkalinity, Hydroxide (as $CaCO_3$)	mg/L	1.0	1.0	-	1.0	-	0.50	0.50	0.50	0.50	0.50	1.00	1.00	0.50	1.00	-	0.75	-	0.50	1.00	1.000	0.923	1.00
Alkalinity, Total (as $CaCO_3$)	mg/L	54.8	55.4	-	55.1	-	22.1	33.0	27.5	27.5	33.0	17.1	17.0	36.4	56.1	-	46.3	-	38.7	95.7	68.7	70.7	92.6
Anions and Nutrients																							
Ammonia, Total (as N)	mg/L	0.00250	0.00250	-	0.00250	-	0.0054	0.0125	0.0073	0.0081	0.0119	0.00730	0.00670	0.00250	0.00250	-	0.00250	-	0.00250	0.00250	0.00250	0.00250	0.00250
Bromide (Br)	mg/L	0.0250	0.0250	-	0.0250	-	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	-	0.0250	-	0.0250	0.0850	0.0250	0.0342	0.0850
Chloride (Cl)	mg/L	0.250	0.250	-	0.250	-	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	-	0.250	-	0.250	0.250	0.250	0.250	0.250
Fluoride (F)	mg/L	0.023	0.037	-	0.030	-	0.010	0.021	0.010	0.013	0.019	0.0100	0.0100	0.0360	0.0520	-	0.0440	-	0.0290	0.0490	0.0350	0.0371	0.0484
Nitrate (as N)	mg/L	0.036	0.056	-	0.046	-	0.0025	0.0251	0.0158	0.0148	0.0250	0.00660	0.00610	0.0148	0.0187	-	0.0168	-	0.0388	0.666	0.0845	0.145	0.408
Nitrite (as N)	mg/L	0.001	0.001	-	0.001	-	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	-	0.000500	-	0.000500	0.000500	0.000500	0.000500	0.000500
Total Kjeldahl Nitrogen	mg/L	0.025	0.025	-	0.025	-	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	-	0.0250	-	0.0250	0.2520	0.0250	0.0699	0.2016
Total Nitrogen	mg/L	0.025	0.025	-	0.025	-	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	-	0.0250	-	0.0250	0.802	0.100	0.201	0.609
Orthophosphate-Dissolved (as P)	mg/L	0.000500	0.000500	-	0.000500	-	0.000500	0.00180	0.00140	0.00128	0.00176	0.00140	0.00310	0.00110	0.00150	-	0.00130	-	0.000500	0.000500	0.000500	0.000500	0.000500
Phosphorus (P)-Total	mg/L	0.00350	0.00360	-	0.00355	-	0.247	0.399	0.333	0.328	0.396	0.259	0.261	0.0172	0.689	-	0.353	-	0.0010	0.0462	0.0050	0.0147	0.0442
Sulphate (SO_4)	mg/L	28.0	32.3	-	30.2	-	5.03	12.1	8.47	8.52	12.1	4.96	5.04	19.0	47.6	-	33.3	-	13.5	36.3	30.8	29.6	35.1
Cyanides																							
Cyanide, Total	mg/L	0.000500	0.000500	-	0.000500	-	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	-	0.000500	-	0.000500	0.00250	0.000500	0.000700	0.00155
Cyanide, WAD	mg/L	0.000500	0.000500	-	0.000500	-	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	-	0.000500	-	0.000500	0.00210	0.000500	0.000685	0.00162
Organic Carbon																							
Total Organic Carbon	mg/L	0.250	0.250	-	0.250	-	1.30	1.81	1.47	1.51	1.78	0.250	1.14	0.250	0.250	-	0.250	-	0.250	2.11	0.680	0.745	1.71
Total Metals																							
Aluminum (Al)	mg/L	*0.197*	*0.300*	-	*0.249*	-	*9.65*	*11.1*	*10.5*	*10.4*	*11.1*	*11.7*	*11.2*	*0.995*	*17.5*	-	*9.25*	-	0.0104	*3.15*	*0.222*	*0.837*	*3.06*
Antimony (Sb)	mg/L	0.0005	0.0006	-	0.0005	-	0.00117	0.00181	0.00149	0.00149	0.00176	0.00137	0.00131	0.000290	0.00116	-	0.000725	-	0.000160	0.000670	0.000390	0.000395	0.000640
Arsenic (As)	mg/L	0.0007	0.0008	-	0.0007	-	0.0085	0.0126	0.0109	0.0107	0.0124	0.00968	0.00948	0.000660	0.0127	-	0.00668	-	0.000280	0.00216	0.000510	0.000826	0.00209
Barium (Ba)[2]	mg/L	0.03410	0.03510	-	0.03460	-	0.179	0.200	0.190	0.190	0.199	0.215	0.204	0.09030	0.518	-	0.304	-	0.0365	0.101	0.0475	0.0560	0.0954
Beryllium (Be)[2]	mg/L	0.000050	0.000050	-	0.000050	-	0.000190	0.000230	0.000210	0.000210	0.000227	0.000200	0.000200	0.000050	0.000530	-	0.000290	-	0.000050	0.000250	0.000250	0.000235	0.000250
Bismuth (Bi)	mg/L	0.000250	0.000250	-	0.000250	-	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	-	0.000250	-	0.000250	0.000250	0.000250	0.000250	0.000250
Boron (B)	mg/L	0.00500	0.00500	-	0.00500	-	0.00500	0.01100	0.00500	0.00650	0.01010	0.00500	0.00500	0.00500	0.01300	-	0.00900	-	0.00500	0.0120	0.00500	0.00777	0.0120
Cadmium (Cd)[2]	mg/L	0.000015	0.000016	-	0.000016	-	0.000224	0.000368	0.000295	0.000296	0.000358	0.000243	0.000244	0.000016	0.000314	-	0.000165	-	0.000010	0.000351	0.000023	0.000060	0.000200
Calcium (Ca)	mg/L	25.4	27.7	-	26.6	-	9.7	17.1	13.3	13.3	17.0	10.8	11.0	32.1	33.6	-	32.9	-	16.8	41.5	35.5	33.7	40.7
Chromium (Cr)	mg/L	0.00027	0.00038	-	0.00033	-	**0.0104**	**0.0161**	**0.0138**	**0.0135**	**0.0158**	**0.0124**	**0.0118**	0.00077	**0.0120**	-	**0.00639**	-	0.00016	**0.00434**	0.00040	**0.00112**	**0.00420**
Cobalt (Co)	mg/L	0.0001	0.0001	-	0.0001	-	0.00553	0.00724	0.00670	0.00654	0.00717	0.00605	0.00606	0.0003	0.0118	-	0.00604	-	0.00005	0.00149	0.00014	0.00041	0.00147
Copper (Cu)	mg/L	0.00065	0.00079	-	0.00072	-	**0.0206**	**0.0285**	**0.0256**	**0.0251**	**0.0285**	**0.0221**	**0.0218**	0.00056	**0.0229**	-	**0.0117**	-	0.00025	0.00573	0.00092	0.00178	0.00563
Iron (Fe)	mg/L	0.215	0.290	-	0.253	-	**12.9**	**17.0**	**15.5**	**15.2**	**16.8**	**14.4**	**14.0**	0.795	**28.9**	-	**14.8**	-	0.0150	**3.35**	0.279	0.892	**3.28**
Lead (Pb)	mg/L	0.0001	0.0001	-	0.0001	-	0.0070	0.0096	0.0084	0.0083	0.0094	0.0080	0.0079	0.0003	0.0128	-	0.00656	-	0.0000	0.0018	0.0003	0.0005	0.0016
Lithium (Li)[2]	mg/L	0.0006	0.0006	-	0.0006	-	0.00661	0.00831	0.00766	0.00756	0.00828	0.00741	0.00692	0.0017	0.0185	-	0.0101	-	0.00060	0.00250	0.00250	0.00235	0.00250
Magnesium (Mg)	mg/L	2.67	2.86	-	2.77	-	4.64	6.79	5.84	5.78	6.69	5.29	5.13	3.06	10.1	-	6.58	-	2.80	5.08	3.33	3.52	4.82
Manganese (Mn)	mg/L	0.00697	0.00794	-	0.00746	-	0.305	0.415	0.373	0.366	0.414	0.338	0.354	0.0242	0.878	-	0.451	-	0.0008	0.0813	0.0102	0.0241	0.0734
Mercury (Hg)	mg/L	0.000005	0.000005	-	0.000005	-	0.0000250	0.0000470	0.0000285	0.0000323	0.0000443	0.0000290	0.0000260	0.000005	0.000025	-	0.000015	-	0.0000050	0.0000050	0.0000050	0.0000050	0.0000050
Molybdenum (Mo)	mg/L	0.00153	0.00159	-	0.00156	-	0.000810	0.001400	0.001137	0.001121	0.001390	0.001010	0.000968	0.0020	0.0020	-	0.0020	-	0.000408	0.001670	0.001340	0.001227	0.001562
Nickel (Ni)[2]	mg/L	0.0003	0.0003	-	0.0003	-	0.0095	0.0124	0.0114	0.0112	0.0124	0.0104	0.0104	0.000560	0.0154	-	0.0080	-	0.000250	0.0029	0.000560	0.0010	0.0029
Phosphorus (P)	mg/L	0.150	0.150	-	0.150	-	0.150	0.370	0.255	0.258	0.369	0.150	0.150	0.150	0.740	-	0.445	-	0.150	0.150	0.150	0.150	0.150
Potassium (K)	mg/L	0.472	0.535	-	0.504	-	1.77	2.34	2.15	2.10	2.33	2.51	2.32	0.728	3.82	-	2.27	-	0.229	1.31	0.583	0.674	1.30
Selenium (Se)	mg/L	0.000500	0.000550	-	0.000525	-	0.000440	0.000690	0.000580	0.000573	0.000683	0.000450	0.000450	0.000410	0.000740	-	0.000575	-	0.000100	0.000670	0.000550	0.000525	0.000652
Silicon (Si)	mg/L	1.25	1.49	-	1.37	-	19.2	22.9	20.4	20.7	22.7	29.1	29.4	3.67	31.9	-	17.8	-	1.29	7.78	2.31	3.18	7.50

(continued)

Table 13.3-5. Baseline Water Quality of Bowser River and Wildfire/Scott/Todedada Creek Watersheds (Off-site Areas), Brucejack Gold Mine Project (continued)

Project Area		Off-site Areas																					
Site		Knipple Lake Inflow/Outflow (2 sites)[1]										Knipple Lake (KL)[1]		Knipple Glacier Outflow (KG OF)[1]					Bowser River (3 sites)				
		Low Flow (n=2)					High Flow (n=4)					Open Water		High Flow (n=2)					Low Flow (n=13)				
	Units	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P	Shallow (1 m)	Deep (30 m)	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P
Total Metals *(cont'd)*																							
Silver (Ag)	mg/L	0.000011	0.000011	-	0.000011	-	**0.000125**	**0.000183**	**0.000156**	**0.000155**	**0.000180**	**0.000161**	**0.000160**	0.000012	**0.000205**	-	**0.000109**	-	0.000005	0.000033	0.000005	0.000010	0.000029
Sodium (Na)	mg/L	1.00	1.00	-	1.00	-	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	2.10	-	1.55	-	1.00	1.00	1.00	1.00	1.00
Strontium (Sr)	mg/L	0.149	0.161	-	0.155	-	0.0630	0.0982	0.0805	0.0806	0.0981	0.0686	0.0706	0.189	0.253	-	0.221	-	0.1550	0.3200	0.2060	0.2108	0.3014
Thallium (Tl)	mg/L	0.000005	0.000005	-	0.000005	-	0.000070	0.000099	0.000082	0.000083	0.000098	0.000098	0.000092	0.000019	0.000211	-	0.000115	-	0.000005	0.000050	0.000050	0.000047	0.000050
Tin (Sn)	mg/L	0.00005	0.00005	-	0.00005	-	0.00005	0.00014	0.00011	0.00010	0.00014	0.00015	0.00011	0.00005	0.00014	-	0.000095	-	0.00005	0.00005	0.00005	0.00005	0.00005
Titanium (Ti)	mg/L	0.00500	0.0110	-	0.00800	-	0.376	0.459	0.435	0.426	0.457	0.520	0.522	0.059	0.406	-	0.233	-	0.00500	0.13100	0.01700	0.03015	0.112
Uranium (U)	mg/L	0.000115	0.000120	-	0.000118	-	0.00017	0.00027	0.00022	0.00022	0.00027	0.00022	0.00021	0.000198	0.000492	-	0.000345	-	0.00005	0.00016	0.00012	0.00011	0.00014
Vanadium (V)	mg/L	0.000500	0.00100	-	0.000750	-	0.0243	0.0356	0.0306	0.0303	0.0349	0.0287	0.0280	0.0025	0.0393	-	0.0209	-	0.00050	0.00960	0.00050	0.00242	0.00930
Zinc (Zn)	mg/L	0.00150	0.00150	-	0.00150	-	**0.0443**	**0.0548**	**0.0526**	**0.0511**	**0.0547**	**0.0504**	**0.0495**	0.00150	**0.0772**	-	**0.0394**	-	0.00150	0.0119	0.00480	0.00502	0.0116
Dissolved Metals																							
Aluminum (Al)	mg/L	0.0138	0.0182	-	0.0160	-	**0.136**	**0.195**	**0.157**	**0.161**	**0.190**	**0.301**	**0.231**	0.0903	**0.206**	-	**0.148**	-	0.0039	**1.05**	0.0149	0.0927	**0.439**
Antimony (Sb)	mg/L	0.000460	0.000520	-	0.000490	-	0.000410	0.000680	0.000560	0.000553	0.000667	0.000460	0.000450	0.000230	0.000270	-	0.000250	-	0.000110	0.000490	0.000370	0.000343	0.000466
Arsenic (As)	mg/L	0.00048	0.00056	-	0.00052	-	0.00067	0.00094	0.00075	0.00078	0.00091	0.00072	0.00070	0.00039	0.00060	-	0.00050	-	0.00020	0.00083	0.00033	0.00036	0.00060
Barium (Ba)	mg/L	0.0285	0.0328	-	0.0307	-	0.0133	0.0295	0.0194	0.0204	0.0284	0.0217	0.0225	0.0681	0.0742	-	0.0712	-	0.0217	0.0598	0.0419	0.0419	0.0530
Beryllium (Be)	mg/L	0.000050	0.000050	-	0.000050	-	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	-	0.000050	-	0.000050	0.000250	0.000250	0.000235	0.000250
Bismuth (Bi)	mg/L	0.000250	0.000250	-	0.000250	-	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	-	0.000250	-	0.000250	0.000250	0.000250	0.000250	0.000250
Boron (B)	mg/L	0.005	0.005	-	0.005	-	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.005	0.005	-	0.005	-	0.00500	0.0110	0.00500	0.00592	0.01100
Cadmium (Cd)	mg/L	0.000005	0.000016	-	0.000011	-	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	-	0.000005	-	0.000005	0.000037	0.000013	0.000016	0.000032
Calcium (Ca)	mg/L	25.6	29.1	-	27.4	-	8.27	14.4	11.41	11.4	14.4	9.27	9.11	18.3	32.0	-	25.2	-	16.0	44.4	34.6	33.2	42.7
Chromium (Cr)	mg/L	0.00005	0.00005	-	0.00005	-	0.00010	0.00017	0.00012	0.00013	0.00016	0.00028	0.00019	0.00005	0.00005	-	0.00005	-	0.00005	0.00116	0.00005	0.00017	0.00057
Cobalt (Co)	mg/L	0.00005	0.00005	-	0.00005	-	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	-	0.00005	-	0.00005	0.00036	0.00005	0.00007	0.00017
Copper (Cu)	mg/L	0.00025	0.00025	-	0.00025	-	0.00025	0.00056	0.00025	0.00033	0.00051	0.00025	0.00051	0.00025	0.00025	-	0.00025	-	0.00025	0.00159	0.00025	0.00039	0.00099
Iron (Fe)	mg/L	0.015	0.015	-	0.015	-	0.0900	0.183	0.106	0.121	0.173	0.218	0.160	0.055	0.097	-	0.076	-	0.0150	**0.831**	0.0150	0.0778	0.341
Lead (Pb)	mg/L	0.00003	0.00003	-	0.00003	-	0.000059	0.000094	0.000069	0.000073	0.000091	0.00013	0.00011	0.00003	0.00006	-	0.00004	-	0.000025	0.000330	0.000025	0.000048	0.000147
Lithium (Li)	mg/L	0.0003	0.0003	-	0.0003	-	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	0.0005	0.0011	-	0.0008	-	0.00025	0.00250	0.00250	0.00233	0.00250
Magnesium (Mg)	mg/L	2.60	2.61	-	2.61	-	0.602	1.31	0.940	0.948	1.30	0.647	0.637	1.28	2.73	-	2.01	-	2.13	5.04	3.07	3.21	4.67
Manganese (Mn)	mg/L	0.0015	0.0020	-	0.0018	-	0.00159	0.00291	0.00200	0.00212	0.00281	0.00428	0.00316	0.0018	0.0021	-	0.0020	-	0.00037	0.01590	0.00072	0.00265	0.00998
Mercury (Hg)	mg/L	0.000005	0.000005	-	0.000005	-	0.000005	0.000005	0.000005	0.000005	0.000005	0.00001	0.00001	0.000005	0.000005	-	0.000005	-	0.000005	0.000005	0.000005	0.000005	0.000005
Molybdenum (Mo)	mg/L	0.001500	0.001600	-	0.001550	-	0.000553	0.001020	0.000800	0.000793	0.001010	0.00067	0.00063	0.001260	0.001870	-	0.001565	-	0.000353	0.001620	0.001350	0.001197	0.001506
Nickel (Ni)[2]	mg/L	0.00025	0.00025	-	0.00025	-	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	-	0.00025	-	0.00025	0.00099	0.00025	0.00033	0.00071
Phosphorus (P)	mg/L	0.150	0.150	-	0.150	-	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	-	0.150	-	0.150	0.150	0.150	0.150	0.150
Potassium (K)	mg/L	0.434	0.452	-	0.443	-	0.279	0.427	0.373	0.363	0.421	0.377	0.361	0.382	0.432	-	0.407	-	0.199	0.895	0.489	0.468	0.712
Selenium (Se)	mg/L	0.00052	0.00054	-	0.00053	-	0.0003	0.0005	0.0004	0.0004	0.0005	0.00022	0.00024	0.0003	0.00039	-	0.000345	-	0.000210	0.000630	0.000520	0.000508	0.000630
Silicon (Si)	mg/L	0.908	0.922	-	0.915	-	0.575	1.03	0.758	0.780	1.02	1.08	0.781	1.02	1.42	-	1.22	-	0.931	3.55	1.58	1.76	2.91
Silver (Ag)	mg/L	0.0000050	0.0000050	-	0.0000050	-	0.0000050	0.0000050	0.0000050	0.0000050	0.0000050	0.0000050	0.0000050	0.0000050	0.0000050	-	0.0000050	-	0.0000050	0.0000050	0.0000050	0.0000050	0.0000050
Sodium (Na)	mg/L	1.00	1.00	-	1.00	-	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-	1.00	-	1.00	1.00	1.00	1.00	1.00
Strontium (Sr)	mg/L	0.1410	0.1560	-	0.1485	-	0.0408	0.0768	0.0589	0.0588	0.0766	0.0474	0.0481	0.127	0.239	-	0.183	-	0.151	0.316	0.202	0.205	0.306
Thallium (Tl)	mg/L	0.000005	0.000005	-	0.000005	-	0.000005	0.000005	0.000005	0.000005	0.000005	0.00001	0.00001	0.000005	0.000012	-	0.0000085	-	0.000005	0.000050	0.000050	0.000047	0.000050
Tin (Sn)	mg/L	0.00005	0.00005	-	0.00005	-	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	-	0.00005	-	0.00005	0.00005	0.00005	0.00005	0.00005
Titanium (Ti)	mg/L	0.0050	0.0050	-	0.0050	-	0.0050	0.0050	0.0050	0.0050	0.0050	0.0110	0.0050	0.0050	0.0050	-	0.0050	-	0.0050	0.0260	0.0050	0.0066	0.0134
Uranium (U)	mg/L	0.000109	0.000110	-	0.000110	-	0.00003	0.00008	0.00006	0.00006	0.00008	0.00004	0.00004	0.000100	0.000173	-	0.000137	-	0.00003	0.00012	0.00011	0.00009	0.00012
Vanadium (V)	mg/L	0.00050	0.00050	-	0.00050	-	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	-	0.00050	-	0.00050	0.00330	0.00050	0.00072	0.00162
Zinc (Zn)	mg/L	0.00150	0.00150	-	0.00150	-	0.00150	0.00150	0.00150	0.00150	0.00150	0.00150	0.00150	0.00150	0.00150	-	0.00150	-	0.00050	0.00340	0.00150	0.00155	0.00226

(continued)

Table 13.3-5. Baseline Water Quality of Bowser River and Wildfire/Scott/Todedada Creek Watersheds (Off-site Areas), Brucejack Gold Mine Project (continued)

Project Area		Off-site Areas																					
Site		Bowser River (3 sites)					Bowser Lake (BL1)[1]		Scott Creek (2 sites)										Todedada Creek (3 sites)				
		High Flow (n=18)					Open Water		Low Flow (n=11)					High Flow (n=9)					Low Flow (n=10)				
	Units	Min.	Max.	Median	Mean	95th P	Shallow (1 m)	Deep (30 m)	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P
Physical Tests																							
Colour	CU	2.50	10.5	2.50	3.27	8.72	2.50	2.50	2.50	6.00	2.50	2.82	4.25	2.50	12.5	2.50	4.43	11.5	2.50	7.10	2.50	3.28	6.47
Conductivity	µS/cm	50.9	159	109	111	150	91.1	92.4	101	222	166	170	221	78.6	155	123	120	153	129	306	246	232	298
Hardness (as $CaCO_3$)	mg/L	23.2	71.8	51.2	51.4	68.3	43.3	43.5	43.1	110	78.1	81.3	110	35.0	69.0	57.1	55.8	68.5	62.4	155	129	119	152
pH	pH	7.18	8.24	7.90	7.83	8.20	7.73	7.77	7.40	8.18	8.00	7.89	8.17	7.73	8.29	7.93	7.95	8.26	7.86	8.20	8.07	8.07	8.19
Total Suspended Solids	mg/L	3.30	229	57.0	80.6	197	18.1	11.1	1.50	38.0	1.50	7.41	28.6	1.50	192	4.8	44.8	158	1.50	160	4.05	40.1	157
Total Dissolved Solids	mg/L	50.0	118	83.0	82.6	112	72.0	77.0	59.0	135	99.0	99.1	135	52.0	93.0	77.0	77.4	91.4	85	181	143	138	176
Turbidity	NTU	3.32	294	84.9	111	277	40.8	41.4	0.290	8.62	0.750	1.78	5.80	0.75	236	3.33	51.1	188	0.32	138	3.10	34.1	130
Acidity	mg/L	0.50	4.90	2.60	2.76	4.14	5.70	4.60	1.80	6.30	3.00	3.18	5.65	1.20	4.60	2.50	2.64	4.32	1.50	6.80	2.50	3.08	5.99
Alkalinity, Bicarbonate (as $CaCO_3$)	mg/L	22.2	52.3	42.0	41.0	51.0	35.0	35.6	27.4	80.4	33.9	49.0	79.5	21.0	49.4	36.4	37.4	48.5	45.2	121	85.8	84.0	116
Alkalinity, Carbonate (as $CaCO_3$)	mg/L	0.500	1.00	0.500	0.639	1.00	0.500	0.500	1.00	1.00	1.00	1.00	1.00	0.500	1.00	1.00	0.778	1.00	0.500	1.00	1.00	0.900	1.00
Alkalinity, Hydroxide (as $CaCO_3$)	mg/L	0.500	1.00	0.500	0.639	1.00	0.500	0.40	1.00	1.00	1.00	1.00	1.00	0.500	1.00	1.00	0.778	1.00	0.500	1.00	1.00	0.900	1.00
Alkalinity, Total (as $CaCO_3$)	mg/L	22.2	52.3	42.0	41.0	51.0	35.0	35.6	27.4	80.4	33.9	49.0	79.45	21.0	49.4	36.4	37.4	48.5	45.2	121	85.8	84.0	116
Anions and Nutrients																							
Ammonia, Total (as N)	mg/L	0.00250	0.03080	0.00250	0.00459	0.0118	0.00250	0.00250	0.0025	0.0133	0.0025	0.0049	0.01195	0.0025	0.0025	0.0025	0.0025	0.0025	0.00250	0.0179	0.00250	0.00556	0.0147
Bromide (Br)	mg/L	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250
Chloride (Cl)	mg/L	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
Fluoride (F)	mg/L	0.0100	0.0270	0.0100	0.0160	0.0262	0.0100	0.0100	0.0220	0.0490	0.0310	0.0345	0.0490	0.0100	0.0220	0.0100	0.0138	0.022	0.0290	0.0500	0.0455	0.0419	0.0496
Nitrate (as N)	mg/L	0.0067	0.379	0.0480	0.0894	0.376	0.0415	0.0454	0.00550	0.327	0.0586	0.135	0.288	0.00250	0.392	0.0355	0.0708	0.258	0.0089	0.245	0.0555	0.0670	0.176
Nitrite (as N)	mg/L	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.00100	0.000500	0.000556	0.000800	0.000500	0.000500	0.000500	0.000500	0.000500
Total Kjeldahl Nitrogen	mg/L	0.0250	0.0920	0.0250	0.0450	0.0852	0.0590	0.0750	0.0250	0.255	0.0250	0.0824	0.230	0.0250	0.0970	0.0250	0.0330	0.0682	0.0250	0.173	0.0565	0.0652	0.144
Total Nitrogen	mg/L	0.0250	0.450	0.0800	0.132	0.433	0.0005	0.0005	0.0600	0.480	0.180	0.206	0.455	0.025	0.420	0.07	0.102	0.312	0.0250	0.300	0.125	0.126	0.282
Orthophosphate-Dissolved (as P)	mg/L	0.000500	0.00190	0.00120	0.00120	0.00183	0.0590	0.0750	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phosphorus (P)-Total	mg/L	0.00790	0.394	0.100	0.120	0.261	0.0222	0.0220	0.00100	0.0584	0.00430	0.0110	0.0374	0.00350	0.367	0.0103	0.0722	0.273	0.00100	0.139	0.00645	0.0389	0.139
Sulphate (SO_4)	mg/L	5.0	26.9	13.3	13.8	24.0	11.3	11.6	20.9	52.3	36.6	35.3	49.0	9.65	38.8	17.6	21.2	37.6	17.9	59.7	33.7	36.6	56.0
Cyanides																							
Cyanide, Total	mg/L	0.000500	0.0005	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.0025	0.0005	0.00115	0.0025	0.0005	0.001	0.0005	0.000563	0.000825	0.0005	0.00250	0.0005	0.000914	0.00217
Cyanide, WAD	mg/L	0.000500	0.00290	0.00110	0.00118	0.00290	0.000500	0.000500	0.000500	0.0022	0.0013	0.00126	0.0019	0.0005	0.0038	0.0011	0.00148	0.00344	0.0005	0.00250	0.00115	0.00119	0.00223
Organic Carbon																							
Total Organic Carbon	mg/L	0.560	2.52	1.12	1.31	2.36	1.50	1.37	0.25	2.22	0.98	1.06	1.87	0.56	3.21	1.2	1.52	2.97	0.530	2.48	1.34	1.41	2.24
Total Metals																							
Aluminum (Al)	mg/L	*0.159*	*11.2*	*3.87*	*4.67*	*9.59*	*1.96*	*1.92*	0.0071	0.094	0.0357	0.0407	0.088	0.0280	*7.31*	*0.246*	*1.80*	*6.26*	0.0106	*6.55*	0.0837	*1.58*	*6.20*
Antimony (Sb)	mg/L	0.000130	0.00140	0.000550	0.000671	0.001366	0.000410	0.000410	0.000050	0.000180	0.000050	0.000104	0.000180	0.000050	0.00115	0.000140	0.000308	0.000930	0.00012	0.00146	0.00027	0.000498	0.00144
Arsenic (As)	mg/L	0.0003	0.0101	0.00282	0.00360	0.0085	0.00126	0.00125	0.000130	0.000500	0.000310	0.00031818	0.000465	0.00012	0.00728	0.00032	0.00172	0.00577	0.00023	0.00627	0.00112	0.00213	0.00620
Barium (Ba)[2]	mg/L	0.0309	0.248	0.106	0.114	0.211	0.0683	0.0667	0.0196	0.0446	0.0285	0.0313	0.0435	0.0149	0.160	0.0291	0.0587	0.141	0.0350	0.141	0.0497	0.0661	0.137
Beryllium (Be)[2]	mg/L	0.000190	0.000280	0.000250	0.000248	0.000255	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250
Bismuth (Bi)	mg/L	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250
Boron (B)	mg/L	0.00500	0.0130	0.00500	0.00678	0.0122	0.0110	0.0110	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Cadmium (Cd)[2]	mg/L	0.000028	0.000302	0.000161	0.000148	0.000268	0.000057	0.000051	0.000005	0.000112	0.000017	0.000025	0.000069	0.000005	0.000665	0.000036	0.000112	0.000456	0.000070	0.00109	0.000098	0.000319	0.00107
Calcium (Ca)	mg/L	9.3	26.3	18.6	18.5	25.8	16.0	16.0	11.3	37.5	22.7	24.8	36.9	9.05	24.6	18.3	17.6	22.9	20.6	52.2	41.7	39.2	51.3
Chromium (Cr)	mg/L	0.00037	**0.0158**	**0.00318**	**0.00570**	**0.0141**	**0.00234**	**0.00236**	0.00012	0.0005	0.00024	0.00027182	0.000495	0.00017	**0.0067**	0.00059	**0.0016033**	**0.0052**	0.00005	**0.00558**	0.00026	**0.00151**	**0.00537**
Cobalt (Co)	mg/L	0.00010	0.00674	0.00185	0.00250	0.00575	0.00079	0.00079	0.00005	0.00062	0.00021	0.00028273	0.00062	0.00012	0.00498	0.00028	0.00110556	0.003828	0.00005	0.00305	0.000225	0.000874	0.00300
Copper (Cu)	mg/L	0.00080	**0.0212**	0.00421	**0.00819**	**0.0201**	0.00316	0.00306	0.00025	0.00209	0.00052	0.00063	0.00158	0.00025	**0.01090**	0.00123	0.00241	**0.00814**	0.00025	0.00854	0.00038	0.00233	0.00840
Iron (Fe)	mg/L	0.193	**15.3**	**4.32**	**5.93**	**13.3**	**1.76**	**1.84**	0.015	0.815	0.099	0.31909091	0.757	0.183	**10.9**	0.313	**2.45**	**8.92**	0.015	**7.23**	0.503	**2.11**	**7.08**
Lead (Pb)	mg/L	0.0001	0.0081	0.0021	0.0029	0.0068	0.0010	0.0011	0.00003	0.00019	0.00007	0.00009	0.00019	0.0000	0.0047	0.0001	0.0010	0.0037	0.000025	0.002920	0.000073	0.000734	0.00287
Lithium (Li)[2]	mg/L	0.00250	0.00910	0.00250	0.00365	0.00723	0.00250	0.00250	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0059	0.0025	0.00287778	0.00454	0.0025	0.006	0.0025	0.00316	0.00582
Magnesium (Mg)	mg/L	2.34	6.74	3.64	3.80	6.31	1.96	1.99	3.51	6.59	5.09	4.87	5.97	2.34	5.91	3.76	3.90	5.89	4.37	7.19	6.41	6.21	6.99
Manganese (Mn)	mg/L	0.0093	0.4530	0.1250	0.1549	0.3162	0.0449	0.0467	0.0007	0.1340	0.0110	0.0515	0.1320	0.0088	0.4050	0.0319	0.0988	0.3086	0.0017	0.405	0.173	0.177	0.388
Mercury (Hg)	mg/L	0.0000050	0.0000370	0.0000115	0.0000132	0.0000277	0.0000050	0.0000050	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000044	0.000005	1.0111E-05	0.0000312	0.000005	0.000036	0.000005	0.0000096	0.0000288
Molybdenum (Mo)	mg/L	0.000445	0.001470	0.000806	0.000911	0.001453	0.000746	0.000793	0.00019	0.00081	0.00033	0.00048	0.00079	0.00031	0.00124	0.00077	0.00073	0.00111	0.000834	0.00196	0.00119	0.00130	0.00196
Nickel (Ni)[2]	mg/L	0.000250	0.0127	0.0030	0.0047	0.0110	0.0016	0.0017	0.0003	0.0019	0.0017	0.0011	0.0019	**0.0003**	**0.0083**	**0.0015**	**0.0021**	**0.0062**	0.0003	0.0105	0.0009	0.00308	0.0104
Phosphorus (P)	mg/L	0.150	0.390	0.150	0.163	0.186	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.350	0.150	0.172	0.270	0.150	0.150	0.150	0.150	0.150
Potassium (K)	mg/L	0.220	3.05	1.52	1.48	2.48	0.889	0.87	0.196	0.268	0.223	0.227	0.256	0.220	2.21	0.279	0.769	2.08	0.290	2.11	0.386	0.764	2.02
Selenium (Se)	mg/L	0.000100	0.000660	0.000380	0.000378	0.000635	0.000360	0.000280	0.000270	0.001000	0.000480	0.000574	0.000920	0.000100	0.000730	0.000400	0.000403	0.000678	0.000660	0.00208	0.00115	0.00123	0.002035
Silicon (Si)	mg/L	2.32	25.4	8.20	10.8	24.6	4.04	3.90	1.81	2.53	2.04	2.14	2.49	1.47	14.3	2.19	4.56	12.4	2.22	16.2	2.88	5.55	$15.0

(continued)

Table 13.3-5. Baseline Water Quality of Bowser River and Wildfire/Scott/Todedada Creek Watersheds (Off-site Areas), Brucejack Gold Mine Project (continued)

Project Area		Off-site Areas																					
Site		Bowser River (3 sites)					Bowser Lake (BL1)[1]		Scott Creek (2 sites)										Todedada Creek (3 sites)				
		High Flow (n=18)					Open Water		Low Flow (n=11)					High Flow (n=9)					Low Flow (n=10)				
	Units	Min.	Max.	Median	Mean	95th P	Shallow (1 m)	Deep (30 m)	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P
Total Metals *(cont'd)*																							
Silver (Ag)	mg/L	0.000005	**0.000166**	0.000048	0.000060	**0.000128**	0.000014	0.000016	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	**0.000129**	0.000005	0.000026	0.000096	0.000005	0.000103	0.000005	0.000029	0.000103
Sodium (Na)	mg/L	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	2.10	1.00	1.32	2.10
Strontium (Sr)	mg/L	0.0572	0.2000	0.1320	0.1311	0.1992	0.0935	0.0944	0.108	0.334	0.204	0.221	0.329	0.0984	0.198	0.144	0.155	0.196	0.19	0.359	0.292	0.286	0.357
Thallium (Tl)	mg/L	0.000050	0.000128	0.000050	0.000056	0.000080	0.000050	0.000050	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.0002	0.00005	0.00007	0.00014	0.00005	0.00024	0.00005	0.000093	0.000236
Tin (Sn)	mg/L	0.00005	0.00015	0.00005	0.00006	0.00012	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
Titanium (Ti)	mg/L	0.00500	0.513	0.131	0.175	0.431	0.0420	0.0410	0.005	0.005	0.005	0.005	0.005	0.005	0.165	0.005	$0.0408	0.151	0.005	0.166	0.005	0.0389	0.148
Uranium (U)	mg/L	0.00003	0.00032	0.00014	0.00014	0.00023	0.00008	0.00009	0.000005	0.000057	0.000005	0.0000	0.000056	0.000005	0.00018	0.000025	0.000056	0.0001544	0.000044	0.000203	0.000097	0.000104	0.000202
Vanadium (V)	mg/L	0.00050	0.03300	0.00965	0.0130	0.0302	0.00550	0.00510	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0178	0.0005	0.00427	0.0149	0.0005	0.0142	0.0005	0.00374	0.01348
Zinc (Zn)	mg/L	0.00150	**0.0514**	0.0174	0.0200	**0.0432**	0.00800	0.00830	0.0015	0.0035	0.0015	0.0017	0.0025	0.0005	**0.0542**	0.0032	0.0105	**0.0390**	0.0015	**0.0868**	0.0041	0.0231	**0.0845**
Dissolved Metals																							
Aluminum (Al)	mg/L	0.0204	**0.240**	0.0602	0.0688	**0.158**	0.0530	0.0449	0.0015	0.0156	0.0035	0.0050	0.0130	0.0031	**0.139**	0.0261	0.0458	**0.130**	0.0015	0.0493	0.0090	0.0165	0.0414
Antimony (Sb)	mg/L	0.000120	0.000610	0.000235	0.000269	0.000525	0.000280	0.000280	0.000050	0.000190	0.000050	0.000103	0.000180	0.000050	0.000190	0.000110	0.000110	0.000186	0.000120	0.000300	0.000185	0.000195	0.000291
Arsenic (As)	mg/L	0.00021	0.00079	0.00035	0.00038	0.00060	0.00027	0.00028	0.00005	0.00035	0.00026	0.00023364	0.00034	0.00005	0.00042	0.00021	0.00025222	0.000408	0.0002	0.00083	0.000245	0.000432	0.000812
Barium (Ba)	mg/L	0.0167	0.0385	0.0283	0.0287	0.0375	0.0318	0.0313	0.0193	0.0402	0.0284	0.0306	0.04015	0.0129	0.0385	0.0264	0.0250	0.0361	0.0194	0.0556	0.0342	0.03529	0.05416
Beryllium (Be)	mg/L	0.000050	0.000250	0.000250	0.000228	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250
Bismuth (Bi)	mg/L	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250
Boron (B)	mg/L	0.00500	0.01000	0.00500	0.00528	0.00575	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.005	0.005	0.005	0.005	0.005
Cadmium (Cd)	mg/L	0.000005	0.000049	0.000019	0.000021	0.000046	0.000012	0.000005	0.000005	0.000042	0.000012	0.000015	0.000032	0.000005	0.000031	0.000016	0.000014	0.000027	0.000028	0.000112	0.000062	0.000065	0.000099
Calcium (Ca)	mg/L	8.32	24.9	17.3	17.5	23.8	15.2	15.3	11.3	35.6	21.7	24.4	35.4	9.06	23.1	17.5	16.9	21.5	19.3	50.5	41.3	38.2	49.7
Chromium (Cr)	mg/L	0.00005	0.00020	0.00010	0.00011	0.00017	0.00010	0.00010	0.00005	0.00016	0.00005	0.000092	0.000155	0.00005	0.00025	0.0001	0.000146	0.00025	0.00005	0.00012	0.0001	0.000085	0.00012
Cobalt (Co)	mg/L	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00055	0.00005	0.00022091	0.000545	0.00005	0.00027	0.00005	0.000094	0.000226	0.00005	0.00046	0.00005	0.000117	0.000366
Copper (Cu)	mg/L	0.00015	0.00136	0.00031	0.00044	0.00106	0.00022	0.00043	0.00025	0.00025	0.00025	0.00025	0.00025	0.00016	0.00093	0.00025	0.00035333	0.00083	0.00025	0.00066	0.00025	0.000329	0.000566
Iron (Fe)	mg/L	0.0150	0.192	0.0410	0.0474	0.108	0.0330	0.0150	0.015	0.113	0.034	0.0505	0.1125	0.015	0.08	0.015	0.0403	0.0784	0.015	0.203	0.015	0.0512	0.1706
Lead (Pb)	mg/L	0.000025	0.000142	0.000025	0.000035	0.000072	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025
Lithium (Li)	mg/L	0.00025	0.00250	0.00250	0.00225	0.00250	0.00250	0.00250	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025
Magnesium (Mg)	mg/L	0.599	3.62	1.71	1.87	3.58	1.29	1.31	3.60	6.50	5.03	4.89	6.03	1.43	5.55	3.00	3.29	5.50	3.45	7.11	6.18	5.70	6.93
Manganese (Mn)	mg/L	0.00123	0.01030	0.00292	0.00392	0.00975	0.00190	0.00096	0.000178	0.129	0.0115	0.0438	0.128	0.000601	0.0767	0.00371	0.0163	0.0563	0.000726	0.378	0.008585	0.0783	0.297
Mercury (Hg)	mg/L	0.000005	0.000012	0.000005	0.000005	0.000006	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005
Molybdenum (Mo)	mg/L	0.000406	0.001240	0.000644	0.000738	0.001189	0.000754	0.000760	0.000169	0.00079	0.000323	0.00045182	0.0007635	0.000282	0.000871	0.000593	0.00060356	0.0008334	0.000514	0.00157	0.000987	0.0010514	0.001543
Nickel (Ni)[2]	mg/L	0.00025	0.00071	0.00025	0.00030	0.00069	0.00025	0.00025	0.00025	0.00177	0.00127	0.00097364	0.00175	0.00025	0.00153	0.00025	0.00053333	0.00133	0.00025	0.0008	0.00025	0.000428	0.000751
Phosphorus (P)	mg/L	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
Potassium (K)	mg/L	0.156	0.443	0.234	0.274	0.429	0.285	0.280	0.195	0.239	0.222	0.218	0.238	0.180	0.254	0.191	0.197	0.232	0.239	0.383	0.301	0.312	0.381
Selenium (Se)	mg/L	0.000100	0.000620	0.000335	0.000306	0.000527	0.000360	0.000360	0.000260	0.000960	0.000430	0.000530	0.000895	0.0001	0.00056	0.00036	0.00032889	0.000548	0.00059	0.00159	0.00114	0.00112	0.00159
Silicon (Si)	mg/L	0.505	2.39	1.10	1.24	2.39	0.764	0.720	1.77	2.49	1.99	2.10	2.44	0.941	2.35	1.34	1.47	2.17	1.52	2.91	2.26	2.26	2.90
Silver (Ag)	mg/L	0.0000050	0.0000050	0.0000050	0.0000050	0.0000050	0.0000050	0.0000050	0.0000050	0.0000050	0.0000050	0.0000050	0.0000050	0.0000050	0.0000050	0.0000050	0.0000050	0.0000050	0.0000050	0.0000050	0.0000050	0.0000050	0.0000050
Sodium (Na)	mg/L	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	2.40	1.00	1.13	1.70	1.00	1.00	1.00	1.00	1.00	1.00	2.10	1.00	1.41	2.06
Strontium (Sr)	mg/L	0.0421	0.199	0.122	0.122	0.195	0.0879	0.0891	0.111	0.320	0.204	0.218	0.320	0.0987	0.189	0.147	0.149	0.187	0.174	0.351	0.297	0.280	0.346
Thallium (Tl)	mg/L	0.000005	0.000050	0.000050	0.000045	0.000050	0.000050	0.000050	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
Tin (Sn)	mg/L	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
Titanium (Ti)	mg/L	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050
Uranium (U)	mg/L	0.00002	0.00011	0.00003	0.00005	0.00010	0.00005	0.00005	0.000005	0.000054	0.000005	0.000024	0.000054	0.000005	0.000048	0.000024	0.000024	0.0000476	0.000031	0.000118	0.0000615	0.0000672	0.000108
Vanadium (V)	mg/L	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050
Zinc (Zn)	mg/L	0.00050	0.00150	0.00080	0.00098	0.00150	0.00050	0.00050	0.00150	0.00150	0.00150	0.00150	0.00150	0.00050	0.00150	0.00110	0.00101	0.00150	0.00150	0.00540	0.00150	0.00196	0.00383

