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Appendix 5.3.3B: Surface Water Quality Goldsim Model (AMEC E&I)

Appendix 5.3.3C: Dry Return Period - Water Quality Prediction Summaries (AMEC E&I)

5.3.3 Surface Water Quality

5.3.3.1 Introduction

This section of the Application for an Environmental Assessment Certificate/Environmental Impact Statement (Application) discusses the potential effects of the proposed Blackwater Gold Project (the Project) on surface water quality in watersheds that are either within or adjacent to the Project during the construction, operation, closure, and post-closure phases. The scoping process concluded that surface water quality is a key Valued Component (VC) for the aquatic subject area under the environmental pillar for this EA. Refer to **Section 5.3.1** for further discussion on VC selection. As this section only pertains to surface water quality, other sections in Aquatic Environment contain further information on surface water flows and lake levels, sediment quality, fish and fish habitat, groundwater quantity and quality, and wetlands.

5.3.3.1.1 Applicable Guidelines and Regulations

Guidelines pertinent to surface water quality in British Columbia (BC) are:

- British Columbia Ministry of Environment (BC MOE). 2006a. A Compendium of Working Water Quality Guidelines for British Columbia;
- BC MOE. 2006b. British Columbia Approved Water Quality Guidelines. Available at www.env.gov.bc.ca/wat/wq. Accessed 2013;
- BC MOE. 2008. Ambient Aquatic Life Guidelines for Iron;
- BC MOE. 2009. Water Quality Guidelines for Nitrogen (nitrate, nitrite, and ammonia);
- BC MOE. 2012a. Water and Air Baseline Monitoring Guidance Document for Mine Proponents and Operators;
- BC MOE. 2012b. Draft Ambient Water Quality Guidelines for Sulphate. Approved 2013; and
- Canadian Council of Ministers of the Environment (CCME). 2007. Environmental Quality Guidelines.

The BC approved water quality guidelines also cover drinking water, recreational use, and wildlife use; drinking water guidelines are similar to Health Canada's guidelines. The CCME guidelines cover protection of freshwater aquatic life, and include Health Canada drinking water guidelines and guidelines for agriculture and recreational uses of surface water.

In general, where provincial guidelines are in place, federal guidelines do not apply.

Any discharge to surface water bodies in BC requires a permit under the *Environmental Management Act* administered by the BC MOE. If the discharge has the potential to affect fish-bearing waters (as defined by the *Fisheries Act*), an authorization may be required under Section 35 of the *Fisheries Act*. *Metal Mining Effluent Regulations (MMER)* under the *Fisheries Act* will govern maximum allowable concentrations in discharge from sediment control ponds to water bodies during construction and at post closure when the Tailings Storage Facility (TSF) will have a surface discharge to Davidson Creek.

During operations, the Project will not have a direct surface water discharge to streams; discharge will be limited to a small amount of TSF seepage. The Environmental Control Dam (ECD), downstream in Davidson Creek will capture seepage from the main dam (D), and only a small amount of seepage will bypass this latter dam. However, approximately 18 years after end of mineral processing, the tailings impoundment will discharge supernatant water, and an *Environmental Management Act* permit will be required. It is expected that a *Fisheries Act* authorization will be needed for direct effects on fish and fish habitat caused by the TSF, open pit and waste rock dumps footprint. **Section 5.3.8**, Fish Effects Assessment, includes further discussions.

5.3.3.1.2 Information Sources

Prior to commencement of environmental studies for the Project, no baseline water quality data were available for the water bodies in the immediate area of the Project, which include:

- Lakes: Kuyakuz, Tatelkuz, Snake, Top, 1682, 1428, and 1538; and
- Streams: Davidson Creek, Turtle Creek, Fawnie Creek, Creek 705, and Creek 661.

Therefore, a program of water quality monitoring was initiated in March 2011 to fill this gap. The program is outlined in the next section, and a baseline report with all results to June 2013 is presented in **Appendix 5.1.2.2A**. Lake water quality is sampled on a quarterly basis, in recognition that lake water quality is generally more stable than stream water quality.

Source concentrations for input to the water quality assessment were derived from baseline sampling and from models generated by others, including:

- Knight Piésold Ltd.: site, and the watershed water balance;
- AMEC: acid rock drainage / metal leaching (ARD/ML) potential for waste rock and tailings, TSF supernatant chemistry, and open pit lake chemistry;
- SGS Laboratories: cyanide (CN) destruction chemistry;
- Musselwhite and Equity mines data: analogues for checks on TSF water quality; and
- ClearCoast Consulting: wetland performance.

5.3.3.1.3 Spatial and Temporal Scope

5.3.3.1.3.1 Spatial Scope (LSA and RSA)

The Project and associated facilities will be in the headwaters of Davidson Creek, with the exception of the TSF Site C West Dam and the East waste rock dump. The TSF Site C West Dam will be in the headwaters of Creek 705. The East waste rock dump will be in the headwaters of Creek 661. The Local Study Area (LSA) will include:

- Mine site: entire watersheds of Davidson Creek, Creek 661, Turtle Creek, and Creek 705. Tributaries flowing in to the south side of Tatelkuz Lake. Chedakuz Creek, from confluence with Creek 661 to Tatelkuz Lake. Chedakuz Creek, from Tatelkuz Lake to confluence with Turtle Creek; and
- Transmission line including reroute options, transmission line access roads, mine access road, and water supply pipeline: 100 m on either side of the centre line of these proposed developments (i.e., 200 m total width), and airstrip.

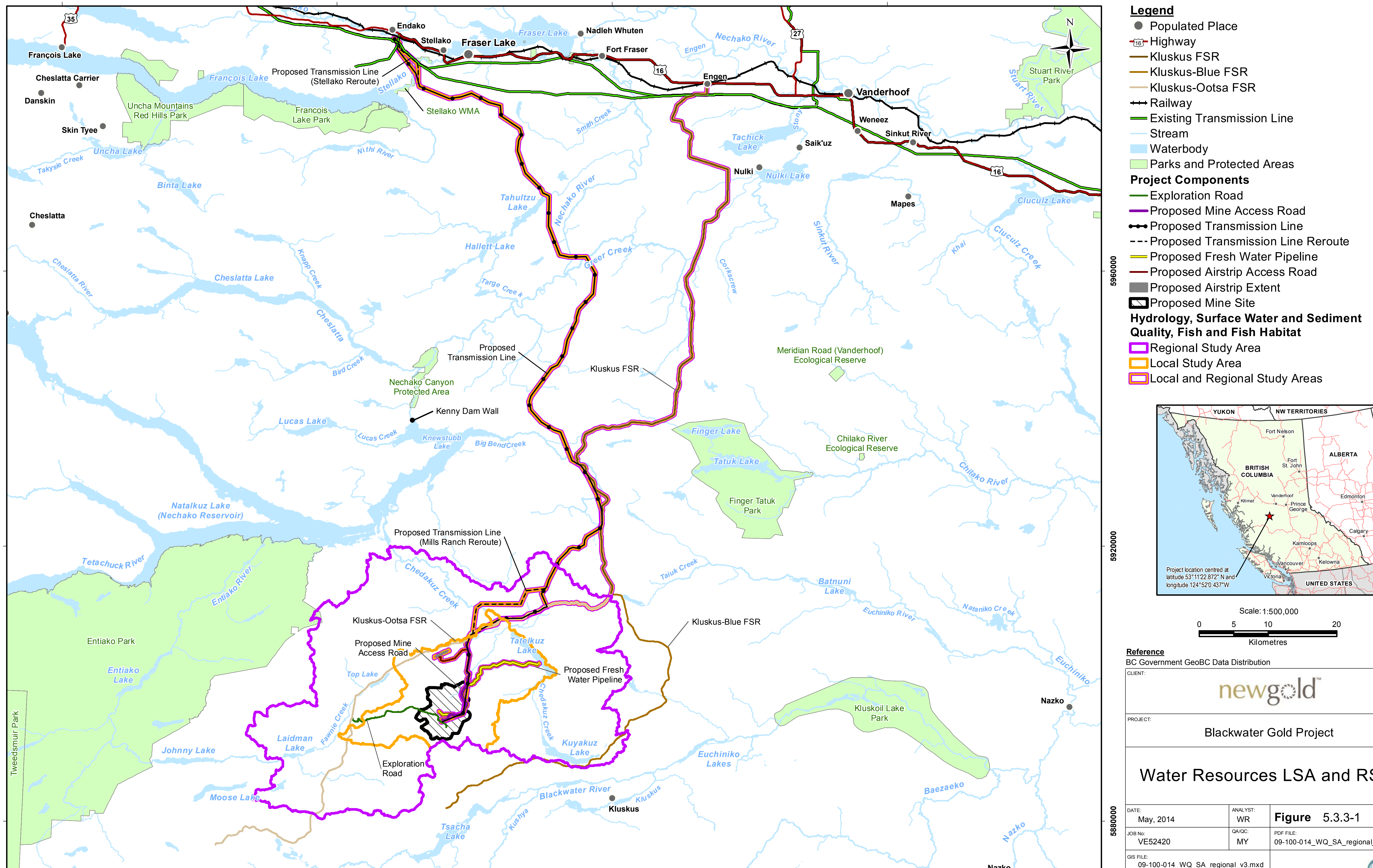
The Regional Study Area (RSA) will include:

- Mine site: entire watershed of Chedakuz Creek not included in LSA. Entire watershed of Laidman Lake not included in the LSA; and
- Transmission line including reroute options, mine access road, and water supply pipeline: same corridor as for LSA (200 m total width) along the proposed road access route, transmission line, water supply pipeline, and airstrip.