(continued)

Table 13.3-5. Baseline Water Quality of Bowser River and Wildfire/Scott/Todedada Creek Watersheds (Off-site Areas), Brucejack Gold Mine Project (continued)

Project Area		Off-site Areas														
Site		Todedada Creek (3 sites)					Wildfire Area Creeks (2 sites)									
		High Flow (n=10)					Low Flow (n=13)					High Flow (n=28)				
	Units	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P
Physical Tests																
Colour	CU	2.50	13.10	2.50	3.49	8.36	2.50	21.9	13.4	13.0	20.0	2.50	24.5	13.0	11.5	24.4
Conductivity	µS/cm	88.4	200	117	133	191	19.2	93.5	37.7	43.9	81.4	19.3	77.6	27.2	35.8	59.2
Hardness (as $CaCO_3$)	mg/L	44.0	91.4	57.1	64.2	91.3	8.8	38.6	15.4	18.1	33.9	8.10	32.8	12.2	15.4	25.7
pH	pH	7.85	8.27	7.99	8.01	8.22	6.43	7.86	7.54	7.37	7.83	6.49	8.18	7.72	7.66	8.14
Total Suspended Solids	mg/L	5.30	205	62.7	74.4	174	1.50	8.40	1.50	2.50	6.15	1.50	52.7	5.80	9.21	34.1
Total Dissolved Solids	mg/L	67.0	122	90.5	92.4	117	24.0	64.0	30.0	36.5	54.4	17.0	47.0	29.5	31.1	44.3
Turbidity	NTU	4.6	183	55.9	69.5	182	0.510	7.77	1.18	2.18	6.20	1.18	21.9	8.31	9.57	19.8
Acidity	mg/L	1.60	4.00	2.30	2.48	3.87	1.60	3.60	2.60	2.65	3.50	0.500	4.20	2.60	2.41	3.97
Alkalinity, Bicarbonate (as $CaCO_3$)	mg/L	35.7	71.6	46.5	50.7	69.8	6.20	25.1	10.5	12.2	21.3	5.40	18.9	7.85	9.61	14.6
Alkalinity, Carbonate (as $CaCO_3$)	mg/L	0.500	1.00	0.500	0.679	1.00	0.500	1.00	1.00	0.942	1.00	0.500	1.00	1.00	0.982	1.00
Alkalinity, Hydroxide (as $CaCO_3$)	mg/L	0.500	1.00	0.500	0.679	1.00	0.500	1.00	1.00	0.942	1.00	0.500	1.00	1.00	0.982	1.00
Alkalinity, Total (as $CaCO_3$)	mg/L	35.7	71.6	46.5	50.7	69.8	6.20	25.1	10.5	12.2	21.3	5.40	18.9	7.85	9.61	14.6
Anions and Nutrients																
Ammonia, Total (as N)	mg/L	0.00250	0.00250	0.00250	0.00250	0.00250	0.00250	0.00250	0.00250	0.00250	0.00250	0.00250	0.01300	0.00250	0.00306	0.00519
Bromide (Br)	mg/L	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250
Chloride (Cl)	mg/L	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
Fluoride (F)	mg/L	0.0100	0.0250	0.0100	0.0157	0.0250	0.0100	0.0400	0.0100	0.0169	0.0334	0.0100	0.0210	0.0100	0.0104	0.0100
Nitrate (as N)	mg/L	0.0025	0.138	0.0025	0.0164	0.0689	0.089	0.501	0.272	0.260	0.469	0.0025	0.300	0.0355	0.0557	0.151
Nitrite (as N)	mg/L	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500
Total Kjeldahl Nitrogen	mg/L	0.0250	0.0700	0.0250	0.0350	0.0635	0.0265	0.900	0.073	0.165	0.581	0.0250	0.244	0.100	0.0983	0.194
Total Nitrogen	mg/L	0.0250	0.180	0.0250	0.0486	0.109	0.177	1.06	0.384	0.439	0.808	0.0250	0.410	0.120	0.137	0.306
Orthophosphate-Dissolved (as P)	mg/L	-	-	-	-	-	0.000500	0.0012	0.000500	0.000609	0.0011	0.000500	0.0013	0.000500	0.000600	0.00123
Phosphorus (P)-Total	mg/L	0.0106	0.261	0.0610	0.0936	0.256	0.00200	0.0109	0.0051	0.00601	0.0104	0.00240	0.0683	0.0107	0.0166	0.0521
Sulphate (SO_4)	mg/L	9.7	31.9	16.6	17.8	28.8	1.95	19.2	5.99	7.29	16.74	1.92	16.7	4.07	6.34	12.8
Cyanides																
Cyanide, Total	mg/L	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.000550	0.0005	0.000504	0.000520	0.0005	0.00170	0.0005	0.000571	0.00102
Cyanide, WAD	mg/L	0.0005	0.00370	0.0005	0.001	0.00247	0.0005	*0.0076*	0.0005	0.00187	*0.00664*	0.0005	0.00500	0.0005	0.00123	0.00353
Organic Carbon																
Total Organic Carbon	mg/L	0.250	2.91	0.745	1.03	2.24	1.81	5.04	3.63	3.66	4.89	0.510	5.50	3.38	2.94	4.41
Total Metals																
Aluminum (Al)	mg/L	*0.244*	*5.58*	*2.14*	*2.40*	*5.20*	0.0305	*0.566*	*0.130*	*0.179*	*0.417*	0.0582	*1.49*	*0.534*	*0.602*	*1.20*
Antimony (Sb)	mg/L	0.00015	0.00153	0.000475	0.000641	0.00152	0.00005	0.00005	0.00005	0.00005	0.00005	0.000050	0.000360	0.000050	0.000064	0.000102
Arsenic (As)	mg/L	0.00038	0.00753	0.0025	0.00302	0.00745	0.00005	0.0002	0.0001	0.000092	0.000158	0.00005	0.00063	0.000205	0.000219	0.000476
Barium (Ba)[2]	mg/L	0.0257	0.126	0.0636	0.0702	0.119	0.009	0.0205	0.0122	0.0126	0.0180	0.0097	0.0241	0.0150	0.0158	0.0222
Beryllium (Be)[2]	mg/L	0.000250	0.000250	0.000250	0.000250	0.000250	0.000050	0.000250	0.000050	0.000081	0.000250	0.000050	0.000250	0.000050	0.000064	0.000180
Bismuth (Bi)	mg/L	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250
Boron (B)	mg/L	0.005	0.011	0.005	0.00543	0.0071	0.005	0.005	0.005	0.005	0.005	0.00500	0.0110	0.00500	0.00521	0.00500
Cadmium (Cd)[2]	mg/L	0.000072	0.00123	0.000166	0.000373	0.001204	0.000005	0.000017	0.000005	0.000006	0.000011	0.000005	0.000027	0.000005	0.000009	0.000021
Calcium (Ca)	mg/L	15.4	31.9	19.7	22.0	31.6	2.32	11.1	4.32	5.15	9.71	2.34	8.28	3.37	4.33	7.37
Chromium (Cr)	mg/L	0.00024	**0.00533**	0.00091	**0.00185**	**0.00506**	0.0002	**0.00146**	0.00041	0.00052	**0.00109**	0.0003	**0.00415**	**0.0014**	**0.00162**	**0.00323**
Cobalt (Co)	mg/L	0.00014	0.00339	0.00106	0.00127	0.00329	0.00005	0.00037	0.00005	0.000105	0.000256	0.00005	0.00132	0.000310	0.000378	0.000960
Copper (Cu)	mg/L	0.00025	**0.00944**	0.00215	0.00337	**0.00943**	0.00086	0.00295	0.00114	0.00128	0.00215	0.00100	**0.00358**	0.00151	0.00173	0.00296
Iron (Fe)	mg/L	0.288	**9.19**	**2.82**	**3.44**	**8.93**	0.015	0.585	0.073	0.153	0.390	0.04200	**1.89**	0.541	0.611	**1.43**
Lead (Pb)	mg/L	0.0001	0.0038	0.0013	0.0015	0.0038	0.000025	0.000159	0.000025	0.000041	0.000112	0.000025	0.000553	0.000143	0.000170	0.000415
Lithium (Li)[2]	mg/L	0.0025	0.0059	0.0025	0.00295	0.005575	0.00025	0.0025	0.00074	0.000889	0.0025	0.00025	0.00250	0.000875	0.00107	0.00242
Magnesium (Mg)	mg/L	2.24	5.17	3.05	3.32	4.65	0.75	2.91	1.13	1.41	2.57	0.775	2.51	1.21	1.35	2.10
Manganese (Mn)	mg/L	0.0145	0.319	0.108	0.124	0.298	0.000778	0.0274	0.00269	0.00643	0.0182	0.00135	0.0812	0.0135	0.0184	0.0587
Mercury (Hg)	mg/L	0.000005	0.000061	0.0000085	0.00002	0.0000545	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005
Molybdenum (Mo)	mg/L	0.000599	0.00224	0.00130	0.00135	0.00215	0.000025	0.000307	0.000095	0.000113	0.000287	0.000053	0.000410	0.000138	0.000193	0.000393
Nickel (Ni)[2]	mg/L	0.0006	0.00968	0.00114	0.00304	0.00938	0.00065	0.00225	0.00099	0.00110	0.00177	0.00085	0.00563	0.00187	0.00220	0.00432
Phosphorus (P)	mg/L	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
Potassium (K)	mg/L	0.323	2.37	1.11	1.17	2.25	0.102	0.209	0.141	0.143	0.185	0.126	0.386	0.212	0.236	0.380
Selenium (Se)	mg/L	0.000100	0.00145	0.000740	0.000789	0.00137	0.000050	0.000400	0.000160	0.000171	0.000394	0.000050	0.000430	0.000170	0.000195	0.000340
Silicon (Si)	mg/L	1.70	11.8	4.92	5.97	11.54	1.69	2.32	1.99	2.04	2.28	1.66	3.39	2.30	2.33	3.01

(continued)

Table 13.3-5. Baseline Water Quality of Bowser River and Wildfire/Scott/Todedada Creek Watersheds (Off-site Areas), Brucejack Gold Mine Project (completed)

Project Area		Off-site Areas														
Site		Todedada Creek (3 sites)					Wildfire Area Creeks (2 sites)									
		High Flow (n=10)					Low Flow (n=13)					High Flow (n=28)				
	Units	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P
Total Metals *(cont'd)*																
Silver (Ag)	mg/L	0.000005	**0.000156**	0.000030	0.000049	**0.000156**	0.000005	0.000010	0.000005	0.000005	0.000007	0.000005	0.000024	0.000005	0.000009	0.000023
Sodium (Na)	mg/L	1.00	33.0	1.00	3.29	12.2	1.00	2.90	1.00	1.26	2.66	1.00	1.00	1.00	1.00	1.00
Strontium (Sr)	mg/L	0.0913	0.249	0.1325	0.154	0.234	0.0282	0.129	0.0493	0.0596	0.114	0.0278	0.0962	0.0402	0.0506	0.0896
Thallium (Tl)	mg/L	0.00005	0.00027	0.00005	0.000111	0.00027	0.000005	0.00005	0.000005	0.0000	0.00005	0.000005	0.00005	0.000005	0.000010	0.0000472
Tin (Sn)	mg/L	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
Titanium (Ti)	mg/L	0.005	0.128	0.05	0.0564	0.1215	0.005	0.005	0.005	0.005	0.005	0.005	0.0320	0.0145	0.0133	0.0246
Uranium (U)	mg/L	0.000027	0.000241	0.000108	0.000126	0.000240	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000018	0.000005	0.000008	0.000017
Vanadium (V)	mg/L	0.0005	0.0154	0.0049	0.006043	0.014555	0.0005	0.0012	0.0005	0.000554	0.00078	0.0005	0.00340	0.00120	0.00138	0.00287
Zinc (Zn)	mg/L	0.0032	**0.0838**	0.0119	0.0255	**0.0832**	0.0015	0.0037	0.0015	0.0021	0.0036	0.00150	0.0102	0.00395	0.00408	0.00816
Dissolved Metals																
Aluminum (Al)	mg/L	0.0060	**1.1700**	0.0360	**0.1223**	**0.4784**	0.0185	**0.144**	0.0802	0.0810	**0.1362**	0.0256	**0.251**	0.0793	0.0883	**0.1547**
Antimony (Sb)	mg/L	0.000130	0.000400	0.000225	0.000235	0.000342	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050
Arsenic (As)	mg/L	0.00020	0.00120	0.00034	0.00042	0.00096	0.00005	0.00011	0.00005	0.00005	0.00007	0.00005	0.00011	0.00005	0.00005	0.00005
Barium (Ba)	mg/L	0.0172	0.0395	0.0264	0.0266	0.03781	0.00735	0.0198	0.0105	0.01140923	0.01728	0.00655	0.0169	0.00917	0.0095	0.013495
Beryllium (Be)	mg/L	0.000250	0.000250	0.000250	0.000250	0.000250	0.000050	0.000250	0.000050	0.000081	0.000250	0.000050	0.000250	0.000050	0.000064	0.000180
Bismuth (Bi)	mg/L	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250	0.000250
Boron (B)	mg/L	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Cadmium (Cd)	mg/L	0.000013	0.000129	0.000053	0.000057	0.000125	0.000005	0.000010	0.000005	0.000005	0.000007	0.000005	0.000013	0.000005	0.000005	0.000005
Calcium (Ca)	mg/L	15.3	29.7	19.2	21.2	29.6	2.33	10.8	4.35	5.06	9.50	2.21	9.12	3.35	4.27	7.14
Chromium (Cr)	mg/L	0.00005	0.00074	0.0001	0.00017	0.000422	0.00017	0.00041	0.00027	0.000276	0.000386	0.00005	0.00063	0.000265	0.000284	0.000417
Cobalt (Co)	mg/L	0.00005	0.00035	0.00005	0.00008	0.000240	0.00005	0.0001	0.00005	0.000054	0.00007	0.00005	0.00005	0.00005	0.00005	0.00005
Copper (Cu)	mg/L	0.00005	0.00085	0.000215	0.000311	0.000844	0.00061	0.00111	0.00081	0.000829	0.00110	0.00025	0.00134	0.000655	0.000676	0.00104
Iron (Fe)	mg/L	0.015	**0.869**	0.0150	0.111	**0.521**	0.0150	0.0900	0.0440	0.0437	0.0882	0.0150	0.218	0.0450	0.0513	0.106
Lead (Pb)	mg/L	0.000025	0.000456	0.000025	0.00007	0.00029	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025
Lithium (Li)	mg/L	0.0025	0.0025	0.0025	0.0025	0.0025	0.00025	0.0025	0.00072	0.000862	0.0025	0.00025	0.0025	0.00025	0.00049	0.00188
Magnesium (Mg)	mg/L	1.42	5.14	2.33	2.76	4.50	0.652	2.79	1.11	1.33	2.45	0.616	2.43	0.913	1.14	1.89
Manganese (Mn)	mg/L	0.000601	0.0613	0.0025	0.0122	0.0419	0.00042	0.0104	0.00183	0.00260	0.00658	0.000852	0.00478	0.00263	0.00275	0.00466
Mercury (Hg)	mg/L	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005
Molybdenum (Mo)	mg/L	0.000592	0.00177	0.00107	0.00104	0.00155	0.000025	0.000288	0.000087	0.000102	0.000260	0.000025	0.000371	0.000109	0.000166	0.000364
Nickel (Ni)[2]	mg/L	0.00025	0.00077	0.00025	0.000366	0.000744	0.00063	0.00111	0.0009	0.000898	0.00107	0.00025	0.00158	0.000775	0.000742	0.00103
Phosphorus (P)	mg/L	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
Potassium (K)	mg/L	0.187	0.670	0.249	0.269	0.419	0.090	0.160	0.121	0.119	0.146	0.076	0.170	0.122	0.117	0.152
Selenium (Se)	mg/L	0.00010	0.00130	0.00070	0.00073	0.00123	0.00005	0.00036	0.00017	0.00015	0.000342	0.00005	0.00039	0.000145	0.00017661	0.0003365
Silicon (Si)	mg/L	0.798	3.93	1.12	1.47	2.86	1.4	2.14	1.91	1.85	2.134	0.681	1.95	1.31	1.31	1.92
Silver (Ag)	mg/L	0.0000050	0.0000160	0.0000050	0.0000064	0.0000147	0.0000050	0.0000100	0.0000050	0.0000054	0.0000070	0.0000050	0.0000050	0.0000050	0.0000050	0.0000050
Sodium (Na)	mg/L	1.00	1.00	1.00	1.00	1.00	1.00	2.70	1.00	1.23	2.46	1.00	1.00	1.00	1.00	1.00
Strontium (Sr)	mg/L	0.0894	0.252	0.124	0.148	0.225	0.0283	0.126	0.0487	0.0580	0.112	0.0249	0.104	0.0392	0.0494	0.0871
Thallium (Tl)	mg/L	0.00005	0.00005	0.00005	0.00005	0.00005	0.000005	0.00005	0.000005	0.000012	0.00005	0.000005	0.00005	0.000005	0.000008	0.000034
Tin (Sn)	mg/L	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00015	0.00005	0.000058	0.000090	0.00005	0.00005	0.00005	0.00005	0.00005
Titanium (Ti)	mg/L	0.0050	0.0460	0.0050	0.0079	0.0194	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0110	0.0050	0.0052	0.0050
Uranium (U)	mg/L	0.000024	0.000098	0.0000615	0.000060	0.000095	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000012	0.000005	0.00000525	0.000005
Vanadium (V)	mg/L	0.00050	0.00320	0.00050	0.00069	0.00145	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050
Zinc (Zn)	mg/L	0.00050	0.00780	0.00050	0.00172	0.00533	0.00150	0.00150	0.00150	0.00150	0.00150	0.00150	0.00440	0.00150	0.00169	0.00300

Notes:

- Parameter not reported.

As hydrological regime is an important determinant of surface water quality in the Project Area, concentrations (predicted and baseline) assessed for both high flow (June to October) and low flow (November to May) periods.

Grey highlighted values exceed BC chronic water quality guidelines for the protection of aquatic life; bolded font values exceed BC acute (maximum) water quality guidelines.

Italicized font indicates exceedance of CCME guidelines for the protection of aquatic life, applied in the absence of an applicable BC guideline.

Orange font indicates exceedance of health-based drinking water quality guidelines.

[1] Samples where n ≤ 3, median and 95th percentile summary statistics were not calculated.

[2] Working guideline.

The proposed Project has the potential to affect surface water quality during the Construction, Operation, Closure, and Post-closure phases. Through a review of relevant regulations and guidelines, scientific literature, other recent Application/EIS documents in BC, as well as professional experience and judgement, surface water quality was selected for inclusion as a single receptor VC, rather than assessing individual physical or chemical constituents. Indictors of surface water quality include concentrations of total and dissolved metals, nutrients, turbidity, TSS, and temperature (BC EAO 2014). For Brucejack Lake and the downstream receiving environment (i.e., sites within the water balance and predictive water quality models) indicators are defined as quantitatively identified chemicals of potential concern (COPC; Section 13.6.1). Water quality indicators will be semi-quantitatively assessed for the receiving environment outside of the predictive model domains. Water quality indicators will be qualitatively assessed for the receiving environment outside of the predictive model domains in off-site areas.

13.4.1.1 Potential Interactions between the Project and Valued Components

Table 13.4-1 provides an impact scoping matrix of Project components and surface water quality that includes Project components and activities that have possible or likely interactions resulting in a detectable change to surface water quality. An impact scoping matrix for all VCs, including Project components and activities without interactions, is provided in Table 6.4-1 of Chapter 6, Assessment Methodology.

Table 13.4-1. Interaction of Project Components and Physical Activities with Surface Water Quality

Project Components and Physical Activities by Phase	Surface Water Quality
Construction Phase	
Activities at existing adit	
Air transport of personnel and goods	
Avalanche control	
Chemical and hazardous material storage, management and handling	
Construction of back-up diesel power plant	
Construction of Bowser Aerodrome	
Construction of detonator storage area	
Construction of electrical tie-in to BC hydro grid	
Construction of electrical substation at mine site	
Construction of equipment laydown areas	
Construction of helicopter pad	
Construction of incinerators	
Construction of Knipple Transfer Area	
Construction of local site roads	
Construction of mill building (electrical induction furnace, backfill paste plant, warehouse, mill/ concentrator)	
Construction of mine portal and ventilation shafts	
Construction of Brucejack Operations Camp	
Construction of ore conveyer	
Construction of tailings pipeline	

(continued)

Table 13.4-1. Interaction of Project Components and Physical Activities with Surface Water Quality (continued)

Project Components and Physical Activities by Phase	Surface Water Quality
Construction Phase *(cont'd)*	
Construction and decommissioning of Tide Staging Area construction camp	
Construction of truck shop	
Construction and use of sewage treatment plant and discharge	
Construction and use of surface water diversions	
Construction of water treatment plant	
Development of underground portal and facilities	
Employment and labour	
Equipment maintenance/machinery and vehicle refuelling/fuel storage and handling	
Explosives storage and handling	
Grading of the mine site area	
Helicopter use	
Installation and use of Project lighting	
Installation of surface and underground crushers	
Installation of transmission line and associated towers	
Machinery and vehicle emissions	
Potable water treatment and use	
Pre-production ore stockpile construction	
Procurement of goods and services	
Quarry construction	
Solid Waste management	
Transportation of workers and materials	
Underground water management	
Upgrade and use of exploration access road	
Use of Granduc Access Road	
Operation Phase	
Air transport of personnel and goods and use of aerodrome	
Avalanche control	
Backfill paste plant	
Back-up diesel power plant	
Bowser Aerodrome	
Brucejack Access Road use and maintenance	
Brucejack Operations Camp	
Chemical and hazardous material storage, management, and handling	
Concentrate storage and handling	
Contact water management	
Detonator storage	

(continued)

Table 13.4-1. Interaction of Project Components and Physical Activities with Surface Water Quality (continued)

Project Components and Physical Activities by Phase	Surface Water Quality
***Operation Phase** (cont'd)*	
Discharge from Brucejack Lake	
Electrical induction furnace	
Electrical substation	
Employment and labour	
Equipment laydown areas	
Equipment maintenance/machine and vehicle refuelling/fuel storage and handling	
Explosives storage and handling	
Helicopter pad(s)	
Helicopter use	
Knipple Transfer Area	
Machine and vehicle emissions	
Mill building	
Non-contact water management	
Ore conveyer	
Potable water treatment and use	
Pre-production ore storage	
Procurement of goods and services	
Project lighting	
Quarry operation	
Sewage treatment and discharge	
Solid waste management/incinerators	
Subaqueous tailings disposal	
Subaqueous waste rock disposal	
Surface crushers	
Tailings pipeline	
Truck shop	
Transmission line operation and maintenance	
Underground backfill tailing storage	
Underground backfill waste rock storage	
Underground crushers	
Underground: drilling, blasting, excavation	
Underground explosives storage	
Underground mine ventilation	
Underground water management	
Use of mine site haul roads	
Use of portals	

(continued)

Table 13.4-1. Interaction of Project Components and Physical Activities with Surface Water Quality (continued)

Project Components and Physical Activities by Phase	Surface Water Quality
***Operation Phase** (cont'd)*	
Ventilation shafts	
Warehouse	
Waste rock transfer pad	
Water treatment plant	
Closure Phase	
Air transport of personnel and goods	
Avalanche control	
Chemical and hazardous material storage, management, and handling	
Closure of mine portals	
Closure of quarry	
Closure of subaqueous tailing and waste rock storage (Brucejack Lake)	
Decommissioning of Bowser Aerodrome	
Decommissioning of back-up diesel power plant	
Decommissioning of Brucejack Access Road	
Decommissioning of camps	
Decommissioning of diversion channels	
Decommissioning of equipment laydown	
Decommissioning of fuel storage tanks	
Decommissioning of helicopter pad(s)	
Decommissioning of incinerators	
Decommissioning of local site roads	
Decommissioning of Mill Building	
Decommissioning of ore conveyer	
Decommissioning of Project lighting	
Decommissioning of sewage treatment plant and discharge	
Decommissioning of surface crushers	
Decommissioning of surface explosives storage	
Decommissioning of tailings pipeline	
Decommissioning of transmission line and ancillary structures	
Decommissioning of underground crushers	
Decommissioning of waste rock transfer pad	
Decommissioning of water treatment plant	
Employment and labour	
Helicopter use	
Machine and vehicle emissions	
Procurement of goods and services	

(continued)

Table 13.4-1. Interaction of Project Components and Physical Activities with Surface Water Quality (completed)

Project Components and Physical Activities by Phase	Surface Water Quality
Closure Phase *(cont'd)*	
Removal or treatment of contaminated soils	[grey]
Solid waste management	
Transportation of workers and materials (mine site and access roads)	
Post-closure Phase	
Discharge from Brucejack Lake	[black]
Employment and labour	
Environmental monitoring	
Procurement of goods and services	
Subaqueous tailing and waste rock storage	[black]
Underground mine	[grey]

Black = likely interaction between Project components/physical activities and a valued environmental or socio-economic component
Grey = possible interaction between Project components/physical activities and a valued environmental or socio-economic component
White = interaction not expected between Project components/physical activities and a valued environmental or socio-economic component

Interactions between the Project and surface water quality were assigned a colour code as follows:

- **Likely (black):** These include Project components and activities that involve:
  - directed discharge of effluent (e.g., the water treatment plant);
  - site water management activities (e.g., surface water diversion of contact and non-contact water); and
  - activities with potential to result in metal leaching/acid rock drainage (ML/ARD) effects (e.g., earth works and surface disturbances, waste rock and tailings deposition).
- **Possible (grey):** If no mitigation measures are in place, several Project components and activities could potentially affect surface water quality. For example, activities resulting in potential increases in surface run off, erosion and sedimentation, (e.g., site construction and decommissioning). The likelihood, as well as the temporal and spatial scales, of these effects are much less than those of the activities with likely (black) interactions; and
- **Not expected (white)**: Interactions coded as not expected, are considered to have no potential for adverse effects on a subject area, and are not considered further. These include interactions between the Project and surface water quality resulting from hazardous waste materials and potential spills as these are related to occurrences of low likelihood outside of normal operating conditions. These potential effects are addressed in Chapter 31, Accidents and Malfunctions, as well as the Spill Prevention and Response Plan (Section 29.14).

13.4.1.2 Consultation Feedback on Valued Components

VC scoping feedback was received for the surface water quality as a receptor VC from Aboriginal groups, EA Working Group comments during the AIR and EIS guidelines review phase, and comments received during public comment periods (see Chapter 3, Information Distribution and Consultation). No comments were received from Nisga'a Nation. No other surface water VCs were suggested by

Aboriginal Groups, public agencies, or the public. Surface water quality VC selection included interests and issues identified through the extensive consultation process with regulators, Skii km Lax Ha, Nisga'a Nation, Tahltan Nation, the Métis, governments (BC provincial, federal, Aboriginal, and American state and federal), local interest groups, and the general public.

13.4.1.3 Summary of Valued Components Included/Excluded in the Application/EIS

Surface water quality was selected as a single VC, rather than assessing individual physical or chemical constituents (Table 13.4-2). Therefore, no potential VCs were excluded from further assessment. Indicators of surface water quality include concentrations of total and dissolved metals, nutrients, turbidity, TSS, and temperature (BC EAO 2014). For Brucejack Lake and the downstream receiving environment (i.e., sites within the water balance and predictive water quality models) indicators are defined as quantitatively identified COPCs (Section 13.6.1). Water quality indicators will be semi-quantitatively assessed for the receiving environment outside of the predictive model domains.

Table 13.4-2. Surface Water Quality as a Receptor Valued Component Included in the Application/EIS

Valued Component	Identified by*				Rationale for Inclusion
	AG	G	P/S	IM	
Surface water quality	X	X	X	X	Surface water quality was identified as a key environmental issue with potential effects on fish and wildlife habitat as well as human health by aboriginal groups and BC provincial and federal regulatory agencies. Potential effects on water quality have importance to other identified biophysical VCs including primary and secondary producers, fish and fish habitat, as well as human health.

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

13.4.1.4 Assessment Boundaries for Surface Water Quality

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 surface water quality 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 of the assessment process of surface water quality, and encompasses possible direct, indirect, and induced Project effects, inclusive of Project effects on relevant intermediate components, as well as the trends in processes that may be relevant.

13.4.1.5 Spatial Boundaries

Spatial boundaries reflect the Project components and, in the case of surface water quality, boundaries are shared with surface water quantity predictive study (Section 10.4.2.1) and aquatic resources effects assessment (Section 14.4.2.1). Spatial boundaries for assessment of fish or fish habitat VCs (15.4.2.1) differ as there are no fish or fish habitat present within the mine site area based upon baseline and historical data (see Chapter 15, Assessment of Potential Fish and Fish Habitat Effects).

The spatial boundaries include the baseline study area watershed boundaries, and have considered watersheds over a range of spatial scales from local (i.e., immediately downstream of Brucejack Lake) to regional (i.e., Unuk River at the international border). The spatial boundaries have been divided into a Local Study Area (LSA) and a Regional Study Area (RSA), discussed below.

Local Study Area

The LSA constitutes the Project footprint (physical structures and activities that comprise the Project) and encompass watersheds that could be potentially directly affected by mine development and operation (Figure 13.3-1). These include lakes and streams located within and downstream of waste rock and tailings storage, effluent discharge from water and sewage treatment plants, and the quarry (mine site area), as well as ancillary infrastructure in off-site areas, including the proposed transmission line corridor, access road corridor, Knipple Transfer Area and the Bowser Aerodrome. Spatial boundaries for the quantitative water quality effects assessment were confined to the mine site area (Brucejack Watershed) and downstream limits of predicted changes as determined by predictive water quality modelling (see Section 13.6).

The LSA is depicted in Figure 13.4-1 and consists of three main areas:

- Brucejack Lake watershed (mine site area) and receiving environment;
- access road corridor, and
- the transmission line corridor.

Water quality will be assessed at release points (end-of-pipe) and receiving environment locations. The point of discharge from the mine during Operation will be the outlet of Brucejack Lake; this point constitutes the upstream assessment point. That is, the surface water quality effects assessment does not explicitly consider changes in water quality within Brucejack Lake itself (site of permanent waste rock and tailings disposal, water treatment plant/sewage treatment plant discharges during Operation), only at the lake outlet. Within the Brucejack watershed the LSA follows the boundary of the Brucejack Lake watershed at hydrometric station BJL-H1 (corresponds to water quality monitoring station BJ2). This boundary was defined by the predictive surface water quality model.

The spatial boundaries of the LSA along the eastern extent of the Project were identified as buffer zones around the access corridor and transmission line corridor. At the eastern terminus of the access road corridor, the LSA is bounded by the Bell-Irving River, which was considered to represent a boundary for potential Project-related effects (i.e., potential effects from the Project would not be expected to occur within the Bell-Irving River). At this stage, Project-related activities in these areas are not expected to directly affect streamflows (Chapter 10, Surface Water Hydrology Predictive Study), water quality or aquatic resources (Chapter 14, Assessment of Potential Aquatic Resources Effects). Therefore, these LSA did not include the entire watershed boundaries of streams within them, and, further, quantitative watershed-based studies were not performed in such areas. Qualitative assessments on water quality indicators were performed in these areas.

Regional Study Area

The Regional Study Area (RSA), shown in Figure 13.4-1, extends beyond the LSA and includes the portion of the watersheds downstream of the Project with a potential for both direct and indirect effects on surface water quality. The boundaries of the RSA include watersheds upstream of those with a potential for direct effects.

The RSA includes the following watersheds:

- Sulphurets Creek and the Unuk River,
- Lower Bowser River (downstream of Knipple Lake, Scott Creek, Todedada Creek, and Wildfire Creek), and

- Upper Bowser River (upstream of Knipple Lake).

Along the proposed discharge flow path (Brucejack Creek), spatial boundaries of the RSA encompasses areas upstream of where the Brucejack creek passes under Sulphurets Glacier (mid-field receiving environment) to Sulphurets Creek downstream of Sulphurets Lake and the Unuk River (far-field receiving environments; Figure 13.3-1). There is a potential for change to surface water quality due to Project activities in the headwaters of the Sulphurets/Unuk watersheds. Potential effects on the Unuk River may have international transboundary implications. The access road and transmission line corridors are within the Lower Bowser River and Upper Bowser River watersheds.

At this stage, the Project related activities in these areas are not expected to directly affect surface water quality and quantitative predictive studies were not performed in such areas. Qualitative assessments of water quality indicators were performed in these areas.

13.4.1.6 Temporal Boundaries

A temporal boundary is the period of time when the Project has an effect on the environment. The temporal boundaries per phase of the Project include the following:

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

13.4.2 Identifying Potential Effects on Surface Water Quality

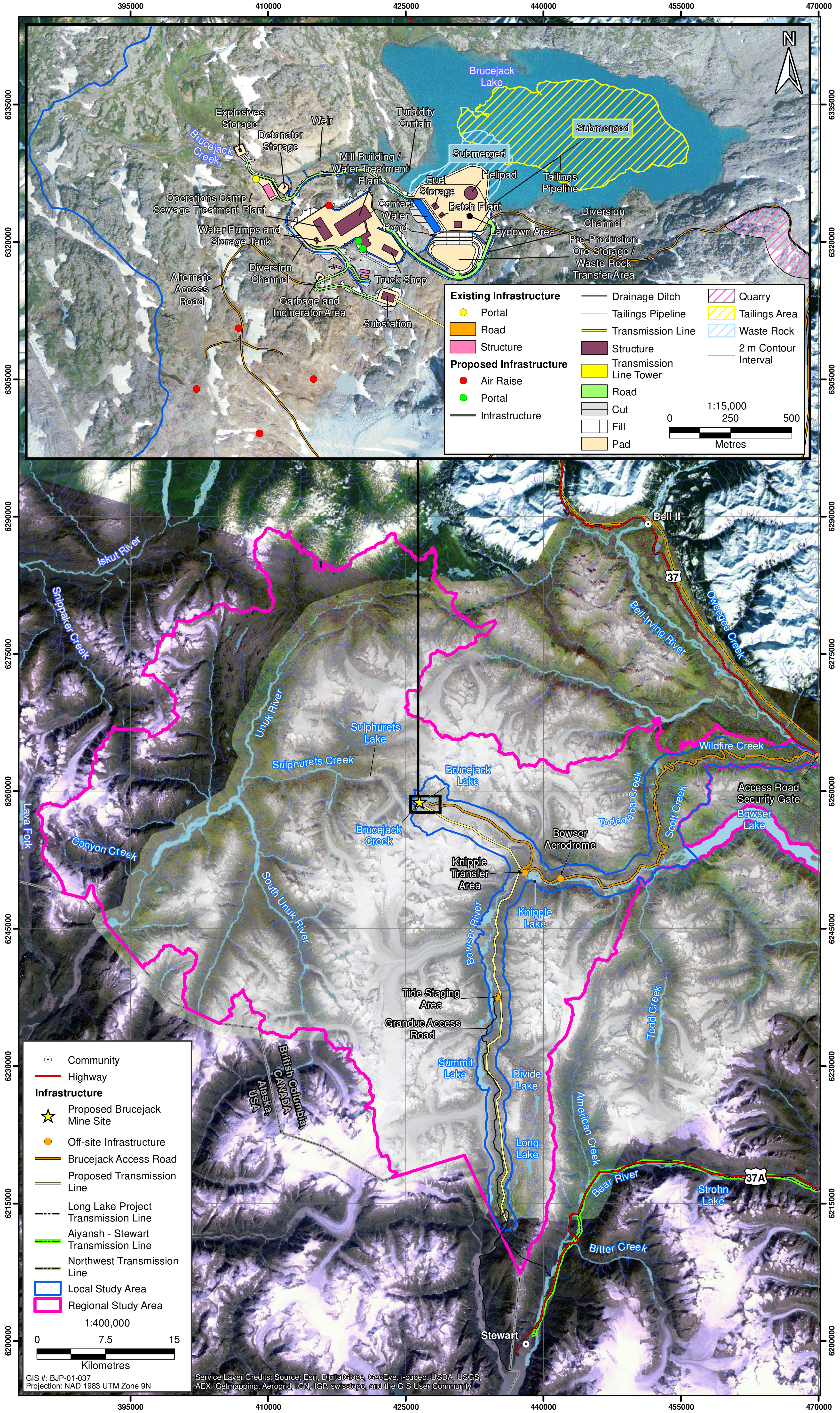
Potential effects to surface water quality originating from Project activities are identified in this section. Changes in surface water quality have the potential to occur through various pathways during the life of the Project, many of which overlap in terms of definition and scope. For the purposes of the surface water quality effect assessment, six categories were generated for scoping effects.

- Discharges, including:
  - effluent release (water treatment plant, sewage treatment plant) into Brucejack Creek during the Construction phase;
  - activities at existing adit (Construction phase); and
  - discharge from Brucejack Lake (site of permanent tailings and waste rock disposal, water treatment plant/sewage treatment plant discharge during Operation).
- ML/ARD.
- Erosion and sedimentation.
- Leaching of nitrogen residues generated from blasting.
- Groundwater and surface water interactions and seepage.
- Atmospheric deposition.

These pathways are summarized in the following sections.

Figure 13.4-1

Regional and Local Study Areas for the Surface Water Quality Assessment, Brucejack Gold Mine Project



Predictive study results from the following intermediate components will be used to support the effects assessment for surface water quality:

- Chapter 7, Air Quality Predictive Study;
- Chapter 9, Hydrogeology Predictive Study; and
- Chapter 10, Surface Water Hydrology Predictive Study.

13.4.2.1 Construction

Construction activities for the Project are focused at the mine site area and along the access road and transmission line corridors; effects on surface water quality have the potential to occur through various pathways. These include the following.

- **Discharges**: potential change of water quality through the directed discharge of effluent into upper Brucejack Creek during the Construction phase; this includes discharges from the water treatment plant and the sewage treatment plant, as well as discharge from Brucejack Lake (site of waste rock disposal during the Construction phase).
- **ML/ARD**: potential change of water quality from ML/ARD generated from surface disturbances/earth works and subsequent weathering of newly exposed rock (e.g., access roads, pad development (mill building, detonator storage, explosive storage, laydown areas), subaqueous deposition of waste rock into Brucejack Lake, quarry operation, ore stockpiles, and underground workings.
- **Erosion and sedimentation**: potential change of water quality through erosion of surface disturbances leading to sedimentation; this includes potential disturbance of the terrain during the upgrade and use of the Brucejack Access Road as well as construction of the Bowser Aerodrome, the transmission line and surface water diversions. Deposition of waste rock into Brucejack Lake during the Construction phase may also increase TSS and turbidity concentrations in Brucejack Creek.
- **Nitrogen loading from blasting residues**: potential change of water quality through the release of nitrogen as nitrate, nitrite, and ammonia from blasting residues used in construction (e.g., local site roads, pre-production ore stockpiles, quarry construction, waste rock).
- **Groundwater interactions and seepage**: potential change of surface water quality through underground workings as well as camp septic fields.
- **Atmospheric deposition**: airborne contaminant loading from crushing rock, disturbing soils, and airborne particulates generated from road traffic.

13.4.2.2 Operation

During Operation, the majority of Project-activities are focused at the mine site area. Effects on surface water quality have the potential to occur through various pathways. These include the following.

- **Discharges**: potential change of receiving and downstream water quality through the directed discharge of effluent into Brucejack Lake; these include the water treatment plant, sewage treatment plant, and tailings pipeline; deposition of waste rock and tailings into Brucejack Lake (discharge from lake outlet).
- **ML/ARD**: potential degradation of water quality from continued weathering of rock from surface disturbances (e.g., access roads, pad development (mill building, detonator storage, explosive storage, laydown areas), subaqueous deposition of waste rock and tailings into

Brucejack Lake, quarry operation, surface waste rock storage when disposal in the lake is not possible, and underground workings.

- **Erosion and sedimentation**: runoff and erosion of surface disturbances leading to sedimentation (e.g., laydown areas, surface water diversions); changes in sediment load of Brucejack Lake outlet could affect the erodibility, scouring, and the sediment load of Brucejack Creek.
- **Nitrogen loading from blasting residues**: potential degradation of water quality through the release of nitrogen as nitrate, nitrite, and ammonia from blasting residues used in mining operations.
- **Groundwater interactions and seepage**: potential change of water quality through underground workings as well as camp septic fields.
- **Atmospheric deposition**: airborne contaminant loading from crushing rock, disturbing soils, airborne particulates generated from road traffic.

13.4.2.3 Closure and Reclamation

During Closure, water quality effects have the potential to occur through various pathways that ultimately lead to changes in surface water quality. These pathways are outlined below.

- **Discharges**: potential change of receiving and downstream water quality due to the directed discharge of effluent into Brucejack Lake; these include the water treatment plant, sewage treatment plant as well as prior deposition of waste rock and tailings into Brucejack Lake (discharge from lake outlet).
- **ML/ARD:** potential degradation of water quality from ML/ARD generated from un-reclaimed surface disturbances, waste rock and underground workings.
- **Erosion and sedimentation**: potential effects on surface water quality through surface runoff and erosion of un-reclaimed surface disturbances and disturbances generated through decommissioning/reclamation activities; changes in sediment load of Brucejack Lake outlet could affect the erodibility, scouring, and the sediment load of Brucejack Creek.
- **Nitrogen loading from blasting residues**: potential degradation of water quality through the release of nitrogen as nitrate, nitrite, and ammonia from blasting residues used in mining operations.
- **Groundwater interactions and seepage**: potential change of water quality in the underground mine workings as well as camp septic fields (lower camps).
- **Atmospheric deposition**: airborne contaminant loading from disturbing soils, dust emissions from site disturbance that will occur during site re-contouring and other activities that are part of reclamation and decommissioning, as well as airborne particulates generated from road traffic.

13.4.2.4 Post-closure

During Post-closure, water quality effects have the potential to occur through various pathways that ultimately lead to a change of surface water quality condition. These pathways are outlined below:

- **Discharges**: discharge from Brucejack Lake (site of permanent waste rock and tailings deposition).
- **ML/ARD:** potential degradation of water quality from ML/ARD generated from surface disturbances, waste rock, and underground workings (pertinent to unflooded workings for potential ARD generation).

- **Erosion and sedimentation**: potential effects on surface water quality through surface runoff and erosion of un-reclaimed surface disturbances; changes in sediment load of Brucejack Lake outlet could affect the erodibility, scouring, and the sediment load of Brucejack Creek.
- **Nitrogen loading from blasting residues**: potential degradation of water quality through the release of nitrogen as nitrate, nitrite, and ammonia from blasting residues used in mining operations.
- **Groundwater interactions and seepage**: potential change in water quality of groundwater seepage from underground workings as well as camp septic fields.

13.5 EFFECTS ASSESSMENT AND MITIGATION FOR SURFACE WATER QUALITY

Assessment of effects identified in Section 13.4.3 provides a comprehensive understanding of the potential impacts on surface water quality. Effects of different components and physical activities of the Project on surface water quality during the Construction, Operation, Closure, and Post-closure phases are identified and ranked in Table 13.5-1. The ranking scheme is based on the expected significance of the potential effects.

- **Red:** Key interaction resulting in potential significant major adverse effect or significant concern; further consideration is required.
- **Yellow**: Potential moderate adverse effect requiring unique active management/monitoring/ mitigation; further consideration is required.
- **Green:** Negligible to minor adverse effect expected; implementation of best practices, standard mitigation and management measures; no monitoring required, no further consideration is required.
- **No colour:** Effects are not expected to be detectable.

The potential and likelihood for residual effects varies with Project area (i.e., the mine site area versus off-site Project infrastructure areas). Assessments of Project components and physical activities that could potentially cause key effects during different phases of the Project (Table 13.5-1) are thus presented separately for the mine site area /receiving environment and off-site areas as follows:

- Sections 13.5.1 and 13.5.2: mine site area (Brucejack watershed) and downstream receiving environments (Sulphurets/ Unuk watersheds); and
- Section 13.5.3 and 13.5.4: off-site areas (off-site, ancillary Project infrastructure).

13.5.1 Identifying Key Effects: Mine Site Area

13.5.1.1 Discharges

Various discharges associated with the Project have the potential to alter receiving environment water quality within the mine site area during the Construction, Operation, Closure and Post-closure phases. These include:

- directed discharge of water treatment plant and sewage treatment plant effluent into Brucejack Creek (Construction phase) and Brucejack Lake (Operation and Closure phases);
- activities at the existing adit (Construction phase); and
- discharge from Brucejack Lake (site of permanent waste rock and tailings disposal).

Table 13.5-1. Ranking of Potential Effects on Surface Water Quality, Brucejack Gold Mine Project

Project Components and Physical Activities by Phase	Mine Site Area (M); Off-site Area (O)	Erosion/ Sedimentation	Discharges	ML/ARD	Nutrient Loading from Blasting Residues	Atmospheric Deposition	Groundwater Interactions and Seepage
Construction Phase							
Activities at existing adit	M	🟡	🔴	🔴	○	○	○
Air transport of personnel and goods	M	○	○	○	○	○	○
Avalanche control	M; O	○	○	○	○	○	○
Chemical and hazardous material storage, management, and handling	M; O	○	○	○	○	○	○
Construction of back-up diesel power plant	M	🟢	○	○	○	○	○
Construction of Bowser Aerodrome	O	🟢	○	🟡	○	○	○
Construction of detonator storage area	M	🟢	○	🟡	🟡	○	○
Construction of electrical substation at mine site	M	🟢	○	🟡	🟡	○	○
Construction of equipment laydown areas	M;O	🟢	○	🟡	🟡	○	○
Construction of helicopter pad	M	🟢	○	○	○	○	○
Construction of incinerators	M	🟢	○	○	○	○	○
Construction of Knipple Transfer Area	O	🟢	○	○	○	○	○
Construction of local site roads	M	🟢	○	🟡	🟡	○	○
Construction of mill building (electrical induction furnace, backfill paste plant, warehouse, mill/concentrator	M	🟡	○	🔴	🟡	○	○
Construction of mine portal and ventilation shafts	M	🟢	○	🟡	🟡	○	○
Construction of Brucejack Operations Camp	M	🟢	○	○	○	○	○
Construction of ore conveyer	M	🟢	○	○	○	○	○
Construction of tailings pipeline	M	🟡	🟡	○	○	○	○
Construction and decommissioning of Tide Staging Area construction camp	O	🟢	○	○	○	○	○
Construction of truck shop	M	🟢	○	🟡	🟡	○	○
Construction and use of sewage treatment plant and discharge	M	🔴	🔴	○	○	○	○
Construction and use of surface water diversions	M	🔴	🔴	🟡	🟡	○	○
Construction of water treatment plant	M	🟡	🟡	○	○	○	○
Development of underground portal and facilities	M	○	○	🟡	🟡	○	🟡
Employment and Labour	M;O	○	○	○	○	○	○
Equipment maintenance/machinery and vehicle refuelling/fuel storage and handling	M;O	○	○	○	○	○	○
Explosives storage and handling	M;O	○	○	○	○	○	○
Grading of the mine site area	M	🟡	○	🔴	🔴	🟡	○
Helicopter use	M	○	○	○	○	○	○
Installation and use of Project lighting	M;O	○	○	○	○	○	○
Installation of surface and underground crushers	M	○	○	○	○	○	○
Installation of transmission line and associated towers	M;O	🟢	○	○	○	○	○
Machinery and vehicle emissions	M;O	○	○	○	○	○	○
Potable water treatment and use	M;O	○	○	○	○	○	○
Pre-production ore stockpile construction	M	🟢	○	🟡	🟡	🟡	○
Procurement of goods and services	M;O	○	○	○	○	○	○
Quarry construction	M	🟢	○	○	🟡	🟢	○
Solid Waste management	M:O	○	○	○	○	○	○
Transportation of workers and materials	M;O	○	○	○	○	○	○
Underground water management	M	○	○	🔴	🔴	○	🔴
Upgrade and use of exploration access road	O	🟢	○	🟡	🟡	🟢	○
Use of Granduc access road	O	○	○	○	○	🟢	○
Operation Phase							
Air transport of personnel and goods and use of aerodrome	O	○	○	○	○	○	○
Avalanche control	M;O	○	○	○	○	○	○
Backfill paste plant	M	○	○	○	○	○	○
Back-up diesel power plant	M	○	○	○	○	○	○
Bowser Aerodrome	O	🟢	○	🟢	○	🟢	○
Brucejack Access Road use and maintenance	M	🟢	○	🟢	🟢	🟢	○
Brucejack Operations Camp	M	○	○	○	○	○	○

(continued)

Table 13.5-1. Ranking of Potential Effects on Surface Water Quality, Brucejack Gold Mine Project (continued)

Project Components and Physical Activities by Phase	Mine Site Area (M); Off-site Area (O)	Erosion/ Sedimentation	Discharges	ML/ARD	Nutrient Loading from Blasting Residues	Atmospheric Deposition	Groundwater Interactions and Seepage
***Operation Phase** (cont'd)*							
Chemical and hazardous material storage, management,	M;O	○	○	○	○	○	○
Concentrate storage and handling	M	○	○	○	○	○	○
Contact water management	M	● (red)	● (red)	● (red)	● (yellow)	○	● (yellow)
Detonator storage	M	○	○	○	○	○	○
Discharge from Brucejack Lake	M	● (red)	● (red)	● (red)	● (yellow)	○	● (yellow)
Electrical induction furnace	M	○	○	○	○	○	○
Electrical substation	M	○	○	○	○	○	○
Employment and Labour	M;O	○	○	○	○	○	○
Equipment laydown areas	M	● (green)	○	● (green)	● (green)	○	○
Equipment maintenance/machine and vehicle refueling/ fuel storage and handling	M;O	○	○	○	○	○	○
Explosives storage and handling	M	○	○	○	○	○	○
Helicopter pad(s)	M	○	○	○	○	○	○
Helicopter use	M	○	○	○	○	○	○
Knipple Transfer Area	O	● (green)	○	● (yellow)	○	○	● (green)
Machine and vehicle emissions	M;O	○	○	○	○	○	○
Mill building	M	○	○	○	○	○	○
Non-contact water management	M;O	● (green)	● (green)	○	○	○	○
Ore conveyer	M	○	○	○	○	○	○
Potable water treatment and use	M;O	○	○	○	○	○	○
Pre-production ore storage	M	● (green)	○	● (yellow)	● (yellow)	● (yellow)	○
Procurement of goods and services	M;O	○	○	○	○	○	○
Project lighting	M;O	○	○	○	○	○	○
Quarry operation	M	● (green)	○	○	○	● (yellow)	○
Sewage treatment and discharge	M;O	● (green)	● (red)	○	○	○	○
Solid waste management/incinerators	M	○	○	○	○	○	○
Subaqueous tailings disposal	M	● (red)	● (red)	● (red)	● (yellow)	○	● (yellow)
Subaqueous waste rock disposal	M	● (red)	● (red)	● (red)	● (red)	○	● (yellow)
Surface crushers	M	○	○	○	○	○	○
Tailings pipeline	M	● (green)	● (yellow)	● (yellow)	○	○	○
Truck shop	M	○	○	○	○	○	○
Transmission line operation and maintenance	M;O	● (green)	○	○	○	○	○
Underground backfill tailing storage	M	○	○	○	○	○	● (yellow)
Underground backfill waste rock storage	M	○	○	○	○	○	● (yellow)
Underground crushers	M	○	○	○	○	○	○
Underground: drilling, blasting, excavation	M	○	○	● (yellow)	● (yellow)	○	● (red)
Underground explosives storage	M	○	○	○	○	○	○
Underground mine ventilation	M	○	○	○	○	○	○
Underground water management	M	○	○	○	○	○	● (red)
Use of mine site haul roads	M;O	● (green)	○	○	○	● (green)	○
Use of portals	M	○	○	○	○	○	○
Ventilation shafts	M	○	○	○	○	○	○
Warehouse	M	○	○	○	○	○	○
Waste rock transfer pad	M	● (green)	○	● (yellow)	● (yellow)	● (yellow)	○
Water treatment plant	M	● (green)	● (red)	○	○	○	● (yellow)
Closure Phase							
Air transport of personnel and goods	M;O	○	○	○	○	○	○
Avalanche control	M;O	○	○	○	○	○	○
Chemical and hazardous material storage, management, and handling	M;O	○	○	○	○	○	○
Closure of mine portals	M	○	○	○	○	○	○
Closure of quarry	M	● (green)	○	○	○	● (green)	○
Closure of subaqueous tailing and waste rock storage (Brucejack Lake)	M	● (red)	● (red)	● (red)	● (red)	○	● (red)
Decommissioning of Bowser Aerodrome	O	● (green)	○	○	○	○	○

(continued)

Table 13.5-1. Ranking of Potential Effects on Surface Water Quality, Brucejack Gold Mine Project (completed)

Project Components and Physical Activities by Phase	Mine Site Area (M); Off-site Area (O)	Erosion/ Sedimentation	Discharges	ML/ARD	Nutrient Loading from Blasting Residues	Atmospheric Deposition	Groundwater Interactions and Seepage
Closure Phase *(cont'd)*							
Decommissioning of back-up diesel power plant	M	● green	○	○	○	○	○
Decommissioning of Brucejack Access Road	M;O	● yellow	○	● yellow	○	○	○
Decommissioning of camps	M;O	● green	○	○	○	○	○
Decommissioning of diversion channels	M	● yellow	○	● yellow	○	○	○
Decommissioning of equipment laydown	M	● green	○	● yellow	○	○	○
Decommissioning of fuel storage tanks	M;O	● green	○	○	○	○	○
Decommissioning of helicopter pad(s)	M	● green	○	○	○	○	○
Decommissioning of incinerators	M	● green	○	○	○	○	○
Decommissioning of local site roads	M;O	● green	○	● yellow	○	○	○
Decommissioning of mill building	M	● green	○	○	○	○	○
Decommissioning of mill/concentrators	M	● green	○	○	○	○	○
Decommissioning of ore conveyer	M	● green	○	○	○	○	○
Decommissioning of Project lighting	M;O	○	○	○	○	○	○
Decommissioning of sewage treatment plant and discharge	M	● green	● yellow	○	○	○	○
Decommissioning of surface crushers	M	● green	○	○	○	○	○
Decommissioning of surface explosives storage	M	● green	○	○	● yellow	○	○
Decommissioning of tailings pipeline		● green	● yellow	○	○	○	○
Decommissioning of transmission line and ancillary structures	M	● green	○	○	○	○	○
Decommissioning of underground crushers	M	○	○	○	○	○	○
Decommissioning of waste rock transfer pad	M	● green	○	● yellow	● yellow	○	○
Decommissioning of water diversion channels	M	● yellow	● yellow	● yellow	● yellow	○	○
Decommissioning of water treatment plant	M	● green	● yellow	○	○	○	○
Employment and Labour	M;O	○	○	○	○	○	○
Helicopter use	M;O	○	○	○	○	○	○
Machine and vehicle emissions	M	○	○	○	○	○	○
Procurement of goods and services	M	○	○	○	○	○	○
Removal or treatment of contaminated soils	M;O	● yellow	○	○	○	○	○
Solid waste management	M	○	○	○	○	○	○
Transportation of workers and materials (mine site and access roads)	M	○	○	○	○	○	○
Post-closure Phase							
Discharge from Brucejack Lake	M	● red	● red	● red	● red	○	● yellow
Employment and Labour	M;O	○	○	○	○	○	○
Environmental monitoring	M;O	○	○	○	○	○	○
Procurement of goods and services	M;O	○	○	○	○	○	○
Subaqueous tailing and waste rock storage	M	● yellow	○	● red	● yellow	○	● yellow
Underground mine	M	○	○	● yellow	○	○	● yellow

Notes:

○ = *No detectable interaction anticipated.*

● green = *Negligible to minor adverse effect expected; implementation of best practices, standard mitigation and management measures; no monitoring*

● yellow = *Potential moderate adverse effect requiring unique active management/monitoring/mitigation; warrants further consideration.*

● red = *Key interaction resulting in potential significant major adverse effect or significant concern; warrants further consideration.*

In the absence of active management and mitigation, directed discharges into Brucejack Lake have the potential to increase concentrations of water quality parameters at the lake outlet and also in the downstream receiving environment. As outlined in Table 13.5-1, changes in water quality to Brucejack Lake will result from surface water interactions with potential sources of ML/ARD, erosion and sedimentation, and nitrogen loading. Further, the directed discharge of effluent has the potential for temperature changes in the lake. The potential for residual effects of discharges on water quality of Brucejack Lake, and of the downstream receiving environment inclusive of active management and mitigation measures, were quantitatively assessed using predictive water quality modelling (Section 13.6).

13.5.1.2 Metal Leaching/Acid Rock Drainage

ARD occurs when sulphide minerals are exposed to oxygen and water and naturally oxidize without the presence of sufficient quantities of neutralizing minerals. Mining can accelerate the rate of this process by excavating, crushing, and relocating large quantities of rock. In the event that ARD is formed, the lower pH can accelerate the rate of ML. However, ML can also occur at sites of neutral and alkaline drainage. Metals occur naturally in the watercourses within the LSA and RSA (see Section 13.3) due to the presence of mineralized deposits and surficial materials, sometimes at concentrations above federal and/or provincial guidelines (e.g., copper, cadmium, and silver; see Tables 13.3-3 to 13.3-4).

A comprehensive ML/ARD characterization study was undertaken to support the Project (for detailed results, see Appendix 5-B, Brucejack Environmental Assessment ML/ARD Baseline Report). Results from the ML/ARD characterization study were used to inform predictive water quality modelling (Section 13.6) as well as management plans (Chapter 29, Environmental Management and Monitoring Plans). Within the mine site area, ML/ARD has the potential to occur as a result of surface disturbances during the Construction phase and subsequent weathering of newly exposed rock. Potential Project-specific sources of ML/ARD effects include:

- contact water within the upper laydown area that will be the site of pre-production ore storage during the Construction phase and temporary waste rock transfer during the Operation phase;
- the site of the mill building, and portal, which require extensive cuts into the bedrock (some of which are currently predicted to be potentially acid-generating (PAG);
- construction and use of diversion channels (non-contact water) and collection ditches (contact water);
- grading of the mine site; and
- subaqueous deposition of tailings and waste rock into Brucejack Lake.

In the absence of active management and mitigation, the above Project components may result in ML/ARD effects on water quality of Brucejack Lake and potentially that of its immediate downstream receiving environment (Brucejack Creek), as well as mid- and far-field receiving environments (Sulphurets Creek, Unuk River, respectively).

Approximately 2.28 Mm^3 of waste rock and 8 Mt of flotation tailings will be disposed of in Brucejack Lake over the life of the mine (BGC Engineering Inc. 2013b). Acid base accounting (ABA) was used to characterize and assess the neutralization potential ratio (NPR) of waste materials to determine which materials are classified as PAG. In total, 391 drill core samples were collected from across the Project site, across the mineralized zones of Gossan Hill, Valley of the Kings (VOK) and West Zone (WZ; BGC Engineering Inc. 2013a). According to the analyzed frequency distribution, 77 to 85% of waste rock generated at the mine site is likely PAG material (NPR < 2). There is also enrichment of Ag, As, Cd, Mo, Pb, Sb, Se, and Zn in waste rock and As, Sb, Ag and Cd may be a concern for metal leaching when waste rock is exposed to water. Waste and water management strategies were thus developed to effectively mitigate ML/ARD processes associated with this waste material (see Section 13.5.2.2). In contrast, the results from the tailings ML/ARD program indicate that tailings will be non-PAG material; however, waste management strategies were developed (i.e., subaqueous deposition and backfill) for the tailings to minimize metal leaching.

The upper laydown area (pre-production ore storage), mill building and portal sites, have the potential for ML/ARD effects on surface water quality from runoff. For this reason, the potential change in surface water quality would exhibit substantial intra-seasonal variation. During spring freshet and rain events there is greater potential for increased surface run-off. However, watercourses are of generally high flow and the receiving environment would provide moderate dilution capacity during spring freshet and rain events, thus potentially minimizing the potential for ML/ARD effects.

Post-mitigation ML/ARD effects to water quality of Brucejack Lake and of the downstream receiving environment, inclusive of active mitigation and management measures, were quantitatively assessed using predictive water quality modelling (Section 13.6).

13.5.1.3 Erosion and Sedimentation

In the absence of mitigation and management measures, physical disturbance of the terrain during all Project phases has the potential to increase surface runoff and erosion, resulting in increased turbidity, TSS, and sedimentation in receiving waters. Further, the geographic scope of erosion and sedimentation can range from localized to far-reaching events, depending on the amount and type (e.g., particle size) of particulate and colloidal materials introduced into the aquatic environment. Soil disturbance and loss associated with vegetation clearing, erosion, slope failure, burial, excavation, or infrastructure construction also reduces the land area available to support vegetation growth and to provide nutrients, carbon, and water cycling. Similarly, changes in site drainage patterns, soil contamination, or alteration of soil attributes such as organic matter content, pH, nutrient availability, and microbial activity can affect the ecological functionality of adjacent aquatic environments. Project-related increases in surface runoff, erosion and sedimentation could thus affect surface water quality as well as surface water hydrology (Chapter 10, Surface Water Hydrology Predictive Study) and sediment quality and aquatic resources (Chapter 14, Assessment of Potential Aquatic Resources Effects) of receiving environments within the LSA and RSA.

Surface runoff, erosion and sedimentation could affect surface water quality in all areas of the Project during construction and site decommissioning. Surface disturbance during construction and decommissioning has the potential to result in increased sedimentation and erosion of soils and overburden materials and encourage siltation (i.e., TSS) in the water column.

Potential Project-specific sources of sedimentation and erosion within the mine site area include:

- subaqueous tailings and waste rock disposal (Brucejack Lake, discharge from lake outlet effecting downstream receiving environment);
- construction and use of surface water diversions for contact and non-contact water; and
- grading of the mine site area.

Subaqueous tailings and waste rock disposal in Brucejack Lake has the potential to result in periodic releases of waters with elevated TSS at the lake outlet, depending on the efficacy of flocculation and settling and other mitigation measures. Tailings remobilization could result in increased TSS loads to the downstream receiving environment, and encourage siltation in the water column. Hydrodynamic modelling of Brucejack Lake was conducted to assess the effects of tailings discharge on the migration of tailings solids to the surface layer of the lake, and thus increased TSS loads at the lake outlet (Appendix 13-B, Hydrodynamic Modelling of Brucejack Lake: Effect of Proposed Tailings Discharge). Results of this modelling and effects assessment are discussed in Section 13.6.

Recovery from sedimentation will be more rapid in high-velocity streams relative to wetlands or lakes. Many streams and rivers in the LSA and RSA have naturally high sediment loads due to glacial origins, including Sulphurets Creek (Tables 13.3-3, 13.3-4), and thus will not be affected to the extent of clear, low-velocity streams. However, Brucejack Creek has relatively low TSS loads compared to other streams within the LSA/RSA (mean: 7.5 mg/L; max: 17.3 mg/L) and thus has greater potential to be affected by erosion and sedimentation events.

Post-mitigation effects to water quality of Brucejack Lake and of the downstream receiving environment, inclusive of active mitigation and management measures, are further assessed in Section 13.6.

13.5.1.4 Nitrogen Loading from Blasting Residues

Residues from blasting will contain nitrogen compounds that will remain on the surface of newly exposed rock, waste rock, tailings and other mine components and be available to leach. The accumulation of these highly soluble residues (nitrate, nitrite, ammonia) on disturbed rock material and the corresponding nitrogen load to the aquatic environment will depend on the volume and type of explosives used. Most nitrogen loading from this source will occur from runoff, although a minor source may be from dust/atmospheric loading.

During the Construction phase, the existing exploration explosives magazines will continue to be used for the development of the underground works. During Operation, explosives consumption at full production is estimated to be 2.7 t/day of bulk emulsion explosives, or about 80 t/month at full production.

Total baseline nitrogen concentrations were generally low within watercourses within the study area (see Section 13.3 and Appendix 13-A, Cumulative Surface Water Quality Baseline Report). Nitrogen loading may thus increase the potential for eutrophication in nitrogen-limited aquatic systems if there is sufficient phosphorus and other micronutrients for primary production. The effects of nutrient loading from blasting residues on aquatic resources (primary producers, secondary producers, and sediment quality) are detailed in Chapter 14, Assessment of Potential Aquatic Resources Effects. Potential residual effects on surface water quality, inclusive of active mitigation and management measures, due to nitrogen loading within the mine site area and downstream receiving environment were quantitatively assessed using water predictive water quality modelling (Section 13.6).

13.5.1.5 Groundwater Interactions and Seepage

Groundwater quality and seepage is an intermediate component to surface water quality. Uncaptured seepage from the underground workings has the potential to interact with surface water quality (Table 13.5-1). Groundwater interactions and seepage could result in ML/ARD and nitrogen loading effects to surface water quality. A detailed predictive study on changes in ground water quality and quantity is provided in Chapter 9, Hydrogeology Predictive Study. Results from Chapter 9 informed the predictive water quality modelling and subsequent assessment for potential residual effects to surface water quality (Section 13.6).

13.5.1.6 Atmospheric Deposition

Air quality is an intermediate component to surface water quality via aerial deposition of Project-generated dust. Dust deposition from blasting and other mining activities has the potential to affect surface water quality during the Construction, Operation and Closure phases.

Fugitive dust emission will occur during vehicle traffic along local site roads at the mine site area (Chapter 7, Air Quality Predictive Study). Other potential pathways to effects on surface water quality include particulate matter from the smelting furnace, incinerators, and diesel generators. Areas cleared for infrastructure (i.e., laydown areas) can also be sources of dust; predictive air quality modelling is presented in Chapter 7. Dustfall disposition rates, as per predictive modelling inclusive of mitigation measures, were used to identify potential residual effects of atmospheric deposition on surface water quality measures (Section 13.5.2.6).

13.5.2 Mitigation Measures: Mine Site Area

Extensive mitigation and management plans for Project effects on surface water quality were included in the design for the proposed Project. Proposed mitigation strategies include measures to avoid, reduce, and monitor adverse effects to surface water quality.

The Project will employ design and alternatives analyses to minimize/eliminate potential effects and will use relevant Best Management Practices (BMPs) to further mitigate or eliminate residual effects on the aquatic environment. Details of mitigation and management strategies relevant to the surface water quality (receptor VC) are available in the following Application/EIS chapters:

- Chapter 7, Air Quality Predictive Study;
- Chapter 9, Hydrogeology Predictive Study;
- Chapter 10, Surface Water Hydrology Predictive Study;
- Chapter 11, Terrain and Soils Predictive Study; and
- Chapter 15, Assessment of Potential Fish and Fish Habitat Effects.

Additional mitigation and management measures relevant to surface water quality are provided in the following environmental monitoring and management plans:

- Section 29.2, Air Quality Management Plan;
- Section 29.3, Aquatic Effects Monitoring Plan;
- Section 29.10, ML/ARD Management Plan;
- Section 29.13, Soils Management Plan;
- Section 29.15, Tailings Management Plan;
- Section 29.18, Waste Rock Management Plan;
- Section 29.19, Water Management Plan; and
- Chapter 30, Closure and Reclamation.

Monitoring programs will verify accuracy of the predictions of the Application/EIS, ensure detection of measureable alterations in surface water quality, allow for identification of potential causes, and include the provision of additional mitigation or adaptive management strategies. Summaries of specific mitigation measures developed for the various pathways that Project components can potentially interact with surface water quality are summarized below (Sections 13.5.2, 13.5.4).

Successful implementation of management and monitoring plans will require adaptation to updates in Project design as well as site conditions. Adaptive management is a process for continually improving management practices by learning from the outcomes of operational approaches. Adaptive management applies responses to observations of changing environmental conditions and the performance of existing water treatment and management structures. Management and mitigation of potential surface water quality effects is therefore a cyclical ongoing process of monitoring, maintenance, and reassessment. Adaptive management procedures and BMPs related to surface water quality, including surface water hydrology, aquatic resources are also described in corresponding management plans detailed in Chapter 29, Environmental Management and Monitoring Plans.

13.5.2.1 Discharges

Within the mine site area, potential changes to surface water quality may occur from the directed release of effluent into Brucejack Creek during the Construction phase, and to Brucejack Lake during the Operation and Closure phases. These include:

- effluent release (water treatment plant/sewage treatment plant); and
- discharge from Brucejack Lake (site of tailings and waste rock disposal).

Mitigation and management of ML/ARD, nutrient loading and erosion and sedimentation effects on Brucejack Lake outflow water quality, including BMPs, are discussed in Sections 13.5.2.1 and 13.5.2.2.

Details on water treatment plant design and proposed treatment process are provided in Section 5.12.16 of Chapter 5, Project Description. The proposed treatment process will involve chemical precipitation as well as ferric hydroxide floc formation, which will act to remove dissolved metals by absorption /co-precipitation reactions. The pH will be adjusted to optimize metal removal depending on the exact composition of the water. Clarifiers will be designed to remove suspended solids present in the raw water as well as produced metal hydroxides from the precipitation step. The treatment plant will include the necessary chemical feeding systems, storage tanks, agitators, dosing pumps, clarifiers, filters, pumps, and precipitate collection and discharge systems.

During operations, sediments from the contact water collection pond will be excavated from time to time and transported to the tailings thickener for discharge to either the paste plant or lake with tailings. The excess sludge from both clarifiers will be sent to a sludge retention tank. A cationic polymer will be added in order to ease dewatering of this slurry. The sludge will then be pumped to a filter press to increase the solid content.

There will be an on-site laboratory to test influent and effluent water quality, including at least colour, pH, turbidity, and temperature in addition to sampling required during the mill and processing.

13.5.2.2 Metal Leaching/ Acid Rock Drainage

The results from the waste rock ML/ARD program indicate that majority of waste rock will be PAG material; further, while tailings are expected to be non-PAG material; management strategies were developed for the tailings to minimize potential adverse environmental effects. These strategies are detailed in the ML/ARD Management Plan (Section 29.10), Waste Rock Management Plan (Section 29.18), Tailings Management Plan (Section 29.15), and the Water Management Plan (Section 29.19). The proposed ML/ARD Management Plan for the Project further involves the prediction, monitoring, prevention and mitigation of ML/ARD and applies to the construction, operation, closure and post-closure phases of the Project. The main objective of the plan is to prevent or mitigate potentially adverse effects from ML/ARD that may be generated from materials produced or exposed by the Project and that could affect surface water quality and/or groundwater quality (Section 29.10).

The majority (85%) of waste rock geologic units generated at the Project are predominantly composed of PAG material (Appendix 5-B). Tailings material has been identified as non-PAG (Appendix 5-B). Considering the high percentage of PAG material in the waste rock, all waste rock is treated as PAG in the ML/ARD Management Plan, and so does not require a material segregation plan. Waste rock sampling frequencies will include one composite sample for every 75,000 tonnes of waste rock (MEND, 2009), for the purpose of continually monitoring the ML/ARD characteristics of excavated waste rock during construction and operation phases (Section 29.10).

The planned waste rock and tailings management strategies at the Brucejack property involve disposal in (1) the underground workings, and (2) Brucejack Lake (see Chapter 5, Project Description). During subaqueous deposition in Brucejack Lake, a 1 m water cover over the PAG waste rock will be maintained to limit exposure to oxygen and minimize sulphide oxidation and metal leaching.

Approximately 40% the waste rock from the underground workings will be used as backfill underground. Use of waste rock as backfill is described in Section 5.8.2.7 and Appendix 5-A of the Application/EIS and will be further detailed as part of Pretivm's application for a *Mines Act* Permit. The cement added to the paste backfill will contain lime, such that any acidity generated by the oxidation of pyrite and other metal sulphides will be consumed. Moreover, the $CaCO_3$ is expected to maintain a neutral to slightly alkaline pH in the drainage water (BGC Engineering Inc. 2013a), resulting in a strongly reduced chemical mobility and bioavailability of metal cations and hydroxyl-complexes including those of copper, lead, nickel, zinc and iron (Stumm and Morgan 1996; Drever 1997). However, dissolved arsenic may still occur at relatively high concentrations in the drainage water (Appendix 5-B) due to the high chemical mobility of dissolved arsenic species at circumneutral to slightly alkaline pH (oxyanions, e.g., $HAsO_4^{2-}$). Further, at Closure the adit will be plugged and the underground workings will be flooded by the inflow of groundwater; the resulting low-oxygen to possibly anoxic conditions will severely restrict oxidation of pyrite and other metal sulphides that cause ML/ARD. Potential metal-leaching of arsenic (and other potential COPCs) will also be actively mitigated by collecting seepage water from underground working and diverting it to the water treatment plant for subsequent treatment and use/release (see Chapter 5, Project Description).

In addition to underground disposal, it is estimated that approximately 2.28 Mm^3 of waste rock and 8 Mt of flotation tailings will be disposed of in Brucejack Lake over the life of the mine (BGC Engineering Inc. 2013b). To minimize the potential for ML/ARD, waste rock will be disposed in Brucejack Lake via an advancing platform/causeway into the lake. The causeway will consist of PAG material, with a minimum of 1 m depth of submersion and capped with non-PAG material. The PAG rock will be end-dumped from haul trucks onto the platform/causeway and then either pushed over the side by a bulldozer or cast over the side by an excavator (Appendix 5-D, Geotechnical Stability of Waste Rock Deposition in Brucejack Lake; BGC 2013), in order to ensure a minimum 1-m depth of submersion. A similar method was previously used to dispose of waste rock into Brucejack Lake in 1999 following advanced underground exploration activities for the Sulphurets Project completed by Newhawk (Price 2009).

The upper laydown area (pre-production ore storage), mill building, and portal sites have the potential for ML/ARD effects on surface water quality from runoff. To mitigate these potential effects, runoff from the laydown area and mill building/portal site will be captured by a perimeter ditch system and conveyed to an excavated and lined contact water collection pond with sufficient capacity to contain the 24-hour, 200-year return period rain-on-snow event (49,000 m^3; Appendix 5-C, Brucejack Project Environmental Assessment – Water Management Plan). The contained runoff will be pumped to the water treatment plant for treatment prior to use in the process plant or discharge as part of fluidized tailings to Brucejack Lake. Further, an 80 mil high-density polyethylene geomembrane liner will be placed under the collection pond and pre-production ore storage area; a 300 mm (minimum) thick cushion layer of 30 mm minus granular material (< 10% pasting 0.75 mm) will be placed under the liner. Appropriate armoring will also be placed over the liner to protect it from erosion and damage during clean out the ditches and the pond.

Reclamation material stockpiles will be seeded and silt fences will be installed around the perimeter of any stockpiles to prevent erosion during construction.

ML/ARD-related monitoring will be implemented for mine wastes (i.e., waste rock, tailings, sludge, paste, surface materials) and site contact waters (i.e., tailings effluent, WTP influent, underground sumps, quarry runoff). Monitoring during construction and operations will enable the validation of ML/ARD predictions developed for the Project Environmental Assessment (Appendix 5-B) and, depending on monitoring results, allow for the refinement of waste or contact water handling procedures (where appropriate).

13.5.2.3 Erosion and Sedimentation

Water quality effects due to erosion and sedimentation will be mitigated by implementation of the Soils Management Plan (Section 29.13) and Water Management Plan (Section 29.19).

Mitigation and management activities include the following.

- Erosion and sediment control BMPs will be implemented. These include development sequencing (contact water pond and associated collection ditches to be constructed before surface facilities within the water management area contained by these facilities), 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 sedimentation.
- Minimization of all clearing and grubbing dimensions during construction activities.
- Controlling and directing runoff from disturbed areas by grading slopes and ditching.
- Minimizing runoff energy by limiting the length and steepness of bare exposed slopes and by applying appropriate surface drainage techniques (e.g., ditch blocks, ditch surface lining, and rip-rap).
- Stabilizing water diversion channels and ditches and protecting channel banks with rocks, gabions, or fibre mats.
- Protecting disturbed areas from water erosion, and collecting surface water from disturbed areas and treating it to meet discharge standards prior to release.
- Regular inspection and maintenance of all water management and sediment control structures. Maintenance procedures will include prompt attention to potential erosion sites, ditch or culvert failure, ditch or culvert blockage, or outside seepage as such problems could lead to structure failure and sediment transport. Maintenance will also include routine removal of accumulated sediment from ditches and retention structures.
- Re-establish vegetation cover during site restoration and reclamation, where possible, as detailed in Chapter 11, Terrain and Soils Predictive Study, and Chapter 30, Closure and Reclamation.

The tailings and waste rock deposition system has been developed to minimize the concentration of fine suspended solids in the outflow of Brucejack Lake to Brucejack Creek to comply with discharge standards outlined in the MMER (maximum TSS limit = 15 mg/L; Rescan 2013a; Tetra Tech 2013). Waste rock will be deposited subaqueously in the southwest corner of Brucejack Lake during the initial Operation phase of the Project, until voids are available for waste rock to be backfilled underground (Rescan 2013a; Tetra Tech 2013). Further, Pretivm will install a turbidity curtain across the width of the lake at a location downstream of the waste rock and tailings disposal area (see Section 5.12.22). The objective of the turbidity curtain is to force water flow to the bottom of the lake so that suspended sediments are not permitted to flow out to Brucejack Creek. A second turbidity curtain may be installed around the perimeter of the waste rock disposal area if the dumping of waste rock into the lake causes unacceptable levels of suspended sediment (Section 5.12.22).

13.5.2.4 Nitrogen Loading from Blasting Residues

Change of water quality within the mine site area due to nitrogen loading from leaching of blasting residues will be mitigated through water treatment during the Construction and Operation phases.

Explosives transportation, storage and use will be consistent with the requirements of the federal *Explosives Act* (1985a), *Transportation of Dangerous Goods Act* (1992), and the provincial *Health, Safety and Reclamation Code for Mines in British Columbia* (BC MEMPR 2008). The Hazardous Materials Management Plan (Section 29.7), to be developed prior to the Construction phase, will guide the safe transportation, storage, use and disposal of explosives at the site throughout the life of the Project.

13.5.2.5 Groundwater Interactions and Seepage

Groundwater seepage into the underground workings is expected to vary from approximately 3,800 m^3/day to 6,500 m^3/day throughout the life of the mine (Chapter 5, Project Description). Mitigation and management activities are described in the Water Management Plan (Section 29.19)

Seepage water from the underground mine will be sent directly to the water treatment plant for treatment during the Construction and Operation phases, as detailed above (Section 13.5.4.3). Priority of use for this treated water will be in the process plant. When excess amounts remain after process requirements, treated water may be used as fluidization water in the tailings pipeline. Any excess water not used in the process or as fluidization water will be discharged directly to Brucejack Lake. Occasional reclaim from the lake is expected to be needed, as there will be periods when the groundwater inflows to the underground mine are predicted to be less than the process requirements.

13.5.2.6 Atmospheric Deposition

Mitigation of potential effects to surface water quality due to atmospheric deposition of dust during the Construction, Operation, Closure, and Post-closure phases will be achieved through the management of fugitive dust emissions as detailed in the Air Quality Management Plan (Section 29.2).

Within the mine site area, blasting and part of the material handling and ore processing will occur underground, limiting the effect on ambient air quality. Due to the large particle sizes, fugitive dust sources do not typically travel upward toward the air raises to be eventually transported to the ambient air. Primary crushing of ore will also take place underground to control fugitive dust emissions to the environment. The crushed ore will be transported to the mill through the conveyor decline where ore will be further processed. Several dust pickup points will be installed along the crushing and conveyor circuit to capture dust in baghouses to reduce fugitive dust emissions.

Stockpiles will not be mitigated (no watering); the dust emission from open stockpiles at the Project was deemed negligible and was not included in the air quality dispersion model (see Section 7.5.1, Air Emission Inventory). This is because the ore stockpile is for a limited time period and waste stockpiles are not expected to be common or extensive (Chapter 5, Project Description).

Waste rock and tailings will be stored in the underground or subaqueously (minimizing the need to stockpile material), and blasting and crushing will primarily occur underground, which will limit the potential for fugitive emissions from these sources.

The air quality effects assessment indicates an increased dust deposition rate during the Construction and Operation Phases of the Project. The methodology and assumptions used in the air quality dispersion model and the results are described in Chapter 7, Air Quality Predictive Study. Results from modelling indicate that highest 24-hour TSP (Total Suspended Particulates), for all dust generating sources, concentration of 107 µg/m3 during the Construction phase. At Brucejack Lake and Creek, TSP concentration range from 20 $\mu g/m^3$ to 50 $\mu g/m^3$. These values are less than the National Ambient Air Quality Objectives (NAAQO) of 120 $\mu g/m^3$ and BC objective of 150 $\mu g/m^3$ (see Table 7.6-15 of Chapter 7, Air Quality Predictive Study). Further, these values represent suspended dust, which means they are likely to stay in ambient air.

The *Pollution Control Objectives for the Mining, Smelting, and Related Industries of British Columbia* (BC MOE 1979) dustfall objectives from 1.7 to 2.9 mg/dm^2/day aim to protect the quality of BC's environment. Modelling results indicate that the maximum 30-day dust deposition during the life of the Project within the mine site area range from 0.8 mg/dm^2/day to 2.7 mg/dm^2/day (see Figures 7.6-14 and 7.6-29 of Chapter 7, Air Quality Predictive Study), with highest rates observed at Brucejack Lake and substantially lower rates predicted for Brucejack Creek (0.8 to 1.1 mg/dm^2/day). These dustfall rates from atmospheric deposition are within the range of the BC objectives and, further, are negligible as compared to baseline TSS loads of potential receiving waters (mean: 7.5 mg/L, maximum 17 mg/L). It is thus anticipated that effects from atmospheric deposition to water quality will be negligible and will be undetectable from background conditions.

Considering these potential effects on surface water quality due to atmospheric deposition/ dustfall, as well as mitigation to minimize effects, the overall potential Project-related residual effect on surface water is considered to be fully mitigated and will not be considered further.

13.5.2.7 Residual Effects

Despite active management and mitigation, potential residual effects on surface water quality due to discharges, ML/ARD, erosion and sedimentation, nitrogen loading from blasting residues and groundwater interactions and seepage, may occur. Within the mine site area, quantifying the residual effects of the Project on surface water quality was accomplished using predictive water quality modelling (Section 13.6); it was assumed that all aforementioned mitigation measures were in place. That is, the predictive study results (Section 13.6) represent the predicted residual effects on surface water quality. Water quality is semi-quantitatively assessed for the receiving environment outside of the predictive model domains.

Effects on surface water quality due to atmospheric deposition are considered to be fully mitigated given the proposed management strategies summarized above and presented in detail within the management and mitigation plans listed above (Section 13.4.2).

13.5.3 Identifying Key Effects: Off-site Areas

Project infrastructure and activities outside the mine site area occur in the following areas (Figure 13.5-1):

- Bowser River watershed;
- Knipple Lake; and
- Wildfire Creek/Scott/Todedada watersheds.

The Brucejack Transmission Line, Tide Staging Area, Knipple Transfer Area, Bowser Aerodrome, as well as the majority of the Brucejack Access Road are situated within the Bowser River watershed (Figure 13.5-1). The proposed Knipple Transfer Area is located adjacent to Knipple Lake. The Brucejack Access Road travels through the upper Bowser River and Wildfire Creek watersheds.

13.5.3.1 Discharges

As described in Section 13.4.3, there are no proposed points of discharge outside of the mine site area (Chapter 5, Project Description); accordingly, potential effects of discharge will not be considered further in the effects assessment. The Knipple Transfer Area and Tide Staging Area will have a septic system for disposal of effluent; associated effects are addressed in Sections 13.5.3.5 and 13.5.4.5 (groundwater interactions and seepage).

13.5.3.2 Metal Leaching/ Acid Rock Drainage

In off-site areas, ML/ARD has the potential to occur as a result of surface disturbances during the Construction phase and subsequent weathering of newly exposed rock. The following are potential Project-specific sources of ML/ARD in off-site areas.

- Construction of the Bowser Aerodrome in the Bowser River Valley; ML/ARD has the potential to occur during the levelling of high ground to provide safe approach and take off angles for air traffic.
- Upgrades to the existing exploration access road to accommodate mine traffic. Surface disturbances resulting in ML/ARD have the potential to occur during re-alignments of the sharper curves, reduction of the steeper grades and additional surfacing of some road sections; it is not anticipated that any upgrades to stream crossing will be required (Section 5.7.4, Construction of On-site and Off-site Surface Facilities).
- The continued weathering of exposed rock cuts and fills from historical and current road construction and use.

The level of disturbance with respect to exposing new rock will be low for the transmission line as no blasting is anticipated and BMPs will be implemented to minimize land disturbance and preserve stream bank integrity (see Section 13.5.4). Thus, the potential for ML/ARD effects along the transmission line is considered negligible during all Project phases and potential effects will not be considered further.

A site characterization program was conducted to assess the ML/ARD characteristics of surface materials near the proposed aerodrome as well as along the Brucejack Access Road. Results are summarized in Table 13.5-2, below. For complete details of the ML/ARD baseline study, see Appendix 5-B, Brucejack Environmental Assessment ML/ARD Baseline Report.

Table 13.5-2. Summary of ML/ARD Baseline Characterization Study along Brucejack Access Road and Bowser Aerodrome

Region	Lithology	ARD Potential	ML Potential/POC
Brucejack Access Road	Conglomerate	>3 - nPAG	Cu
	Intermediate volcanic	0.3-34 - Uncertain	As
	Undifferentiated porphyry	>100 - nPAG	As
	Mudstone	3.67 – nPAG	As, Co
	Sandstone	14.3 – nPAG	As, Ni, Cr
	Shale	1.08 – PAG	Mo, Cd
	Till	6.55 – nPAG	As
Bowser Aerodrome	Intermediate volcanic	>100 – nPAG	As
	Till	>3 – nPAG	As

Samples taken from the high ground to be removed west of the aerodrome are characterized as non-PAG (Table 13.5-2) and thus the potential for ML/ARD effects is considered very low with negligible effects and will not be considered further.