Figure 5.3.3-1 shows place names that indicate the Project footprint, water resources LSA, and the RSA.

The LSA includes all water bodies that have the potential to be measurably affected by the Project's development and operations, plus adjacent water bodies. The RSA includes water bodies upstream and downstream of the Project that either potentially influence LSA water body water quality, or could be influenced indirectly by the Project.

Administrative boundaries (as defined in **Section 4.3.1.3**) do not apply to the water quality assessment as all waters in the subject watershed potentially affected by the Project are considered. Technical boundaries (as defined in **Section 4.3.1.4**) only apply to assessment of water quality in respect of the detection limits for parameters predicted to be below these limits and thus not measurable directly, e.g., cyanide. As all detection limits are below relevant water quality guidelines, this limitation does not affect conclusions drawn for potential water quality effects.



Reference
BC Government GeoBC Data Distribution

CLIENT: newgold

PROJECT: Blackwater Gold Project

Water Resources LSA and RSA

DATE: May, 2014	ANALYST: WR	Figure 5.3.3-1
JOB No: VE52420	QA/QC: MY	PDF FILE: 09-100-014_WQ_SA_regional_v3.pdf
GIS FILE: 09-100-014_WQ_SA_regional_v3.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

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5.3.3.1.3.2 Temporal Scale

The temporal scale for the surface water quality effects assessment is from pre-construction (baseline) through post-closure (when the TSF discharges). Baseline water quality is required to determine whether effects are occurring during construction and operations of the Project. During operations, and for a period of time after closure, there will be no surface water discharge from the TSF, only limited TSF seepage; during construction limited discharge will occur from sediment control ponds. However, approximately 18 years after cessation of mill operations, the TSF will discharge to Davidson Creek, and this discharge may influence water quality in the creek.

5.3.3.1.3.3 Assessment Approach

The Goldsim™ mass balance model was used to produce quantitative water quality predictions at various locations and during all phases of mining, from construction through post-closure. Source terms were provided from geochemistry models of site features (e.g., open pit, NAG and overburden dumps), chemical testing (e.g., results of aging tests for tailings supernatant, cyanide destruction testing). Geochemistry source terms are discussed in the ML/ARD Characterization Report (**Section 5.1.3.1** and **Appendix 5.1.3.1A**). Potential effects from the transmission line and mine access road construction were not quantitatively modelled as they are expected to be limited to the construction period and mitigated sedimentation through best management practices.

5.3.3.2 Valued Component Baseline

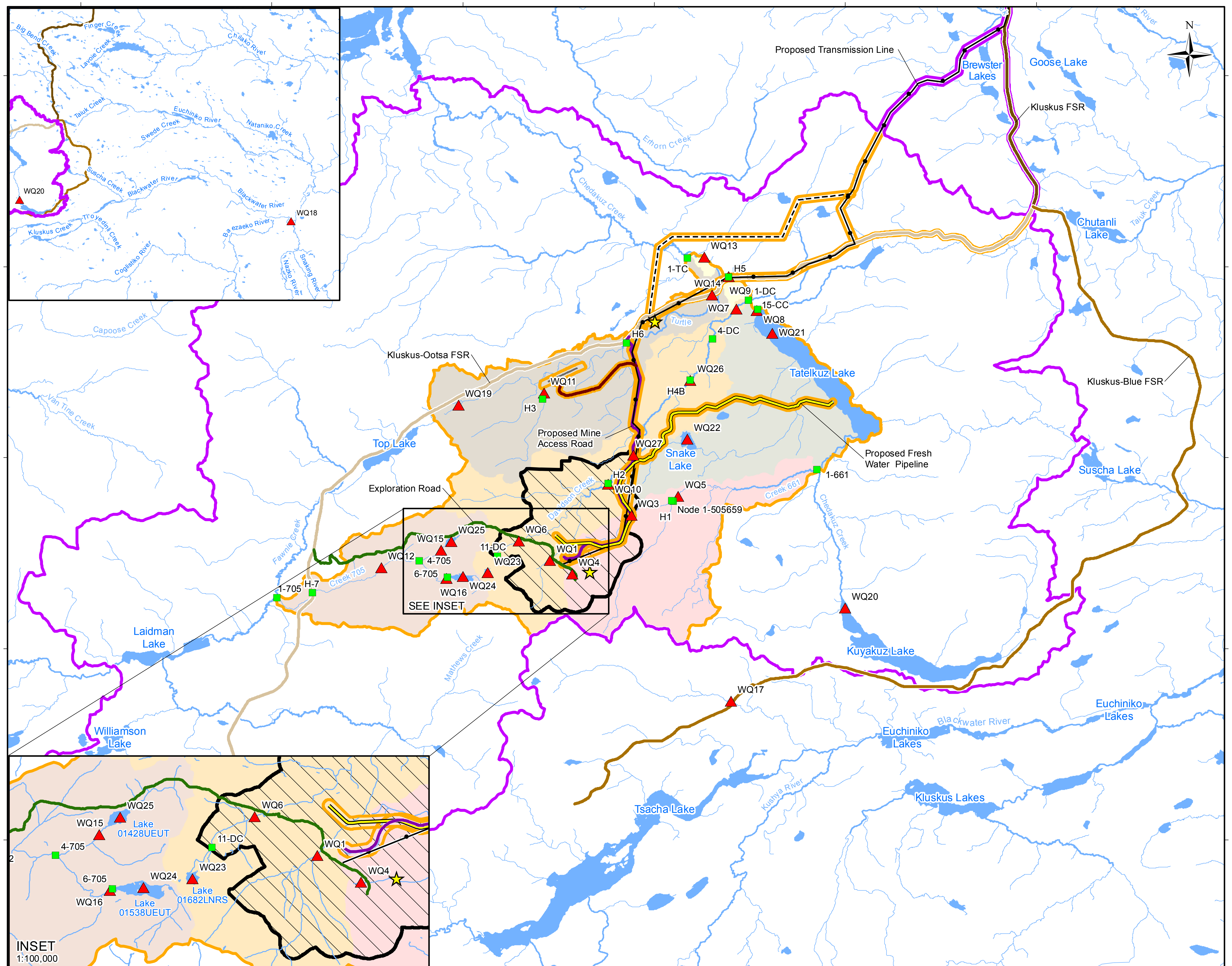
Water was collected on a monthly basis at a total of 16 stream sites (weekly at freshets in 2011, 2012, and 2013); however, the number of sites varied from 2011 through 2013, with sites being added as the Project description changed. Lakes in the Project area were sampled on a quarterly basis when it was safe to do so. During freeze-up and break-up, sampling was not possible due to ice conditions. Summary results are presented in the following tables. The complete Surface Water Quality Baseline Report is included in **Appendix 5.1.2.2A**. **Table 5.3.3-1** lists water quality monitoring sites and rationale for choice and **Figure 5.3.3-2** shows the water quality sites in relation to the Project.

Table 5.3.3-2 lists mean water quality (including the weekly freshet samples) for the parameters analyzed, exceedances of the BC FWG (BC MOE, 2006a, 2006b, 2008, 2009, and 2012), and exceedances of CCME (2007) guidelines. Minimums and means for sites with less than detection values were calculated for streams and lakes using regression on order statistics (ROS). ROS calculates summary statistics with a regression equation on a probability plot. Censored data (less than the detection limit) values are estimated from a regression equation obtained by using observed data. The regression equation is obtained by fitting observed values to the probability plot, and the explanatory variable in the regression is the normal scores of observed values. Hence, the ROS uses exponentiated (if y is in log units) predicted values of unobserved data as well as observed data to compute summary statistics (Helsel, 2012).

Table 5.3.3-1: Water Quality Monitoring Sites and Choice Rationale

Site	Rationale
WQ1	Drains the Blackwater mineral deposit
WQ3	Drains the Blackwater mineral deposit
WQ4	Drains the Blackwater mineral deposit
WQ5	Drains the Blackwater mineral deposit
WQ6	Background water quality
WQ7	Integrate water quality of Davidson Creek
WQ8	Background water quality
WQ9	Monitor influence of Davidson Creek
WQ10	Downstream of a potential TSF
WQ11	Downstream of potential TSF indirect effects
WQ12	Downstream of potential TSF indirect effects
WQ13	Monitor influence of Turtle Creek; potential cumulative effects site
WQ14	Integrate water quality in Turtle Creek
WQ15	Proximate to TSF saddle dam
WQ16	Proximate to TSF saddle dam
WQ17	Requested by BC MOE for comparison with the Project drainages
WQ18	Requested by BC MOE for comparison with the Project drainages
WQ19	Origin of source water for Turtle Creek
WQ20	Early optional source of make-up water for Davidson Creek
WQ21	Potential source of make-up water for Davidson Creek
WQ22	Potential source of post closure low flow water for Davidson Creek
WQ23	Proximate to TSF saddle dam
WQ24	Proximate to TSF saddle dam
WQ25	Proximate to TSF saddle dam
WQ26	Proximate to EEM mid-field point on Davidson Creek

Note: BC MOE = British Columbia Ministry of Environment; TSF = Tailings Storage Facility



Legend

- Meteorology Station
- Hydrology Station
- Water Quality Site
- Kluskus FSR
- Kluskus-Blue FSR
- Kluskus-Ootsa FSR
- Stream (>= 2nd Order)
- Waterbody (> 50 Ha)