The majority of access road samples have NPR values greater than 2.0 (i.e., non-PAG materials; Table 13.5-2). Shale material poses the greatest risk of ARD as over half of the samples show NPR values below 2.0. Contributing to the low shale NPR values is low to very low (below detection limit) carbonate content. However, level of disturbance with respect to exposing new rock will be relatively low from the access road upgrades (Chapter 5, Project Description). Thus potential effects of ML/ARD for the road are considered low for all Project phases.

13.5.3.3 Erosion and Sedimentation

In the absence of mitigation and management measures, physical disturbance of the terrain during all Project phases has the potential to increase surface runoff and erosion, resulting in increased turbidity, TSS, and sedimentation in receiving waters, as discussed above for the Brucejack Mine Site (Section 13.5.1.3). This will also be applicable to the off-site areas.

The following are potential Project-specific sources of sedimentation and erosion in off-site areas:

- Construction and installation of towers along the transmission line may require surface clearings and grubbing of the surface, resulting in loss of vegetation and increases in erosion and sedimentation over very small areas within the Bowser River and Knipple Lake watersheds.
- Rehabilitation of the Bowser Aerodrome facility, including the elongation and widening of the original Newhawk airstrip as well as clearing of the high ground to be removed west of the aerodrome.
- Construction of the Knipple Transfer Area near the base of the Knipple Glacier, adjacent to Knipple Lake.
- Upgrades to the existing 73-km exploration access road to accommodate mine traffic. There is a potential for landslides and debris along the road route which could generate siltation in the receiving water courses. However, this potential is only associated with the event of upgrades to the access road resulting in increased terrain instability in these areas; these effects are addressed in Chapter 11, Terrain and Soils Predictive Study.

Vehicle traffic on the Knipple Glacier has the potential to increase sediment deposition on the glacier, resulting in increased TSS in glacier outflow and associated receiving waters upon ice melt. However, effects to surface water quality are expected to be negligible/ indistinguishable from background due to the high amount of natural sediment on the glaciers and corresponding naturally elevated TSS in the glacier outflow (Section 13.3). Effects to surface water quality from vehicle traffic on Knipple Glacier will not be considered further in this assessment.

The potential effects to surface water quality as a result of erosion and sedimentation events for off-site areas are similar to those outlined in Section 13.5.1.3.

13.5.3.4 Nitrogen Loading from Blasting Residues

Residues from blasting will contain nitrogen compounds that will remain on the surface of newly exposed rock, and laydown areas may have surface residues of nitrogen compounds from blasting. These nitrogen compounds (nitrate, nitrite, and ammonia) are derived from the ammonium nitrate explosives and residues and can be transported in the freshwater environment through runoff or atmospheric deposition. Project-related sources of nitrogen loading from blasting residues in the off-site Project infrastructure areas include:

- construction of the Bowser Aerodrome in the Bowser River Valley; blasting will occur during the levelling of high ground to provide safe approach and take off angles for air traffic; and
- Brucejack Access Road upgrades.

Most nitrogen loading from these sources will occur from runoff, although a minor source may be from dust/atmospheric loading (Chapter 7, Air Quality Predictive Study). For this reason, the potential for this effect would exhibit substantial intra-seasonal variation, and be the greatest during spring freshet and rain events. However, watercourses in off-site areas are of generally high flow and receiving would provide high dilution capacity during spring freshet and rain events.

Total nitrogen concentrations were generally low within Bowser River, Knipple Lake, and Wildfire Creek areas (Section 13.3.4). Thus, nitrogen loading has the potential to shift overall system productivity and also increase the potential for eutrophication in these previously nitrogen-limited aquatic systems if there is sufficient phosphorus and other micronutrients (e.g., iron) and light to promote primary production; the potential for these effects are discussed in detail in Chapter 14, Assessment of Potential Aquatic Resources Effects. The second concern is toxicity to fish or aquatic life associated with some forms of nitrogenous compounds (e.g., ammonia, nitrate, and nitrite); the potential for these effects are discussed in detail in Chapters 14 (Assessment of Potential Aquatic Resources Effects) and 15 (Assessment of Potential Fish and Fish Habitat Effects).

13.5.3.5 Groundwater Interactions and Seepage

Outside the mine site area, un-captured seepage from camp septic fields at the Knipple Transfer Area camp and Tide Staging Area could potentially be introduced into the receiving environment. This seepage could result in nutrient loading in receiving waterbodies, potentially shifting overall system productivity and also increase the potential for eutrophication; the potential for effects on aquatic resources (primary and secondary producers) as well as fish and fish habitat are discussed in detail in Chapters 14 and 15, respectively.

13.5.3.6 Atmospheric Deposition

Air quality is an intermediate component to surface water quality via aerial deposition of Project-generated dust. Dust can be generated by a variety of Project activities, including blasting, emissions from fuel combustion and fugitive dust emission from traffic along the Brucejack Access Road. Areas cleared for infrastructure (i.e., laydown areas, Knipple Transfer Area) can also be sources of dust.

Dust deposition into the freshwater environment could affect the surface water quality by introducing suspended material and associated metals and nutrients into surrounding waterbodies. The potential effects from dust deposition may occur during all phases of the Project; predictive modelling results are presented in Chapter 7, Air Quality Predictive Study. Dustfall deposition rates, as per predictive modelling inclusive of mitigation measures, were used to identify potential residual effects (Section 13.5.3.6) to surface water quality.

13.5.4 Mitigation Measures: Off-site Areas

Extensive mitigation and management of Project effects on surface water quality was included in the design for the proposed Project. Proposed mitigation strategies include measures to avoid and reduce effects to surface water quality and are similar to those described for the Brucejack Mine Site (Section 13.5.2).

The Project employed alternatives analyses to minimize/avoid potential effects and will use relevant BMPs to further mitigate or avoid residual effects on the aquatic environment. Details of mitigation and management strategies relevant to surface water quality are available in the predictive study, effects assessments, and environmental monitoring and management plans, listed above in Section 13.5.2.

Additional mitigation and management strategies specific to off-site areas are summarized below.

13.5.4.1 Discharges

There are no proposed points of surface discharge outside of the mine site area (Chapter 5, Project Description); effects of discharges to surface water quality in off-site areas will not be considered further. The Knipple Transfer Area and Tide Staging Area will have a septic system for disposal of effluent; associated effects are addressed in Sections 13.5.3.5 and 13.5.4.5 (groundwater interactions and seepage).

13.5.4.2 Metal Leaching/ Acid Rock Drainage

General strategies and BMPs are as described above for the Brucejack Mine Site (Section 13.5.2.2). The ML/ARD Management Plan (Section 29.10) covers various disturbed materials exposed and produced during construction and operations, including materials used for cut and fill at the proposed Bowser Aerodrome and the Brucejack Access Road. Further, post-closure monitoring programs to evaluate the long-term performance of the proposed ML/ARD management strategies at the Project will be as described in Section 29.10.

Mitigation and management measures for ML/ARD will include the re-establishment of vegetation cover during site restoration and reclamation, as detailed in Chapter 16, Assessment of Potential Terrestrial Ecology Effects, and Chapter 30, Closure and Reclamation.

In off-site areas, most ML/ARD sources will occur from runoff and weathering of exposed surface disturbances. ML/ARD effects would thus likely exhibit substantial intra-seasonal variation and be the greatest during spring freshet and rain events. However, watercourses in off-site areas are of generally high flow and drainage area; the receiving environment would thus provide a correspondingly high dilution capacity during spring freshet and rain events. Further, many waterbodies within the LSA and RSA in off-site areas have naturally high sediment loads due to glacial origins, and correspondingly naturally elevated metal concentrations; these include Knipple Lake, Knipple Glacier outflows, the Bowser River, and Bowser Lake (Table 13.3-5). Metal concentrations also exhibit substantial natural variability, with the greatest background concentrations of total metals associated with high flow months due to corresponding increases in TSS (see Figures 5.2-4 to 5.2-20 of Appendix 13-A, Cumulative Surface Water Quality Baseline Report). Due to the limited extent of blasting and surface disturbances, high dilution capacity of the receiving environment, and that the majority of rock being classified as non-PAG in off-site areas, it is expected that ML/ARD effects, should they occur, would not be outside the large natural range of variability and, further, would be indistinguishable from naturally elevated background metal concentrations, particularly within the glacially-headed Bowser River watershed.

13.5.4.3 Erosion and Sedimentation

Implementation of erosion and sediment control BMPs, as described above for the Brucejack Mine Site (Section 13.5.2.3), would also be implemented in the off-site areas, as appropriate, and are expected to minimize the potential for surface runoff, erosion, and sedimentation (Section 13.5.2.3).

Transmission line construction is anticipated to have minimal effects on water quality. The proposed transmission line route follows bedrock-dominated terrain that is characterized by gentle to moderate slopes, bedrock hummocks, and discrete debris flow/snow avalanche tracks. Along the full length of the transmission line, construction activities (i.e., equipment access, construction of transmission structures, and conductor stringing) will be conducted in a manner that minimizes riparian vegetation effects and maintains stream bank integrity. Therefore, the effects of sedimentation during transmission line construction and maintenance will be negligible.

Planned access road upgrades have the potential to cause erosion and sedimentation due to soil disturbing activities. Development of roads will be guided by the *Forest Road Engineering Guidebook* (BC MOF 2002) and maintained to ensure low landslide risk and continuous, efficient, controlled water drainage. Additional erosion and sediment control BMPs that will be implemented during road upgrades are provided in Section 29.16, Transportation and Access Management Plan. The access road will be decommissioned upon site closure (Chapter 30, Closure and Reclamation).

Recovery from sedimentation in off-site areas will be more rapid in high-velocity streams relative to wetlands or lakes. Many waterbodies within the LSA and RSA in off-site areas have naturally high sediment loads due to glacial origins, including Knipple Lake, the Bowser River and Bowser Lake (Table 13.3-5). That is, TSS and turbidity were generally greatest within the Bowser River watershed relative to other watersheds in the baseline study area, ranging from 1.5 mg/L to 229 mg/L and 0.54 to 368 NTU (see Table 13.3-5). Similarly, Knipple Lake had the highest TSS and turbidity of all study area lakes (218 to 226 mg/L; 308 to 316 NTU). Further, the majority of watercourses in the LSA and RSA of off-site areas are high-velocity and exhibit substantial seasonal variability (mean TSS high flow: 44.8 mg/L to 318 mg/L; mean TSS low flow: 1.5 mg/L to 40.0 mg/L; see Figure 5.1-23 of Appendix 13-A, Cumulative Surface Water Quality Baseline Report). Thus, sedimentation erosion events, should they occur, would not be expected to be outside this large natural range of variability.

13.5.4.4 Nitrogen Loading from Blasting Residues

General strategies and BMPs for managing nitrogen loading are as described above for the mine site area (Section 13.5.2.3). Blasting is expected to be very limited in off-site areas (Chapter 5, Project Description).

In off-site areas, leaching of blasting residues will be mitigated by minimizing use during the Construction phase (i.e., no blasting is anticipated during transmission line installation). Explosives transportation, storage and use will be consistent with the requirements of the federal *Explosives Act* (1985a), *Transportation of Dangerous Goods Act* (1992), and the provincial *Health, Safety and Reclamation Code for Mines in British Columbia* (BC MEMPR 2008). The Hazardous Materials

Management Plan (Section 29.7), to be developed prior to the Construction phase, will guide the safe transportation, storage, use, and disposal of explosives at the site throughout the life of the Project.

Most nitrogen loading from these sources will occur from runoff, and the potential for this effect would exhibit substantial intra-seasonal variation, and be the greatest during spring freshet and rain events. However, watercourses in off-site areas are of generally high flow and the receiving environment would provide a correspondingly high dilution capacity during spring freshet and rain events. Thus, although nitrogen concentrations were generally low within the Bowser River, Knipple Lake, and Wildfire Creek areas (nitrate range: 0.0025 mg/L to 0.67 mg/L; ammonia range: 0.0025 mg/L to 0.031 mg/L; Table 13.3-5), exceedances of BC Ministry of Environment guidelines for the protection of aquatic life are not expected to occur due to the limited extent of blasting as well as high dilution capacity of the receiving environment. Nitrogen loading has the potential to shift overall system productivity and also increase the potential for eutrophication in these previously nitrogen-limited aquatic systems if there is sufficient phosphorus and other micronutrients (e.g., iron) plus light to promote primary production; the potential for these effects is discussed in detail in Chapter 14, Assessment of Potential Aquatic Resources Effects.

13.5.4.5 Groundwater Interactions and Seepage

General mitigation strategies and BMPs for groundwater interactions and seepage are as described above for the mine site area (Section 13.5.2.5).

In off-site areas, un-captured seepage from septic fields at the Knipple Transfer Area (Knipple Lake) and Tide Staging Area camps could potentially be introduced into the receiving environment. Sewage management for the Project will be consistent with the requirements of the *Environmental Management Act* (2004) and the Municipal Wastewater Regulation (BC Reg. 87/2012). The Knipple Transfer Area will have a septic tank treatment with drain field for disposal of effluent (Chapter 5, Project Description). The Tide Staging Area will have a septic system for disposal of effluent.

The mitigation and management measures are expected to fully mitigate potential effects from changes in surface water quantity in the off-site Project infrastructure areas because of the adherence of activities to the applicable guidelines, regulations, and BMPs. As a result, no residual effects due to groundwater interactions and seepage in the off-site Project infrastructure areas are predicted and will not be considered further.

13.5.4.6 Atmospheric Deposition

Along the Brucejack Access Road, planned mitigations for atmospheric deposition and dustfall include lowered speed limits, surface improvement, and surface treatment. Watering of the road to reach at least a 2% moisture ratio has been included as part of the operations plan. The roadway will also be properly graded, compacted, and maintained in order to reduce fugitive dust.

Other general strategies and BMPs are as described above for the mine site area (Section 13.5.2.4). These activities will ensure that fugitive dust emissions are compliant with applicable regulations and standards, which will avoid degradation of water quality of receiving waters due to atmospheric deposition.

The air quality effects assessment indicates an increased dust deposition rate during the Construction and Operation phases (Chapter 7, Air Quality Predictive Study). Maximum 30-day dust deposition rates within 170 m, of the access road corridor during Operation in off-site areas range from 0.8 to 3.7 mg/dm^2/day. These dustfall rates from atmospheric deposition are negligible compared to baseline TSS loads of potential receiving waters (mean: 7.5 mg/L, maximum 21.6 mg/L.)

At Knipple Glacier, the air quality dispersion model predicted increased dustfall levels along the lower 3 km and upper 0.2 km of the Knipple Glacier as result of access road traffic and mine site area activities during the Construction and Operation phases of the Project (see Figures 10.6-20 and 10.6-21). The dustfall level on these areas of the glacier is predicted to be up to 0.95 mg/dm^2/day based on the highest 30-day average (see Chapter 7, Air Quality Predictive Study, for details). Compared to the baseline level of 0.71 gm/dm^2/day, this is approximately an increase of 34%, but is still lower than the provincial objectives of 1.7 to 2.9 mg/dm^2/day (BC MOE 1979). Baseline dustfall monitoring results from July to September 2012 varied from 0.14 to 2.67 mg/dm^2/day, indicating natural variation of dustfall levels exceed anticipated average dustfall rates for the Project.

Considering these potential effects on surface water quality due to atmospheric deposition/ dustfall, as well as mitigation to minimize effects, the overall potential Project-related residual effect on surface water quality is considered to be fully mitigated and will not be considered further.

13.5.4.7 Residual Effects

In off-site area there is generally minimal risk of effects to surface water quality due to the limited extent of Project activities in these areas. Best management practices, planned mitigation and management measures, combined with the small extent and duration of surface disturbances and blasting activities are predicted to fully avoid and mitigate potential effects to surface water quality through the identified pathways detailed above.

However, to be conservative, potential effects to surface water quality cannot be completely ruled out with certainty; there is potential for a change in surface water quality due to an aggregated/combined effects of the pathways outlined above. That is, ML/ARD mitigation, sediment and erosion control, and explosives management, as described in Chapter 29, Environmental Management and Monitoring Plans, and in Section 13.5.4 will prevent substantial change of surface water quality near the access road and other ancillary Project infrastructure. It is likely, however, that some change in surface water quality of receiving watercourses in off-site areas will occur at some point during the life of the Project given this high runoff environment and associated potentials for ML/ARD and sedimentation/erosion effects to receiving waters, as well as low background nitrogen concentrations. These are further discussed in Section 13.6.

13.6 RESIDUAL EFFECTS ON SURFACE WATER QUALITY

Potential for residual effects of the Project on surface water quality identified in Section 13.5 were subsequently assessed using both quantitative water quality modelling as well as qualitative methods, including a combination of best available data and professional judgment/experience.

Predictive water quality models were developed for the Construction, Operation, Closure, and Post-closure Phases for Brucejack Lake and the downstream receiving environment (LSA). The most recent feasibility study report from June 2014 (Appendix 5-A) describes an 18 year Operation phase, while an earlier feasibility study (Tetra Tech 2013) had identified a 22 year Operation phase. For the purposes of this environmental assessment and the predictive water qual89reaplceity modelling, an Operation phase of 22 years has been used as this is expected to provide, overall, a more conservative effects assessment associated with greater waste rock and tailings production and longer period of active disturbance prior to reclamation activities. Predictive water quality models, semi-quantitative and best judgment assessment approaches were used for the mid and far-field receiving environment, i.e., areas downstream of boundaries of the model domain. No effects are anticipated for the Knipple Transfer Area, Bowser Aerodrome, Tide Staging Area, Brucejack Transmission Line (see Sections 13.5.3 and 13.5.4). Qualitative/best judgment assessment approaches were used for assessment of residual effects associated with the access road.

The key assumptions of the surface water quality residual effects assessment are:

- assessment and determination of any potential residual and cumulative effects assumed that all guidelines, mitigation and management plans, BMPs, regulations, and operating standards designed to reduce effects on surface water quality and aquatic resources are strictly adhered to; and
- assessment and determination of discharge-related potential effects on downstream receiving environments relies upon the accuracy of water quality modelling data results.

13.6.1 Predictive Water Quality Modelling

In support of the environmental assessment and permitting requirements, Lorax Environmental Services Ltd. generated water quality predictions for Brucejack Lake and Brucejack Creek for the Project. A summary of the model approach, assumptions, and sensitivity analyses are provided in the following sections. Full details are provided in report developed for the Project, appended as Appendix 13-C, Predictive Water Quality Report.

13.6.1.1 General Model Approach and Assumptions

The primary objective of water quality modelling for the Project was to predict the concentrations of total and dissolved metals, nutrients, and anions within the Project footprint and in the surrounding surface waters that will receive direct effluent discharge, waste rock and tailings deposition, and/or seepage from Project components. Water quality modelling also considered various model sensitivities that account for uncertainty in the model assumptions; see Section 13.6.1.2 (Appendix 13-C, Predictive Water Quality Report).

The water quality model for the Project was developed using a mass balance calculation approach in GoldSim™ to model the volume and flow of water and the concentrations and transport of chemical species as a function of time. GoldSim™ program was developed to model complex environmental systems and has been extensively and successfully applied to simulate water resource management, mining operation, contaminant transport, and radioactive waste management. GoldSim™ is a simulation program that includes Project components as “containers” that are made up of “elements.” These containers include the formulas, data, conditions, and/or operation criteria for different Project components.

The water quality model was informed by the logic and architecture of the Project water balance developed by BGC Engineering Inc. (Appendix 5-C, Brucejack Project Environmental Assessment – Water Management Plan). The water balance model is based on monthly time steps and tracks all contact and non-contact waters that report to Brucejack Lake and Brucejack Creek. In the water quality model, contact and non-contact water quality concentrations are assigned to the various flows identified in the water balance model.

Geochemical source terms were provided by BGC Engineering Inc. (see Chapter 4 of Appendix 13-C, Predictive Water Quality Report) and were used to represent contact water quality signatures in the water quality model. Mass balance modelling of Brucejack Lake and Brucejack Creek considered inputs (i.e. source terms) from all mine-related sources including:

- Waste rock
- Discharge of tailings solids and effluent
- Underground mine discharges
- Plant-site runoff

- Runoff from the quarry
- WTP discharges

Non-contact water quality signatures were derived from baseline monitoring for the Project (see Section 4.1 of Appendix 13-C, Predictive Water Quality Report).

Results of water quality predictions are inclusive of water treatment as well as active management and mitigation measures; that is, results represent potential residual effects to surface water quality. These mitigations include the following.

- A sewage treatment plant which will meet design objectives for discharge water quality. Treated water will be discharged to Brucejack Creek during Construction (Year -1 to Year 1) and to Brucejack Lake during Operation (Year 1 to Year 23).
- A water treatment plant will treat contact water from the site and meet design objectives for effluent water quality. Treated water will be discharged to Brucejack Creek during Construction (Year -1 to Year 1) and to Brucejack Lake during Operation (Year 1 to Year 23).
- Disposal of waste rock into Brucejack Lake during the Construction Phase (Year -1 to Year 1) and during the Operation phase until voids become available in the underground. It was assumed in the model that suspended sediment associated with waste rock will be managed using turbidity curtains.
- Disposal of tailings and effluent into the bottom of Brucejack Lake via a tailings pipeline; it was assumed in the model that tailings will remain at the bottom of the Lake. This assumption was supported by hydrodynamic modelling completed for the Project (Appendix 13-B, Hydrodynamic Modelling of Brucejack Lake: Effect of Proposed Tailings Discharge),
- TSS management of Brucejack Lake water as required such that TSS levels will meet discharge limits as defined by MMER and BC MOE.

13.6.1.2 Sensitivity Analyses: Water Quality Modelling Cases

Predictive water quality model results were dependent on a large number of input parameters including operation schedules and mine development in addition to hydrology, climate, and chemical inputs. Water quality modelling for the Project also considered various model cases (i.e., sensitivity analyses) to account for uncertainty in the model assumptions and inputs. A summary of the sensitivity analysis is presented in this section. Full details are provided in Appendix 13-C, Predictive Water Quality Report.

Base case and sensitivity scenarios in the water quality model are summarized in Table 13.6-1. The base case model results (scenario 1, expected case) represent conservative average year (expected) predictions. These results are based on average hydrological conditions (Appendix 5-C, Brucejack Project Environmental Assessment – Water Management Plan) and base case source terms (see Chapter 4 of Appendix 13-C, Predictive Water Quality Report). Additional sensitivity cases were run using a variety of conservative assumptions for site water flows and geochemical source terms to test the sensitivity of the receiving environment to changes in model inputs. These sensitivity cases were specifically selected to evaluate areas of uncertainty in the model, including: 1) flow conditions; 2) hydraulic conductivity of bedrock; and 3) geochemical source terms. Detailed discussion of the water balance and water quality source terms are provided in Chapters 3 and 4, respectively, of Appendix 13-C, Predictive Water Quality Report. The water treatment plant and sewage treatment plant were assumed to perform to design parameters for all model scenarios, irrespective of flow or influent chemistry (Appendix 13-C). Cumulative conservative cases were not considered in the assessment of effects. This is due to the very low likelihood of occurrence of the cumulative conservative cases. For example, the cumulative conservative case assumes both a 100-year dry event as well as highest estimation of water reporting to the underground (i.e., high K; Appendix 13-C).

Table 13.6-1. GoldSim™ Model Scenarios (Base Case and Sensitivity Cases) and Associated Assumptions

Modelled Case		Flow	Source Terms
1	Base Case (expected Case)	Average stream flow and hydraulic conductivity (K)	Average source terms
2	High K (upper case)	High K and high recharge groundwater modelling scenario; increased seepage to mine	Average source terms
3	Low K	Low K groundwater modelling scenario; reduced groundwater seepage to mine	Average source terms
4	100 Year Wet	100 year wet annual rainfall applied to the last year of the Construction Phase, last year of Operation, and years 10 onward of Post-closure, average K	Average source terms
5	100 Year Dry	100 year dry annual rainfall applied to the last year of the Construction Phase, last year of Operation, and years 10 onward of Post-closure, average K	Average source terms
6	Conservative Adit Lag	Average stream flow and average K	Shortest estimated lag time between pre- and post- acidic conditions in the underground workings
7	Conservative Adit Concentration	Average stream flow and average K	95th percentile pre- and post- acidic conditions in the underground workings
8	Conservative Background	Average stream flow and average K	95th percentile baseline concentrations
9	Conservative Solids	Average stream flow and average K	95th percentile loadings for tailings and waste rock deposition

13.6.1.3 Screening of Contaminants of Potential Concern

Potential residual effects on water quality in the receiving environment were identified through the calculation of hazard quotients (HQs) for modelled water quality parameters. In environmental effects assessments, the calculation of HQs can be a useful screening tool for determining the potential for a chemical to cause toxicity in receptors in the receiving environment, such as aquatic resources (primary producers, secondary producers, sediment quality), fish, or wildlife species (US EPA 1998). HQs are most often calculated as a ratio of the concentration of a chemical (either a measured or predicted concentration) compared to the relevant guideline value. An HQ greater than 1.0 may indicate a potential for effects in receptors, while an HQ less than 1.0 is considered to not carry additional risk of toxicity to receptors.

The screening process used for the receiving environment is illustrated in Figure 13.6-1. As hydrological regime is an important determinant of surface water quality in the Project area, water quality, including anions and nutrients, total and dissolved metals, will be assessed separately for both high flow (June to October) and low flow (November to May) periods (Appendix 13-A, Cumulative Surface Water Quality Baseline Report). The proposed screening method will utilize both maximum and mean predicted values. This will prevent masking of potential COPCs by averaging over high flow and low flow months (i.e., if maximum predicted values are not in exceedance, monthly means will not be in exceedance). This is also generally a more conservative approach (i.e., monthly means will not necessarily be in exceedance even if maximum predicted values are in exceedance).

The scope of the water quality effects assessment is restricted to parameters with an approved BC water quality guideline for the protection of freshwater aquatic life and the following parameters with working BC water quality guidelines: cadmium, nickel, thallium, and chromium. CCME guidelines were employed in the absence of an applicable BC guideline. Science-based environmental benchmarks (SBEBs; BC MOE 2013b) were employed for nitrite, cadmium, copper, lead, silver, and zinc; originally derived as part of the application for an *Environmental Management Act* (2004) permit for exploration phase discharges (Figure 13.6-1). SBEBs are based on BC water quality objectives and are further refined using specific methodologies to take local conditions into account (BC MOE 2013c). This approach ensures the protection of the aquatic receiving environment but also informs impact and management decisions when use of BC water quality guidelines are not appropriate.

In the first screening step, HQs were calculated by dividing the predicted seasonal mean and maximum concentration of water quality parameters by the appropriate 30-day average or maximum guideline or SBEB. Water quality parameters with an HQ less than or equal to 1.0 were screened out of the assessment for residual effects, since the guidelines are determined by the BC Ministry of Environment to be protective of freshwater aquatic life receptors; therefore, there is no potential for adverse effects to water quality. Water quality parameters with an HQ greater than 1.0 relative to the guideline limit were retained for a second screening step prior to significance determination.

In the second screening step, predicted seasonal mean and maximum water quality parameters were compared to the seasonal mean and maximum baseline concentrations, or SBEB if applicable (Figure 13.6-1). Note, as described in Section 13.3.3, only those data determined to best characterize background conditions, constituting the curated baseline database, were used for the calculation of means and related statistics and as a basis for describing baseline or background conditions. That is, for the effects assessment, HQs were derived using the curated baseline dataset. The comparison of predicted concentrations to baseline concentrations provides a good indicator of the potential for incremental change due to Project-related activities. This step screens out those contaminants where concentrations are at or above guidelines under baseline conditions; naturally occurring guideline exceedances are not a Project-related effect. If the HQ calculated during this screening step were greater than 1.0, the parameter was considered a possible Project-related COPC and retained for further assessment. If the final HQ was equal to or less than 1.0, the parameter was not considered a COPC and was not assessed further.

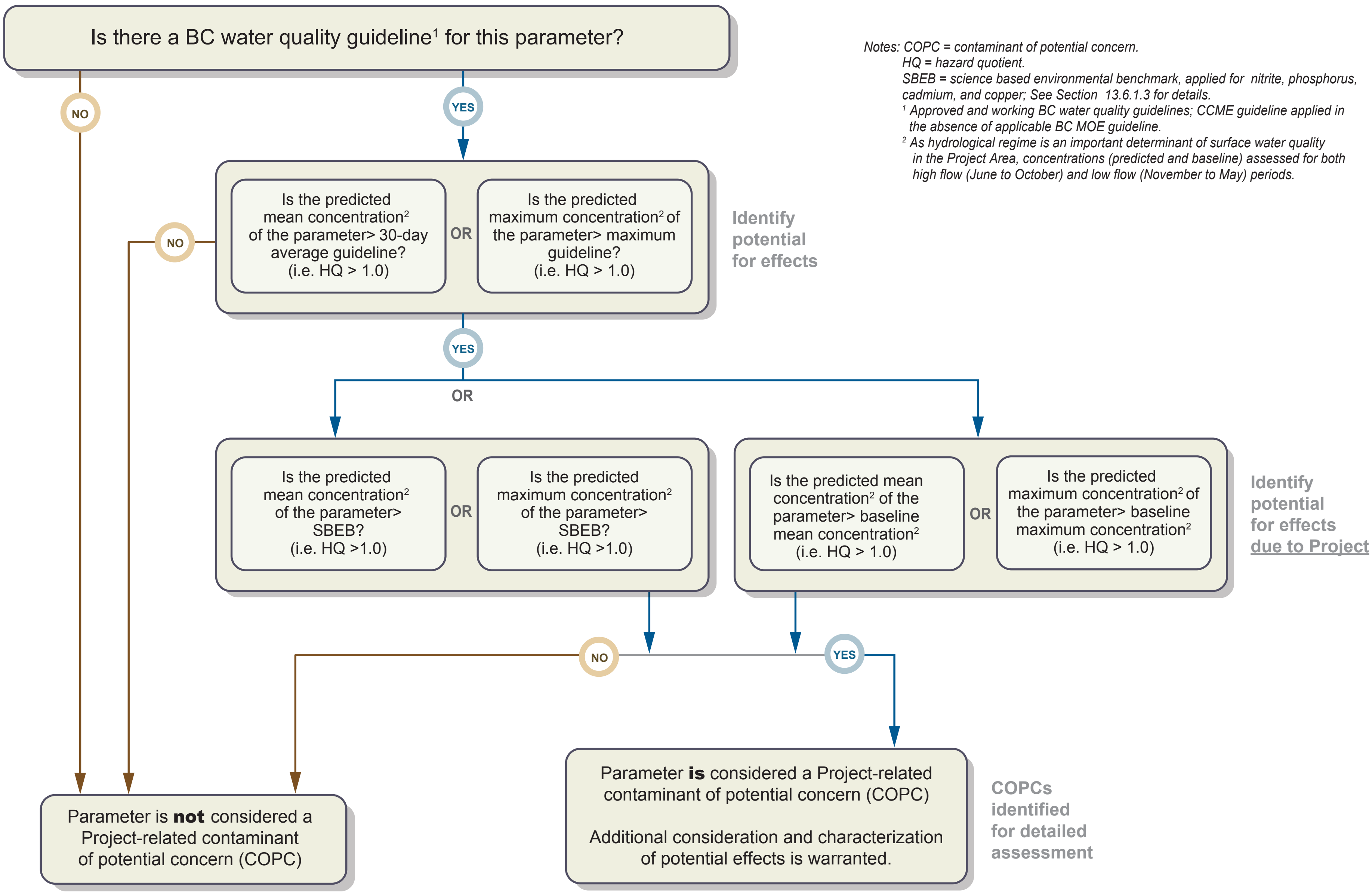
Brucejack Lake will be the site of permanent deposition of waste rock and tailings and will be viewed in a regulatory light as part of the mine; the surface water quality effects assessment does not explicitly consider changes in water quality within Brucejack Lake itself. The screening process for assessment of compliance at end-of-pipe (Brucejack Lake outlet) was as described above for the downstream receiving environment. However, in the first screening step, HQ were calculated by dividing the predicted seasonal mean and maximum concentration of water quality parameters by relevant MMER or Pollution Control Objective (PCO; BC MOE 1979) guidelines, as appropriate. BC water quality guidelines for the protection of aquatic life were applied if MMER or PCO guidelines were unavailable.

HQs are only useful as a screening tool to determine the potential for residual effects, and they should not be used to assess the magnitude of potential effects (i.e., an HQ of 8 is not necessarily worse than an HQ of 2 (US EPA 1998).

Figure 13.6-1

Screening Process for Selection of Contaminants of Potential Concern (COPC) for Surface Water Quality Assessment, Brucejack Gold Mine Project

ERM



Notes: COPC = contaminant of potential concern.
HQ = hazard quotient.
SBEB = science based environmental benchmark, applied for nitrite, phosphorus, cadmium, and copper; See Section 13.6.1.3 for details.
[1] Approved and working BC water quality guidelines; CCME guideline applied in the absence of applicable BC MOE guideline.
[2] As hydrological regime is an important determinant of surface water quality in the Project Area, concentrations (predicted and baseline) assessed for both high flow (June to October) and low flow (November to May) periods.

By following the COPC screening procedure as outlined above, the significance determination for water quality effects included water quality parameters that are predicted to increase in concentration above water quality guidelines and above the range of natural variability. The screening procedure thus focuses the significance determination on those parameters with the potential for a Project-related effect. The significance determination considers, but is not limited to, factors such as the sensitivity of potential receptors in the receiving environment, uncertainty in guideline limits (e.g., due to safety factors or the underlying studies used to derive the guidelines), or other Project-specific information (e.g., uncertainty in the predicted concentrations or other factors that may affect the metal concentration or toxicity). For the summary of COPC screening results for base case and sensitivity cases predictions for the Brucejack Lake outlet and Brucejack Creek assessment point (BJ 200mD/S) please see Tables 13.6-4 and 13.6-5, respectively.

13.6.2 Residual Effects on Water Quality: Mine Site Area and Receiving Environment

This section presents the water quality predictions for Brucejack Lake outflow and downstream receiving environment (assessment point: BJ 200m D/S) for the nine modelled scenarios or sensitivity analyses, described above, as well as the semi-quantitative assessment of mid- and far-field receiving environments (Sulphurets and Unuk watersheds).

Figures 13.6-2 to 13.6-5 present the expected case (scenario 1, base case) and upper case (scenario 2, high K) water quality predictions for Brucejack Lake outflow during the Construction, Operation, Closure, and Post-closure phases for parameters regulated under MMER (i.e., arsenic, copper, nickel, lead, and zinc) as well as for COPCs identified at the downstream objective/assessment point, BJ 200m D/S (arsenic, zinc, chromium, total aluminum and phosphorus). Figures 13.6-6 to 13.6-9 present the expected (scenario 1, base case) and upper case (scenario 2, high K) water quality predictions at the Brucejack Creek objective site (BJ 200m D/S) during Construction, Operation, Closure, and Post-closure phases for the identified COPCs.

Tables 13.6-2 and 13.6-3 presents statistical summaries of predicted concentrations (min, max, median, mean, 95th percentile) of all modelled parameters for the expected case (base case) for all Project phases for Brucejack Lake outflow and BJ 200m D/S, respectively. Tables 13.6-4 and 13.6-5 present a summary of COPC screening results for Brucejack Lake outflow and BJ 200m D/S, respectively, for all modelled cases.

Detailed water quality predictions and COPC screening results for modelled cases 1 to 9 are presented in the following appendices:

- Appendix 13-C, Water Quality Model Report;
- Appendix 13-D, Contaminants of Potential Concern (COPC) Screening Results for Brucejack Lake Outflow, Modelled Cases 1 to 9; and
- Appendix 13-E, Contaminants of Potential Concern (COPC) Screening Results for Brucejack Creek (BJ 200m D/S), Modelled Cases 1 to 9.

Table 13.6-2. Predicted Water Quality at Brucejack Lake outlet (Base Case), Brucejack Gold Mine Project

Phase		Construction (2 Years)										Operation (22 Years)									
		Low Flow (November to May)					High Flow (June to October)					Low Flow (November to May)					High Flow (June to October)				
	Units	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P
Physical Tests																					
Colour	CU	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Conductivity	μS/cm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hardness (as $CaCO_3$)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
pH	pH	7.32	8.02	7.79	7.72	8.00	7.53	7.94	7.79	7.76	7.93	6.81	7.98	6.93	6.99	7.42	6.88	7.73	7.01	7.04	7.29
Total Suspended Solids	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Dissolved Solids	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Turbidity	NTU	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Acidity	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alkalinity, Bicarbonate (as $CaCO_3$)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alkalinity, Carbonate (as $CaCO_3$)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alkalinity, Hydroxide (as $CaCO_3$)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alkalinity, Total (as $CaCO_3$)	mg/L	27.8	33.1	31.3	30.7	32.8	29.4	32.4	31.2	31.0	32.4	30.5	37.1	35.5	35.1	36.8	30.4	36.0	34.5	34.1	35.7
Anions and Nutrients																					
Ammonia, Total (as N)	mg/L	0.00238	0.00241	0.00239	0.00240	0.00241	0.00239	0.00241	0.00241	0.00240	0.00241	0.0128	0.295	0.236	0.231	0.285	0.0762	0.260	0.204	0.199	0.247
Bromide (Br)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chloride (Cl)	mg/L	1.99	2.03	2.01	2.01	2.03	2.00	2.03	2.02	2.02	2.03	2.02	7.57	6.71	6.37	7.43	2.97	6.88	6.03	5.78	6.76
Fluoride (F)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrate (as N)	mg/L	0.0872	0.0889	0.0880	0.0879	0.0888	0.0876	0.0889	0.0884	0.0884	0.0889	0.0899	0.318	0.242	0.232	0.308	0.126	0.291	0.223	0.211	0.275
Nitrite (as N)	mg/L	0.00157	0.00158	0.00157	0.00157	0.00158	0.00157	0.00158	0.00158	0.00158	0.00158	0.00165	0.00579	0.00509	0.00492	0.00564	0.00235	0.00523	0.00463	0.00450	0.00514
Total Kjeldahl Nitrogen	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Nitrogen	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Orthophosphate-Dissolved (as P)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phosphorus (P)-Total	mg/L	0.00107	0.00112	0.00109	0.00109	0.00112	0.00108	0.00112	0.00110	0.00110	0.00112	0.00119	0.00631	0.00529	0.00505	0.00618	0.00219	0.00568	0.00476	0.00452	0.00558
Sulphate (SO_4)	mg/L	14.8	16.5	15.9	15.7	16.4	15.2	16.3	15.9	15.9	16.3	16.4	32.0	28.9	28.4	31.6	18.9	30.0	27.2	26.6	29.6
Cyanides																					
Cyanide, Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cyanide, WAD	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Organic Carbon																					
Total Organic Carbon	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Metals																					
Aluminum (Al)	mg/L	0.0138	0.0207	0.0184	0.0178	0.0205	0.0160	0.0199	0.0183	0.0181	0.0199	0.0207	0.0352	0.0309	0.0305	0.0345	0.0226	0.0327	0.0286	0.0283	0.0318
Antimony (Sb)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Arsenic (As)	mg/L	0.00215	0.00401	0.00338	0.00321	0.00394	0.00274	0.00378	0.00334	0.00329	0.00377	0.00388	0.00618	0.00540	0.00531	0.00607	0.00374	0.00568	0.00497	0.00486	0.00556
Barium (Ba)[1]	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Beryllium (Be)[1]	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bismuth (Bi)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Boron (B)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cadmium (Cd)[1]	mg/L	0.0000049	0.0000062	0.0000053	0.0000054	0.0000061	0.0000051	0.0000060	0.0000055	0.0000055	0.0000059	0.0000062	0.0000207	0.0000181	0.0000175	0.0000203	0.0000085	0.0000189	0.0000164	0.0000159	0.0000184
Calcium (Ca)	mg/L	15.1	15.6	15.5	15.4	15.6	15.3	15.6	15.5	15.5	15.6	15.6	22.0	20.7	20.5	21.8	16.5	21.2	20.1	19.8	21.1
Chromium (Cr)[1]	mg/L	0.000057	0.000071	0.000066	0.000065	0.000070	0.000061	0.000069	0.000066	0.000066	0.000069	0.000070	0.000854	0.000707	0.000677	0.000834	0.000205	0.000761	0.000619	0.000596	0.000744
Cobalt (Co)	mg/L	0.000049	0.000060	0.000056	0.000055	0.000060	0.000052	0.000059	0.000056	0.000056	0.000059	0.000060	0.000464	0.000327	0.000322	0.000436	0.000105	0.000414	0.000292	0.000285	0.000376
Copper (Cu)	mg/L	0.000249	0.000291	0.000277	0.000272	0.000289	0.000263	0.000286	0.000278	0.000276	0.000286	0.000289	0.00115	0.000944	0.000920	0.00111	0.000406	0.00105	0.000858	0.000835	0.000984
Iron (Fe)	mg/L	0.0173	0.0175	0.0174	0.0174	0.0175	0.0173	0.0175	0.0174	0.0174	0.0175	0.0174	0.1013	0.0815	0.0778	0.0972	0.0295	0.0909	0.0731	0.0696	0.0845
Lead (Pb)	mg/L	0.0000250	0.0000307	0.0000287	0.0000282	0.0000304	0.0000268	0.0000300	0.0000287	0.0000285	0.0000300	0.0000307	0.0000845	0.0000697	0.0000676	0.0000811	0.0000373	0.0000775	0.0000635	0.0000622	0.0000727
Lithium (Li)[1]	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Magnesium (Mg)	mg/L	0.403	0.565	0.512	0.495	0.558	0.453	0.545	0.511	0.505	0.545	0.563	2.73	2.30	2.22	2.66	0.932	2.45	2.02	1.96	2.38
Manganese (Mn)	mg/L	0.00197	0.00378	0.00317	0.00299	0.00371	0.00252	0.00356	0.00317	0.00310	0.00355	0.00380	0.0996	0.0685	0.0672	0.0931	0.0150	0.0877	0.0603	0.0583	0.0790
Mercury (Hg)	mg/L	0.0000053	0.0000144	0.0000127	0.0000110	0.0000144	0.0000091	0.0000135	0.0000118	0.0000114	0.0000132	0.0000052	0.0000130	0.0000060	0.0000069	0.0000098	0.0000052	0.0000114	0.0000058	0.0000065	0.0000093
Molybdenum (Mo)	mg/L	0.000632	0.000873	0.000790	0.000766	0.000863	0.000703	0.000844	0.000791	0.000781	0.000841	0.000868	0.00586	0.00486	0.00456	0.00576	0.00175	0.00524	0.00433	0.00402	0.00517
Nickel (Ni)[1]	mg/L	0.000242	0.000273	0.000262	0.000259	0.000272	0.000251	0.000269	0.000262	0.000261	0.000269	0.000271	0.000770	0.000676	0.000648	0.000762	0.000353	0.000709	0.000619	0.000593	0.000697
Phosphorus (P)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Potassium (K)	mg/L	0.121	0.428	0.327	0.297	0.415	0.217	0.390	0.322	0.312	0.389	0.429	1.80	1.43	1.35	1.76	0.539	1.60	1.28	1.18	1.55
Selenium (Se)	mg/L	0.000263	0.000367	0.000332	0.000321	0.000362	0.000294	0.000354	0.000332	0.000327	0.000353	0.000366	0.000676	0.000588	0.000569	0.000664	0.000375	0.000626	0.000550	0.000528	0.000615
Silicon (Si)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Silver (Ag)	mg/L	0.0000049	0.0000059	0.0000055	0.0000054	0.0000058	0.0000052	0.0000057	0.0000055	0.0000055	0.0000057	0.0000058	0.0000242	0.0000195	0.0000184	0.0000233	0.0000084	0.0000219	0.0000178	0.0000165	0.0000210

(continued)

Table 13.6-2. Predicted Water Quality at Brucejack Lake outlet (Base Case), Brucejack Gold Mine Project (continued)

Phase		Construction (2 Years)										Operation (22 Years)									
		Low Flow (November to May)					High Flow (June to October)					Low Flow (November to May)					High Flow (June to October)				
	Units	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P
Total Metals *(cont'd)*																					
Sodium (Na)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Strontium (Sr)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallium (Tl)	mg/L	0.0000091	0.0000150	0.0000130	0.0000125	0.0000147	0.0000109	0.0000143	0.0000129	0.0000127	0.0000142	0.0000127	0.0000229	0.0000198	0.0000193	0.0000223	0.0000124	0.0000213	0.0000186	0.0000178	0.0000207
Tin (Sn)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Titanium (Ti)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Uranium (U)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vanadium (V)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zinc (Zn)	mg/L	0.00144	0.00151	0.00148	0.00148	0.00151	0.00146	0.00151	0.00149	0.00148	0.00150	0.00150	0.0112	0.00552	0.00557	0.00851	0.00215	0.0102	0.00492	0.00509	0.00738
Dissolved Metals																					
Aluminum (Al)	mg/L	0.00623	0.0138	0.0112	0.0105	0.0135	0.00857	0.0128	0.0112	0.0109	0.0128	0.0137	0.0283	0.0239	0.0235	0.0276	0.0156	0.0258	0.0215	0.0212	0.0249
Antimony (Sb)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Arsenic (As)	mg/L	0.00203	0.00406	0.00336	0.00318	0.00398	0.00265	0.00381	0.00335	0.00328	0.00379	0.00377	0.00608	0.00531	0.00522	0.00597	0.00363	0.00558	0.00487	0.00476	0.00545
Barium (Ba)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Beryllium (Be)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bismuth (Bi)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Boron (B)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cadmium (Cd)	mg/L	0.0000049	0.0000065	0.0000055	0.0000055	0.0000064	0.0000051	0.0000063	0.0000057	0.0000057	0.0000062	0.0000065	0.0000207	0.0000181	0.0000175	0.0000202	0.0000088	0.0000189	0.0000164	0.0000159	0.0000184
Calcium (Ca)	mg/L	15.1	15.6	15.5	15.4	15.6	15.3	15.6	15.5	15.5	15.6	15.6	22.0	20.7	20.5	21.8	16.5	21.2	20.1	19.8	21.1
Chromium (Cr)	mg/L	0.000049	0.000065	0.000060	0.000058	0.000065	0.000054	0.000064	0.000060	0.000059	0.000063	0.000065	0.000847	0.000700	0.000670	0.000827	0.000199	0.000754	0.000612	0.000589	0.000737
Cobalt (Co)	mg/L	0.000049	0.000061	0.000057	0.000056	0.000061	0.000053	0.000060	0.000057	0.000057	0.000060	0.000061	0.000464	0.000327	0.000322	0.000436	0.000106	0.000414	0.000292	0.000285	0.000376
Copper (Cu)	mg/L	0.000249	0.000299	0.000282	0.000276	0.000298	0.000264	0.000295	0.000285	0.000282	0.000294	0.000298	0.001153	0.000944	0.000920	0.001113	0.000413	0.001047	0.000858	0.000836	0.000983
Iron (Fe)	mg/L	0.0143	0.0146	0.0145	0.0145	0.0146	0.0144	0.0146	0.0145	0.0145	0.0146	0.0145	0.0984	0.0786	0.0749	0.0944	0.0266	0.0880	0.0702	0.0667	0.0816
Lead (Pb)	mg/L	0.000025	0.000033	0.000030	0.000029	0.000033	0.000027	0.000033	0.000031	0.000030	0.000032	0.000033	0.000084	0.000069	0.000067	0.000081	0.000039	0.000077	0.000063	0.000062	0.000072
Lithium (Li)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Magnesium (Mg)	mg/L	0.393	0.556	0.503	0.486	0.550	0.444	0.536	0.502	0.496	0.536	0.554	2.727	2.287	2.207	2.654	0.923	2.445	2.015	1.956	2.370
Manganese (Mn)	mg/L	0.000712	0.00261	0.00197	0.00178	0.00254	0.00128	0.00240	0.00198	0.00190	0.00237	0.00264	0.0985	0.0674	0.0661	0.0920	0.0139	0.0865	0.0591	0.0572	0.0778
Mercury (Hg)	mg/L	0.000613	0.000866	0.000779	0.000753	0.000857	0.000686	0.000838	0.000781	0.000770	0.000833	0.000862	0.00585	0.00484	0.00455	0.00574	0.00174	0.00522	0.00431	0.00400	0.00515
Molybdenum (Mo)	mg/L	0.000005	0.000014	0.000013	0.000011	0.000014	0.000009	0.000014	0.000012	0.000011	0.000013	0.000005	0.000013	0.000006	0.000007	0.000010	0.000005	0.000011	0.000006	0.000007	0.000009
Nickel (Ni)[1]	mg/L	0.000283	0.000313	0.000303	0.000300	0.000312	0.000292	0.000310	0.000303	0.000302	0.000310	0.000312	0.000806	0.000713	0.000685	0.000797	0.000393	0.000745	0.000657	0.000630	0.000733
Phosphorus (P)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Potassium (K)	mg/L	0.120	0.430	0.328	0.297	0.417	0.217	0.391	0.324	0.313	0.390	0.430	1.80	1.43	1.35	1.76	0.540	1.60	1.28	1.18	1.55
Selenium (Se)	mg/L	0.000268	0.000379	0.000341	0.000329	0.000374	0.000300	0.000366	0.000342	0.000337	0.000364	0.000378	0.000680	0.000592	0.000573	0.000668	0.000380	0.000630	0.000554	0.000532	0.000619
Silicon (Si)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Silver (Ag)	mg/L	0.000005	0.000006	0.000006	0.000006	0.000006	0.000005	0.000006	0.000006	0.000006	0.000006	0.000006	0.000024	0.000020	0.000018	0.000023	0.000008	0.000022	0.000018	0.000016	0.000021
Sodium (Na)	mg/L	1.05	2.17	1.78	1.68	2.12	1.39	2.03	1.78	1.74	2.02	1.47	2.21	1.64	1.66	1.89	1.43	2.04	1.56	1.57	1.77
Strontium (Sr)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallium (Tl)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tin (Sn)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Titanium (Ti)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Uranium (U)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vanadium (V)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zinc (Zn)	mg/L	0.00144	0.00154	0.00150	0.00149	0.00154	0.00146	0.00153	0.00150	0.00150	0.00153	0.00153	0.0112	0.00552	0.00557	0.00850	0.00217	0.0102	0.00492	0.00509	0.00738

(continued)

Table 13.6-2. Predicted Water Quality at Brucejack Lake outlet (Base Case), Brucejack Gold Mine Project (continued)

Phase		Closure (2 Years)										Post-closure (3 Years)									
		Low Flow (November to May)					High Flow (June to October)					Low Flow (November to May)					High Flow (June to October)				
	Units	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P
Physical Tests																					
Colour	CU	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Conductivity	µS/cm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hardness (as $CaCO_3$)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
pH	pH	7.08	7.50	7.37	7.29	7.50	7.21	7.50	7.39	7.38	7.49	7.51	7.62	7.58	7.57	7.61	7.54	7.61	7.59	7.58	7.61
Total Suspended Solids	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Dissolved Solids	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Turbidity	NTU	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Acidity	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alkalinity, Bicarbonate (as $CaCO_3$)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alkalinity, Carbonate (as $CaCO_3$)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alkalinity, Hydroxide (as $CaCO_3$)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alkalinity, Total (as $CaCO_3$)	mg/L	29.6	30.7	30.0	30.2	30.6	29.5	30.3	29.8	29.8	30.2	29.4	29.8	29.6	29.6	29.7	29.3	29.6	29.4	29.4	29.5
Anions and Nutrients																					
Ammonia, Total (as N)	mg/L	0.0431	0.185	0.0886	0.114	0.184	0.0441	0.142	0.0796	0.0821	0.133	0.0067	0.0427	0.0209	0.0213	0.0424	0.0068	0.0333	0.0130	0.0159	0.0301
Bromide (Br)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chloride (Cl)	mg/L	3.19	6.76	4.34	4.98	6.74	3.21	5.69	4.11	4.16	5.45	2.27	3.19	2.65	2.65	3.18	2.27	2.95	2.42	2.50	2.86
Fluoride (F)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrate (as N)	mg/L	0.100	0.129	0.109	0.115	0.129	0.100	0.120	0.107	0.108	0.119	0.0923	0.100	0.0952	0.0953	0.100	0.0923	0.0978	0.0936	0.0942	0.0971
Nitrite (as N)	mg/L	0.00232	0.00467	0.00307	0.00349	0.00465	0.00233	0.00396	0.00292	0.00296	0.00381	0.00171	0.00231	0.00195	0.00195	0.00230	0.00171	0.00215	0.00182	0.00187	0.00210
Total Kjeldahl Nitrogen	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Nitrogen	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Orthophosphate-Dissolved (as P)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phosphorus (P)-Total	mg/L	0.00167	0.00333	0.00220	0.00250	0.00332	0.00168	0.00283	0.00210	0.00212	0.00272	0.00124	0.00167	0.00142	0.00142	0.00167	0.00124	0.00156	0.00131	0.00135	0.00152
Sulphate (SO_4)	mg/L	17.8	26.1	20.4	21.9	26.0	17.8	23.6	19.9	20.0	23.0	15.6	17.7	16.5	16.5	17.7	15.6	17.2	16.0	16.2	17.0
Cyanides																					
Cyanide, Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cyanide, WAD	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Organic Carbon																					
Total Organic Carbon	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Metals																					
Aluminum (Al)	mg/L	0.0168	0.0236	0.0190	0.0202	0.0236	0.0168	0.0216	0.0186	0.0187	0.0211	0.0150	0.0168	0.0158	0.0158	0.0168	0.0150	0.0163	0.0153	0.0155	0.0162
Antimony (Sb)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Arsenic (As)	mg/L	0.00316	0.00404	0.00351	0.00362	0.00403	0.00310	0.00373	0.00334	0.00333	0.00365	0.00297	0.00331	0.00315	0.00314	0.00329	0.00290	0.00315	0.00298	0.00299	0.00310
Barium (Ba)[1]	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Beryllium (Be)[1]	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bismuth (Bi)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Boron (B)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cadmium (Cd)[1]	mg/L	0.0000080	0.0000169	0.0000109	0.0000125	0.0000169	0.0000081	0.0000142	0.0000103	0.0000104	0.0000136	0.0000057	0.0000080	0.0000067	0.0000067	0.0000080	0.0000057	0.0000074	0.0000061	0.0000063	0.0000072
Calcium (Ca)	mg/L	16.6	19.4	17.5	18.0	19.4	16.6	18.6	17.3	17.4	18.4	15.9	16.6	16.2	16.2	16.6	15.9	16.4	16.0	16.1	16.4
Chromium (Cr)[1]	mg/L	0.000137	0.000404	0.000223	0.000271	0.000402	0.000139	0.000324	0.000206	0.000210	0.000306	0.000069	0.000137	0.000096	0.000097	0.000136	0.000069	0.000119	0.000081	0.000087	0.000113
Cobalt (Co)	mg/L	0.000085	0.000204	0.000123	0.000144	0.000203	0.000086	0.000168	0.000116	0.000118	0.000160	0.000055	0.000085	0.000067	0.000067	0.000085	0.000055	0.000077	0.000060	0.000062	0.000074
Copper (Cu)	mg/L	0.000438	0.00102	0.000626	0.000731	0.00102	0.000442	0.000848	0.000589	0.000599	0.000810	0.000288	0.000437	0.000347	0.000349	0.000435	0.000288	0.000399	0.000314	0.000326	0.000385
Iron (Fe)	mg/L	0.0254	0.0500	0.0333	0.0378	0.0499	0.0256	0.0426	0.0317	0.0321	0.0410	0.0191	0.0254	0.0217	0.0217	0.0254	0.0191	0.0237	0.0202	0.0207	0.0232
Lead (Pb)	mg/L	0.0000373	0.0000632	0.0000456	0.0000504	0.0000631	0.0000372	0.0000554	0.0000439	0.0000441	0.0000536	0.0000307	0.0000376	0.0000335	0.0000337	0.0000376	0.0000304	0.0000357	0.0000315	0.0000322	0.0000349
Lithium (Li)[1]	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Magnesium (Mg)	mg/L	0.817	2.12	1.24	1.47	2.11	0.823	1.73	1.15	1.17	1.64	0.483	0.815	0.619	0.620	0.814	0.482	0.728	0.537	0.566	0.697
Manganese (Mn)	mg/L	0.0112	0.0412	0.0208	0.0262	0.0411	0.0114	0.0322	0.0189	0.0194	0.0302	0.00349	0.0111	0.00659	0.00664	0.0111	0.00348	0.00914	0.00477	0.00542	0.00844
Mercury (Hg)	mg/L	0.0000051	0.0000052	0.0000052	0.0000052	0.0000052	0.0000051	0.0000052	0.0000051	0.0000051	0.0000052	0.0000051	0.0000051	0.0000051	0.0000051	0.0000051	0.0000051	0.0000051	0.0000051	0.0000051	0.0000051
Molybdenum (Mo)	mg/L	0.00120	0.00218	0.00153	0.00170	0.00217	0.00119	0.00188	0.00144	0.00145	0.00180	0.000961	0.00125	0.00107	0.00109	0.00124	0.000936	0.00115	0.00100	0.00101	0.00111
Nickel (Ni)[1]	mg/L	0.000300	0.000466	0.000353	0.000383	0.000465	0.000301	0.000416	0.000343	0.000345	0.000405	0.000257	0.000300	0.000275	0.000275	0.000299	0.000257	0.000289	0.000264	0.000268	0.000285
Phosphorus (P)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Potassium (K)	mg/L	0.258	0.581	0.364	0.423	0.581	0.257	0.484	0.340	0.343	0.461	0.177	0.266	0.212	0.216	0.264	0.172	0.239	0.186	0.195	0.229
Selenium (Se)	mg/L	0.000297	0.000385	0.000325	0.000341	0.000385	0.000297	0.000359	0.000319	0.000321	0.000353	0.000274	0.000297	0.000283	0.000283	0.000296	0.000274	0.000291	0.000278	0.000280	0.000289
Silicon (Si)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Silver (Ag)	mg/L	0.0000060	0.0000086	0.0000068	0.0000073	0.0000086	0.0000060	0.0000078	0.0000066	0.0000067	0.0000076	0.0000053	0.0000060	0.0000056	0.0000056	0.0000060	0.0000053	0.0000058	0.0000054	0.0000055	0.0000057

(continued)

Table 13.6-2. Predicted Water Quality at Brucejack Lake outlet (Base Case), Brucejack Gold Mine Project (completed)

Phase		Closure (2 Years)										Post-closure (3 Years)									
		Low Flow (November to May)					High Flow (June to October)					Low Flow (November to May)					High Flow (June to October)				
	Units	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P
Total Metals *(cont'd)*																					
Sodium (Na)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Strontium (Sr)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallium (Tl)	mg/L	0.0000099	0.0000128	0.0000108	0.0000113	0.0000128	0.0000099	0.0000119	0.0000107	0.0000107	0.0000117	0.0000091	0.0000099	0.0000095	0.0000095	0.0000099	0.0000091	0.0000097	0.0000093	0.0000093	0.0000096
Tin (Sn)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Titanium (Ti)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Uranium (U)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vanadium (V)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zinc (Zn)	mg/L	0.00366	0.0111	0.00605	0.00739	0.01106	0.00372	0.00887	0.00558	0.00570	0.00838	0.00176	0.00365	0.00251	0.00253	0.00363	0.00176	0.00315	0.00208	0.00224	0.00298
Dissolved Metals																					
Aluminum (Al)	mg/L	0.00898	0.0163	0.0113	0.0126	0.0162	0.00903	0.0141	0.0109	0.0110	0.0136	0.00712	0.00896	0.00786	0.00788	0.00895	0.00712	0.00850	0.00744	0.00759	0.00833
Antimony (Sb)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Arsenic (As)	mg/L	0.00303	0.00393	0.00339	0.00350	0.00392	0.00298	0.00361	0.00322	0.00321	0.00353	0.00285	0.00319	0.00302	0.00301	0.00316	0.00278	0.00303	0.00286	0.00286	0.00297
Barium (Ba)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Beryllium (Be)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bismuth (Bi)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Boron (B)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cadmium (Cd)	mg/L	0.0000080	0.0000169	0.0000109	0.0000125	0.0000168	0.0000080	0.0000142	0.0000103	0.0000104	0.0000136	0.0000057	0.0000080	0.0000066	0.0000066	0.0000080	0.0000057	0.0000074	0.0000061	0.0000063	0.0000072
Calcium (Ca)	mg/L	16.6	19.4	17.5	18.0	19.4	16.6	18.6	17.3	17.4	18.4	15.9	16.6	16.2	16.2	16.6	15.9	16.4	16.0	16.1	16.4
Chromium (Cr)	mg/L	0.000130	0.000396	0.000215	0.000263	0.000395	0.000131	0.000316	0.000199	0.000203	0.000298	0.000061	0.000129	0.000088	0.000089	0.000128	0.000061	0.000111	0.000073	0.000078	0.000105
Cobalt (Co)	mg/L	0.000085	0.000204	0.000123	0.000144	0.000203	0.000086	0.000168	0.000116	0.000118	0.000160	0.000055	0.000085	0.000067	0.000067	0.000085	0.000055	0.000077	0.000060	0.000062	0.000074
Copper (Cu)	mg/L	0.000437	0.001023	0.000625	0.000730	0.001019	0.000441	0.000848	0.000588	0.000598	0.000809	0.000287	0.000436	0.000346	0.000348	0.000435	0.000288	0.000398	0.000313	0.000326	0.000385
Iron (Fe)	mg/L	0.0222	0.0470	0.0301	0.0346	0.0469	0.0223	0.0395	0.0285	0.0290	0.0379	0.0158	0.0221	0.0183	0.0184	0.0221	0.0158	0.0204	0.0169	0.0174	0.0199
Lead (Pb)	mg/L	0.000035	0.000063	0.000044	0.000049	0.000063	0.000035	0.000055	0.000042	0.000043	0.000053	0.000028	0.000035	0.000031	0.000031	0.000035	0.000028	0.000033	0.000029	0.000030	0.000033
Lithium (Li)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Magnesium (Mg)	mg/L	0.808	2.112	1.226	1.462	2.105	0.814	1.720	1.142	1.163	1.634	0.473	0.806	0.610	0.611	0.805	0.472	0.719	0.527	0.556	0.687
Manganese (Mn)	mg/L	0.00989	0.0400	0.0196	0.0250	0.0399	0.0101	0.0310	0.0176	0.0181	0.0290	0.00216	0.00983	0.00526	0.00531	0.00979	0.00215	0.00783	0.00345	0.00410	0.00712
Mercury (Hg)	mg/L	0.00118	0.00216	0.00151	0.00169	0.00216	0.00117	0.00186	0.00142	0.00143	0.00179	0.000941	0.001229	0.00105	0.00107	0.00122	0.000917	0.00113	0.000975	0.000990	0.00109
Molybdenum (Mo)	mg/L	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005
Nickel (Ni)	mg/L	0.000341	0.000504	0.000394	0.000423	0.000503	0.000342	0.000455	0.000383	0.000386	0.000444	0.000300	0.000341	0.000316	0.000317	0.000341	0.000299	0.000330	0.000306	0.000310	0.000327
Phosphorus (P)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Potassium (K)	mg/L	0.258	0.582	0.364	0.423	0.581	0.257	0.484	0.340	0.343	0.461	0.176	0.265	0.212	0.215	0.264	0.172	0.239	0.186	0.195	0.229
Selenium (Se)	mg/L	0.000301	0.000389	0.000330	0.000345	0.000389	0.000302	0.000363	0.000324	0.000325	0.000357	0.000279	0.000301	0.000288	0.000288	0.000301	0.000278	0.000295	0.000282	0.000284	0.000293
Silicon (Si)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Silver (Ag)	mg/L	0.000006	0.000009	0.000007	0.000007	0.000009	0.000006	0.000008	0.000007	0.000007	0.000008	0.000005	0.000006	0.000005	0.000005	0.000006	0.000005	0.000006	0.000005	0.000005	0.000006
Sodium (Na)	mg/L	1.16	1.65	1.32	1.40	1.64	1.16	1.50	1.29	1.29	1.47	1.04	1.16	1.09	1.09	1.16	1.04	1.13	1.06	1.07	1.12
Strontium (Sr)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallium (Tl)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tin (Sn)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Titanium (Ti)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Uranium (U)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vanadium (V)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zinc (Zn)	mg/L	0.00366	0.0111	0.00605	0.00738	0.0111	0.00371	0.00886	0.00557	0.00570	0.00838	0.00175	0.00364	0.00250	0.00252	0.00363	0.00176	0.00315	0.00208	0.00224	0.00298

Notes:

- Parameter not reported.

As hydrological regime is an important determinant of surface water quality in the Project Area, concentrations (predicted and baseline) assessed for both high flow (June to October) and low flow (November to May) periods.

Grey highlighted values exceed BC chronic water quality guidelines for the protection of aquatic life; ***bolded fon*** *t values exceed BC acute (maximum) water quality guidelines.*

Table 13.6-3. Predited Water Quality (Base Case) of Brucejack Creek (BJ200m D/S), Brucejack Gold Mine Project

Phase		Construction (2 Years)										Operation (22 Years)									
		Low Flow (November to May)					High Flow (June to October)					Low Flow (November to May)					High Flow (June to October)				
	Units	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P
Physical Tests																					
Colour	CU	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Conductivity	μS/cm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hardness (as $CaCO_3$)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
pH	pH	4.84	7.95	5.78	6.17	7.80	5.99	7.64	7.24	7.04	7.63	6.80	7.91	6.96	7.00	7.40	6.90	7.80	7.08	7.10	7.38
Total Suspended Solids	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Dissolved Solids	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Turbidity	NTU	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Acidity	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alkalinity, Bicarbonate (as $CaCO_3$)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alkalinity, Carbonate (as $CaCO_3$)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alkalinity, Hydroxide (as $CaCO_3$)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alkalinity, Total (as $CaCO_3$)	mg/L	32.7	86.5	72.3	65.2	85.4	38.3	69.2	42.5	48.0	67.9	30.5	38.2	35.5	35.4	38.0	30.4	37.2	35.1	34.9	37.0
Anions and Nutrients																					
Ammonia, Total (as N)	mg/L	0.259	1.23	0.853	0.779	1.22	0.259	0.775	0.298	0.406	0.774	0.0127	0.447	0.242	0.272	0.428	0.107	0.408	0.317	0.303	0.396
Bromide (Br)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chloride (Cl)	mg/L	2.01	2.31	2.03	2.10	2.30	2.02	2.31	2.26	2.21	2.31	2.00	7.60	6.71	6.38	7.46	3.21	6.94	6.10	5.85	6.83
Fluoride (F)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrate (as N)	mg/L	0.201	2.91	2.15	1.78	2.87	0.453	1.94	0.608	0.893	1.91	0.089	0.323	0.247	0.234	0.309	0.126	0.298	0.228	0.219	0.283
Nitrite (as N)	mg/L	0.00339	0.0121	0.00891	0.00815	0.0120	0.00343	0.00822	0.00382	0.00481	0.00822	0.00164	0.00656	0.00519	0.00514	0.00642	0.00279	0.00605	0.00511	0.00507	0.00597
Total Kjeldahl Nitrogen	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Nitrogen	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Orthophosphate-Dissolved (as P)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phosphorus (P)-Total	mg/L	0.00676	0.0212	0.00927	0.0119	0.0212	0.00714	0.0201	0.0179	0.0158	0.0201	0.00118	0.0260	0.00546	0.0102	0.0257	0.00265	0.0243	0.0206	0.0173	0.0242
Sulphate (SO_4)	mg/L	16.3	65.6	52.1	46.3	64.6	24.3	48.9	27.1	31.7	48.2	16.3	33.8	29.3	29.0	33.6	20.0	32.0	28.3	28.1	31.7
Cyanides																					
Cyanide, Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cyanide, WAD	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Organic Carbon																					
Total Organic Carbon	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Metals																					
Aluminum (Al)	mg/L	0.0177	0.0882	0.0213	0.0372	0.0855	0.0192	0.0839	0.0727	0.0622	0.0838	0.0205	0.104	0.0315	0.0487	0.102	0.0231	0.0976	0.0840	0.0730	0.0969
Antimony (Sb)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Arsenic (As)	mg/L	0.00330	0.00612	0.00543	0.00503	0.00600	0.00338	0.00550	0.00427	0.00424	0.00523	0.00388	0.00626	0.00541	0.00534	0.00616	0.00379	0.00579	0.00503	0.00495	0.00567
Barium (Ba)[1]	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Beryllium (Be)[1]	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bismuth (Bi)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Boron (B)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cadmium (Cd)[1]	mg/L	0.0000063	0.0000415	0.0000316	0.0000300	0.0000408	0.0000204	0.0000295	0.0000214	0.0000230	0.0000289	0.0000061	0.0000315	0.0000185	0.0000204	0.0000305	0.0000100	0.0000294	0.0000245	0.0000232	0.0000289
Calcium (Ca)	mg/L	15.4	29.4	25.5	24.0	29.1	18.0	24.7	18.7	20.0	24.4	15.4	22.6	20.9	20.6	22.4	16.8	21.8	20.4	20.2	21.7
Chromium (Cr)[1]	mg/L	0.000071	0.000228	0.000186	0.000168	0.000225	0.000096	0.000177	0.000106	0.000121	0.000174	0.000070	0.000832	0.000703	0.000671	0.000820	0.000211	0.000741	0.000611	0.000587	0.000725
Cobalt (Co)	mg/L	0.000059	0.000795	0.000594	0.000521	0.000780	0.000238	0.000541	0.000269	0.000327	0.000532	0.000059	0.000541	0.000346	0.000344	0.000505	0.000126	0.000492	0.000346	0.000342	0.000456
Copper (Cu)	mg/L	0.000290	0.000542	0.000351	0.000388	0.000526	0.000325	0.000528	0.000488	0.000457	0.000528	0.000286	0.00135	0.000982	0.000976	0.00130	0.000458	0.00125	0.00100	0.000980	0.00119
Iron (Fe)	mg/L	0.0174	0.127	0.0177	0.0459	0.127	0.0175	0.1204	0.105	0.0875	0.120	0.0172	0.209	0.0849	0.106	0.201	0.0352	0.194	0.157	0.141	0.187
Lead (Pb)	mg/L	0.000032	0.000171	0.000160	0.000146	0.000170	0.000119	0.000164	0.000153	0.000148	0.000164	0.000030	0.000208	0.000072	0.000100	0.000199	0.000040	0.000195	0.000162	0.000143	0.000190
Lithium (Li)[1]	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Magnesium (Mg)	mg/L	0.557	2.25	1.80	1.59	2.21	0.759	1.71	0.886	1.06	1.67	0.558	2.71	2.29	2.21	2.64	0.982	2.43	2.02	1.96	2.36
Manganese (Mn)	mg/L	0.0038	0.190	0.139	0.119	0.186	0.0422	0.125	0.0506	0.0668	0.123	0.0038	0.111	0.0725	0.0708	0.104	0.0205	0.100	0.0691	0.0678	0.0920
Mercury (Hg)	mg/L	0.0000071	0.0000146	0.0000116	0.0000109	0.0000143	0.0000097	0.0000137	0.0000112	0.0000115	0.0000134	0.0000052	0.0000132	0.0000064	0.0000071	0.0000101	0.0000052	0.0000119	0.0000064	0.0000070	0.0000097
Molybdenum (Mo)	mg/L	0.000861	0.00306	0.00249	0.00217	0.00301	0.00101	0.00236	0.00120	0.00144	0.00231	0.000860	0.00567	0.00482	0.00450	0.00559	0.00169	0.00502	0.00423	0.00390	0.00495
Nickel (Ni)[1]	mg/L	0.000269	0.0016	0.0012	0.0011	0.0016	0.000470	0.0011	0.0005	0.0007	0.0011	0.000269	0.000793	0.000676	0.000655	0.000786	0.000388	0.000737	0.000634	0.000615	0.000726
Phosphorus (P)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Potassium (K)	mg/L	0.422	2.78	2.18	1.86	2.73	0.636	2.05	0.846	1.09	1.98	0.425	1.81	1.44	1.36	1.76	0.548	1.61	1.30	1.20	1.57
Selenium (Se)	mg/L	0.000299	0.000396	0.000365	0.000360	0.000394	0.000304	0.000385	0.000354	0.000342	0.000376	0.000363	0.000663	0.000582	0.000564	0.000650	0.000373	0.000611	0.000542	0.000519	0.000600
Silicon (Si)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Silver (Ag)	mg/L	0.0000059	0.0000221	0.0000071	0.0000107	0.0000217	0.0000065	0.0000211	0.0000187	0.0000163	0.0000211	0.0000058	0.0000395	0.0000206	0.0000225	0.0000384	0.0000084	0.0000367	0.0000274	0.0000268	0.0000359

(continued)

Table 13.6-3. Predited Water Quality (Base Case) of Brucejack Creek (BJ200m D/S), Brucejack Gold Mine Project (continued)

Phase		Construction (2 Years)										Operation (22 Years)									
		Low Flow (November to May)					High Flow (June to October)					Low Flow (November to May)					High Flow (June to October)				
	Units	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P
Total Metals *(cont'd)*																					
Sodium (Na)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Strontium (Sr)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallium (Tl)	mg/L	0.0000147	0.0000821	0.0000642	0.0000555	0.0000806	0.0000222	0.0000602	0.0000271	0.0000341	0.0000588	0.0000127	0.0000244	0.0000199	0.0000197	0.0000238	0.0000125	0.0000229	0.0000194	0.0000190	0.0000223
Tin (Sn)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Titanium (Ti)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Uranium (U)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vanadium (V)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zinc (Zn)	mg/L	0.00151	0.00625	0.00494	0.00475	0.00615	0.00363	0.00461	0.00370	0.00389	0.00455	0.00149	0.0122	0.00570	0.00596	0.00870	0.00246	0.0114	0.00601	0.00608	0.00787
Dissolved Metals																					
Aluminum (Al)	mg/L	0.0106	0.0159	0.0145	0.0138	0.0158	0.0109	0.0152	0.0136	0.0132	0.0150	0.0136	0.0290	0.0241	0.0237	0.0283	0.0158	0.0266	0.0221	0.0219	0.0258
Antimony (Sb)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Arsenic (As)	mg/L	0.00291	0.00611	0.00539	0.00493	0.00599	0.00303	0.00554	0.00403	0.00405	0.00525	0.00377	0.00594	0.00526	0.00517	0.00584	0.00359	0.00542	0.00478	0.00467	0.00530
Barium (Ba)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Beryllium (Be)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bismuth (Bi)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Boron (B)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cadmium (Cd)	mg/L	0.000007	0.000015	0.000011	0.000011	0.000015	0.000009	0.000015	0.000014	0.000013	0.000015	0.000006	0.000029	0.000019	0.000020	0.000028	0.000010	0.000027	0.000022	0.000021	0.000026
Calcium (Ca)	mg/L	15.4	29.4	25.5	24.0	29.1	18.0	24.7	18.7	20.0	24.4	15.4	22.6	20.9	20.6	22.4	16.8	21.8	20.4	20.2	21.7
Chromium (Cr)	mg/L	0.000066	0.000173	0.000145	0.000130	0.000171	0.000073	0.000140	0.000084	0.000095	0.000137	0.000065	0.000824	0.000695	0.000661	0.000809	0.000196	0.000725	0.000600	0.000573	0.000708
Cobalt (Co)	mg/L	0.000061	0.000214	0.000173	0.000168	0.000211	0.000132	0.000164	0.000138	0.000142	0.000161	0.000060	0.000504	0.000340	0.000335	0.000468	0.000127	0.000458	0.000324	0.000319	0.000421
Copper (Cu)	mg/L	0.000297	0.000359	0.000341	0.000334	0.000356	0.000304	0.000343	0.000328	0.000322	0.000339	0.000295	0.00114	0.000944	0.000918	0.00111	0.000435	0.00104	0.000858	0.000836	0.000979
Iron (Fe)	mg/L	0.0144	0.0162	0.0146	0.0149	0.0161	0.0145	0.0161	0.0159	0.0156	0.0161	0.0144	0.0964	0.0785	0.0744	0.0933	0.0277	0.0862	0.0693	0.0660	0.0801
Lead (Pb)	mg/L	0.00003	0.00014	0.00011	0.00010	0.00014	0.00004	0.00011	0.00005	0.00006	0.00010	0.00003	0.00008	0.00007	0.00007	0.00008	0.00004	0.00008	0.00006	0.00006	0.00007
Lithium (Li)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Magnesium (Mg)	mg/L	0.550	2.01	1.63	1.44	1.98	0.708	1.55	0.825	0.976	1.51	0.549	2.69	2.28	2.20	2.62	0.961	2.41	2.01	1.95	2.34
Manganese (Mn)	mg/L	0.00261	0.0993	0.0728	0.0635	0.0972	0.0267	0.0661	0.0307	0.0383	0.0648	0.00261	0.1069	0.0704	0.0688	0.0991	0.0193	0.0960	0.0655	0.0645	0.0877
Mercury (Hg)	mg/L	0.0000051	0.0000136	0.0000100	0.0000096	0.0000133	0.0000087	0.0000128	0.0000101	0.0000105	0.0000125	0.0000052	0.0000130	0.0000060	0.0000069	0.0000097	0.0000052	0.0000112	0.0000058	0.0000065	0.0000092
Molybdenum (Mo)	mg/L	0.000795	0.001806	0.001578	0.001416	0.001797	0.000824	0.001541	0.000978	0.001072	0.001498	0.000854	0.005657	0.004807	0.004478	0.005572	0.001681	0.005001	0.004208	0.003883	0.004928
Nickel (Ni)	mg/L	0.000309	0.000469	0.000430	0.000416	0.000467	0.000353	0.000422	0.000370	0.000376	0.000416	0.000309	0.000819	0.000713	0.000689	0.000811	0.000426	0.000763	0.000665	0.000645	0.000752
Phosphorus (P)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Potassium (K)	mg/L	0.426	1.85	1.52	1.30	1.85	0.497	1.44	0.68	0.82	1.39	0.426	1.79	1.44	1.35	1.75	0.549	1.59	1.29	1.19	1.55
Selenium (Se)	mg/L	0.000276	0.000375	0.000322	0.000320	0.000363	0.000297	0.000353	0.000329	0.000327	0.000352	0.000375	0.000667	0.000586	0.000568	0.000653	0.000376	0.000613	0.000545	0.000522	0.000602
Silicon (Si)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Silver (Ag)	mg/L	0.0000056	0.0000072	0.0000068	0.0000066	0.0000071	0.0000057	0.0000069	0.0000062	0.0000062	0.0000067	0.0000060	0.0000235	0.0000193	0.0000182	0.0000228	0.0000084	0.0000212	0.0000176	0.0000162	0.0000204
Sodium (Na)	mg/L	2.14	12.05	9.46	8.12	11.84	3.06	8.91	3.87	4.92	8.66	1.47	2.43	1.66	1.73	2.03	1.45	2.29	1.78	1.76	1.97
Strontium (Sr)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallium (Tl)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tin (Sn)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Titanium (Ti)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Uranium (U)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vanadium (V)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zinc (Zn)	mg/L	0.00153	0.00376	0.00314	0.00306	0.00371	0.00254	0.00301	0.00260	0.00267	0.00297	0.00152	0.0114	0.00566	0.00573	0.00850	0.00247	0.0106	0.00540	0.00552	0.00751

(continued)

Table 13.6-3. Predited Water Quality (Base Case) of Brucejack Creek (BJ200m D/S), Brucejack Gold Mine Project (continued)

Phase		Closure (2 Years)										Post-closure (3 Years)									
		Low Flow (November to May)					High Flow (June to October)					Low Flow (November to May)					High Flow (June to October)				
	Units	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P
Physical Tests																					
Colour	CU	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Conductivity	µS/cm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hardness (as $CaCO_3$)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
pH	pH	7.08	8.23	7.73	7.66	8.23	7.34	8.04	7.60	7.62	7.92	7.67	8.56	8.23	8.15	8.54	7.69	8.16	7.77	7.85	8.15
Total Suspended Solids	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Dissolved Solids	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Turbidity	NTU	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Acidity	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alkalinity, Bicarbonate (as $CaCO_3$)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alkalinity, Carbonate (as $CaCO_3$)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alkalinity, Hydroxide (as $CaCO_3$)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alkalinity, Total (as $CaCO_3$)	mg/L	30.6	46.9	36.7	37.2	44.8	32.2	40.0	32.7	34.1	39.1	32.2	48.3	41.6	40.7	48.3	32.1	40.1	32.7	34.3	40.1
Anions and Nutrients																					
Ammonia, Total (as N)	mg/L	0.0464	0.338	0.137	0.162	0.335	0.0466	0.303	0.211	0.198	0.295	0.0103	0.213	0.0255	0.0719	0.200	0.0099	0.199	0.160	0.134	0.196
Bromide (Br)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chloride (Cl)	mg/L	3.21	6.76	4.36	5.02	6.75	3.22	5.82	4.21	4.30	5.59	2.30	3.41	2.68	2.75	3.38	2.30	3.21	2.67	2.71	3.13
Fluoride (F)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrate (as N)	mg/L	0.108	0.144	0.123	0.123	0.143	0.107	0.137	0.122	0.122	0.135	0.100	0.118	0.105	0.107	0.118	0.099	0.116	0.110	0.109	0.115
Nitrite (as N)	mg/L	0.00262	0.00545	0.00372	0.00392	0.00539	0.00260	0.00489	0.00366	0.00372	0.00474	0.00203	0.00333	0.00235	0.00252	0.00331	0.00199	0.00319	0.00277	0.00268	0.00313
Total Kjeldahl Nitrogen	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Nitrogen	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Orthophosphate-Dissolved (as P)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phosphorus (P)-Total	mg/L	0.00175	0.0237	0.00280	0.00816	0.0231	0.00175	0.0224	0.0193	0.0159	0.0223	0.00133	0.0222	0.001523	0.00711	0.0220	0.00132	0.0212	0.0186	0.0151	0.0211
Sulphate (SO_4)	mg/L	23.5	36.0	28.6	28.7	33.9	22.3	28.1	24.7	24.8	27.8	19.7	35.0	27.8	27.2	33.9	19.6	26.4	20.9	21.6	26.0
Cyanides																					
Cyanide, Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cyanide, WAD	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Organic Carbon																					
Total Organic Carbon	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Metals																					
Aluminum (Al)	mg/L	0.0236	0.0957	0.0642	0.0633	0.0944	0.0482	0.0915	0.0842	0.0781	0.0913	0.0542	0.0920	0.0701	0.0732	0.0911	0.0530	0.0889	0.0826	0.0772	0.0886
Antimony (Sb)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Arsenic (As)	mg/L	0.00390	0.00673	0.00478	0.00494	0.00627	0.00366	0.00513	0.00394	0.00409	0.00504	0.00357	0.00683	0.00537	0.00525	0.00674	0.00343	0.00505	0.00358	0.00389	0.00501
Barium (Ba)[1]	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Beryllium (Be)[1]	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bismuth (Bi)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Boron (B)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cadmium (Cd)[1]	mg/L	0.0000169	0.0000740	0.0000386	0.0000403	0.0000655	0.0000244	0.0000470	0.0000265	0.0000302	0.0000446	0.0000215	0.0000775	0.0000515	0.0000497	0.0000766	0.0000215	0.0000463	0.0000235	0.0000286	0.0000459
Calcium (Ca)	mg/L	18.6	24.3	20.8	20.9	23.4	18.2	20.9	19.1	19.3	20.9	17.4	24.2	21.0	20.8	23.8	17.3	20.5	17.8	18.3	20.4
Chromium (Cr)	mg/L	0.000175	0.000404	0.000261	0.000291	0.000402	0.000161	0.000326	0.000221	0.000224	0.000309	0.000093	0.000194	0.000131	0.000134	0.000184	0.000088	0.000133	0.000104	0.000107	0.000132
Cobalt (Co)	mg/L	0.000159	0.000290	0.000204	0.000212	0.000290	0.000150	0.000264	0.000204	0.000204	0.000257	0.000126	0.000198	0.000161	0.000161	0.000192	0.000121	0.000182	0.000159	0.000155	0.000179
Copper (Cu)	mg/L	0.000815	0.00122	0.00101	0.00100	0.001204	0.000730	0.00108	0.000848	0.000861	0.001047	0.000595	0.00102	0.000733	0.000753	0.000936	0.000571	0.000685	0.000613	0.000619	0.000679
Iron (Fe)	mg/L	0.0500	0.192	0.151	0.131	0.174	0.111	0.156	0.142	0.139	0.155	0.123	0.201	0.149	0.153	0.198	0.120	0.144	0.136	0.134	0.144
Lead (Pb)	mg/L	0.000064	0.00156	0.000640	0.000674	0.00138	0.000212	0.000971	0.000289	0.000413	0.000884	0.000243	0.00171	0.00112	0.00102	0.00170	0.000254	0.000987	0.000314	0.000459	0.00098
Lithium (Li)[1]	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Magnesium (Mg)	mg/L	1.25	2.12	1.71	1.72	2.12	0.999	1.76	1.32	1.32	1.68	0.637	1.52	1.04	1.04	1.39	0.615	1.03	0.734	0.761	0.960
Manganese (Mn)	mg/L	0.0386	0.0599	0.0435	0.0461	0.0572	0.0318	0.0490	0.0373	0.0383	0.0472	0.0246	0.0544	0.0351	0.0363	0.0503	0.0233	0.0315	0.0254	0.0263	0.0300
Mercury (Hg)	mg/L	0.0000052	0.0000145	0.0000089	0.0000090	0.0000134	0.0000062	0.0000109	0.0000067	0.0000075	0.0000103	0.0000065	0.0000154	0.0000118	0.0000112	0.0000154	0.0000065	0.0000110	0.0000069	0.0000078	0.0000109
Molybdenum (Mo)	mg/L	0.00136	0.00218	0.00168	0.00177	0.00217	0.00122	0.00182	0.00144	0.00146	0.00175	0.00103	0.00148	0.00122	0.00122	0.00142	0.00095	0.00119	0.00104	0.00105	0.00115
Nickel (Ni)[1]	mg/L	0.000341	0.000502	0.000400	0.000418	0.000497	0.000336	0.000461	0.000382	0.000389	0.000451	0.000300	0.000363	0.000323	0.000326	0.000354	0.000294	0.000343	0.000316	0.000317	0.000339
Phosphorus (P)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Potassium (K)	mg/L	0.426	0.649	0.540	0.537	0.638	0.371	0.565	0.437	0.444	0.544	0.303	0.524	0.381	0.390	0.479	0.281	0.357	0.308	0.311	0.347
Selenium (Se)	mg/L	0.000322	0.000385	0.000357	0.000357	0.000385	0.000306	0.000357	0.000329	0.000328	0.000352	0.000280	0.000343	0.000311	0.000310	0.000335	0.000279	0.000311	0.000289	0.000290	0.000306
Silicon (Si)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Silver (Ag)	mg/L	0.0000086	0.0000756	0.0000389	0.0000387	0.0000672	0.0000255	0.0000484	0.0000275	0.0000309	0.0000447	0.0000262	0.0000816	0.0000550	0.0000534	0.0000816	0.0000261	0.0000487	0.0000276	0.0000323	0.0000487