Project Components

- Exploration Road
- Proposed Mine Access Road
- Proposed Transmission Line
- Proposed Transmission Line (Mills Ranch Re-route)
- Proposed Fresh Water Pipeline
- Proposed Airstrip Access Road
- Proposed Airstrip
- Proposed Mine Site

Watersheds

- Chedakuz Creek Local
- Creek 661
- Creek 705
- Davidson Creek
- Tatelkuz Lake Tributaries
- Turtle Creek

Hydrology, Surface Water and Sediment Quality, Fish and Fish Habitat

- Regional Study Area
- Local Study Area
- Regional and Local Study Areas

Scale:1:200,000

0 2.5 5 10

Kilometres

Reference
BC Government GeoBC Data Distribution

CLIENT: newgold

PROJECT: Blackwater Gold Project

Surface Water Quality Monitoring Sites

DATE: May, 2014	ANALYST: WR	**Figure** 5.3.3-2
JOB No: VE52420	QA/QC: MY	PDF FILE: 09-100-003_v22_SA_WQ_sites.pdf
GIS FILE: 09-100-003_v22.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

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Table 5.3.3-2: Mean Stream Surface Water Quality Summary for the Project

		WQ1	WQ3	WQ4	WQ5	WQ6	WQ7	WQ8	WQ9	WQ10	WQ11	WQ12	WQ13	WQ14	WQ15	WQ16	WQ17	WQ18	WQ19	WQ26	BC MoE Guideline		CCME	
Parameters	**Unit**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**30-day**	Maximum	Long Term	*Short Term*
Physical Tests																								
pH at 25°C	pH	6.64	7.57	7.09	7.15	7.2	7.57	7.91	7.84	7.42	7.36	7.29	7.83	7.8	7.32	7.31	7.43	7.95	8.04	7.55	6.5-9.0			6.5-9.0
Conductivity at 25°C	μS/cm	22.9	77.2	53.9	41.1	40.4	80	145.8	130.1	63.7	66.3	43.5	127	142.6	54.4	46	70.2	150	199.3	78.6				
T-Dissolved Solids at 180°C	mg/L	42.9	64	52.4	52.6	39.8	65.3	97.7	83.7	51.6	68.9	45.4	84.6	109	65	50.7	45.2	96.8	124	64.4				
Total Suspended Solids at 105°C	mg/L	1.8	3	3.8	2.9	1.6	10.8	6	4.7	2.3	<2	<2	5.4	2.2	2.1	6.2	<2	<2	<2	3.1				
Turbidity	NTU	2.63	1.83	3	1.34	1.5	4.43	3.63	2.21	1.58	1.58	1.57	2.26	1.52	1.55	2.79	0.62	***10.06***	0.8	1.44	8			8
T-Hardness as $CaCO_3$	mg/L	7.2	33.6	20.7	17.2	15.9	38.1	70.1	61.8	27.5	31.3	18.9	58.9	85.6	25.4	20.1	29.2	64.5	100.2	37.1				
Dissolved Anions																								
Total Alkalinity as $CaCO_3$	mg/L	5.9	38.6	13.8	17.7	16.9	38.7	75.4	63.7	30	31.2	20.4	62.4	71.5	23.3	21.6	31.8	76.6	98.7	38.8				
Fluoride-D	mg/L	0.03	0.06	0.05	0.05	0.04	0.05	0.07	0.07	0.05	0.05	0.04	0.07	0.07	0.04	0.03	0.05	*0.13*	0.06	0.05		0.4-1.33c		0.12
Sulphate-D	mg/L	1.3	1.5	7.5	0.9	1.5	2.1	4	3.9	2	1.4	1.2	3.7	2.9	1.4	1.4	2.8	1.7	3	2.2	115-270c			
Chloride-D	mg/L	0.5	0.4	0.9	0.3	0.4	0.4	0.5	0.5	0.3	0.4	0.3	0.8	0.6	0.3	0.3	0.3	0.8	1.2	0.3	150		120	640
Nutrients																								
Ammonia - Nitrogen	mg/L	<0.02	<0.02	0.01	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.424-2.08(1)	2.91-28.7(1)		0.42-189.97(1)
Nitrate-N-D	mg/L	0.01	0.021	0.013	0.023	0.015	0.018	0.034	0.03	0.021	0.022	0.018	0.02	0.017	0.028	0.029	0.046	0.066	0.179	0.03	3	31.3	13	550
Nitrite-N-D	mg/L	0.002	0.002	<0.003	<0.003	<0.003	<0.003	0.002	0.002	<0.003	<0.003	0.002	0.002	0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.02	0.06		0.06
Total Kjeldahl Nitrogen (TKN)	mg/L	0.22	0.18	0.38	0.19	0.14	0.17	0.27	0.23	0.16	0.19	0.18	0.23	0.2	0.2	0.24	0.21	0.55	<0.08	0.11				
Phosphorous-Ortho-	mg/L	0.006	0.018	0.006	<0.003	0.006	0.007	0.008	0.006	0.007	0.005	<0.003	0.008	0.007			<0.003	<0.003	<0.003					
Phosphorous (Total-Dissolved)	mg/L	0.01	0.03	<0.02	<0.02	<0.02	0.4	0.01	0.01	0.01	0.01	<0.02	0.01	0.01	0.01	0.01	<0.01	0.04	<0.01	0.01				
Organic Parameters																								
Carbon (Total Organic)	mg/L	11.2	7.2	10.5	11.5	7.5	8.1	9.7	9.3	7.6	14.9	8.6	10.5	10.3	9.3	6.1	6.6	9.6	7.9	6.5				
Carbon (Dissolved Organic)	mg/L	10.4	6.9	10.5	11	7.3	8.1	9.1	8.9	7.4	14.5	8.6	9.4	10.2	8.9	6	6.5	9.4	7.1	6.4				
Total Metals																								
Aluminum-T	mg/L	*0.302*	*0.113*	*0.261*	*0.185*	*0.139*	*0.224*	0.027	0.071	*0.164*	*0.35*	*0.134*	0.076	0.06	0.059	*0.103*	0.063	*0.223*	<0.002	*0.109*				0.1(2)
Antimony-T	mg/L	0.00005	0.00006	0.00016	<5e-05	0.00005	0.00004	<5e-05	0.00004	<5e-05	<5e-05	<5e-05	0.00004	<5e-05	<5e-05	0.00005	<5e-05	<5e-05	<5e-05	0.00004		0.02		
Arsenic-T	mg/L	0.0005	0.0008	0.0018	0.0004	0.0006	0.0005	0.0005	0.0005	0.0005	0.0002	0.0002	0.0005	0.0003	0.0003	0.0005	0.0004	0.0006	0.0004	0.0007	0.005			0.005
Barium-T	mg/L	0.00387	0.00503	0.00382	0.00406	0.00577	0.00874	0.00658	0.00761	0.00672	0.00838	0.00652	0.01034	0.01438	0.00885	0.00515	0.00633	0.01274	0.00903	0.00763	1	5		
Beryllium-T	mg/L	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04		0.0053		
Boron-T	mg/L	0.001	0.001	0.001	0.001	<0.001	0.001	0.001	0.001	0.001	0.001	<0.001	0.001	0.002	0	<0.001	<0.001	0.001	0.001	0.003	1.2		1.5	29
Cadmium-T	mg/L	***0.000018***	<1.5e-05	***0.000116***	<1.5e-05	<1.5e-05	***0.000016***	<1.5e-05	<1.5e-05	<1.5e-05	<1.5e-05	<1.5e-05	0.000014	<1.5e-05	<1.5e-05	***0.000024***	<1.5e-05	<1.5e-05	<1.5e-05	<1.5e-05	0.000010 – 0.000033(3)		0.000017-0.00016(3)	0.00014-0.0021(3)
Calcium-T	mg/L	2.3	9.9	6.7	4.8	5.1	11	20.8	18.5	8.5	9.7	6.1	17.8	26.4	8.3	6.3	8.2	13.6	32.8	11.2				
Chromium-T	mg/L	0.0002	0.0008	<3e-04	0.0002	<3e-04	0.0004	<5e-04	<5e-04	0.0002	0.0003	<5e-04	<5e-04	<3e-04	<3e-04	<3e-04	<3e-04	<3e-04	<3e-04	<3e-04		0.001-0.0089(3)		0.001-0.0089(3)
Cobalt-T	mg/L	0.00006	0.00005	0.00006	0.00006	0.00003	0.0001	0.00003	0.00005	0.00003	0.00005	0.00004	0.00005	0.00004	0.00002	0.00003	0.00004	0.00037	<2e-05	0.00003	0.004	0.11		
Copper-T	mg/L	0.0008	0.0005	0.0006	0.0004	0.0003	0.0014	0.0005	0.0004	0.0003	0.001	0.0004	0.0004	0.0009	0.0003	0.0002	0.0005	0.0013	<1e-04	0.0004	0.002-0.004(3)c	0.00267-0.0114(3)c		0.002-0.0024d(3)
Iron-T	mg/L	0.2255	0.164	0.1879	0.1655	0.1372	*0.3082*	0.0689	0.1804	0.1237	0.1661	0.2194	0.217	*0.3526*	0.1292	0.1936	0.0801	*0.8952*	0.0213	0.094		1		0.3
Lead-T	mg/L	0.00006	0.00006	0.00028	0.00004	0.00006	0.00012	<5e-05	<5e-05	0.00005	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	0.00016	<5e-05	<5e-05	<5e-05	0.00005	0.0036-0.0065c	0.003-0.081c		0.001-0.0032c
Lithium-T	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.014	0.87		
Magnesium-T	mg/L	0.5	2.32	1.11	1.36	0.86	3.07	4.82	4.16	1.68	1.9	1.02	4.01	5.48	1.27	1.19	2.34	8.23	4.32	2.35				
Manganese-T	mg/L	0.012094	0.009346	0.026335	0.017403	0.008651	0.025601	0.023165	0.025236	0.006504	0.003713	0.016478	0.030234	0.029154	0.023624	0.034923	0.008892	0.082472	0.001563	0.007634	0.64-1.05d(3)	0.62-1.64d(3)		
Mercury-T	mg/L	<8e-06	<8e-06	<8e-06	<8e-06	<8e-06	<8e-06	<8e-06	<8e-06	<8e-06	0.000006	<8e-06	<8e-06	<8e-06	<5e-06	<5e-06	<8e-06	<8e-06	<5e-06	<5e-06	0.00002	0.0001		0.000026
Molybdenum-T	mg/L	0.00014	0.00055	0.00009	0.00014	0.00038	0.00049	0.00054	0.00057	0.00047	0.00015	0.00043	0.00054	0.00067	0.00059	0.00077	0.00187	0.00071	0.00069	0.00055	1	2		0.073
Nickel-T	mg/L	0.00027	0.00032	0.00032	0.00021	0.00023	0.00037	0.00026	0.00026	0.00018	0.00023	0.00012	0.00028	0.00041	0.00008	0.00008	0.00016	0.00154	<5e-05	0.00016		0.025-0.065d(3)		0.025-0.096d(3)
Phosphorous-T	mg/L	0.01	0.04	0.01	<0.02	0.01	0.14	0.02	0.01	0.01	0.01	0.01	0.01	0.02	<0.02	0.02	<0.02	0.09	<0.02	0.01				