(continued)

Table 13.6-3. Predited Water Quality (Base Case) of Brucejack Creek (BJ200m D/S), Brucejack Gold Mine Project (completed)

Phase		Closure (2 Years)										Post-closure (3 Years)									
		Low Flow (November to May)					High Flow (June to October)					Low Flow (November to May)					High Flow (June to October)				
	Units	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P	Min.	Max.	Median	Mean	95th P
Total Metals *(cont'd)*																					
Sodium (Na)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Strontium (Sr)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallium (Tl)	mg/L	0.0000116	0.0000148	0.0000128	0.0000129	0.0000148	0.0000114	0.0000141	0.0000127	0.0000127	0.0000139	0.0000109	0.0000126	0.0000117	0.0000117	0.0000124	0.0000107	0.0000121	0.0000116	0.0000115	0.0000120
Tin (Sn)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Titanium (Ti)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Uranium (U)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vanadium (V)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zinc (Zn)	mg/L	0.00753	0.0124	0.0108	0.0102	0.0122	0.00612	0.0103	0.00799	0.00792	0.00990	0.00406	0.01067	0.00714	0.00703	0.00963	0.00393	0.00659	0.00467	0.00484	0.00621
Dissolved Metals																					
Aluminum (Al)	mg/L	0.0108	0.0174	0.0132	0.0140	0.0172	0.0106	0.0156	0.0124	0.0126	0.0152	0.0090	0.0117	0.0098	0.0100	0.0112	0.0087	0.0104	0.0093	0.0094	0.0102
Antimony (Sb)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Arsenic (As)	mg/L	0.00335	0.00398	0.00377	0.00372	0.00395	0.00304	0.00356	0.00329	0.00329	0.00355	0.00301	0.00381	0.00341	0.00339	0.00371	0.00283	0.00328	0.00294	0.00298	0.00324
Barium (Ba)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Beryllium (Be)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bismuth (Bi)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Boron (B)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cadmium (Cd)	mg/L	0.000017	0.000049	0.000029	0.000030	0.000044	0.000020	0.000032	0.000023	0.000024	0.000031	0.000017	0.000050	0.000033	0.000033	0.000049	0.000017	0.000031	0.000019	0.000021	0.000030
Calcium (Ca)	mg/L	18.6	24.3	20.8	20.9	23.4	18.2	20.9	19.1	19.3	20.9	17.4	24.2	21.0	20.8	23.8	17.3	20.5	17.8	18.3	20.4
Chromium (Cr)	mg/L	0.000162	0.000396	0.000247	0.000277	0.000395	0.000145	0.000308	0.000204	0.000208	0.000291	0.000075	0.000178	0.000118	0.000118	0.000169	0.000071	0.000119	0.000086	0.000091	0.000116
Cobalt (Co)	mg/L	0.000113	0.000254	0.000171	0.000176	0.000252	0.000109	0.000227	0.000165	0.000167	0.000219	0.000083	0.000149	0.000102	0.000109	0.000148	0.000079	0.000141	0.000120	0.000115	0.000139
Copper (Cu)	mg/L	0.000496	0.00102	0.000683	0.000762	0.00102	0.000482	0.000852	0.000617	0.000622	0.000816	0.000339	0.000524	0.000399	0.000408	0.000508	0.000326	0.000427	0.000355	0.000364	0.000414
Iron (Fe)	mg/L	0.0297	0.0470	0.0379	0.0388	0.0470	0.0257	0.0403	0.0311	0.0316	0.0388	0.0188	0.0336	0.0252	0.0255	0.0315	0.0184	0.0251	0.0204	0.0209	0.0239
Lead (Pb)	mg/L	0.00005	0.00022	0.00011	0.00012	0.00020	0.00005	0.00015	0.00006	0.00008	0.00014	0.00004	0.00023	0.00016	0.00014	0.00023	0.00004	0.00014	0.00005	0.00007	0.00014
Lithium (Li)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Magnesium (Mg)	mg/L	1.22	2.11	1.71	1.71	2.11	0.979	1.74	1.30	1.30	1.66	0.614	1.51	1.03	1.03	1.38	0.592	1.02	0.718	0.743	0.953
Manganese (Mn)	mg/L	0.0271	0.0512	0.0376	0.0380	0.0505	0.0249	0.0442	0.0309	0.0319	0.0423	0.0189	0.0364	0.0236	0.0245	0.0322	0.0171	0.0231	0.0185	0.0193	0.0225
Mercury (Hg)	mg/L	0.0000052	0.0000069	0.0000058	0.0000058	0.0000066	0.0000053	0.0000062	0.0000053	0.0000055	0.0000061	0.0000053	0.0000070	0.0000063	0.0000062	0.0000070	0.0000053	0.0000062	0.0000053	0.0000055	0.0000062
Molybdenum (Mo)	mg/L	0.001335	0.002163	0.001657	0.001748	0.002157	0.001195	0.001796	0.001417	0.001434	0.001728	0.001007	0.001447	0.001195	0.001199	0.001394	0.000927	0.001163	0.001014	0.001023	0.001130
Nickel (Ni)	mg/L	0.000380	0.000530	0.000434	0.000453	0.000524	0.000376	0.000489	0.000416	0.000421	0.000479	0.000340	0.000401	0.000360	0.000363	0.000390	0.000335	0.000373	0.000348	0.000351	0.000370
Phosphorus (P)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Potassium (K)	mg/L	0.387	0.628	0.498	0.509	0.616	0.344	0.543	0.414	0.420	0.522	0.279	0.462	0.341	0.349	0.423	0.256	0.322	0.283	0.284	0.319
Selenium (Se)	mg/L	0.000324	0.000389	0.000361	0.000360	0.000389	0.000308	0.000359	0.000333	0.000331	0.000355	0.000282	0.000348	0.000316	0.000315	0.000339	0.000281	0.000315	0.000292	0.000293	0.000311
Silicon (Si)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Silver (Ag)	mg/L	0.0000073	0.0000182	0.0000112	0.0000117	0.0000166	0.0000071	0.0000130	0.0000080	0.0000088	0.0000127	0.0000061	0.0000185	0.0000135	0.0000127	0.0000182	0.0000062	0.0000127	0.0000068	0.0000081	0.0000126
Sodium (Na)	mg/L	1.64	4.06	2.43	2.56	3.69	1.70	2.86	1.84	2.02	2.77	1.53	4.19	3.04	2.91	4.13	1.54	2.82	1.65	1.91	2.79
Strontium (Sr)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallium (Tl)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tin (Sn)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Titanium (Ti)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Uranium (U)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vanadium (V)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zinc (Zn)	mg/L	0.00654	0.0113	0.00929	0.00921	0.0112	0.00515	0.00944	0.00692	0.00695	0.00900	0.00306	0.00842	0.00543	0.00550	0.00753	0.00295	0.00530	0.00363	0.00379	0.00493

Notes:

- Parameter not reported.

As hydrological regime is an important determinant of surface water quality in the Project Area, concentrations (predicted and baseline) assessed for both high flow (June to October) and low flow (November to May) periods.

Figure 13.6-2

Water Quality Predictions for the Base Case and Upper Case (High K): Brucejack Lake Outlet, Construction

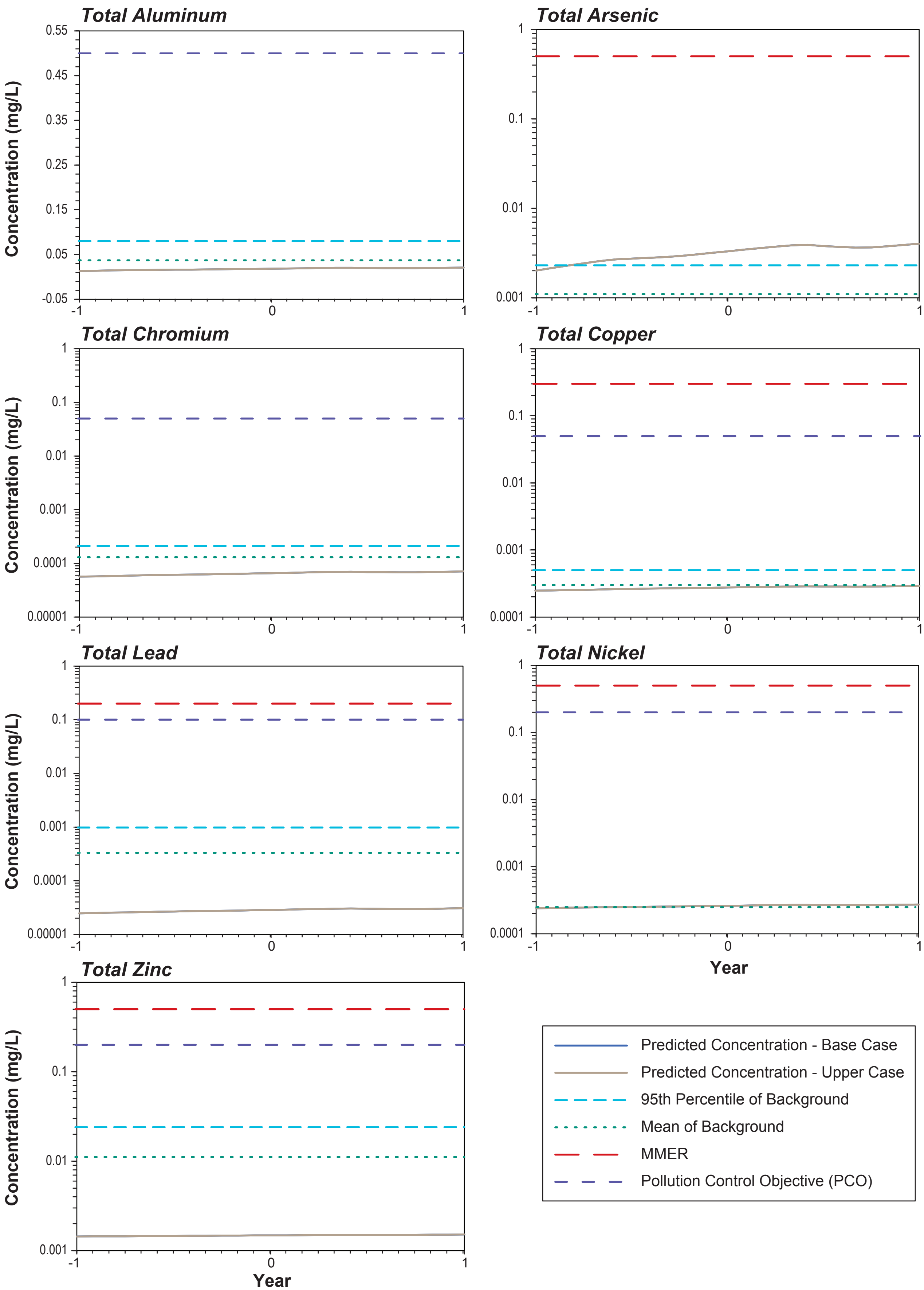


Figure 13.6-3

Water Quality Predictions for the Base Case and Upper Case (High K): Brucejack Lake Outlet, Operation

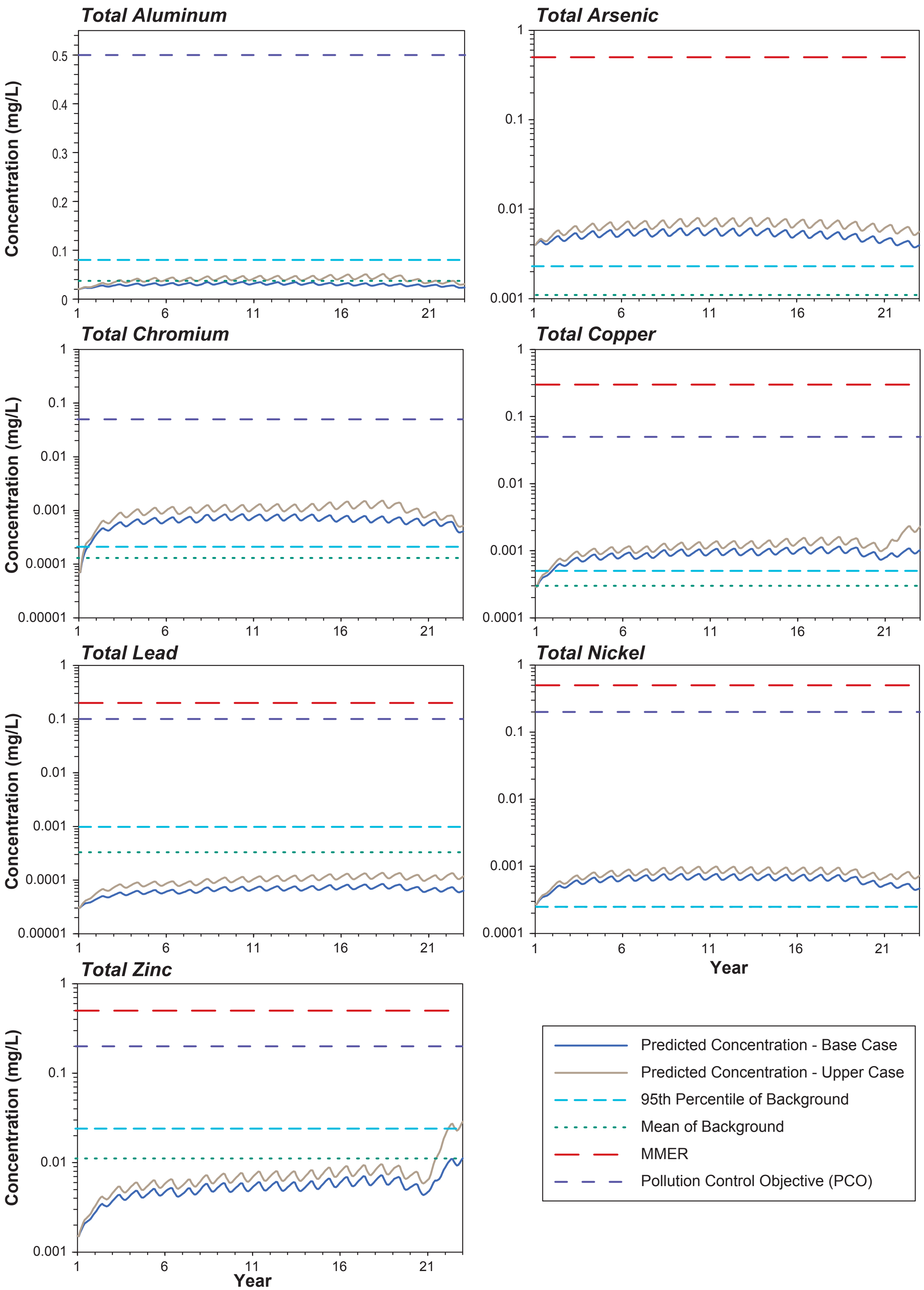


Figure 13.6-4

Water Quality Predictions for the Base Case and Upper Case (High K): Brucejack Lake Outlet, Closure

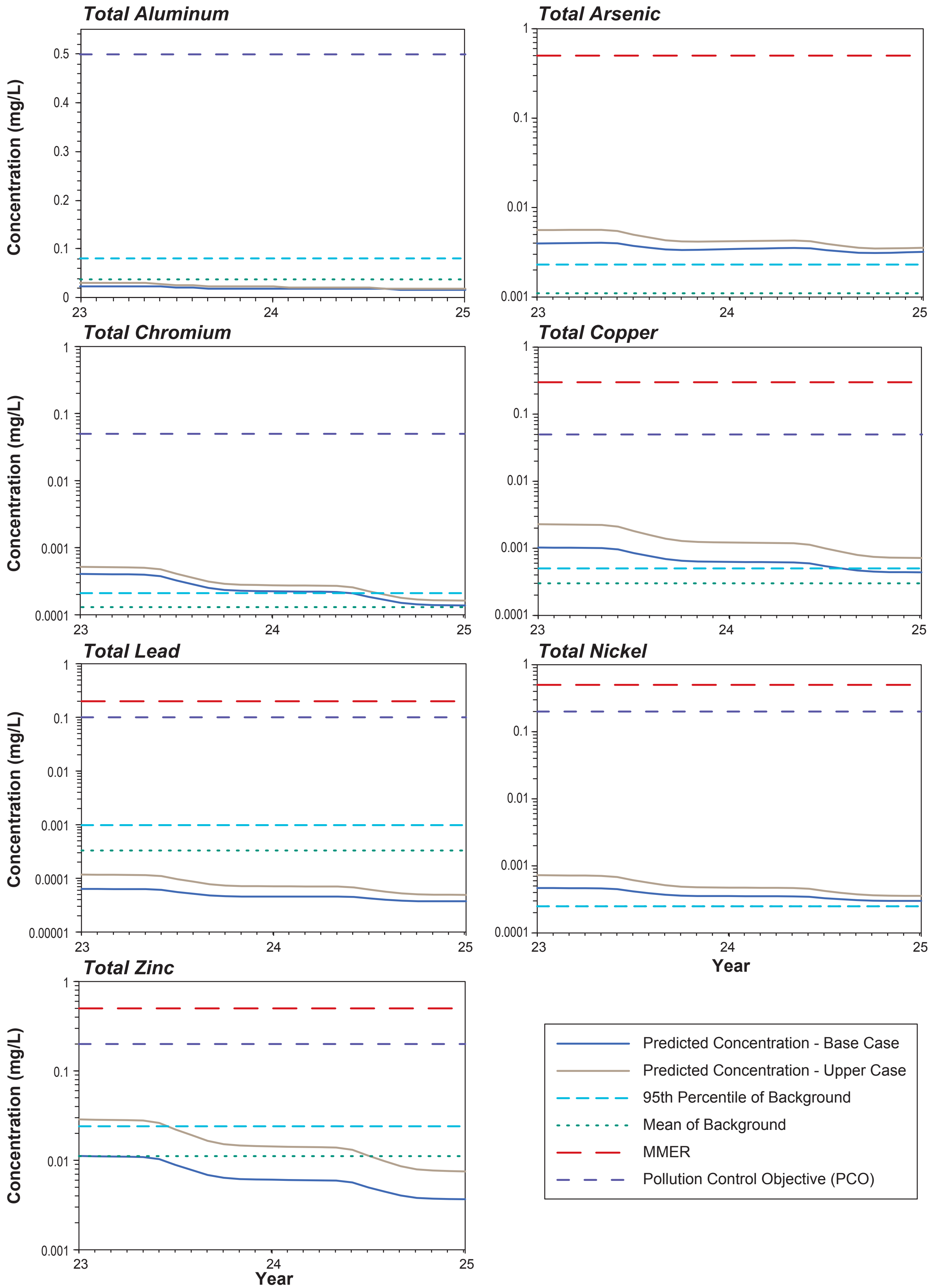


Figure 13.6-5

Water Quality Predictions for the Base Case and Upper Case (High K): Brucejack Lake Outlet, Post-Closure

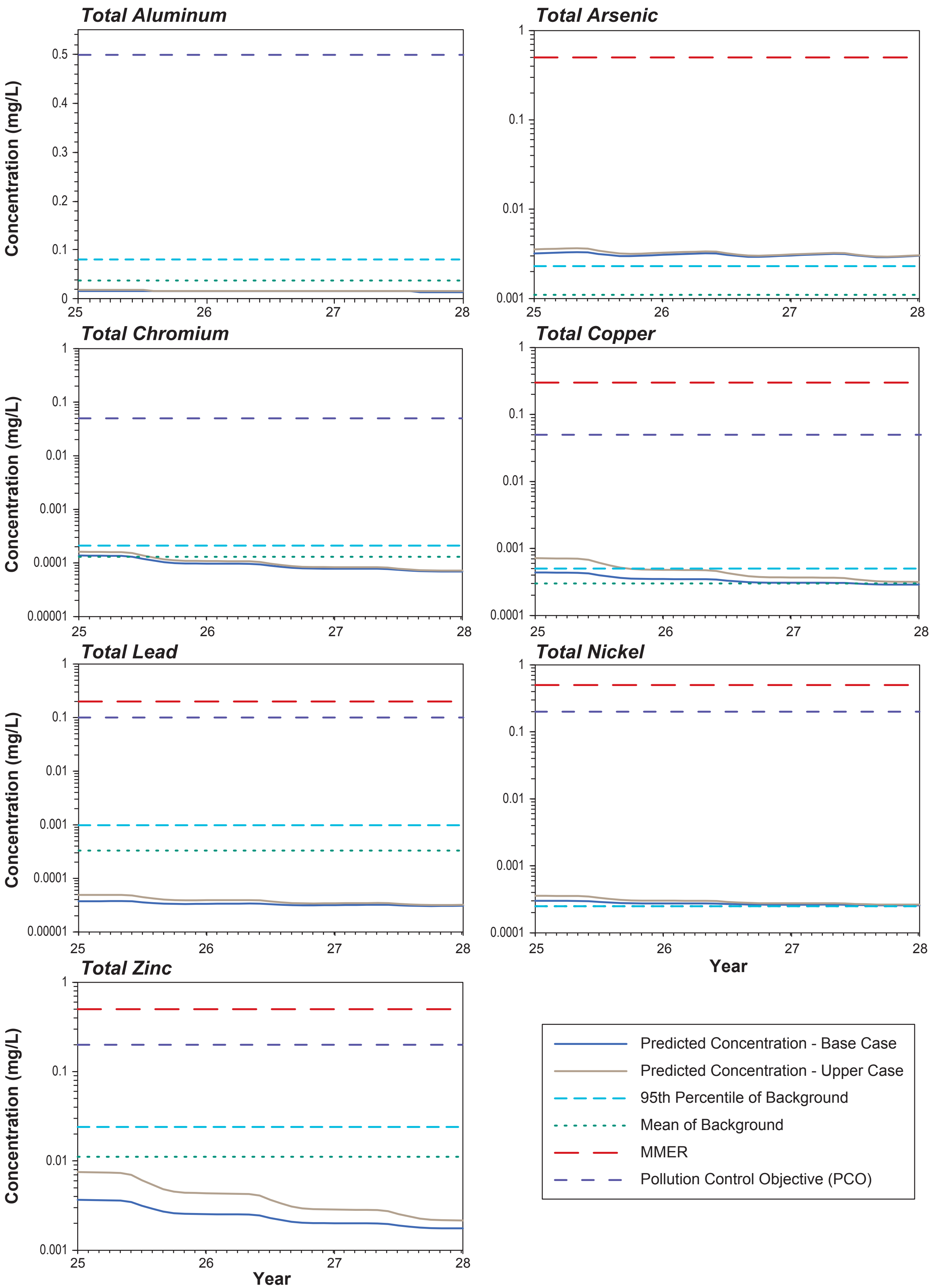


Figure 13.6-6

Water Quality Predictions for the Base Case and Upper Case (High K): Brucejack Creek, Construction

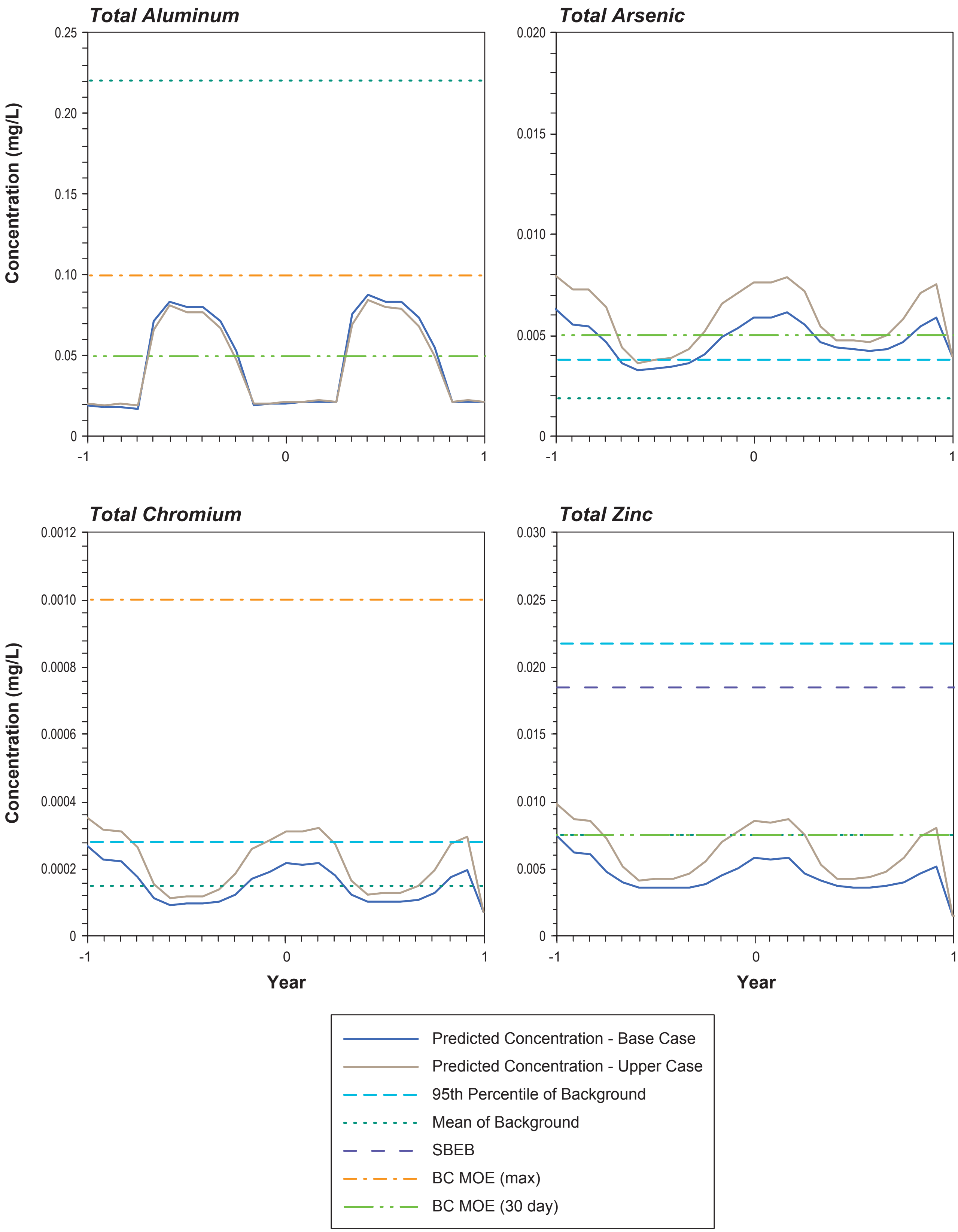


Figure 13.6-7

Water Quality Predictions for the Base Case and Upper Case (High K): Brucejack Creek, Operation

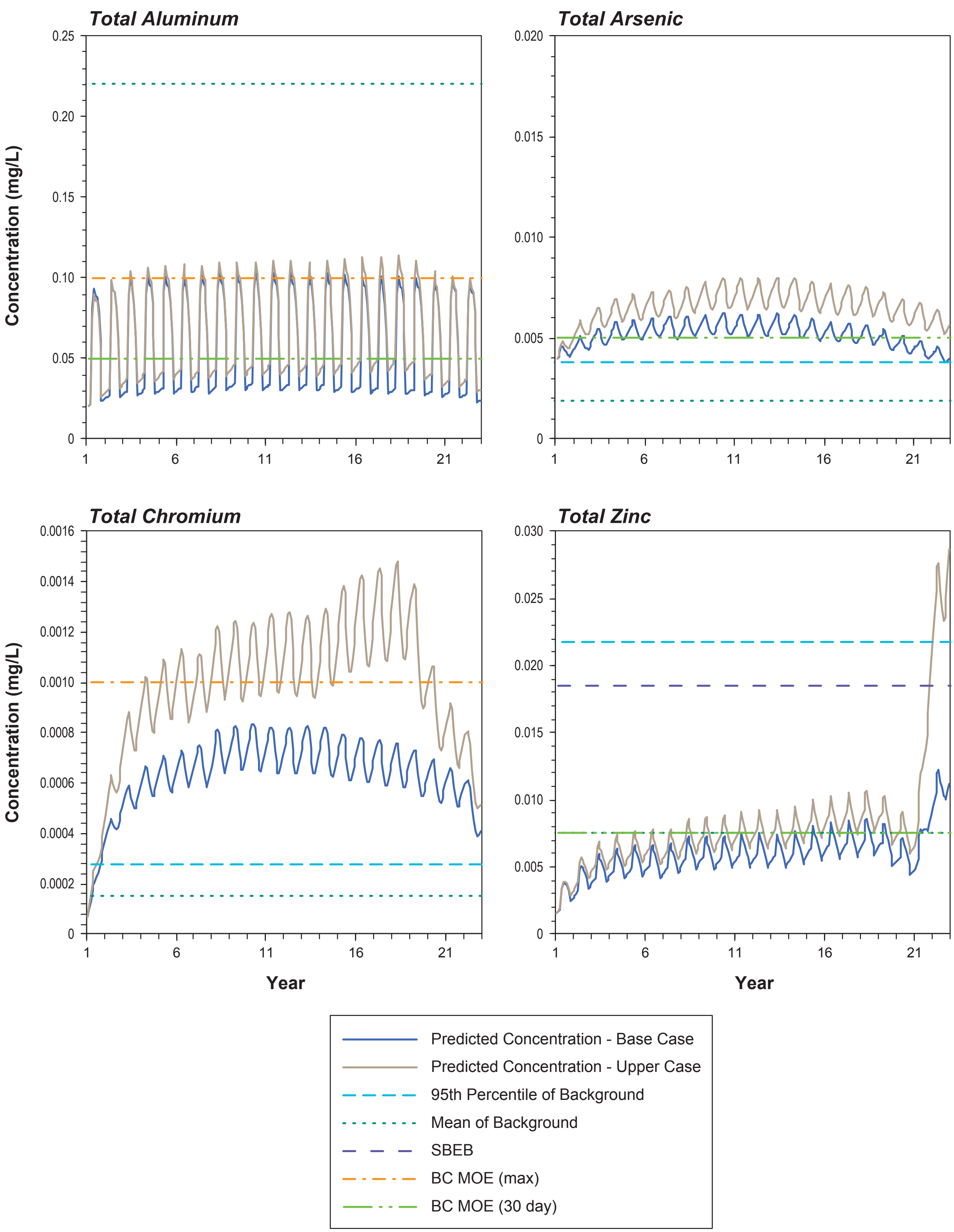


Figure 13.6-8

Water Quality Predictions for the Base Case and Upper Case (High K): Brucejack Creek, Closure

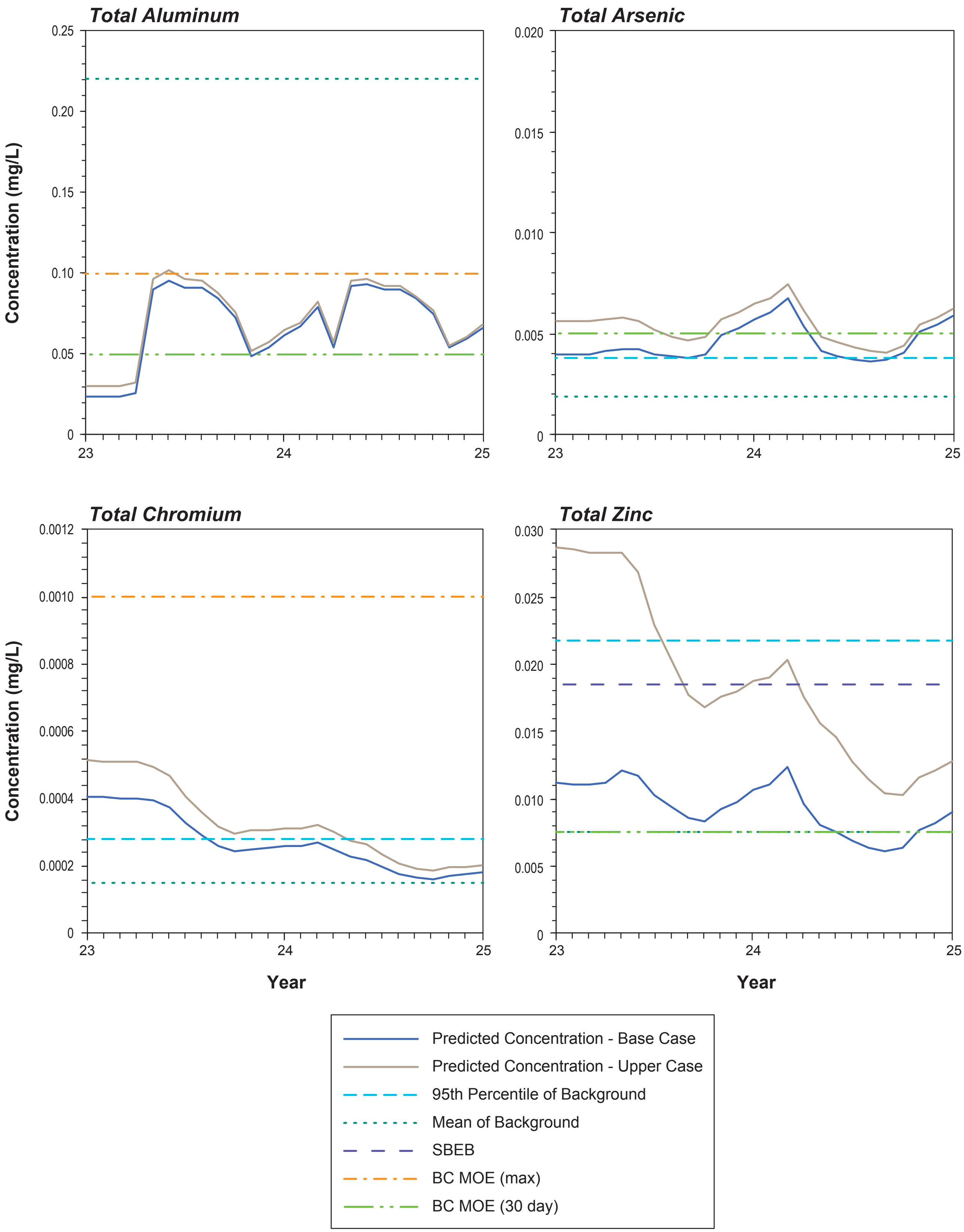


Figure 13.6-9

Water Quality Predictions for the Base Case and Upper Case (High K): Brucejack Creek, Post-Closure

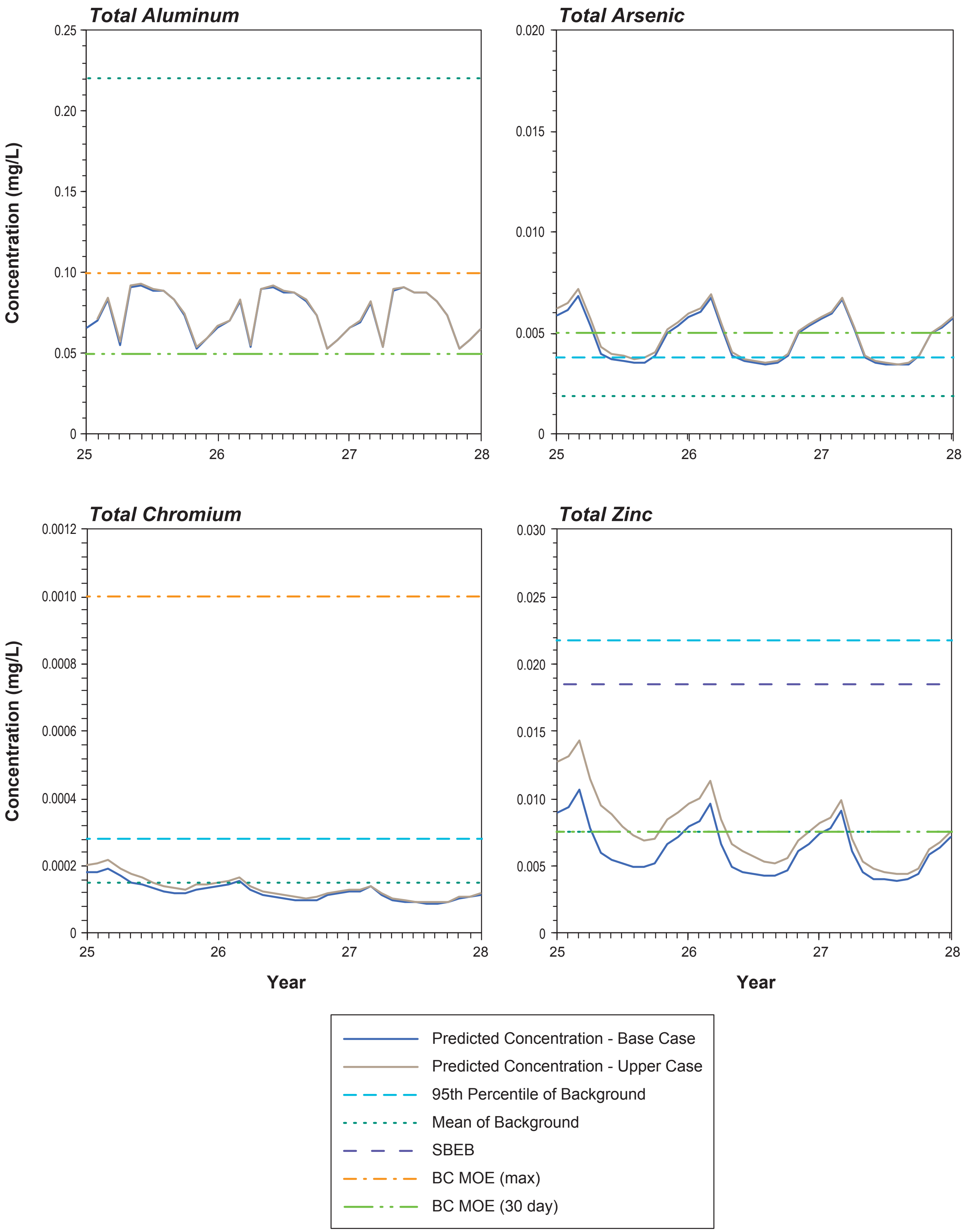


Table 13.6-4. Summary of Identified COPCs at Brucejack Lake Outlet, Modelled Cases 1 to 9

Phase			Construction (2 years)		Operation (22 years)		Closure (2 years)		Post-closure (3 years)	
Modelled Case		Hydrolgical Regime	Mean Predicted Concentration	Maxiumum Predicted Concentration	Mean Predicted Concentration	Maxiumum Predicted Concentration	Mean Predicted Concentration	Maxiumum Predicted Concentration	Mean Predicted Concentration	Maxiumum Predicted Concentration
1	Base Case (expected case)	Low Flow	-	-	-	-	-	-	-	-
		High Flow	-	-	-	-	-	-	-	-
2	High K	Low Flow	-	-	-	-	-	-	-	-
		High Flow	-	-	-	-	-	-	-	-
3	Low K	Low Flow	-	-	-	-	-	-	-	-
		High Flow	-	-	-	-	-	-	-	-
4	100 Year Wet	Low Flow	-	-	-	-	-	-	-	-
		High Flow	-	-	-	-	-	-	-	-
5	100 Year Dry	Low Flow	-	-	-	-	-	-	-	-
		High Flow	-	-	-	-	-	-	-	-
6	Conservative Adit Lag	Low Flow	-	-	-	-	-	-	-	-
		High Flow	-	-	-	-	-	-	-	-
7	Conservative Adit Concentration	Low Flow	-	-	-	-	-	-	-	-
		High Flow	-	-	-	-	-	-	-	-
8	Conservative Background	Low Flow	-	-	-	-	-	-	-	-
		High Flow	-	-	-	-	-	-	-	-
9	Conservative Solids	Low Flow	-	-	-	-	-	-	-	-
		High Flow	-	-	-	-	-	-	-	-

Notes:

COPC for the effects assessment were identified through the derivation and application of hazard quotients (HQ) for predicted water quality parameters; see Section 13.6.1 for details.

- Hazard quotient < 1.0 for all modelled parameters.

High Flow = June through October

Low Flow = November through May

Table 13.6-5. Summary of Identified COPCs for Lower Brucejack Creek (BJ 200m D/S), Modelled Cases 1 to 9

Phase			Construction (2 years)		Operation (22 years)		Closure (2 years)		Post-closure (3 years)	
Modelled Case		Hydrolgical Regime	Mean Predicted Concentration	Maxiumum Predicted Concentration	Mean Predicted Concentration	Maxiumum Predicted Concentration	Mean Predicted Concentration	Maxiumum Predicted Concentration	Mean Predicted Concentration	Maxiumum Predicted Concentration
1	Base Case (expected case)	Low Flow	-	As	As	As	-	As	-	As
		High Flow	-	As	-	As	-	-	-	-
2	High K (upper case)	Low Flow	As	As	As	As, Cr	As, Zn	As	As	As
		High Flow	-	As	As	As, Cr	-	As	-	-
3	Low K	Low Flow	-	-	-	As	-	As	-	As
		High Flow	-	-	-	As	-	-	-	-
4	100 Year Wet	Low Flow	-	As	As	As	-	As	-	As
		High Flow	-	As	-	As	-	-	-	-
5	100 Year Dry	Low Flow	-	As	As	As	-	As	As	As
		High Flow	-	As	-	As	-	-	-	-
6	Conservative Adit Lag	Low Flow	-	As	As	As	-	As	-	As
		High Flow	-	As	-	As	-	-	-	-
7	Conservative Adit Concentration	Low Flow	-	As	As	As	-	As	-	As
		High Flow	-	As	-	As	-	-	-	-
8	Conservative Background	Low Flow	As	As	As	As, Al^t	As, Al^t	As, Al^t	As, Al^t	As, Al^t
		High Flow	As, P	As, P	As, P	As, P	As, P	As, P	As, P	As, P
9	Conservative Solids	Low Flow	As	As	As	As	As	As	As	As
		High Flow	-	As	As	As	-	As	-	As

Notes:

COPC for the effects assessment were identified through the derivation and application of hazard quotients (HQ) for predicted water quality parameters; see Section 13.6.1 for details.

- Hazard quotient < 1.0 for all modelled parameters.

High Flow = June through October

Low Flow = November through May

Al^t = total aluminum; As = arsenic; Cr = chromium; P = phosphorus; Zn = zinc

13.6.2.1 Brucejack Lake Outflow

Predictive Water Quality

Brucejack Lake will be the site of waste rock and tailings disposal during the Construction and Operation phases of the Project. It will also receive water treatment plant and sewage treatment plant effluent discharges during Operation. Predictive water quality modelling assumes full mixing of Brucejack Lake for all sensitivity analyses and thus model results represent water quality of both the lake and of the lake outlet (Appendix 13-C). The water quality in Brucejack Lake was compared to MMER criteria (SOR/2002-22) and the BC Pollution Control Objectives (BC MOE 1979), as water will be directly discharged to the receiving environment. The BC objectives provide a range of concentrations for each discharge parameter, while specific discharge targets will be set during the permitting stage. Here, comparisons were made to the lower provided range, as applicable (BC MOE 1979). Water quality results from Brucejack Lake outflow in turn informed predictions at the downstream objective/assessment point, BJ 200m D/S, as discussed below.

Overall, general patterns observed for water quality predictions at the lake outlet can be related to seasonal water balance changes, the geochemical behaviour of waste rock as a function of time (e.g., the onset of acid generation), and the timing of mine activities within each mine phase (Appendix 13-C, Predictive Water Quality Report).

During the Construction (pre-production) and Operation phases, increasing concentrations of most modelled water quality parameters over time at the lake outlet are a reflection of increased accumulation of waste rock and tailings, and therefore an increased chemical loading to Brucejack Lake (Appendix 13-C). Deposition of waste rock in Brucejack Lake occurs during the Construction phase and the initial years of the Operation phase; loadings from waste rock become insignificant once deposition has ceased (Appendix 13-C). In both the expected case (base case, scenario 1) and upper case (high K, scenario 2) the concentrations of MMER-regulated deleterious substances were less than the maximum authorized concentration; i.e., calculated HQ for MMER parameters were equal to or less than 1.0 (Figures 13.6-2 to 13.6-5, Appendix 13-D, Contaminants of Potential Concern (COPC) Screening Results for Brucejack Lake Outflow, Modelled Cases 1 to 9). Concentrations of water quality parameters were also less than the lower limit of the BC PCOs for modelled parameters in the expected case (Table 13.6-4, Appendix 13-D). Manganese concentrations are predicted to be higher than the lower specific limit (guideline= 0.1 mg/L) for upper case (high K) maximum predictions during Operation and in sensitivity analyses 6 through 9 (Appendix 13-D). However, predicted concentrations of manganese in all modelled cases do not exceed BC 30-day guidelines for the protection of aquatic life (guideline = 0.70 to 0.73 mg/L). As BC 30-day guidelines are determined by BC Ministry of Environment to be protective of freshwater aquatic life receptors, there is expected to be no potential for adverse effects to water quality and manganese is not considered a COPC for the Project during the Construction and Operation phases (Table 13.6-5).

During the Closure and Post-closure phases, the concentrations of water quality parameters are predicted to substantially decrease due to cessation of directed discharges into the lake as well as dilution from surface runoff and precipitation (Appendix 13-C, Predictive Water Quality Report). Manganese concentrations exceed the lower PCO-specified limit (guideline= 0.1 mg/L) in modelled cases 6 through 8 (Appendix 13-D, Contaminants of Potential Concern (COPC) Screening Results for Brucejack Lake Outflow, Modelled Cases 1 to 9). However, in all modelled cases, manganese concentrations do not exceed BC 30-day guidelines for the protection of aquatic life (guideline = 0.70 to 0.73 mg/L). As BC 30-day guidelines are determined by BC Ministry of Environment to be protective of freshwater aquatic life receptors, there is expected to be no potential for adverse effects to water quality and manganese is not considered a COPC for the Project during the Closure and Post-closure phases.

In the upper case, concentrations of chromium, zinc, and copper concentrations are elevated relative to base case, with zinc and copper concentrations peaking over Years 23 to 24, corresponding to site closure and flooding of the underground workings, before substantially decreasing over Year 25 to Year 28 (Figures 13.6-2 to 13.6-5 of Appendix 13-C, Predictive Water Quality Report). The elevation of upper case (high K) relative to the base for these elements reflects the higher permeability term as well as the overall sensitivity of groundwater inputs for these elements in the model. That is, zinc, copper, and chromium are associated with potential ML/ARD in the underground source terms in the model and thus the high hydraulic conductivity (i.e., higher seepage) scenario results in increasing concentrations associated with increasing load. However, no parameters are predicted to exceed MMER or BC Pollution Control Objectives in any Project phase and these elements are not considered COPCs at the lake outlet (HQ ≤1.0; Appendix 13-D, Contaminants of Potential Concern (COPC) Screening Results for Brucejack Lake Outflow, Modelled Cases 1 to 9).

Predictive water quality results for the lake outlet indicate that water quality is expected to be suitable for year-round release and it is not anticipated that ongoing water treatment will be required beyond Operation. The overall potential Project-related residual effect on surface water quality at the Brucejack Lake outlet is considered to be fully mitigated and will not be considered further in this assessment. However, water quality (total and dissolved metals, anions and nutrients) will be monitored through the Aquatic Effects Monitoring Plan (Section 29.3) as per stipulations of authorizations received under MMER and the *Environmental Management Act* (2004) permit obtained for the Project; this will allow for adaptive management if effects on surface water quality and, by extension, aquatic resources, are identified.

Erosion and Sedimentation

The primary goal of sediment mitigation strategies is to prevent soils, sediments, and particulate matter from entering the receiving environment. Although identified mitigation and best management strategies (see Section 13.5.2) are effective in minimizing erosion, sedimentation, and potential siltation of the water column of the receiving environment, these strategies may not fully prevent all surface runoff and sediment entry.

Primarily, potential residual effects from erosion and sediment will occur during the Construction and Closure phases as a result of the disturbance of ground cover leading to increasing runoff of sediment, and during the Operation and Closure phases as a result of potential discharge of suspended material from Brucejack Lake resulting from the deposition of tailings and waste rock. Mitigation and management measures are predicted to be effective, including the construction of water and erosion management structures, routine monitoring of runoff for excess sediment, turbidity curtains for in-water works and waste rock deposition.

Hydrodynamic modelling of the lake was conducted to assess the effects of tailings discharge into Brucejack Lake on the migration of tailings solids to the surface layer of Brucejack Lake, and thus increased TSS loads at the Brucejack Lake outlet (Appendix 13-B, Hydrodynamic Modelling of Brucejack Lake: Effect of Proposed Tailings Discharge). In the presence of flocculation agents (resultant particle sizes ≥ 5 micron), the model results suggest that tailings particles will remain permanently in the lake bottom and thus TSS loads are not expected to increase in surface layers of Brucejack Lake due to tailings deposition (Appendix 13-B). Accordingly, the outflow of Brucejack Lake is expected to be in compliance with MMER limits (TSS = 15 mg/L) and those set by BC MOE.

The contribution of suspended sediments from waste rock deposition into Brucejack Lake may be greater than the contribution from tailings, but will be further mitigated by turbidity curtains and other mitigation measures. Waste rock deposition will also happen sporadically and the frequency of deposition will decrease throughout the Project as space for backfill underground becomes available.

Considering these predictive water quality result as well as mitigation to minimize effects, water quality at the lake outlet will be suitable for year-round release and it is not anticipated that ongoing water treatment will be required beyond Operation. The overall potential Project-related residual effect on surface water quality at the Brucejack Lake outlet is considered to be fully mitigated and will not be considered further in this assessment. However, TSS will be monitored through the Aquatic Effects Monitoring Plan (Section 29.3) as per stipulations of authorizations received under MMER and EMA permit obtained for the Project; this will allow for adaptive management if effects on surface water quality and, by extension, aquatic resources, are identified.

13.6.2.2 Brucejack Creek (BJ 200m D/S)

Predictive Water Quality

Predicted water quality in the receiving environment was assessed for Brucejack Creek (BJ 200m D/S) for the Construction, Operation, Closure, and Post-closure phases. Water quality predictions were compared to appropriate water quality guidelines as well as observed background conditions for both high and low flow periods (see Section 13.6.1.3, Screening of Contaminants of Potential Concern). Table 13.6-5 presents a summary of COPC screening results at the Brucejack Creek objective site (BJ 200m D/S) for modelled cases 1 through 9. Figures 13.6-6 to 13.6-9 present the expected (base case, scenario 1) and upper case (high K, scenario 2) water quality predictions for Construction, Operation, Closure, and Post-closure phases for the identified COPCs:

- arsenic (base case, scenario 1; scenarios 3 to 7, 9);
- arsenic, zinc, chromium (upper case, scenario 2); and
- arsenic, total aluminum, phosphorus (conservative background concentrations, scenario 8).

Table 13.6-3 presents statistical summaries of predicted concentrations (min, max, median, mean, 95th percentile) of modelled parameters for the expected case (base case) for all Project phases. Appendix 13-C, Predictive Water Quality Report, presents the results of the various sensitivity analyses.

Overall, general patterns observed for water quality predictions at the assessment point (BJ 200m D/S) can be related to seasonal water balance changes, the geochemical behaviour of waste rock as a function of time (e.g., the onset of ARD generation) and the timing of mine activities within each mine phase (Appendix 13-C, Predictive Water Quality Report). Most modelled water quality parameters are predicted to exhibit pronounced temporal and seasonal trends (Appendix 13-C). During the Construction (pre-production) phase, increasing concentrations of many water quality parameters at BJ 200m D/S are a reflection of direct discharges (water treatment plant and sewage treatment plant) into Brucejack Creek and therefore an increased chemical loading (Appendix 13-C). At Year 1 in the model (start of Operation phase), water treatment plant and sewage treatment plant discharges are directed to Brucejack Lake; this results in the sharp decline of most predicted water quality parameters at site BJ 200m D/S (Figures 13.6-6 to 13.6-9, Table 13.6-3). During Construction and Closure phases, the highest predicted concentrations of most metal elements are in low-flow months (e.g., arsenic, cadmium, chromium, silver, zinc). Exceptions were observed for concentrations of phosphorus and aluminum, where predicted maxima of these parameters were associated with periods of high flow (i.e., freshet). During Operation, highest predicted concentrations for most modelled water quality parameters are associated with high-flow months (e.g., phosphorus, aluminum, cadmium, silver, and zinc). Exceptions were observed for arsenic and chromium, where predicted maxima of these parameters were associated with low-flow months.

Modeled high values of phosphorus in Brucejack Creek are likely attributed to high P values associated with Camp Creek source terms used in water quality modeling. This dataset contained limited pre-disturbance data (Section 13.3, Appendix 3-A, Appendix 3-C). Specifically, sampling prior to 2010 was limited to summer or higher flow months and provided a limited analyte suite with higher detection limits than observed in current practices. Further sampling of this water course through exploration and early construction is denoted in the ML/ARD Management Plan (Section 29.10), for the purpose of refining Camp Creek source terms and likely additional simulations.

HQ calculations were used to screen for potential residual effects for water quality. Water treatment at the water treatment plant, including flocculation and settling for TSS control, is predicted to reduce the total concentrations of various metals below baseline conditions at BJ 200m D/S (e.g., iron, copper, lead, and silver) or guideline values (e.g., sulphate, ammonia, nitrate, manganese, iron, selenium) during all Project Phases resulting in HQ equal to or less than 1.0 (Appendix 13-E, Contaminants of Potential Concern (COPC) Screening Results for Brucejack Creek (BJ 200m D/S), Modelled Cases 1 to 9).

HQ greater than 1.0 were calculated for total arsenic during the Construction, Operation, Closure and Post-closure phases of the Project at site BJ 200m D/S (Table 13.6-5). However, exceedances of BC guidelines (guideline= 0.005 mg/L) are consistently of low magnitude during all phases (HQ range: 1.1 to 1.6). During Operation, total arsenic concentrations are elevated relative to other Project phases, ranging from 0.0040 mg/L to 0.0063 mg/L (base case) and 0.0040 mg/L to 0.0080 (upper case); HQ greater than 1.0 were found for both maximum and mean predicted concentrations (Table 13.6-5, Appendix 13-E, Contaminants of Potential Concern (COPC) Screening Results for Brucejack Creek (BJ 200m D/S), Modelled Cases 1 to 9). Loadings of arsenic are associated with subaqueous waste rock deposition upstream at Brucejack Lake as well as contact water from the underground mine (Appendix 13-C). Arsenic concentrations generally decline during the final years of the Operation phase as well as within the Closure and Post-closure phases (Figures 13.6-7 to 13.6-9). In Post-closure (Year 25 to Year 28), arsenic concentrations range from 0.0035 to 0.0068 mg/L (base case) and 0.0035 mg/L to 0.0069 mg/L (upper case) at site BJ 200m D/S. In both base case and upper case scenarios HQ greater than 1.0 are only associated with low flow periods and only associated with maximum predicted concentrations for the base case (expected case; Table 16.6-5 of Appendix 13-E, Contaminants of Potential Concern (COPC) Screening Results for Brucejack Creek (BJ 200m D/S), Modelled Cases 1 to 9). Guideline exceedances are of low magnitude during this period: base case (HQ = 1.4), upper case (HQ = 1.1 to 1.4).

To some degree, prediction of elevated arsenic concentrations after implementation of mitigation and management measures, including water treatment, may be reflective of the high degree of conservatism employed in source terms and loadings for all sensitivity analyses (Section 13.6.1.1; Appendix 13-C, Predictive Water Quality Report). Further, the load balance in the model is based on conservation of mass. As such, the model does not include the potential effects of equilibrium reactions that would lead to the formation of secondary minerals, which, in some cases, would result in a net removal of solutes from solution, reducing the concentrations of some parameters upstream at Brucejack Lake as well as at site BJ Creek 200m D/S. Further, at the pH/Eh conditions in Brucejack Creek (i.e., circumneutral to slightly alkaline, fully oxygenated), there is an expectation of sorption and natural attenuation of arsenic, as well as other metal elements, to sedimentary materials and mineral surfaces. Common secondary minerals with strong natural affinity for arsenic expected at these physico-chemical conditions, include hydrous ferric oxides (e.g., ferrihydrite, HFO), goethite (α-FeOOH), disordered mackinawite (FeS), and schwertmannite (an iron-oxyhydroxysulfate). Therefore, both the predicted concentrations and mobility of arsenic may be overestimated within the model. However, arsenic concentrations will be monitored through the Aquatic Effects Monitoring Plan (Section 29.3) which will allow for adaptive management if effects on aquatic life are identified. Further characterization of residual effects to surface water quality associated with arsenic-COPC is presented in Section 13.7, Characterizing Residual Effects, Significance, Likelihood, and Confidence on Surface Water Quality.

In the sensitivity analyses, two additional COPCs were identified as per the upper case (high K, scenario 2): chromium (maximum predicted concentrations during Operation only) and zinc (in low flow periods during the Closure phase). These parameters are associated with potential ML/ARD in the underground and thus the high hydraulic conductivity (i.e., higher seepage) scenario results in increasing concentrations associated with increasing load from the underground. Further, as the upper K scenario relates to higher groundwater recharge, elevated chromium and zinc concentrations are also influenced by naturally enriched values in ground water; in baseline studies all groundwaters measured showed elevated baseline concentrations of total aluminum, silver, arsenic, chromium, copper, iron and zinc (Appendix 9-A). However these COPCs are restricted to this single case and are short in duration (Figures 13.6-6 to 13.6-9). That is, elevated zinc concentrations are only associated with end of Operation and flooding of the underground workings, Year 22 to Year 24 (Figures 13.6-6 to 13.6-9). Chromium concentrations are elevated during Operation in scenario 2, but return to baseline concentrations during the Closure Phase (Year 23 to Year 25). Further, general model conservatism, as described above for arsenic, may have resulted in the overestimation of these parameters; in particular, zinc would exhibit strong cationic sorption/uptake behavior with secondary minerals and sedimentary materials under these physico-chemical conditions. Further characterization of residual effects to surface water quality associated with chromium and zinc COPCs is presented in Section 13.7, Characterizing Residual Effects, Significance, Likelihood and Confidence on Surface Water Quality. Chromium and zinc concentrations will be monitored through the Aquatic Effects Monitoring Plan (Section 29.3), which will allow for adaptive management if effects on aquatic life are identified.

In the conservative background concentration sensitivity analyses (scenario 8), phosphorus and aluminum were identified as additional COPCs for the Project. These modelled cases employed 95th percentile concentrations for baseline water quality parameters (i.e., associated with a low probability, $p \leq 0.05$). The identification of aluminum and phosphorus as COPCs are restricted to this single conservative background case. Model results indicate minor guideline exceedances (range: 1.1 to 1.8 (aluminum); 2.8 to 4.3 (phosphorus). This is a reflection of the application of 95th percentile baseline concentrations rather than mean values to inform the model; all other source terms remain consistent with those used to inform the base case, scenario 1 (Section 13.6.1). Specifically, phosphorus loadings are associated with inputs from Camp Creek and corresponding exceedances (HQ >1.0) were observed for both mean and maximum predicted concentrations for all Project Phases (Table 13.6-5, Appendix 13-E, Contaminants of Potential Concern (COPC) Screening Results for Brucejack Creek (BJ 200m D/S), Modelled Cases 1 to 9). Aluminum loadings are generally associated with baseline water quality source terms as well as waste rock source terms; corresponding guideline exceedances were minor and restricted to low flow periods (HQ range: 1.1 to 1.8). As aluminum and phosphorus exceedances were restricted to this single case, and exceedances are both associated with baseline water quality source terms and are considered to have very low probability. However, concentrations of phosphorus and aluminum will be monitored through the Aquatic Effects Monitoring Plan (Section 29.3) which will allow for adaptive management if effects on surface water quality and, by extension aquatic resources are identified.

Concentrations of some major ions and nutrients, including sulphate, ammonia, nitrite, and nitrate, are expected to increase in concentration in the receiving environment downstream at BJ 200m D/S as per base case and upper case scenarios during the Construction and Operation phases (Appendix 13-C, Predictive Water Quality Report); however all HQ ≤ 1.0 (Table 13.6-3, Appendix 13-E, Contaminants of Potential Concern (COPC) Screening Results for Brucejack Creek (BJ 200m D/S), Modelled Cases 1 to 9). This is generally related to the sewage treatment plant effluent source term (Appendix 13-C). Sewage treatment plant effluent is discharged to Brucejack Creek during the Construction phase and to Brucejack

Lake during the Operation phase. The effect of sewage treatment plant discharge on nutrient levels at BJ 200m D/S is larger when the discharge is not buffered by the lake system (Appendix 13-C). The effect of increased nutrients on aquatic resources (primary and secondary producers, sediment quality) is assessed in Chapter 14, Assessment of Potential Aquatic Resources Effects. Further characterization of residual effects to surface water quality associated with nutrients is presented in Section 13.7, Characterizing Residual Effects, Significance, Likelihood and Confidence on Surface Water Quality. Nutrient concentrations will be monitored through the Aquatic Effects Monitoring Plan (Section 29.3), which will allow for adaptive management if effects on aquatic life are identified.

Erosion and Sedimentation

The primary goal of sediment mitigation strategies is to prevent soils, sediments and particulate matter from entering the receiving environment. Although identified mitigation and best management strategies (Section 13.5.2) are effective in minimizing erosion, sedimentation, and potential siltation of the water column of the receiving environment, these strategies may not fully prevent all surface runoff and sediment entry. Potential residual effects from sedimentation and erosion events are as described above for the Brucejack Lake outlet. It is possible, however, that suspended sediment concentrations will be greater than BC water quality guidelines for the protection of aquatic life due to erosion and sedimentation events, should they occur. TSS loads were generally low in Brucejack Creek (mean: 7.5 mg/L; max: 17.3 mg/L) compared to other streams within the LSA/RSA and thus has greater potential to be impacted by erosion and sedimentation events, should they occur.

Model results suggest that tailings particles will remain permanently in the lake bottom based on normal operating conditions and there is no expected migration of tailings particles to Brucejack Creek and corresponding increase in TSS loads (Section 13.6.2.1).

Further characterization of residual effects to surface water quality associated with erosion and sedimentation is presented in Section 13.7, Characterizing Residual Effects, Significance, Likelihood and Confidence on Surface Water Quality. TSS will be monitored through the Aquatic Effects Monitoring Plan (Section 29.3) which will allow for adaptive management if effects on aquatic life are identified.

13.6.2.3 Sulphurets and Unuk Watersheds

Water Quality Assessment

Project related activities in these areas are not expected to directly affect surface water quality and semi-quantitative assessments were performed in these areas.

Discharges from the lake outlet will undergo further dilution along the flow pathway from BJ 200m D/S (objective/assessment point) to sites upstream and downstream of Sulphurets Glacier (BJ 3 and SC0, respectively). Analysis of 1194 daily flows (recorded during 2008 to 2011; see Chapter 10, Surface Water Hydrology Predictive Study) at hydrometric stations BJL-H1 and SL-H1 shows that the dilution potential due to increased drainage area and stream flows in the Sulphurets watershed ranges between 1.2 and 50.7 (Table 13.6-6). The analysis also suggests a median value of 7.1, which is consistent with the ratio of SL-H1 drainage area to BJL-H1 drainage area (84.2 km^2 / 11.7 km^2 = 7.2).

Table 13.6-6. Summary of Dilution Factors for Discharge Flow Pathway, Brucejack Gold Mine Project

Statistics	Streamflow Ratio ($Q_{SL\text{-}H1}/Q_{BJL\text{-}H1}$)[1,2]
Minimum	1.2
95% exceeded	2.1
75% exceeded	4.3
50% exceeded (median)	7.1
25% exceeded	15.3
5% exceeded	27.0
Maximum	50.7

Notes:
[1] Site SL-H1 Corresponds to hydrometric station SL-H1, at the outlet of Sulphurets Lake (see Chapter 10, Surface Water Hydrology Predictive Study)
[2] Site BJL-H1 corresponds to hydrometric station BJL-H1 at lower Brucejack Creek, and also water quality station BJ 2 (see Chapter 10, Surface Water Hydrology Predictive Study).

Hazard quotients of guideline exceedances for identified COPCs (As, Cr, and Zn) range from 1.1 to 1.6 (base case) and 1.1 to 1.4 (upper case; Appendix 13-E, Contaminants of Potential Concern (COPC) Screening Results for Brucejack Creek (BJ 200m D/S), Modelled Cases 1 to 9). Thus, considering a ratio of 2.1 (lower end of predictions), there will be no identifiable guideline exceedances in Sulphurets Creek due to inputs upstream in Brucejack Creek. Further, predicted water quality at BJ 200m D/S in general has lower mean and median concentrations of total and dissolved metals and other water quality parameters than that of background water quality in Sulphurets Creek (see Tables 13.3-4, 13.6-2). Sulphurets Creek drains the mineralized Kerr and Sulphurets mineral deposits (plus other mineralized zones) and receives poor quality water from Mitchell Creek, which is influenced by naturally occurring acid rock drainage. Thus, the substantial natural change in water chemistry observed as Brucejack Creek passes under Sulphurets Glacier and joins the existing sub-glacial flow of Sulphurets Creek (see Section 13.3.4.2) would result in any potential incremental increase in water quality parameters due to chemical loading upstream at Brucejack creek and lake to be negligible/ undetectable in Sulphurets Creek. Project effects on water quality of Sulphurets Creek will not be considered further in this assessment.

As effects are predicted to be restricted to the Brucejack watershed, the potential for any transboundary effects to occur (i.e., change in water quality 45 km downstream of the outflow of Brucejack Lake) which, in turn, would act as a cause-effect pathway affecting surface water quality the lower Unuk River (Alaska), is considered extremely unlikely and will not be considered further.

Monitoring of environments upstream of Sulphurets Creek and the Unuk watershed will occur through the Aquatic Effects Monitoring Plan (Section 29.3). Monitoring programs will include triggers for risk assessment of potential effects, which will ensure detection of measureable alterations in surface water quality, allow for identification of potential causes, and include the provision of additional mitigation or adaptive management strategies. This will allow for adaptive management if effects on surface water quality are identified upstream, and by extension, possible effects to the downstream environments.

Erosion and Sedimentation

The residual effects from erosion and sedimentation in the mine site area are predicted to be restricted to the LSA. Any material transported by Brucejack Creek will be combined with the sediments entrained under the Sulphurets Glacier, and the baseline sampling program indicates that Brucejack Creek is a negligible contributor to the overall sediment loading (Section 13.3.4). Any contribution of sediments from Project activities will thus be negligible and indistinguishable from background sources of sediments from the Sulphurets Glacier and downstream. Erosion and sedimentation effects on water quality of Sulphurets Creek will not be considered further in this assessment. A summary of anticipated residual effects for surface water quality for the Brucejack Mine Site Area and Receiving Environment is presented in Table 13.6-7.

As no potential effects are anticipated in Sulphurets Creek, the potential for any transboundary effects to occur (i.e., change in water quality 45 km downstream of the outflow of Brucejack Lake) which, in turn, would act as a cause-effect pathway affecting surface water quality in the lower Unuk River (Alaska), is considered extremely unlikely and will not be considered further.

Monitoring of environments upstream of Sulphurets Creek and the Unuk River will occur through the Aquatic Effects Monitoring Plan (Section 29.3). Monitoring programs will ensure detection of measureable alterations in surface water quality, allow for identification of potential causes, and include the provision of additional mitigation or adaptive management strategies. This will allow for adaptive management if effects on surface water quality are identified upstream, and by extension, possible effects to the downstream environments.

13.6.3 Residual Effects: Off-site Areas

13.6.3.1 Change in Surface Water Quality

Residual effects are assessed qualitatively because of the short duration and limited scope and duration of Project activities in off-site areas.

In off-site area there is generally minimal risk of effects to surface water quality due to the limited extent of Project activities in these areas. To be conservative, potential effects to surface water quality cannot be completely ruled out with certainty; there is potential for a change in surface water quality due to aggregate/combined effects of the pathways outlined in Section 13.5.3. That is, ML/ARD mitigation, sediment and erosion control, and explosives management, as described in Chapter 29, Environmental Management and Monitoring Plans, and in Section 13.5.4 will prevent substantial change of surface water quality near access road and other ancillary Project infrastructure. It is likely, however, that some change in surface water quality of receiving watercourses in off-site areas will occur at some point during the life of the Project given this high runoff environment and associated potentials for ML/ARD and sedimentation/erosion effects to receiving waters, as well as low background nitrogen concentrations. Water quality responses to run-off include increased concentrations of TSS, metals, and salinity, but tend to be temporary and localized (Forman 1998). Further, watercourses in off-site areas are of generally high flow and the receiving environment would provide a correspondingly high dilution capacity. Thus it is expected that incremental changes to water quality resulting in guideline exceedances are unlikely to occur.

A summary of anticipated residual effects for surface water quality for off-site areas is presented in Table 13.6-8.

Table 13.6-7. Summary of Residual Effects on Surface Water Quality: Mine Site Area and Downstream Receiving Environment

Sub-Component	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 water quality of receiving environment (Brucejack Creek)	Construction, Operation, Closure, Post-closure.	Water treatment plant and sewage treatment plant discharges into Brucejack Creek (Construction) and Brucejack Lake (Operation, Closure) as well as waste rock and tailings deposition upstream in Brucejack Lake (discharge from lake outlet).	Change of water quality due to chemical loadings upstream at the lake outlet (ML/ARD, discharges, groundwater interactions and seepage); COPC: arsenic, associated with waste rock deposition and contact water from the underground workings.	Implementation of ML/ARD Management Plan (Section 29.10), Waste Rock Management Plan (Section 29.18), Tailings Management Plan (Section 29.15), Water Management Plan (Section 29.19), Aquatic Effects Monitoring Plan (Section 29.3); collection and treatment of seepage from underground workings.	Change of water quality due to localized increases in metal concentrations (COPCs: arsenic).
Change in water quality of receiving environment (Brucejack Creek)	Operation, Closure	Water treatment plant and sewage treatment plant effluent discharges into Brucejack Creek (Construction) and Brucejack Lake (Operation, Closure) as well as waste rock and tailings deposition upstream in Brucejack Lake (discharge from lake outlet).	Change of water quality due to chemical loadings upstream at the lake outlet (ML/ARD, discharges, groundwater interactions and seepage). COPC: chromium and zinc, associated contact water from the underground workings.	Implementation of ML/ARD Management Plan (Section 29.10), Waste Rock Management Plan (Section 29.18), Tailings Management Plan (Section 29.15), Water Management Plan (Section 29.19), Aquatic Effects Monitoring Plan (Section 29.3); collection and treatment of seepage from underground workings.	Change of water quality due to localized increases in sulphate and metal concentrations (COPCs: chromium, zinc).
Change in water quality of receiving environment (nitrogen loading)	Construction, Operation, Closure, Post-closure	Leaching of blasting residues used during pad construction (e.g., mill site, lay-down areas), as well as waste rock.	Change of water quality due to leaching of blasting residues on disturbed rock material/ waste rock deposition upstream at Brucejack Lake	Implementation of Waste Rock Management Plan (Section 29.18), Water Management Plan (Section 29.19), Aquatic Effects Monitoring Plan (Section 29.3); collection and treatment of seepage from underground workings.	Change of water quality due to localized increases in nitrogen as nitrate, nitrite, ammonia
Change in water quality of receiving environment (erosion and sedimentation)	Construction, Operation, Closure, Post-closure	All Project components during construction and site decommissioning phases; during Operation, main components are surface water diversions for contact and non-contact water, deposition of waste rock and tailings in Brucejack Lake; Post-closure include un-reclaimed surface disturbances and discharge from the lake outlet	Change of water quality due to sedimentation and erosion	Use of best management practices to minimize sediment entry to waterbodies; Dust suppression on roads; Implementation of Soils Management Plan (Section 29.13), Water Management Plan (Section 29.19), Aquatic Effects Monitoring Plan (Section 29.3).	Potential degradation of water quality due to localized increases in TSS and turbidity.

[1] *"Cause-effect" refers to the relationship between the Project component/physical activity that is causing the change or effect in the condition of the receptor VC.*

Table 13.6-8. Summary of Residual Effects on Surface Water Quality: Off-site Areas

Sub-Component	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 water quality of receiving environment	Construction, Operation, Closure	Ancillary Project infrastructure (Bowser Aerodrome, Knipple Transfer Area, Brucejack Access Road)	Change of water quality of the receiving environment	Implementation of ML/ARD Management Plan (Section 29.10), Soils Management Plant (Section 29.13), Transportation and Access Management Plan (Section 29.16), BMPs	Potential change of water quality due to temporary, localized increases in metal and sulphate concentrations, TSS and turbidity and nitrogen concentrations, in streams and lakes near off-site ancillary Project infrastructure.

[1] *"Cause-effect" refers to the relationship between the Project component/physical activity that is causing the change or effect in the condition of the receptor VC.*

13.7 CHARACTERIZING RESIDUAL EFFECTS, SIGNIFICANCE, LIKELIHOOD AND CONFIDENCE ON SURFACE WATER QUALITY

13.7.1 Characterizing Residual Effects

Residual effects of the Project on surface water quality identified in Section 13.6 are further characterized and assessed in this section. Residual effects are characterized using standard criteria (i.e., the magnitude, geographic extent, duration, frequency, reversibility, resiliency, and ecological context). Standard ratings (e.g., major, moderate, minor/low, medium, and high) for these characterization criteria are provided in Section 6.6.2 of the methodology chapter; however, Table 13.7-1 provides a summary of definitions for each characterization criterion, specific to surface water quality.

Characterization of residual effects, likelihood, significance, and confidence on surface water quality within the mine site area /receiving environment as well as off-site areas (off-site Project infrastructure) are presented in Tables 13.7.2 and 13.7.3, respectively. The assessment considered results of surface water quality baseline studies, predictive water quality modelling, and feedback received during the pre-Application stage from review participants, relevant legislation/standards, scientific literature and professional experience/judgement.

The magnitude of the effect is determined through comparison of expected case (base case, scenario 1) and upper case (high K, scenario 2) predicted water quality to baseline conditions and BC 30-day mean water quality guidelines for the protection of freshwater aquatic life, as outlined is Section 13.6.1.2. The upper limit to the range of natural variation was defined as the 95th percentile of baseline data.

The geographic extent of the effect is the receiving environment. The local extent is confined to the Project footprint for the off-site areas and the near-field receiving environment for the Brucejack Mine Site (LSA). The landscape extent includes watercourses within the LSA (off-site Areas) and mid- and far- field receiving environments for the Brucejack Mine Site (i.e., outside the LSA in lower Brucejack Creek (BJ 2, BJ3) and Sulphurets Creek). The regional extent includes the Unuk River (mine site area) and water courses within the RSA (off-site areas).

The definitions of duration and frequency are based on the length of Project phases and occurrence of the effect. Duration refers to the length of time the effect lasts; frequency refers to how often the effect occurs.

The reversibility of the effect is based on the source of the effect. Reversible effects are resolvable upon removal of a point source/ cessation of Project-related activity. Irreversible effects are predicted to remain indefinitely upon removal of the point source/ cessation of Project-related activity.

Resiliency refers to the capacity of the habitat to recover following disturbances (i.e., return to baseline conditions).

The ecological context of the effects is dependent on the aquatic habitat value for a specific geographic area as well its condition. For example the Brucejack watershed has low aquatic resources value and no fisheries value. In contrast, the Unuk River, Bowser Lake and Wildfire area creeks have higher aquatic habitat and fisheries value.

Table 13.7-1. Definitions of Characterization Criteria for Residual Effects on Surface Water Quality

Magnitude	Duration	Frequency	Geographic Extent	Reversibility	Resiliency	Ecological Context
Minor: The magnitude of effect is within the range of natural variation and/or is well below a guideline or threshold value.	**Short-term:** Effect lasts approximately 1 year or less	**Once:** The effect that occurs once or infrequently during any phase of the Project	**Local:** The effect is limited to the Project footprint in off-site areas and the LSA for the mine site	**Reversible short-term:** The effect can be reversed relatively quickly	**Low:** The receptor is considered to be of low resiliency following disturbances	**Low:** The receptor is considered to have little to no unique attributes in the geographic area
Moderate: The magnitude of effect approaches the limits of natural variation and/or is below or equal to a guideline or threshold value.	**Medium - term:** Effect lasts more than a year but less than eleven years	**Sporadic:** The effect that occurs at sporadic or intermittent intervals during any phase of the Project	**Landscape:** The effect extends beyond the Project footprint to a broader area (limited to portions of RSA) in off-site areas and mid- and far-field environments for the mine site area	**Reversible medium-term:** The effect can be reversed after a few years	**Neutral:** The receptor is considered to be moderately resilient following disturbances	**Neutral:** The receptor is considered to have some unique attributes in the geographic area
Major: The magnitude of effect is predicted to differ from baseline conditions and exceed guideline or threshold values so that there will be a detectable change beyond the range of natural variation (i.e., change of state from baseline conditions)	**Long-term:** Effect lasts more than eleven years but less than thirty years	**Regular:** The effect that occurs on a periodic basis during any phase of the Project	**Regional:** The effect extends across the RSA. For the mine site area, the effect is regional if it occurs in Sulphurets Creek, downstream of Sulphurets Lake and the Unuk River	**Reversible long-term:** The effect can be reversed after many years	**High:** The receptor is considered to be highly resilient following disturbances	**High:** The receptor is considered to be unique in the geographic area
	Far Future: Effect lasts more thirty years	**Continuous:** The effect that occurs regularly during any phase of the Project and beyond	**Beyond Regional:** The effect extends beyond the RSA possibly across or beyond the province (transboundary effects)	**Permanent:** The effect cannot be reversed		

Table 13.7-2. Characterization of Residual Effects, Significance, Confidence, and Likelihood on Surface Water Quality: Mine Site Area

Description of Residual Effect	Evaluation Criteria: Magnitude *(low, moderate, high)*	Duration *(short, medium, long, far future)*	Frequency *(once, sporadic, regular, continuous)*	Geographic Extent *(local, landscape, regional, beyond regional)*	Reversibility *(reversible short term; reversible medium term; reversible long term; permanent)*	Resiliency *(low, neutral, high)*	Context *(low, neutral, high)*	Significance of Adverse Residual Effects	Likelihood *(low, medium, high)*	Confidence *(low, medium, high)*
Effect: Change in water quality of receiving environment due to ML/ARD, Groundwater Interactions and Seepage (COPCs: arsenic). **Timing**: Construction, Operation, Closure, Post-closure.	High	Far future	Sporadic to Regular	Local	Permanent	High	Low	Not significant	High	High
Effect: Change of water quality due to ML/ARD, Groundwater Interactions and Seepage, Discharges (COPCs: phosphorus, aluminum, chromium, zinc). **Timing:** Operation, Closure.	High	Long	Sporadic	Local	Reversible medium term	High	Low	Not significant	Low	High
Effect: Change of water quality due to localized increases in nitrogen as nitrate, nitrite, ammonia (leaching of blasting residues). **Timing:** Construction, Operation, Closure, Post-closure.	Moderate	Medium	Continuous	Local	Reversible short term	High	Low	Not significant	High	High
Effect: Change of water quality of receiving environment due to erosion and sedimentation. **Timing:** Construction, Operation, Closure, Post-closure.	High	Short	Sporadic	Landscape	Reversible short term	High	Low	Not significant	High	High
Overall Effect	High	Medium	Sporadic	Local	Reversible medium term	High	Low	Not significant	High	High

Table 13.7-3. Characterization of Residual Effects, Significance, Confidence, and Likelihood on Surface Water Quality: Off-site Areas

Description of Residual Effect	Evaluation Criteria							Significance of Adverse Residual Effects	Likelihood *(low, medium, high)*	Confidence *(low, medium, high)*
	Magnitude *(low, moderate, high)*	**Duration** *(short, medium, long, far future)*	**Frequency** *(once, sporadic, regular, continuous)*	**Geographic Extent** *(local, landscape, regional, beyond regional)*	**Reversibility** *(reversible short term; reversible medium term; reversible long term; permanent)*	**Resiliency** *(low, neutral, high)*	**Context** *(low, neutral, high)*			
Effect: Change in water quality of receiving environment due to localized increases in metal and sulphate concentrations, TSS and turbidity and nitrogen concentrations, in streams and lakes near off-site ancillary project infrastructure. **Timing**: Construction, Operation, Closure.	low	Short	Sporadic to Regular	Local	Reversible short term	High	Neutral	Not significant	Low	High
Overall Effect	low	Short	Sporadic	Local	Reversible short term	High	Neutral	Not significant	Low	High

13.7.2 Residual Effects Characterization: Mine Site Area

13.7.2.1 Characterizing Residual Effects: Mine Site Area

A summary of anticipated residual effects for surface water quality is presented in Table 13.6-7. The following sections present characterization, likelihood, and significance of anticipated residual effects, which are summarized in Table 13.7-2.

Change in Water Quality in the Receiving Environment

Best management practices, ML/ARD mitigation, and water treatment, as described in Chapter 29, Environmental Management and Monitoring Plans, and in Section 13.5.2, have minimized potential changes of surface water quality in Brucejack Creek.

A Project related effect on water quality due to increased arsenic concentrations is predicted in the Construction, Operation, Closure, and Post-closure phases (base case, upper case, and modelled cases 3 through 9). As was mentioned in Section 13.6.2 and appendix 3-C, water quality modeling applies a conservative approach to deriving source term values, with the possibility of taking an iterative approach following additional sampling and/or new information. Predicted arsenic exceedances during Construction and initial Operation are likely attributed to the subaqueous disposal of waste rock to Brucejack Lake and the subsequent soluble elemental loads from this activity. These source terms are scaled based particle size distribution results for the purpose of relating laboratory test-work to field conditions. The upper end-member (i.e., most conservative) result was used in this scaling process. In contrast, the application of the least conservative end-member would reduce waste rock loads by a factor of 10. The magnitude of the effect is **major** because arsenic concentrations (mean, maximum) are predicted to be higher than baseline conditions (Section 13.6.2) and to exceed a guideline or threshold value beyond the range of natural variation ("change of state from baseline conditions"). However, exceedances of BC guidelines (guideline= 0.005 mg/L) are consistently of low magnitude during all phases (HQ range: 1.1 to 1.6) and arsenic concentrations generally decline during the final years of the Operation phase as well as within the Closure and Post-closure phases (i.e., year 25 to 28). The effect is described as **local** because it will be confined to the near-field receiving environment (BJ 200m D/S).

Further dilution from the assessment point to Sulphurets Glacier, as well as substantial natural change in water chemistry observed as Brucejack Creek passes under Sulphurets Glacier and joins the existing sub-glacial flow of Sulphurets Creek, results in any potential incremental increase in water quality parameters due to chemical loading upstream at Brucejack creek and lake to be negligible and undetectable in Sulphurets Creek (see Section 13.6.2.3). The duration of the effect is described as **far future** as effects are predicted to extend into Post-closure. The frequency is described as **sporadic to regular** as the effect occurs seasonally (low flow periods in Closure and Post-closure phases) and is restricted to maximum predicted concentrations in the Construction, Closure, and Post-closure phases. The effect is **permanent** because while water quality will improve over time during Closure and Post-closure, exceedances are still predicted to occur. The resiliency of the system is **high**; the ecological context is **low** because the Brucejack watershed has low aquatic life value and no fisheries value.

There is also a potential effect on water quality (high K scenario only) due to increased chromium and zinc concentrations during Operation and Closure. The magnitude of the effect is **major** because chromium and zinc concentrations are predicted to be higher than surface water baseline conditions and to exceed a guideline or threshold value beyond the range of natural variation ("change of state from baseline conditions"). However, the high K scenario relates to higher groundwater recharge, thus modelled concentrations of chromium and zinc are also influenced by naturally elevated concentrations in baseline ground water quality. That is, in baseline studies, all groundwaters measured showed elevated baseline concentrations of total aluminum, silver, arsenic, chromium, copper, iron and zinc (Appendix 9-A). The effect is described as **local** because it will be confined to the near-field receiving environment (BJ 200m D/S). Further dilution from the assessment point to Sulphurets Glacier, as well as substantial natural change in water chemistry observed as Brucejack Creek passes under Sulphurets Glacier and joins the existing sub-glacial flow of Sulphurets Creek, results in any potential incremental increase in water quality parameters due to chemical loading upstream at Brucejack creek and lake to be negligible/ undetectable in Sulphurets Creek (see Section 13.6.2.3). The duration of the effect is described as **medium-term** as effects are either restricted to Operations (chromium) or Closure (zinc) phases. The frequency is described as **sporadic** as the effect either occurs seasonally (low flow periods in Closure) or is restricted to maximum predicted concentrations. The effect is **reversible medium-term** as water quality improves over time and no exceedances are predicted beyond Operation (chromium) or beyond Closure (zinc). The resiliency of the system is **high**; the ecological context is **low** as Brucejack watershed has low aquatic life value and no fisheries value.