		WQ1	WQ3	WQ4	WQ5	WQ6	WQ7	WQ8	WQ9	WQ10	WQ11	WQ12	WQ13	WQ14	WQ15	WQ16	WQ17	WQ18	WQ19	WQ26	BC MoE Guideline		CCME	
Parameters	**Unit**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**30-day**	Maximum	Long Term	*Short Term*
Potassium-T	mg/L	<0.5	0.5	0.6	<0.5	<0.5	0.8	0.9	0.8	<0.5	0.4	<0.5	0.8	0.9	<0.5	<0.5	<0.5	2.5	0.6	0.5				
Selenium-T	mg/L	<6e-04	<6e-04	<6e-04	<6e-04	<6e-04	<6e-04	<6e-04	<6e-04	<6e-04	<6e-04	<6e-04	<6e-04	<6e-04	<6e-04	<6e-04	<6e-04	<6e-04	<6e-04	<6e-04	0.002			0.001
Silicon-T	mg/L	4.78	7.24	5.04	4.87	4.99	5.7	4.24	4.71	5.47	5.75	3.66	4.75	7.76	2.3	1.74	6.05	12.34	6.26	4.85				
Silver-T	mg/L	<5e-05	<5e-05	0.00005	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	0.00005-0.0015 **(3)**	0.0001-0.003 **(3)**		0.0001
Sodium-T	mg/L	1.7	3	2.4	2.1	2	5.5	3.6	3.2	2.4	2.3	1.8	3.2	4.4	1.9	1.9	3.1	5.9	2.8	2.8				
Strontium-T	mg/L	0.020501	0.063794	0.038599	0.032395	0.038406	0.067805	0.098591	0.092993	0.058072	0.059378	0.047007	0.090094	0.129325	0.073019	0.043222	0.051156	0.063088	0.122367	0.067018				
Thallium-T	mg/L	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05		0.0003		0.0008
Tin-T	mg/L	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04				
Titanium-T	mg/L	0.0048	0.0028	0.0049	0.0027	0.0021	0.0066	0.0011	0.0026	0.0026	0.0044	0.0025	0.0027	0.0016	0.0009	0.0019	0.0006	0.0166	<2e-04	0.0019				
Uranium-T	mg/L	0.00015	0.00017	0.00005	0.00007	0.00017	0.00019	0.00009	0.00011	0.0002	0.00018	0.00018	0.00011	0.00012	0.00015	0.00037	0.0001	0.00013	0.00135	0.0002		0.3	0.015	0.033
Vanadium-T	mg/L	0.00026	0.00127	0.00017	0.00026	0.00011	0.00061	0.00015	0.0003	0.00022	0.00038	0.00014	0.0003	0.00021	<1e-04	0.00007	0.00012	0.00242	0.00063	<1e-04		0.006-0.01		
Zinc-T	mg/L	0.0043	0.0026	***0.0445***	0.0027	0.003	**0.0095**	0.0022	0.0016	0.0025	0.002	0.0022	0.0045	0.004	0.0021	0.0032	0.0018	***0.0311***	0.0017	0.0021	0.0075-0.015 **(3)**	0.033-0.0407 **(3)** c		0.03
Dissolved Metals																								
Aluminum-D	mg/L	**0.223**	**0.063**	**0.133**	**0.145**	**0.092**	**0.078**	0.005	0.02	**0.105**	**0.27**	**0.083**	0.025	0.016	0.044	0.023	0.049	0.012	0.003	**0.081**	0.05(2)	0.1(2)		
Antimony-D	mg/L	0.00003	0.00005	0.00014	0.00005	0.00005	0.00007	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00029	0.00005	0.00004	0.00005	0.00006	0.00005	0.00005				
Arsenic-D	mg/L	0.0004	0.0008	0.0013	0.0003	0.0005	0.0004	0.0005	0.0005	0.0004	0.0001	0.0002	0.0005	0.0002	0.0003	0.0004	0.0004	0.0004	0.0004	0.0006				
Barium-D	mg/L	0.00307	0.0043	0.00263	0.00365	0.00519	0.00665	0.00598	0.00694	0.00603	0.00765	0.00586	0.00714	0.01266	0.0083	0.00397	0.00632	0.00544	0.00892	0.00715				
Beryllium-D	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001				
Boron-D	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0	0	0.001	0.001	0.001	0.002				
Cadmium-D	mg/L	0.000012	0.000016	0.000075	0.000017	0.000016	0.000009	0.000015	0.000017	0.000015	0.000017	0.000016	0.000022	0.000017	0.000015	0.000018	0.000015	0.000108	0.000015	0.000015				
Calcium-D	mg/L	2.2	9.7	6.5	4.7	5	10.9	20.3	17.9	8.3	9.4	5.9	17.2	25.5	8.1	6.1	8	13	32.7	10.9				
Chromium-D	mg/L	0.0002	0.0006	0.0003	0.0002	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003				
Cobalt-D	mg/L	0.00003	0.00002	0.00002	0.00003	0.00002	0.00004	0.00001	0.00003	0.00002	0.00004	0.00002	0.00003	0.00003	0.00002	0.00001	0.00003	0.00003	0.00002	0.00002				
Copper-D	mg/L	0.0003	0.0003	0.0005	0.0004	0.0003	0.0013	0.0003	0.0003	0.0003	0.001	0.0003	0.0003	0.0008	0.0003	0.0002	0.0004	0.0008	0.0001	0.0004				
Iron-D	mg/L	0.1352	0.0796	0.0791	0.1115	0.0755	0.1047	0.0298	0.0911	0.0687	0.1188	0.1382	0.1043	0.1842	0.0902	0.066	0.0564	0.1234	0.0132	0.055		0.35		
Lead-D	mg/L	0.00007	0.00005	0.00005	0.00005	0.00006	0.00008	0.00005	0.00005	0.00006	0.00006	0.00005	0.00005	0.00008	0.00005	0.00008	0.00005	0.00005	0.00005	0.00005				
Lithium-D	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001				
Magnesium-D	mg/L	0.5	2.28	1.07	1.33	0.84	2.48	4.69	4.04	1.64	1.87	1	3.88	5.31	1.24	1.17	2.25	7.81	4.28	2.32				
Manganese-D	mg/L	0.00761	0.0042	0.00887	0.00412	0.00439	0.01352	0.00848	0.01747	0.00224	0.00164	0.00709	0.02168	0.01557	0.01142	0.01658	0.00817	0.00412	0.0012	0.00288				
Mercury-D	mg/L	0.000007	0.000006	0.000006	0.000006	0.000006	0.000006	0.000006	0.000006	0.000007	0.000007	0.000006	0.000006	0.000006	0.000005	0.000005	0.000006	0.000006	0.000005	0.000005				
Molybdenum-D	mg/L	0.00011	0.00048	0.00007	0.00012	0.00034	0.00043	0.00049	0.00051	0.00043	0.00014	0.00038	0.00049	0.0006	0.00052	0.00065	0.00164	0.00065	0.00066	0.00051				
Nickel-D	mg/L	0.00025	0.00029	0.00027	0.00018	0.0002	0.00043	0.00021	0.00023	0.00016	0.0002	0.00009	0.00023	0.00035	0.00007	0.00005	0.00014	0.00059	0.00005	0.00015				
Phosphorous-D	mg/L	0.01	0.03	0.01	0.01	0.01	0.41	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.04	0.01	0.01				
Potassium-D	mg/L	0.5	0.5	0.5	0.5	0.5	1.4	0.8	0.8	0.5	0.4	0.5	0.7	0.7	0.5	0.5	0.5	2.4	0.6	0.5				
Selenium-D	mg/L	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0004	0.0004	0.0006	0.0006	0.0006	0.0003				
Silicon-D	mg/L	4.52	6.93	4.71	4.62	4.75	5.31	4	4.47	5.18	5.46	3.4	4.48	7.06	2.11	1.52	5.92	11.02	6.15	4.61				
Silver-D	mg/L	0.00005	0.00005	0.00003	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				
Sodium-D	mg/L	1.6	2.9	2.2	2	1.9	5.4	3.4	3.2	2.3	2.3	1.7	3	3.6	1.8	1.9	3	5.7	2.8	2.6				
Strontium-D	mg/L	0.019419	0.061451	0.036204	0.03112	0.036829	0.063888	0.096156	0.089771	0.056016	0.057454	0.045274	0.087093	0.125312	0.069673	0.039949	0.049712	0.058884	0.119467	0.064182				
Thallium-D	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				
Tin-D	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001				
Titanium-D	mg/L	0.0023	0.0012	0.0015	0.0014	0.0012	0.001	0.0002	0.0005	0.0012	0.0032	0.0012	0.0005	0.0006	0.0006	0.0004	0.0004	0.0008	0.0002	0.0011				
Uranium-D	mg/L	0.00014	0.00014	0.00005	0.00006	0.00015	0.00016	0.00008	0.0001	0.00018	0.00016	0.00016	0.0001	0.00011	0.00014	0.00022	0.00008	0.00011	0.00029	0.00019				
Vanadium-D	mg/L	0.00015	0.00104	0.00006	0.00017	0.00006	0.00024	0.00011	0.00018	0.00014	0.00027	0.00008	0.00018	0.00009	0.00005	0.00005	0.00012	0.00115	0.00064	0.00005				
Zinc-D	mg/L	0.0042	0.0023	0.0405	0.002	0.0025	0.0067	0.0018	0.0016	0.0022	0.0019	0.0023	0.0017	0.003	0.002	0.0027	0.0018	0.0253	0.0017	0.0019				
D-Hardness as $CaCO_3$	mg/L	7.7	34	20.8	18.3	15.5	38.4	68.8	61	27.6	32.4	18.8	61	72.3	24.8	19.8	29.2	64.5	100.2	62				
Cyanide																								
Cyanide (Total)	mg/L	0.006	0.0056	0.0055	0.0059	0.0055	0.0056	0.005	0.0055	0.0058	0.0065	0.0057	0.0055	0.0054	0.005	0.005	0.005	0.005	0.005	0.005				

		WQ1	WQ3	WQ4	WQ5	WQ6	WQ7	WQ8	WQ9	WQ10	WQ11	WQ12	WQ13	WQ14	WQ15	WQ16	WQ17	WQ18	WQ19	WQ26	BC MoE Guideline		CCME	
Parameters	**Unit**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**30-day**	Maximum	Long Term	*Short Term*
Cyanide (WAD)	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	0.005	0.005	0.005	0.005	0.005	0.01		0.005
Cyanate	mg/L	0.28	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2				0.2				
Thiocyanate (SCN)	mg/L	0.42	0.42	0.4	0.44	0.42	0.49	0.44	0.46	0.42	0.55	0.49	0.44	0.46	0.5	0.5				0.5				
Blackwater – Field Parameters																								
Conductivity (EC)	μS/cm	14.5	56.3	39.5	31.3	28.3	65.5	121.4	105.5	49.1	47.8	31.9	107.8	118.5	34.8	31.8	52.2	98.8	120	53.8				
DO Saturation %	%	94.9	97.2	87.5	91.6	96.5	96.5	90.1	96.3	97.7	95.6	91.4	98.7	89.9	84.8	78.5	107.2	113.1	80.7	110.1				
pH	pH	6.6	7.7	7	7.3	7.3	7.7	7.9	7.9	7.4	7.4	7.4	7.8	7.7	7.6	7.6	7.6	7.8	8.6	7.6	6.5-9.0			6.5-9.0
Temperature	°C	3.11	2.64	4.16	4.51	3.6	3.74	7.9	6.69	2.82	3.84	4.54	7.05	6.56	5.14	5.12	1.63	3.31	4.89	3.35		18		

Note: (1) pH and temperature dependent. Assume pH ranges from 6.7 to 8.25, and temperature from 0°C to 19°C. (2) pH dependent. (3) Hardness dependent

Site water has circumneutral pH values and low hardness; alkalinity values are also low, consistent with low hardness and conductivity. For general parameters, only WQ18 on Blackwater River had exceedances based on mean values: BC FWG turbidity (10.1 NTU, versus BC FWG of 8 NTU), and CCME fluoride (0.13 mg/L, versus CCME short-term guide of 0.12 mg/L). WQ18 will not be affected by the Project because it is downstream on the Blackwater River and not connected to any drainage potentially affected by development of the Blackwater mine.

Mean metals concentrations are all low, typically one to several orders of magnitude below their respective guidelines; background exceedances of guidelines are listed in **Table 5.3.3-3**.

Table 5.3.3-3: Mean Background Concentration Exceedances

<table>
<tr><th rowspan="2">Site</th><th colspan="4">Parameters Exceeded</th></tr>
<tr><th>BC FWG 30-day</th><th>BC FWG Max.</th><th>CCME Long Term</th><th>CCME Short Term</th></tr>
<tr><td>WQ1, WQ3, WQ4, WQ5, WQ6, WQ7, WQ10, WQ11, WQ12, WQ16, WQ18, WQ26</td><td></td><td></td><td>Al-t</td><td></td></tr>
<tr><td>WQ1, WQ3, WQ4, WQ5, WQ6, WQ7, WQ10, WQ11, WQ12, WQ13, WQ16, WQ18</td><td>Cd-t</td><td></td><td colspan="2">Cd-t</td></tr>
<tr><td>WQ18</td><td></td><td>Cr-t</td><td></td><td></td></tr>
<tr><td>WQ7, WQ14, WQ18</td><td></td><td></td><td colspan="2">Fe-t</td></tr>
<tr><td>WQ4</td><td>Ag-t</td><td>Zn-t</td><td></td><td></td></tr>
<tr><td>WQ7, WQ18</td><td></td><td>Zn-t</td><td></td><td></td></tr>
<tr><td>WQ1, WQ4, WQ5, WQ10, WQ11, WQ26</td><td></td><td>Al-d</td><td></td><td></td></tr>
<tr><td>WQ3, WQ6, WQ7, WQ12</td><td>Al-d</td><td></td><td></td><td></td></tr>
</table>

Note: d = dissolved, t = total, Al = aluminum, Cd = cadmium, Cr = chromium, Fe = iron, Ag = silver, Zn = zinc
The cadmium guidelines used were BC MOE 2006 and CCME draft 2012

Parameters with provincial or federal guidelines are discussed in detail in the Water Quality Baseline Report (**Appendix 5.1.2.2A**).

Mean results from lake water sampling are presented in **Table 5.3.3-4**, and were generated by combining epilimnion, metalimnion, and hypolimnion results and averaging. There were few exceedances of BC FWG: total cadmium at WQ21, WQ24, and WQ25, and dissolved iron at WQ23, WQ24, and WQ25. The CCME guideline for total iron was exceeded at WQ23 and WQ24.

Complete results are included in the Surface Water Quality Baseline Report in **Appendix 5.1.2.2A**. Quality control for field and laboratory followed BC MOE protocols (2012b) and are discussed in the baseline report.

5.3.3.2.1 Traditional Knowledge

Part C of the Application discusses Traditional Knowledge (TK) with respect to water quality.

Based on information supplied by a First Nations family living at Tatelkuz Lake, the lake and streams in the area used to be safe to drink, but are not any more. According to a spokesperson, there are now E. coli bacteria in the water. This belief may be based on the discoloured water in the Mills Ranch well, which, according to tests conducted by AMEC in 2013, was iron-stained, but did not contain coliform bacteria. The family living at Tatelkuz Lake used to get water from the ranch well, but now get water from Vanderhoof. The possibility that the mine could affect water quality is a voiced concern among local Aboriginal groups.

5.3.3.2.2 Past, Present and Future Activities

Section 4, Subsection 4.3.6.2, Table 4.3-11 shows the Summary Project Inclusion List developed for Cumulative Effects Assessment (CEA) (**Appendix 4C** contains the comprehensive Project Inclusion List).

Logging has occurred in the Project LSA and RSA and continues at present. Where there is overlap of activities either in the past (on the site), at present (access road) and future (access road), logging had, has, and could have the potential to affect water quality. Other activities that may have effects on surface water quality are mining exploration and ranching. Cumulative effects of past, present, and potentially future projects are discussed in **Section 5.3.3.5**.

5.3.3.3 Potential Effects of the Proposed Project and Mitigation

The proposed water management plan for the Project (as described in **Section 2.2.3.5** Water Management and **Appendix 2.2A-2**: Knight Piésold Ltd. Mine Waste and Water Management Design Report) was considered to identify the interactions between the Project and water quality. For surface water quality key interactions included mine site activities at each phase, moderate interactions included site clearing activities for off-site components (access road, transmission line, water supply line, airstrip), and no interaction was assessed for other activities (see **Table 4.3-2**), Key interactions were carried forward and are discussed in detail in this section as direct or indirect effects. Moderate interactions were assessed as those activities that were not likely to have significant effects because established best management practices (BMPs) can mitigate any effects on water quality. Moderate interactions are discussed only briefly. Activities with no interaction are not discussed because there is no link to water quality.

The likelihood of different Project components having direct effects on the surface water quality VC is presented in the following sections. The nature of the expected effects and the likelihood of their occurrence are presented. As well, the effects' indirect interactions are presented in the context of other disciplines potentially affected. Those effects carried forward in the effects assessment are presented.