Concentrations of some major nutrients and ions (ammonia, nitrate, nitrite), are expected to increase in the receiving environment at BJ 200m D/S as per base case and upper case scenarios (Appendix 13-C, Predictive Water Quality Report). Further dilution from the assessment point to Sulphurets Glacier, as well as substantial natural change in water chemistry observed as Brucejack Creek passes under Sulphurets Glacier and joins the existing sub-glacial flow of Sulphurets Creek, results in any potential incremental increase in water quality parameters due to chemical loading upstream at Brucejack creek and lake to be negligible/ undetectable in Sulphurets Creek (see Section 13.6.2.3). The effect of increased nutrients on aquatic resources (primary and secondary producers, sediment quality) is assessed in Chapter 14, Assessment of Potential Aquatic Resources Effects. The magnitude of the effect is **moderate** as the effect approaches limits of natural variation but all HQ ≤ 1.0. The effect is described as **local** because it will be confined to the near-field receiving environment (BJ 200m D/S). The duration of the effect is described as **medium-term** as effects are predicted to be restricted to the Construction phase and improve over the Operation phase. The frequency is described as **continuous** as concentrations are elevated relative to baseline in Construction and Operation phases. The resiliency of the system is **high**; the ecological context is **low** as Brucejack watershed has low aquatic life value and no fisheries value.

Change in Water Quality due to Sedimentation and Erosion

While sediment and erosion control mitigation measures will be implemented (see Section 13.5.2), sedimentation of streams near the Project during the Construction, Operation and Closure phases is likely to occur at some point (Henley 2000).

The Project-related increases in the concentration of suspended material due to erosion of disturbed surfaces will be restricted to the periods when the water and erosion management infrastructure is under construction or decommissioning. Increases in sediment concentrations will occur during periods of significant overland flow, which will only occur during freshet and sporadic rainfall events as well due to potential increase in TSS loads at Brucejack Lake outflow.

The increases in sediment concentrations, which may be greater than baseline values and water quality guidelines, will likely be **short term** and **sporadic**. The magnitude of the effect is **major** because the increased total suspended solids as a result of sedimentation is likely to be greater than water quality guidelines and above the range of natural variation, as TSS loads were generally low in Brucejack Creek compared to other Project areas (Section 13.3). The geographic extent of the residual sedimentation effect will be **landscape** as increased TSS is likely to reach both the near- and mid-field receiving environments.

Implementation of the sediment control measures outlined in Section 13.5.2 will reverse the effect of sedimentation on surface water quality. Further, recovery from sedimentation will be relatively rapid in Brucejack Creek (high-velocity stream) relative to wetlands or lakes and thus erosion and sedimentation events, should they occur, would be **reversible** in the **short term**. The resiliency of the system is **high**; the ecological context is **low** as the Brucejack watershed in both near and mid-field receiving environments has low aquatic life value and no fisheries value.

13.7.2.2 Likelihood for Residual Effects on Surface Water Quality: Mine Site Area

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

Likelihood: This refers to the likelihood that an adverse effect will occur in circumstances where it is not certain that the effect will materialize and is classified as:

- *Low*: an effect that is unlikely, but could occur;
- *Medium*: an effect that is likely, but may not occur; or
- *High*: an effect that is highly likely to occur.

The likelihood of the residual effect occurring was rated as high for all identified residual effects, except for effects due to chromium and zinc concentrations, which were rated as low. This is because identification of these elements as COPCS was restricted to a single modelled case (upper case, high K) of nine modelled cases.

13.7.2.3 Significance of Residual Effects on Surface Water Quality: Mine Site Area

The significance of effects will be ranked according to the two categories described below, as details in Section 6.7.3 of Chapter 6, Assessment Methodology.

- **Not significant**: Residual effects have low or moderate magnitude, local to regional geographic extent, short- or medium-term duration, could occur at any frequency, and are reversible in either the short or long-term. The effects on the receptor VC (e.g., at a species or local population level) are either indistinguishable from background conditions (i.e., occur within the range of natural variation as influenced by physical, chemical, and biological processes), or distinguishable at the individual level. Land and resource management plan objectives will likely be met, but some management objectives may be impaired. There is a medium to high level of confidence in the analyses. Follow up monitoring of these effects may be required if the magnitude is medium.
- **Significant**: Residual effects have high magnitude; have regional or beyond regional geographic extent; duration is long-term or far future; and occur at all frequencies. Residual effects on receptor VCs are consequential (i.e., structural and functional changes in populations, communities, and ecosystems are predicted) and are irreversible. The ability to meet land and resource management plan objectives is impaired. Confidence in the conclusions can be high, medium, or low.

The potential residual effects on surface water quality were associated with ML/ARD, nitrogen leaching from blasting residues, discharges, groundwater interactions and seepage as well as erosion and sedimentation (Table 13.7-2). Considering these potential effects on surface water quality in combination with Project infrastructure in the LSA and RSA, and mitigation to minimize effects, the overall potential Project-related residual effect on surface water is assessed as **not significant** for all residual effects (Table 13.7-2).

13.7.2.4 Characterization of Confidence for Residual Effects on Surface Water Quality: Mine Site Area

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

An assessment/ prediction is considered to have low confidence (less than 50% confidence) leading to a high degree of uncertainty if:

- the cause effect relationship between the Project and its interaction with surface water quality is poorly understood;
- data for the Project area may be incomplete; or
- uncertainty associated with synergistic and/or additive interactions between environmental effects may exist.

An assessment/ prediction is considered to have medium confidence (50 to 80% confidence) and therefore moderate degree of uncertainty if:

- The cause-effect relationship between the Project and its interaction with surface water quality is not fully understood; or
- data for the Project area is incomplete:

An assessment/ prediction is considered high to have high confidence (greater than 80% confidence) and therefore low degree of uncertainty if there is greater than 80% confidence in understanding the cause effect relationship between the Project and its interaction with surface water quality, and all necessary data is available for the Project area.

The confidence in the significance predictions and mitigation measures being followed were rated as high for all potential residual effects. While uncertainty exists in every prediction of future change, the approach used to assess the effects on surface water quality was developed to incorporate quantitative data from baseline reports and literature reviews as well as predictive water quality modelling, including investigation of multiple sensitivities. The goals were to remove as much subjectivity from the assessment as possible and to increase certainty in the predictions of alteration of surface water quality, residual effects, and the determination of significance to ensure a robust, transparent, and defensible approach to the effects assessment of surface water quality. Based upon the certainty associated with the significance conclusions, a more detailed risk assessment (e.g., additional sensitivity analyses) is not required.

13.7.3 Residual Effects Characterization: Off-site Areas

13.7.3.1 Characterizing Residual Effects: Off-site Areas

A summary of anticipated residual effects for surface water quality related to off-site areas is presented in Table 13.6-8. The following sections present characterization, likelihood, and significance of anticipated residual effects, which are summarized in Table 13.7-3.

Change in Surface Water Quality

In off-site areas there is generally minimal risk of effects to surface water quality due to the limited extent and duration of Project activities in these areas. Best management practices, ML/ARD mitigation, sediment and erosion control, and explosives management, as described in Chapter 29, Environmental Management and Monitoring Plans, and in Section 13.5.4, will reduce potential changes of surface water quality in off-site areas. However, a change in water quality of watercourses near the access road corridor and ancillary Project infrastructure may occur at some point during the life of the Project. Water quality changes will be of **short-term** duration and will occur **sporadically** during all Project phases. The magnitude of the effects is **minor** as ML/ARD mitigation, sediment and erosion control, and explosives management, will prevent significant change of surface water quality and any effect is expected to be within the range of natural variation and/or will not exceed guidelines. The geographic extent of the effect will be **local** as effects will be limited to the Project footprint.

Site decommissioning and reclamation of surface disturbances will reverse the water quality effects (**reversible short term**). The resiliency of the system is **high**. The ecological context is **neutral** as the environment is of moderate aquatic resources and fisheries value but is not unique in the geographic area.

13.7.3.2 Likelihood for Residual Effects on Surface Water Quality: Off-site Areas

The likelihood of the residual effect occurring was rated as low for the identified residual effects associated with the access road and other off-site ancillary Project infrastructure. This is because in off-site areas there is generally minimal risk of effects to surface water quality due to the limited extent and duration of Project activities in these areas.

13.7.3.3 Significance of Residual Effects on Surface Water Quality: Off-site Areas

The potential residual effects on surface water quality for off-site areas are summarized in Table 13.6-8. Considering these potential effects on surface water quality, the limited extent and duration of Project activities in the LSA, and mitigation to minimize effects, the overall Project-related residual effect on surface water associated with off-site Project infrastructure is assessed as **not significant.**

13.7.3.4 Characterization of Confidence for Residual Effects on Surface Water Quality: Off-site Area

The confidence in the significance predictions and mitigation measures being followed were rated as high for the identified potential residual effect. While uncertainty exists in every prediction of future change, the approach used to assess the effects on surface water quality was developed to incorporate quantitative data from baseline reports and literature reviews. The goals were to remove as much subjectivity from the assessment as possible and to increase certainty in the predictions of alteration of surface water quality, residual effects, and the determination of significance to ensure a robust, transparent, and defensible approach to the effects assessment of surface water quality. Based upon the certainty associated with the significance conclusions, a more detailed risk assessment (e.g., additional sensitivity analyses) is not required.

13.8 SUMMARY OF RESIDUAL EFFECTS AND SIGNIFICANCE FOR SURFACE WATER QUALITY

Table 13.8-1 presents a summary of residual effects, mitigation, and significance on surface water quality. All identified residual effects in Table 13.8.1 will be carried forward to the Cumulative Effects Assessment (CEA).

Table 13.8-1. Summary of Residual Effects, Mitigation, and Significance on Surface Water Quality

Residual Effects	Project Phase(s)	Mitigation Measures	Significance
Mine Site Area and Receiving Environment			
Change in water quality of receiving environment due to localized increases in sulphate and metal concentrations (COPCs: arsenic).	Construction, Operation, Closure, Post-closure	Implementation of ML/ARD Management Plan (Section 29.10), Waste Rock Management Plan (Section 29.18), Tailings Management Plan (Section 29.15), Water Management Plan (Section 29.19), Aquatic Effects Monitoring Plan (Section 29.3); collection and treatment of seepage from underground workings.	Not significant
Change of water quality due to localized increases in sulphate and metal concentrations (COPCs: chromium, zinc)	Operation, Closure	Implementation of ML/ARD Management Plan (Section 29.10), Waste Rock Management Plan (Section 29.18), Tailings Management Plan (Section 29.15), Water Management Plan (Section 29.19), Aquatic Effects Monitoring Plan (Section 29.3); collection and treatment of seepage from underground workings.	Not significant
Change of water quality due to localized increases in nitrogen as nitrate, nitrite, ammonia (leaching of blasting residues).	Construction, Operation	Implementation of Waste Rock Management Plan (Section 29.18), Water Management Plan (Section 29.19), Aquatic Effects Monitoring Plan (Section 29.3); collection and treatment of seepage from underground workings.	Not significant
Change of water quality of receiving environment due erosion and sedimentation	Construction, Operation, Closure, Post-closure	Use of best management practices to minimize sediment entry to waterbodies; Dust suppression on roads; Implementation of Soils Management Plan (Section 29.13), Water Management Plan (Section 29.19), Aquatic Effects Monitoring Plan (Section 29.3).	Not significant
Off-site Areas (Ancillary Project Infrastructure)			
Change in surface water quality of receiving environment	Construction, Operation, Closure	Implementation of ML/ARD Management Plan (Section 29.10), Soils Management Plant (Section 29.13), Transportation and Access Management Plan (Section 29.16), BMPs	Not significant

13.9 CUMULATIVE EFFECTS ASSESSMENT FOR SURFACE WATER QUALITY

Cumulative effects are defined in this Application/EIS as “effects which are likely to result from the designated project in combination with other projects and activities that have been or will be carried out”. This definition follows that in section 19(1) of the *Canadian Environmental Assessment Act, 2012* (2012) and is consistent with the International Finance Corporation Good Practice Note on Cumulative Impact Assessment (ESSA Technologies Ltd. and IFC 2012), which refers to consideration of other existing, planned and/or reasonably foreseeable future projects and developments. CEA is a requirement of the AIR (BC EAO 2014) and the EIS Guidelines and is necessary for the proponent to comply with the *Canadian Environmental Assessment Act, 2012* (2012) and the BC *Environmental Assessment Act* (2002).

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

The method involves the following key steps which are further discussed in the proceeding sub-sections:

- scoping;
- analysis;
- identification of mitigation measures;
- identification of residual cumulative effects; and
- determination of significance.

13.9.1 Establishing the Scope of the Cumulative Effects Assessment

The scoping process involves identification of the intermediate components and receptor VCs for which residual effects are predicted, definition of the spatio-temporal boundaries of the assessment, and an examination of the relationship between the residual effects of the Project and those of other projects and activities.

13.9.1.1 Identifying Intermediate Components and Receptor Valued Components for the Cumulative Effects Assessment

Receptor VCs included in the surface water quality cumulative effects assessment were selected using four criteria following BC EAO (2013).

1. There must be a residual environmental effect of the project being proposed.
2. Environmental effect must be demonstrated to interact cumulatively with the environmental effects from other projects or activities.
3. Other projects or activities must be known to have been or will be carried out and are not hypothetical.
4. The cumulative environmental effect must be likely to occur.

Project-related residual effects for surface water quality are anticipated at Brucejack Creek (mine site area) due to localized increases in metal concentrations (COPCs; arsenic, chromium, zinc), increases in nitrogen as nitrate, nitrite, ammonia (leaching of blasting residues), and due to erosion and sedimentation (Table 13.8-1). Project-related residual effects are anticipated in off-site areas (ancillary Project infrastructure) due to localized increases in ML/ARD (Table 13.8-1). Section 13.7 provides the significance assessment for Project residual effects.

13.9.1.2 Potential Interaction of Projects and Activities with the Project for Surface Water Quality

A review of the interaction between potential effects of the Project and potential effects of other projects and activities on surface water quality was undertaken. The review assessed the projects and activities identified in Section 6.9.2 of Chapter 6, Assessment Methodology, including:

- regional projects and activities that are likely to affect the surface water quality, even if they are located outside the direct zone of influence of the Project;
- effects of past and present projects and activities that are expected to continue into the future (i.e., beyond the effects reflected in the existing conditions of surface water quality, Section 13.3); and
- activities not limited to other reviewable projects, if those activities are likely to affect the surface water quality cumulatively (e.g., mineral exploration, mining activities).

A matrix identifying the potential cumulative effect interactions for surface water quality is provided in Table 13.9-1 below.

Table 13.9-1. Potential Interaction of Projects and Activities with the Brucejack Gold Mine Project

Projects and Activities	Surface Water Quality
Historical	
Eskay Creek Mine	
Galore Creek Mine	
Goldwedge Mine	
Granduc Mine (Past Producer)	
Johnny Mountain Mine	
Kitsault Mine (Past Producer)	
Silbak Premier Mine	
Snip Mine	
Snowfield Exploration Project	
Sulphurets Advanced Exploration Project	
Swamp Point Aggregate Mine	
Present	
Brucejack Exploration and Bulk Sample Program	
Forrest Kerr Hydroelectric Power facility	
Long Lake Hydroelectric	
McLymont Creek Hydroelectric Project	
Northwest Transmission Line	
Red Chris Mine	
Reasonably Foreseeable Future	
Arctos Anthracite Coal Mine	
Bear River Gravel	
Bronson Slope Mine	
Coastal GasLink Pipeline Project	
Galore Creek Mine	
Granduc Copper Mine	

(continued)

Table 13.9-1. Potential Interaction of Projects and Activities with the Brucejack Gold Mine Project (completed)

Projects and Activities	Surface Water Quality
Reasonably Foreseeable Future *(cont'd)*	
KSM Project	
Kinskuch Hydroelectric Project	
Kitsault Mine	
Kutcho Mine	
LNG Canada Export Terminal Project	
Northern Gateway Pipeline Project	
Prince Rupert Gas Transmission Project	
Prince Rupert LNG Project	
Schaft Creek Mine	
Spectra Energy Transmission Line Project	
Storie Moly Mine	
Treaty Creek Hydroelectric Project	
Turnagain Mine	
Volcano Hydroelectric Project	

Black = likely interaction between Brucejack Gold Mine Project and other project or activity
Grey = possible interaction between Brucejack Gold Mine Project and other project or activity
White = interaction not expected between Brucejack Gold Mine Project and other project or activity

13.9.1.3 Spatio-temporal Boundaries of the Cumulative Effects Assessment

The CEA 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 intermediate component and receptor VCs and with other projects and activities, as well as the constraints that may be placed on the assessment of those interactions due to political, social, and economic realities (administrative boundaries), and limitations in predicting or measuring changes (technical boundaries). The definition of these assessment boundaries is an integral part of the surface water quality cumulative effects assessment, and encompasses possible direct, indirect, and induced effects of the Project on surface water quality.

<u>Spatial Boundaries</u>

Cumulative effects scoping considered past, present and future actions for watersheds downstream of the Brucejack Gold Mine Project (Figure 13.9-1). Watersheds with the potential to be affected by the Project activities include the Unuk River, Sulphurets Creek, Bell-Irving River, and Bowser River watersheds. Past, present, and/or potential future activities may combine to affect surface water quality in the LSA and RSA, within cumulative effects assessment boundaries, or in downstream watersheds. The surface water quality cumulative effects assessment boundary is the same as the RSA used for the residual effects assessment (Section 13.4.1.5). The RSA was selected based upon watersheds within, upstream, and downstream of the Project with a potential for direct effects. Projects that are located outside of the identified watershed boundaries were excluded from the cumulative effects assessment.

The past projects and human activities that may affect surface water quality and spatially overlap potential effects from the Project are (Figure 13.9-1):

- the Eskay Creek Mine (effluent flows into the Unuk River);
- The Goldwedge Mine (historical Catear property that is currently discharging to Brucejack Lake).
- Sulphurets Advanced Exploration Project (waste rock deposition along Brucejack Creek, reclamation activities)
- the Granduc Mine (concentrator effluent flowed into the Bowser River Valley to Bowser Lake; access corridor overlaps);
- The Snowfield Exploration Project; and
- Silbak Premier Mine (in Bowser River watershed).

Present and future projects and human activities that may affect surface water quality and spatially overlap potential effects from the Project are (Figure 13.9-1):

- The Northwest Transmission Line (NTL; access corridor overlaps within Bell-Irving River watershed)
- the Granduc Copper Mine (access corridor overlaps, future mining activities);
- Brucejack Exploration and Bulk Sample Program (blasting and drilling program, access road use); and
- the KSM Project (discharge into Sulphurets Creek; development in Sulphurets Creek and Mitchell Creek; access corridor overlaps).

Temporal Boundaries

Effects to surface water quality from past projects and human activities may temporally overlap with potential effects from the Project, if discharge from the activities persists in the aquatic environment or if habitat has not had sufficient time to recover from past effects.

Temporal linkages for past human actions within the watersheds potentially affected by the proposed Brucejack Gold Mine Project were considered in the development of the baseline program. Past human actions with a temporal linkage to potential water quality effects include:

- the Eskay Creek Mine;
- the Goldwedge Mine;
- Silbak Premier Mine;
- Sulphurets Advanced Exploration Project; and
- the Granduc Mine.

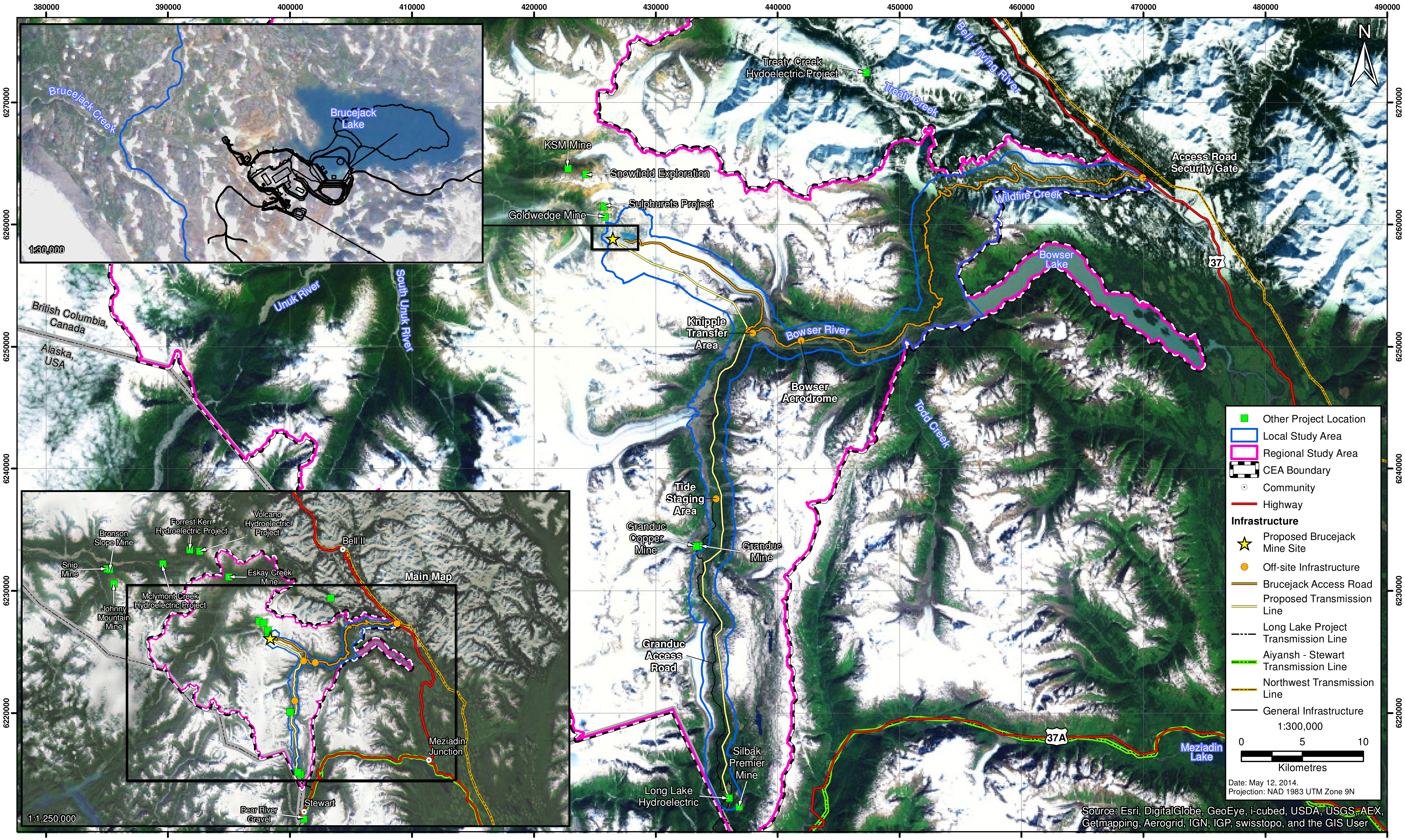
Present and future projects and human activities with potential effects to surface water quality that could overlap temporally with potential effects from the Project are:

- the Granduc Copper Mine;
- Brucejack Exploration and Bulk Sample Program; and
- the KSM Project.

Figure 13.9-1

Surface Water Quality Cumulative Effects Assessment Boundary Showing all other Projects and Activities Relevant to Surface Water Quality near the Project

ERM



13.9.1.4 Potential for Cumulative Effects

Table 13.9-2 presents a summary of projects and activities with the potential to interact cumulatively with expected Project-specific residual effects for surface water quality.

Table 13.9-2. Potential Cumulative Effects between the Brucejack Gold Mine Project Surface Water Quality and Other Projects and Activities

	Brucejack Gold Mine Project	Past Project or Activity	Existing Project or Activity	Reasonably Foreseeable Future Project or Activity	Type of Potential Cumulative Effect
Mine Site Area and Receiving Environment					
Change in water quality of receiving environment due to localized increases in sulphate and metal concentrations (COPCs: arsenic).	X	-	-	KSM Project	Additive
Change of water quality due to localized increases in sulphate and metal concentrations (COPCs: chromium, zinc)	X	-	-	KSM Project	Additive
Change of water quality due to localized increases in nitrogen as nitrate, nitrite, ammonia (leaching of blasting residues).	X	-	-	KSM Project	Additive
Change of water quality of receiving environment due erosion and sedimentation	X	-	-	KSM Project	Additive
Off-site Areas (Ancillary Project Infrastructure)					
Change in water quality of receiving environment localized increases in metal and sulphate concentrations, TSS and turbidity and nitrogen concentrations, in streams and lakes near off-site ancillary Project infrastructure.	X	-	-	-	-

Advanced exploration and bulk sample mining at the Sulphurets Project between 1986 and 1990 resulted in the placement of waste rock and ore into Brucejack Lake as well as waste rock deposition along Brucejack Creek. Detailed assessment and analyses of effects to surface water quality on the Brucejack watershed due to activities associated with the Sulphurets Project, as well as subsequent reclamation activities, is presented in Appendix 13-A, Cumulative Surface Water Quality Baseline Report. In summary, statistical analyses of historical water quality datasets as well as assessment of site activity records indicate that Brucejack Lake and Brucejack Creek has remained largely uninfluenced by activities associated with the Sulphurets Project and exhibit generally consistent physicochemistry as well as concentrations of nutrients, anions, total metals and dissolved metals (see Appendix 10 of Appendix 13-A, Cumulative Surface Water Quality Baseline Report). Reclamation efforts following the Sulphurets exploration work included deposition of waste rock and ore within Brucejack Lake in 1999. This event was associated with short-term increases in alkalinity, hardness, TSS, conductivity, sulphate, chloride, copper, lead, and zinc concentrations in Brucejack Lake as well as lower Brucejack Creek which subsequently decreased and returned to background levels over subsequent years (2000/2001, 2009/2010) (see Appendix 10 of Appendix 13-A, Cumulative Surface Water Quality Baseline Report). No additional cumulative effects related to this project would be expected with development of the Brucejack Gold Mine Project beyond what was already considered in baseline studies as well as within geochemical source terms for Brucejack Lake and Creek used to inform predictive water quality models for the Project (Section 13.6, Appendix 13-C, Predictive Water Quality Report). Therefore, activities associated with the Sulphurets Project will not be considered further in the CEA for surface water quality.

The Eskay Creek Mine operated between 1995 and 2008 and tailing materials and waste rock stored in Albino and Tom MacKay lakes and mine site drainage to Ketchum Creek flow to the Unuk River. The Goldwedge Mine Project involved the small-scale mining of the Catear (Goldwedge) area and included on-land and lake disposal of an un-quantified volume of waste rock and approximately 4,000 t of tailings from a small underground mine. Further detail on the effect of past human actions on the water quality baseline is provided in Section 13.3. Provided that no new changes occur in the conditions at these historical mines or ongoing activities, metal or contaminant inputs that could affect surface water quality should remain stable or decrease over time. No additional cumulative effects related to these projects would be expected with development of the Brucejack Gold Mine Project beyond what was already considered in baseline studies; therefore, activities associated with the Eskay Creek Mine or the Goldwedge Project will not be considered further in the CEA for surface water quality.

The Granduc Mine operated between 1970 and 1978 and between 1980 and 1984 and discharged tailings directly to the upper Bowser River. Further detail on the effect of past human actions on the water quality baseline is provided in Section 13.3. Provided that no new changes occur in the conditions at these historical mines or ongoing activities, metal or contaminant inputs that could affect surface water quality should remain stable or decrease over time. No additional cumulative effects related to this project would be expected with development of the Brucejack Gold Mine Project beyond what was already considered in baseline studies; therefore, activities associated with the historical Granduc Mine will not be considered further in the CEA for surface water quality.

The proposed Granduc Copper Mine is located 40 km northwest of Stewart in northwestern BC and previously operated between 1971 and 1984 (see Section 13.3). Castle Resources Inc. acquired the Granduc property from Bell Copper in July 2010, and began exploration drilling with the aim of redeveloping the mine (Marketwire 2010a; Scales 2012). Castle Resources is currently working on environmental studies and permitting and the proposed mine is planned to begin its operations phase in 2016, if approved, which indicates that a temporal overlap is possible. The drainage from the proposed Granduc Copper Mine is to the Bowser River, Bowser Lake, and ultimately to the Bell-Irving River, suggesting that there is potential for cumulative spatial interaction between the proposed Granduc Copper Mine and ancillary off-site Project infrastructure. However, the project is still in the very early planning stages and no data on expected water quality effects are available. This Project was excluded from the surface water quality CEA given the absence of technical information.

The Snowfield Project is located northeast of the Brucejack Gold Mine Project. The Snowfield deposit area drains downstream to Mitchell Creek (Wardrop 2010) which is a tributary to Sulphurets Creek, downstream of the Brucejack Gold Mine Project. A Preliminary Economic Assessment was completed in 2010 that explored the value of combining the Brucejack and Snowfield Projects (Wardrop 2010). The Snowfield Project proponent (Pretivm) has no current plans to advance development; therefore, the Snowfield Project was excluded from the surface water quality CEA.

The NTL is an approximately 344 km electricity transmission line (BC Hydro 2012). The 287-kilovolt capacity line generally follows the Highway 37 corridor, running from the Skeena Substation at Terrace and connecting with a new substation near Bob Quinn Lake (BC Hydro 2012) and parallels the eastern surface water quality cumulative effects boundary (Figure 13.9-1). BC Hydro received an EA Certificate in February 2011 and construction began in January 2012. The project is expected to be operational in 2014 (BC Hydro 2012). The transmission line will extend the existing provincial electrical grid into northwestern BC making mining, power and other resource projects in these remote regions more economically feasible (BC Hydro 2012). No water quality effects from the NTL are expected to interact with residual effects from the Brucejack Gold Mine Project; therefore, the NTL was excluded from the surface water quality CEA.

Brucejack exploration activities commenced in 2011 and have included a drilling program, bulk sampling program, construction of an exploration access road from Highway 37 to the west end of Bowser Lake, as well as the rehabilitation of an existing access road from the west end of Bowser Lake to Brucejack Mine Site. Waste rock deposition into Brucejack Lake in 2012 as part of the exploration Program. Further detail on the effect of past human actions on the water quality baseline is provided in Section 13.3. No additional cumulative effects related to exploration activities would be expected with development of the Brucejack Gold Mine Project beyond what was already considered in baseline studies; therefore, the Brucejack exploration program will not be considered further in the CEA for surface water quality.

The KSM Project is a gold/copper project located downstream of the Brucejack Gold Mine Project within the Sulphurets Creek watershed, which is a tributary of the Unuk River. The Project is currently in the Environmental Assessment process. The KSM Project has the potential to interact with residual effects from the Brucejack Gold Mine Project; therefore the KSM Project was included in the surface water quality CEA.

13.9.2 Analysis of Cumulative Effects

Cumulative effects on surface water quality can occur when potential Project effects combine with effects caused by other projects. When effects from the Project and other activities combine, the effect of the initial effect can increase due to cumulative or synergistic/antagonistic responses. Cumulative effects from past, present, or potential future activities, along with the Project, were assessed to determine the overall effect to surface water quality in the LSA and RSA and downstream watersheds.

13.9.2.1 Cumulative Effects on Surface Water Quality: Mine Site Area

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

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

Increased selenium loading from the Brucejack Gold Mine Project has the potential to increase concentrations of selenium downstream in Sulphurets Creek and the Unuk River, which could result in a cumulative effect of a greater magnitude in the Unuk River. However, no guideline exceedances of selenium were predicted for the Project and selenium was not identified as a COPC (Section 13.6.1.2). Further, any potential incremental increase in water quality parameters due to chemical loading upstream at Brucejack creek and lake is expected to be negligible/ undetectable in Sulphurets Creek (Section 13.6.2.3). Further dilution from the assessment point to Sulphurets Glacier, as well as substantial natural change in water chemistry observed as Brucejack Creek passes under Sulphurets Glacier and joins the existing sub-glacial flow of Sulphurets Creek, results in any potential incremental increase in water quality parameters due to chemical loading upstream at Brucejack creek and lake to be negligible/ undetectable in Sulphurets Creek (see Section 13.6.2.3). Therefore there are no expected measureable cumulative effects on surface water quality due to selenium concentrations in the Sulphurets and Unuk watersheds. Similarly, as incremental increase in water quality parameters due to chemical loading upstream at Brucejack Creek are expected to be negligible/ undetectable (Section 13.6.1.2), there are no expected measureable cumulative effects on surface water quality due to identified COPCs for the Project (As, Cr, Zn) in the Sulphurets and Unuk watersheds.

13.9.2.2 Cumulative Effects on Surface Water Quality: Off-site Areas

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

13.9.3 Mitigation Measures to Address Cumulative Effects

13.9.3.1 Mitigation Measures to Address Cumulative Effects: Mine Site Area

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

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

13.9.4 Cumulative Residual Effects for Surface Water Quality

Cumulative residual effects are those effects remaining after the implementation of all mitigation measures and are summarized in Table 13.9-3. As described above, no cumulative residual effects were identified, thus characterization of cumulative effects are not assessed (N/A).

Table 13.9-3. Summary of Cumulative Residual Effects on Surface Water Quality: Mine Site Area

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

N/A – Not applicable
[1] Refers to the Project phase or other timeframe during which the effect will be experienced by the intermediate receptor or VC.
[2] "Cause-effect" refers to the relationship between the Project component/physical activity that is causing the change or effect in the condition of the receptor VC.

13.9.5 Characterizing Cumulative Residual Effects, Significance, Likelihood and Confidence for Surface Water Quality

The cumulative residual effects for each intermediate receptor or VC were characterized by considering the Project's incremental contribution to the cumulative residual effect under two scenarios:

- Future case without the Project: a consideration of residual effects from all other past, existing, and future projects and activities on a sub-component <u>without</u> the Brucejack Gold Mine Project.
- Future case with the Project: a consideration of all residual effects from past, existing, and future projects and activities on a sub-component <u>with</u> the Brucejack Gold Mine Project.

This approach helps predict the relative influence of the Project on the residual cumulative effect for each intermediate component or VC, while also considering the role of other projects and activities in causing that effect.

The cumulative effect on water quality from the Project will not influence the descriptors used in the assessment of Project-specific residual effects as concentrations of selenium in the Sulphurets-Unuk watershed are not expected to increase above the Project-specific predictions as a result of cumulative water quality effects. Further, incremental changes in water chemistry of Sulphurets Creek and the Unuk River are predicted to be negligible/ undetectable. Therefore, there will be no residual cumulative effects. The significance determination of cumulative residual effects was thus assessed as **not applicable (N/A)** in Table 13.9-4.

13.10 EFFECTS ASSESSMENT CONCLUSIONS FOR SURFACE WATER QUALITY

Surface water quality is a key indicator of environmental health as it is linked to other important ecosystem components including fish and fish habitat, aquatic resources (primary and secondary producers, sediment quality), soil, vegetation, wildlife, and human health. The effects assessment included several different pathways through which surface water quality can be affected by Project activities, many of which overlap in terms of definition and scope. These included:

- discharges, including:
  - effluent release (water treatment plant/sewage treatment plant) into Brucejack Creek during the Construction phase;
  - activities at the existing adit (Construction phase);
  - discharge from Brucejack Lake (site of permanent tailings and waste rock disposal, water treatment plant/sewage treatment plant discharge during Operation);
- ML/ARD;
- erosion and sedimentation;
- leaching of nitrogen residues generated from blasting;
- groundwater and surface water interactions and seepage; and
- atmospheric deposition.

The surface water quality effects assessment was developed to incorporate quantitative data from baseline reports and literature reviews as well as predictive water quality modelling including sensitivity analyses. The goals were to remove as much subjectivity from the assessment as possible and to increase certainty in the predictions of alteration of surface water quality, residual effects, and the determination of significance to ensure a robust, transparent, and defensible approach to the effects assessment of surface water quality. Table 13.10-1 presents a summary of the assessment of potential environmental effects on surface water quality.

Table 13.9-4. Significance Determination of Cumulative Residual Effects for Surface Water Quality – Future Case with the Project

	Cumulative Residual Effects Characterization Criteria							Significance of Adverse Cumulative Residual Effects	Likelihood of Occurrence	
Cumulative Residual Effects	**Magnitude** *(low, moderate, high)*	**Duration** *(short, medium, long, far future)*	**Frequency** *(once, sporadic, regular, continuous)*	**Geographic Extent** *(local, landscape, regional, beyond regional)*	**Reversibility** *(reversible short-term; reversible long-term; irreversible)*	**Resiliency** *(low, neutral, high)*	**Context** *(low, neutral, high)*	**Significance** *(not significant; significant)*	**Probability** *(low, medium, high)*	**Confidence** *(low, medium, high)*
N/A	N/A							N/A	N/A	

Table 13.10-1. Summary of Project and Cumulative Residual Effects, Mitigation, and Significance for Surface Water Quality

Residual Effects	Project Phase(s)	Mitigation Measures	Significance of Residual Effects	
			Project	Cumulative
Mine Site Area and Receiving Environment				
Change in water quality of receiving environment due to localized increases in sulphate and metal concentrations (COPCs: arsenic).	Construction, Operation, Closure, Post-closure	Implementation of ML/ARD Management Plan (Section 29.10), Waste Rock Management Plan (Section 29.18), Tailings Management Plan (Section 29.15), Water Management Plan (Section 29.19), Aquatic Effects Monitoring Plan (Section 29.3); collection and treatment of seepage from underground workings.	Not significant	N/A
Change of water quality due to localized increases in sulphate and metal concentrations (COPCs: chromium, zinc)	Operation, Closure	Implementation of ML/ARD Management Plan (Section 29.10), Waste Rock Management Plan (Section 29.18), Tailings Management Plan (Section 29.15), Water Management Plan (Section 29.19), Aquatic Effects Monitoring Plan (Section 29.3); collection and treatment of seepage from underground workings.	Not significant	N/A
Change of water quality due to localized increases in nitrogen as nitrate, nitrite, ammonia (leaching of blasting residues).	Construction, Operation,	Implementation of Waste Rock Management Plan (Section 29.18), Tailings Management Plan (Section 29.15), Water Management Plan (Section 29.19), Aquatic Effects Monitoring Plan (Section 29.3); collection and treatment of seepage from underground workings.	Not significant	N/A
Change of water quality of receiving environment due erosion and sedimentation	Construction, Operation, Closure, Post-closure	Use of best management practices to minimize sediment entry to waterbodies; Dust suppression on roads; Implementation of Soils Management Plan (Section 29.13), Water Management Plan (Section 29.19), Aquatic Effects Monitoring Plan (Section 29.3).	Not significant	N/A
Off-site Areas (Ancillary Project Infrastructure)				
Change in water quality of receiving environment	Construction, Operation, Closure,	Implementation of ML/ARD Management Plan (Section29.10), Soils Management Plan (Section 29.13), BMPs	Not significant	N/A

The key assumptions of the surface water quality effects assessment are:

- assessment and determination of any potential residual and cumulative effects assumed that all guidelines, mitigation and management plans, BMPs, regulations, and operating standards designed to reduce effects on surface water quality and aquatic resources are strictly adhered to; and
- assessment and determination of discharge-related potential effects on downstream receiving environments relies upon the accuracy of water quality modelling data results.

Extensive mitigation and management plans for Project effects on surface water quality were included in the design for the proposed Project. Proposed mitigation strategies include measures to avoid, reduce, and monitor adverse effects to surface water quality. Additional mitigation and management measures to minimize effects on surface water include the implementation of the following environmental management plans:

- Aquatic Effects Monitoring Plan (Section 29.3);
- ML/ARD Management Plan (Section 29.10);
- Soils Management Plan (Section 29.13);
- Tailings Management Plan (Section 29.17);
- Waste Rock Management Plan (Section 29.18);
- Water Management Plan (Section 29.19); and
- Closure and Reclamation (Chapter 30).

The proposed mitigation cannot eliminate the Project-related residual effect on water quality and environmental effects assessment identified the following residual effects: change in surface water quality due to sedimentation and erosion, ML/ARD, leaching of blasting, and groundwater interactions and seepage.

Predictive water quality modelling into the far-future has an inherent level of uncertainty. To address this uncertainty, different model scenarios considered the range of possible geochemistry in the form of sensitivity analyses. Further, the water quality monitoring program as per the Aquatic Effects Monitoring Plan (Section 29.3) will verify accuracy of the predictions of the environmental assessment, ensure detection of measureable alterations in surface water quality, allow for identification of potential causes, and include the provision of additional mitigation or adaptive management strategies.

Arsenic concentrations are predicted to be higher than BC water quality guidelines for the protection of freshwater aquatic life in Brucejack Creek (BJ 200m D/S) during the Construction, Operation, Closure, and Post-closure phases. Loadings of arsenic are associated with subaqueous waste rock deposition upstream at Brucejack Lake as well as contact water from the underground mine (Appendix 13-C). Arsenic concentrations generally decline during the final years of the Operation phase as well as within the Closure and Post-closure phases. However, guideline exceedances are consistently of low magnitude during all phases (HQ range: 1.1 to 1.6). Further, water quality generally improves over time and in Post-closure (Year 25 to Year 28) predicted arsenic concentrations range from below guidelines to 0.0068 mg/L (base case) and below guidelines to 0.0069 mg/L (upper case) at site BJ 200m D/S.

In the sensitivity analyses, two additional COPCs were identified as per the upper case (high K, scenario 2): chromium (maximum predicted concentrations during Operation only) and zinc (in low flow periods during Operation and Closure phases). These parameters are associated with potential ML/ARD in the underground and thus the high hydraulic conductivity (i.e., higher seepage) scenario results in increasing concentrations associated within increasing load from the underground. However, as the high K scenario relates to higher groundwater recharge, modelled concentrations of chromium and zinc are also influenced by naturally elevated concentrations in baseline ground water quality. That is, in baseline studies, all groundwaters measured showed elevated baseline concentrations of total aluminum, silver, arsenic, chromium, copper, iron and zinc (Appendix 9-A). Further, these COPCs are restricted to this single case and the effect is water quality improves over time and no exceedances are predicted beyond Operation (chromium) or beyond Closure (zinc).

Project related activities at Brucejack Lake and Brucejack Creek are not expected to affect surface water quality of mid and far-field receiving environments (Sulphurets and Unuk watersheds). Therefore no cumulative effects are expected with any past, present, or reasonably foreseeable projects or activities.

In off-site areas, the potential residual effects on surface water quality were associated with ML/ARD, nitrogen leaching from blasting residues as well as erosion and sedimentation. Considering these potential effects on surface water quality in combination with Project infrastructure in the LSA and RSA, and mitigation to minimize effects, the overall potential Project-related residual effect on surface water is assessed as **not significant** for all residual effects. No cumulative effects are expected.

Based on the environmental effects assessment, the residual effect for the Brucejack Mine Site is assessed as **not significant**, and the residual effect for off-site areas (ancillary Project infrastructure) is assessed as **not significant**.

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