Past, present and future activities include logging, which has occurred in the watersheds where the Project is located. Logging typically leads to increased TSS in streams and potentially changes in nutrient concentrations washed more rapidly from the exposed soils after logging. A ranch is located near the mouth of Davidson Creek and could potentially have some effect on both Davidson and lower Chedakuz creeks. Exploration activities for the Project result in land disturbance, which could potentially have affected water quality in adjacent streams. Cumulative effects of past, present, and potentially future projects are discussed in **Section 5.3.3.5**.

5.3.3.3.1 Potential Direct Effects on Surface Water Quality

Table 5.3.3-5 lists sources of direct effects on surface water quality by mine phase. Link indicates potential effect on the receiving water body listed.

5.3.3.3.1.1 Potential Indirect Effects on Surface Water Quality

Based on the Project Description (**Section 2.2**), the change in baseline surface water quality could have potential indirect effects on freshwater aquatic resources, human health, groundwater quality, and environmental health.

The potential ways in which surface water quality effects may become indirect effects on other disciplines due to surface water quality changes in the receiving water bodies include:

- Freshwater aquatic resources through changes to fish and fish habitat;
- Human health through ingestion;
- Groundwater quality via drawdown; and
- Environmental health through direct contact and ingestion.

5.3.3.3.1.2 Potential Combined Effects

Changes in baseline surface water quality could potentially affect other disciplines. During construction and operations, the potential combined Project effects include changes in surface water quality due to water management in the Project facilities footprint, as a result of seepage from the TSF, runoff from non-acid generating (NAG) waste rock and overburden dumps, or changes in catchment areas of Project components.

During the closure and post-closure phases, a potential combined Project effect is changes in surface water quality due to changes of the Project’s water management.

5.3.3.3.1.3 Potential Indirect Effects on Other VCs

Based on the proposed Project Description (**Section 2.2**), the change in baseline surface water quality could have potential indirect effects on freshwater resources, environmental health, and human health.

Table 5.3.3-4: Lake Water Quality Summary Means

Parameter	Unit	WQ20	WQ21	WQ22	WQ23	WQ24	WQ25	BC FWG		CCME	
								30-day	Max.	Long Term	Short Term
pH at 25°	pH	7.95	7.91	7.65	7.47	7.5	7.47	6.5-9.0			
Conductivity at 25°C	µS/cm	158.7	147.1	99.5	61	53.2	52.5				
T-Dissolved Solids at 180°C	mg/L	104.4	102.2	73.3	31.7	22.9	23.3				
Total Suspended Solids at 105°C	mg/L	6	2.4	2.3	2.9	2.2	2	5	+10%		
Turbidity	NTU	18.37	1.17	2.53	2.41	4.42	1.07	8 above bg	+10%		
Hardness as $CaCO_3$	mg/L	74	69.7	43.8	24.2	22.4	24.8				
Alkalinity as $CaCO_3$	mg/L	84.7	75.8	50.8	26.8	31.7	24.6				
Fluoride-D	mg/L	0.09	0.08	0.08	0.05	0.04	0.04	a	a	0.120	
Sulphate-D	mg/L	2	3.7	0.8	1.9	1.4	1.6	b			
Chloride-D(1)	mg/L	0.6	0.4	0.5	0.4	0.4	0.3	150		120	640
Ammonia - Nitrogen	mg/L	0.07	0.02	0.02	0.11	0.08	0.02	c		c	
Nitrate-N-D(2)	mg/L	0.03	0.047	0.095	0.036	0.04	0.04	3		3	
Nitrite-N-D	mg/L	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.02		0.06	
Total Kjeldahl Nitrogen (TKN)	mg/L	0.5	0.21	0.44	0.18	0.15	0.18				
Phosphorous-Ortho(3)	mg/L	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003				
Phosphorous (Total-Dissolved)	mg/L	0.02	0.02	0.01	0.07	0.03	0.01				
Carbon (Total Organic)(4)	mg/L	13	11.7	17.9	5	5.8	8.8	±20%			
Carbon (Dissolved Organic)(5)	mg/L	12.3	11.4	16	4.5	5.6	8.6				
Aluminum-T(6)	mg/L	0.032	0.01	0.014	0.008	0.015	0.02			0.1	
Antimony-T(7)	mg/L	<0.00005	<0.00005	0.00006	0.00006	0.00006	<0.00005	0.02			
Arsenic-T	mg/L	0.0003	0.0004	0.0003	0.0026	0.0018	<0.0002	0.005		0.005	
Barium-T(8)	mg/L	0.01033	0.00602	0.00764	0.00401	0.00435	0.00891				
Beryllium-T(9)	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001				
Boron-T	mg/L	0.002	0.003	0.002	<0.001	<0.001	<0.001			1.5	29
Cadmium-T	mg/L	0.000012	**0.000024**	0.00002	0.000017	**0.000024**	**0.000032**		d (µg/L)	e (µg/L)	f (µg/L)
Calcium-T(10)	mg/L	21.6	21.1	12.8	7.7	7.2	8.4				
Chromium-T(11)	mg/L	0.0003	<0.0002	0.0003	<0.0002	0.0003	0.0003	g		h	
Cobalt-T	mg/L	0.00003	<0.00002	<0.00002	0.00004	0.00004	<0.00002	0.004	0.110		
Copper-T(12)	mg/L	0.0006	0.0006	0.0004	<0.0001	0.0002	0.0002	i (µg/L)	j (µg/L)	k	
Iron-T(13)	mg/L	0.1251	0.0226	0.1784	0.7836	0.9066	0.0579		1	0.3	
Lead-T(14)	mg/L	0.00143	0.00079	0.00073	0.00006	0.00006	0.00006	l (µg/L)	m (µg/L)	n	
Lithium-T	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.014	0.870		
Magnesium-T(15)	mg/L	5.85	4.81	3.41	1.34	1.3	1.16				
Manganese-T(16)	mg/L	0.115303	0.011469	0.044585	0.111516	0.255154	0.026627	o (µg/L)	p (µg/L)		
Mercury-T(17)	mg/L	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	0.00002	0.0001		
Molybdenum-T	mg/L	0.00078	0.00056	0.00031	0.00081	0.00126	0.00066		1	0.073	
Nickel-T(18)	mg/L	0.00028	0.00025	0.00016	0.00012	<0.00005	0.00008	q		q	
Phosphorous-T	mg/L	0.04	0.02	0.02	0.07	0.04	0.02	5	15		
Potassium-T	mg/L	0.9	0.8	1.1	0.5	0.5	0.5				
Selenium-T	mg/L	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006	0.002		0.001	
Silicon-T	mg/L	7.55	4.61	5.21	4.79	1.86	2				
Silver-T	mg/L	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	r		0.00001	
Sodium-T	mg/L	3.5	3.6	3.2	2.4	1.9	1.8				
Strontium-T	mg/L	0.110778	0.101189	0.0718	0.05105	0.047625	0.080883				

Parameter	Unit	WQ20	WQ21	WQ22	WQ23	WQ24	WQ25	BC FWG		CCME	
								30-day	Max.	Long Term	Short Term
Thallium-T	mg/L	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005		0.0003	0.00008	
Tin-T	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001				
Titanium-T	mg/L	0.0017	<0.0002	0.0003	<0.0002	<0.0002	<0.0002				
Uranium-T	mg/L	<0.00005	0.00009	<0.00005	0.00013	0.00032	0.00013		0.300	0.015	0.033
Vanadium-T	mg/L	<0.0001	<0.0001	<0.0001	0.00008	0.00008	0.00007	0.006			
Zinc-T	mg/L	0.0048	0.0058	0.0055	0.0021	0.0023	0.0026	s (µg/L)	t (µg/L)	0.030	
T-Hardness as $CaCO_3$	mg/L	74.2	68.8	43.5	22.1	18.2	21.7				
Aluminum-D	mg/L	<0.002	0.003	0.01	0.004	0.008	0.014	0.05	0.1		
Antimony-D	mg/L	<0.00005	<0.00005	0.00006	0.00006	0.00006	<0.00005				
Arsenic-D	mg/L	0.0003	0.0004	0.0003	0.0026	0.0017	0.0002				
Barium-D	mg/L	0.00872	0.00555	0.00686	0.0037	0.00388	0.00779				
Beryllium-D	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001				
Boron-D	mg/L	0.003	0.003	<0.001	<0.001	<0.001	<0.001				
Cadmium-D	mg/L	<0.000015	<0.000015	<0.000015	<0.000015	<0.000015	<0.000015				
Calcium-D[(19)]	mg/L	20.1	20	12.1	7.5	6.8	8				
Chromium-D[(20)]	mg/L	0.0003	<0.0002	0.0003	<0.0002	0.0003	0.0003				
Cobalt-D	mg/L	<0.00002	<0.00002	<0.00002	0.00003	0.00004	<0.00002				
Copper-D	mg/L	<0.0001	0.0003	0.0002	<0.0001	0.0002	0.0002				
Iron-D	mg/L	0.048	0.0104	0.1174	0.7383	0.8172	0.0389		0.350		
Lead-D	mg/L	0.00012	0.00031	0.00044	<0.00005	<0.00005	<0.00005				
Lithium-D	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001				
Magnesium-D	mg/L	5.66	4.64	3.29	1.31	1.27	1.12				
Manganese-D	mg/L	0.08753	0.00055	0.03829	0.10352	0.25306	0.02244				
Mercury-D	mg/L	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005				
Molybdenum-D	mg/L	0.00075	0.00055	0.0003	0.00078	0.00117	0.00065				
Nickel-D	mg/L	0.00012	0.00017	0.00009	<0.00005	<0.00005	0.00006				
Phosphorous-D	mg/L	0.02	0.02	<0.01	0.06	0.04	0.01				
Potassium-D	mg/L	0.9	0.8	1.1	<0.5	<0.5	<0.5				
Selenium-D	mg/L	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006				
Silicon-D	mg/L	7.35	4.52	5.08	4.67	1.83	1.98				
Silver-D	mg/L	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005				
Sodium-D	mg/L	3.4	3.5	3.2	2.4	1.9	1.7				
Strontium-D	mg/L	0.1028	0.096611	0.067217	0.049433	0.044375	0.073183				
Thallium-D	mg/L	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005				
Tin-D	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001				
Titanium-D	mg/L	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002				
Uranium-D	mg/L	0.00005	0.00009	<0.00005	0.00013	0.00029	0.00012				
Vanadium-D	mg/L	0.00013	0.0001	0.00008	<0.00005	<0.00005	<0.00005				
Zinc-D	mg/L	0.0037	0.0051	0.0055	0.0021	0.0023	0.0025				
D-Hardness as $CaCO_3$	mg/L	68.1	64.8	40.2	21	16.8	19.6				
Cyanide (Total)	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005				
Cyanide (WAD)	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005		0.005	0.005	0.010

Note: a 0.4 mg/L hardness <10 mg/L [-51.73+92.57 x log{hardness}]x0.01 hardness >10 mg/L; b 115-410 mg/L Hardness=0-250 mg/L; c pH/Temp dependent Refer to Fig. 4.2-1; d 10e(0.86[log{hardness}]-3.2); e 10e(0.83[log{hardness}]-1.71); f 10e(1.01[log{hardness}]-2.46); g 0.001 mg/L Cr6+ 0.0089 mg/L Cr3+; h 0.001 mg/L CR6+ i 0.002 hardness <50 mg/L 0.04 x [mean hardness] hardness >50 mg/L; j (0.094[hardness]) +2 ;k 0.002-0.006 mg/L hardness 0->180 mg/L; l 3.31+e(1.273 ln[mean hardness]-4.704); m 3(1.273 ln[mean hardness]-1.460); n 0.001-0.007 mg/L hardness 0->180 mg/L; o (0.00044 x hardness)+0.605 p (0.1102 x hardness)+0.54 q 0.025-0.150 mg/L hardness 0->180 mg/L; r 0.00005 mg/L hardness <100 mg/L 0.0015 mg/L hardness >100 mg/L; s 7.5 hardness <90 mg/L 7.5 + 0.75 x (hardness -90); t 33 hardness <90 mg/L hardness >90 mg/L 33+0.75 x (hardness -90) hardness >90 mg/L

Table 5.3.3-5: Potential Direct Effects on Surface Water Quality by Mine Phase

Mining Phase	Potential Direct Effects Source	Link (Y/N)	Parameters/Comments	Receiving Water Body
Construction				
Late Year -2 to end Year -1	Sediment Control Pond #5[1]	Y	TSS Limit to MMER	Creek 661
Late Year -2 to end Year -1	Sediment Control Pond #6[1]	Y	TSS Limit to MMER	Davidson Creek
Late Year -2 to end Year -1	Sediment Control Pond #7[1]	Y	TSS Limit to MMER	Davidson Creek
	Sewage treatment plant treated effluent[2]	N	Nutrients, BOD, fecal coliforms	Discharge to ground through rapid infiltration basin
	Groundwater seepage	N	No TSF Background water quality at site	Davidson Creek, Creek 661
Late Year -2 to end Year -1	Mine and transmission line access roads, pipeline access	Y	TSS Control through best management practices, erosion and sediment control plan	Late Year -2 to end Year -1
Operation				
	TSF surface discharge	N	TSF designed for zero discharge of surface water during operations[1]	
	TSF seepage, 2 L/s	Y	Metals, CN, ammonia, nitrite, nitrate.	Davidson Creek
	TSF seepage	N	Hydraulic barrier; no connection to water bodies	Lake 1682, Lake 1428, Creek 705
	Pit area groundwater	N	Cone of depression draws water into the pit	Creek 661
	Sewage treatment plant treated effluent[2]	N	Nutrients, BOD, fecal coliforms	Discharge to ground through rapid infiltration basin
	Mine and transmission line access roads, pipeline access[5]	Y	TSS Control through best management practices, erosion and sediment control plan	
Closure				
Approximately 18 years	TSF discharge	N	Contained behind dams	
Approximately 18 years	TSF seepage to east, 2 L/s	Y	Metals, CN, ammonia, nitrite, nitrate. Predicted to meet BC guidelines or site specific water quality objectives	Davidson Creek
Approximately 18 years	Pit area groundwater	N	Cone of depression until pit fills	
Approximately 18 years	Reclaimed East NAG dump runoff and seepage	N	Captured by collection channel and cut-off trench[3]	
Until decommissioning within 18 years	Sewage treatment plant treated effluent[2]	N	Nutrients, BOD, fecal coliforms	Discharge to ground through rapid infiltration basin
Until decommissioning within 18 years	Mine and transmission line access roads, pipeline access	Y	TSS Control through best management practices, erosion and sediment control plan	
Post-Closure				
Year 35+	TSF surface discharge	Y	Metals, nutrients	Davidson Creek
Year 35+	TSF seepage, 55 L/s	Y	Metals[4]	Davidson Creek
Year 35+	Pit lake discharge	Y	To TSF, loading	To Davidson Creek via TSF
Year 35+	Pit lake seepage	N	Captured by collection channel with unrecovered portion to Creek 661[3]	Creek 661
Year 35+	East NAG dump runoff and infiltration	N	Captured by collection channel[3]	Creek 661
Year 35+	East NAG dump seepage	N	Captured by collection channel with unrecovered portion to Creek 661[3]	Creek 661

Note: [1] Further discussion in the Mine Water Management Plan, **Section 12.2.1.18.4.18**
[2] Further discussion in the Water Quality and Liquid Discharges Management Plan, **Section 12.2.1.18.4.10**
[3] Should water quality reach BC FWG and site specific objectives water will be allowed to discharge into Creek 661
[4] CN is forecast to be below detection and nitrate and nitrite will drop to background concentrations over time as nutrients are used by the wetland plants
[5] Refer to **Section 2.2.4.4.1** for transmission line access road details. The final location of the transmission line access roads will be determined during the detailed engineering and permitting stage, and will consider traditional knowledge and traditional use information provided by Aboriginal groups as appropriate. Its design will follow the same principles of using existing roads avoiding sensitive habitat to the extent possible.

5.3.3.3.1.4 Potential Project Effects Carried Forward for Assessment

Changes in surface water quality from Project activities would have an effect throughout the Project. The water bodies affected could be Davidson Creek, Creek 661, and Creek 705. Effects on Davidson Creek water quality are discussed in detail in the following sections. Effects on Creek 661 are predicted to be negligible during operations and closure and up to 400 years post closure before the seepage from the East NAG Dump and Open Pit reaches the creek. By that time groundwater quality is forecast to be at background. Creek 705 is separated from the project by a constructed hydraulic barrier and groundwater will not seep to the west from the TSF West Dam.

Closure water management of the reclaimed East NAG dump will include monitoring water in the diversion channel east of the dump, which, during operations will direct contact water to the TSF. Should this water prove acceptable for discharge to Creek 661, the diversion channel will be dismantled, thus restoring the upper most watershed area of the creek. Regulatory approval will be required to discharge this water to Creek 661.

Construction of the transmission line, water supply line, and access road upgrades have the potential to result in sediment entering water bodies at stream crossings. Surveys were completed of all applicable rights-of-way (ROW), and stream crossings were identified. It is most important to mitigate sedimentation in fish-bearing streams, due to the potential to degrade fish habitat.

Avison Management Services Ltd. (Avison) conducted surveys of all stream crossings on the proposed and existing access roads and the transmission line corridor in 2012 and 2013. A summary of their findings follows.

The majority of the 2012 and 2013 field-verified stream classifications reflected the 2002-2006 classifications where these existed, but there were some differences. This can be explained in part by the increase in harvest activity in the area over the last 10 years, which has likely led to altered hydrology and changes in stream discharge rates. Additionally, the rapid regeneration of streamside deciduous trees in logged areas often leads to increased beaver activity, which can also alter stream flows and channel morphology. Most of the drainages that were classified as streams in 2012 were known as or defaulted to fish-bearing status, and were observed to contain good overall habitat. The majority of the fish species captured or observed in these streams were rainbow trout. Other species identified during sampling included brassy minnow, lake chub, and white sucker. There were no anadromous fish captured. One spawned sockeye salmon was observed at a Stellako River site. The streams with historical observations of anadromous fish include the Stellako and Nechako Rivers and the lower reaches of Swanson and Greer Creeks. The nearest species at risk is the white sturgeon, which has historically been observed in the middle reaches of the Nechako River.

Riparian vegetation was variable among sites, and dependent on soil moisture and surrounding forest activity. Wetlands and recently burned or harvested areas were dominated by shrub riparian vegetation, while mature forests contained the most standing timber. The average amount of canopy that would be lost to clearing activities (as estimated to a specified cut height) is 4.9%.

Seventeen existing crossings contained closed-bottom culverts that were determined to impede fish passage during all or part of the year. The most common characteristics that supported these determinations included undersized culverts and lack of embeddedness, inferring that upstream passage would be limited because of velocity barriers, especially during freshet or after storm events.

BMPs (in part based on Fisheries and Oceans Canada (DFO) Operational Statements) will be followed for all linear facilities construction, in order to minimize, to the extent possible, any sediment export to affected streams during construction and subsequent activities.

The airstrip is planned for an area approximately 8 km from water bodies. Construction and operations will not result in any export of sediment or other potential contaminants to water bodies as BMPs will be followed.

5.3.3.3.2 Proposed Site-Specific Water Quality Objectives

With few exceptions, BC water quality guidelines for protection of drinking water, wildlife, and aquatic life are used to assess predicted changes in surface water quality due to the Project. However, four site-specific water quality objectives (SQOs) are proposed for the protection of aquatic life, based on a review of the background water quality database for the Davidson Creek system.

The proposed site-specific guidelines to protect freshwater aquatic life for dissolved aluminum and total cadmium, total copper and total zinc are described below.

5.3.3.3.2.1 Dissolved Aluminum

The BC FWG for dissolved aluminum is routinely exceeded in area streams, as is the case in many unaffected water bodies in BC. **Table 5.3.3-6** lists monitoring results.

To ensure receiving environment limits are rarely, if ever, over the dissolved aluminum site objective, the proponent is proposing to use 0.13 mg/L (10% over the mean value at WQ10) for the 30-day average guideline, and 0.25 mg/L (the 95th percentile value for WQ10) for the maximum grab guideline. WQ10 is the water quality-monitoring site closest to the TSF, and is considered the most representative of background water quality in the portion of upper Davidson Creek below Project construction.

Table 5.3.3-6: Mean and 95th Percentile Background Concentrations of Dissolved Aluminum in the Project Area Streams

Mean (mg/L)									
WQ1	**WQ3**	**WQ4**	**WQ5**	**WQ6**	**WQ7**	**WQ8**	**WQ9**	**WQ10**	**WQ11**
0.223	0.063	0.133	0.145	0.092	0.078	0.005	0.02	0.105	0.27
WQ12	**WQ13**	**WQ14**	**WQ15**	**WQ16**	**WQ17**	**WQ18**	**WQ19**	**WQ26**	
0.083	0.025	0.016	0.044	0.023	0.049	0.012	0.003	0.081	
95th Percentile									
WQ1	**WQ3**	**WQ4**	**WQ5**	**WQ6**	**WQ7**	**WQ8**	**WQ9**	**WQ10**	**WQ11**
0.359	0.165	0.236	0.251	0.205	0.202	0.016	0.053	0.246	0.486
WQ12	**WQ13**	**WQ14**	**WQ15**	**WQ16**	**WQ17**	**WQ18**	**WQ19**	**WQ26**	
0.175	0.047	0.043	0.041	0.019	0.134	0.034	0.056	0.223	

5.3.3.3.2.2 Total Cadmium

Several background water quality samples have total cadmium concentrations that exceed the current BC hardness-dependent guideline of 0.000017 mg/L (for soft water) (currently under review). The 2012 CCME hardness-based long-term guideline, derived from the following regression equation, was not exceeded:

$$10^{\{0.83[\log(\text{hardness})]-2.46\}}$$

In the absence of an accepted BC guideline, the proponent engaged Lorax Environmental (Lorax) to derive a site-specific water quality objective for the Project. Based on information provided by BC MOE in Prince George that the federal CCME guideline would not be accepted in BC.

Lorax proposed the following site-specific water quality objective:

$$10^{\{.83[\log(\text{hardness})]-1.649\}}$$

The proposed site-specific objective is protective of rainbow trout and kokanee, the principal aquatic organisms in Davidson Creek. **Table 5.3.3-7** shows a comparison of the difference between the existing BC FWG and CCME (2012) guidelines and the proposed Lorax objective.

Table 5.3.3-7: Comparison of Lorax, BC FWG, and CCME (2012) Total Cadmium Guidelines

Hardness (mg/L as $CaCO_3$)	Proposed Site Specific (µg/L)	BC FWG (µg/L)	CCME (2012) Guideline (µg/L)
50	0.06	0.02	0.10
100	0.10	0.03	0.18
200	0.18	0.06	0.32
300	0.26	0.09	0.42

Lorax's memorandum to the Proponent is provided in **Appendix 5.3.3A**.

5.3.3.3.2.3 Total Copper

The range of background total copper concentrations at the baseline water quality locations is shown in **Figure 5.3.3-3**. Further details are included in **Appendix 5.1.2.2A**. In the following, and all subsequent box and whisker plots, the diamond is the mean, the line in the box is the median; the box encloses the 1st and 3rd quartiles; and the whiskers are minimum and maximum values.

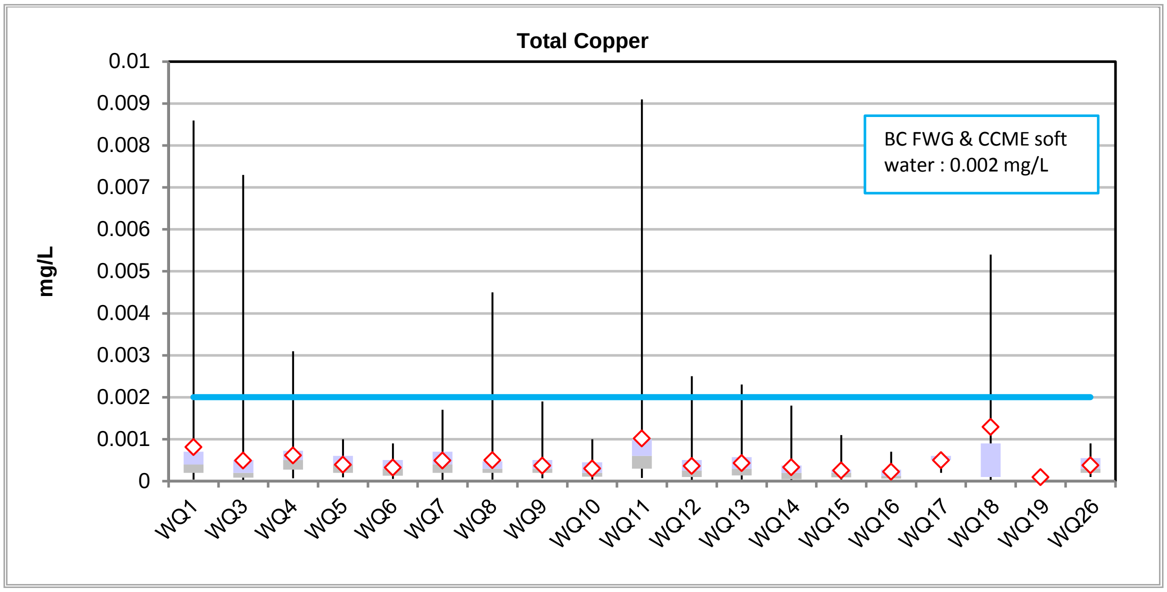


Figure 5.3.3-3: Range in Total Copper Background Concentrations in Project Area Streams

Mean concentrations (diamonds in **Figure 5.3.3-3**) are all less than the BC FWG and soft water CCME guidelines. However, there are occasional outliers that are above these guidelines (maximum values shown **Figure 5.3.3-3**).

For modelling, WQ8 (at the outlet of Tatelkuz Lake) was used as a proxy for Tatelkuz Lake water quality, because monthly data over a three-year period were available. As shown in **Figure 5.3.3-3**, the maximum total copper concentration was 0.0045 mg/L, a concentration greater than the guidelines. Therefore, using Tatelkuz Lake water to maintain fish in-stream flow needs in Davidson Creek, water quality objectives will occasionally be exceeded. The proponent suggests the maximum site-specific water quality objective for copper be set at 0.0045 µg/L.

5.3.3.3.2.4 Total Iron

The Health Canada drinking water guideline for total iron, based on aesthetics, is 0.30 mg/L, and the CCME protection of aquatic life guideline is 0.30 mg/L. Mean total iron concentrations exceeded these guidelines at three sites:

- WQ7 0.308 mg/L;

- WQ14 0.352 mg/L; and
- WQ18 0.895 mg/L.

WQ18 is on the Blackwater River. The Blackwater River will not be affected by the Project.

Table 5.3.3-8 shows the 95th percentile background concentrations for total iron in Project area streams.

Table 5.3.3-8: 95th Percentile Concentrations of Background Total Iron in Blackwater Streams and Mean Concentrations of Total Iron in Lakes

Stream 95th Percentile Total Iron (mg/L)									
WQ1	**WQ3**	**WQ4**	**WQ5**	**WQ6**	**WQ7**	**WQ8**	**WQ9**	**WQ10**	**WQ11**
0.4074	0.3202	0.6645	0.3544	0.368	0.8029	0.2024	0.294	0.277	0.3758
WQ12	**WQ13**	**WQ14**	**WQ15**	**WQ16**	**WQ17**	**WQ18**	**WQ19**	**WQ26**	
0.5373	0.3331	1.091	0.211	0.639	0.0956	3.0183	0.0238	0.229	
Lake Mean Total Iron (mg/L)									
WQ20	**WQ21**	**WQ22**	**WQ23**	**WQ24**	**WQ25**				
0.1251	0.0226	0.1784	0.7836	0.9066	0.0579				

As noted previously, there were not enough data to calculate 95th percentile concentrations for lakes. Exceedances are shown in red font in summary tables **5.3.3-2** and **5.3.3-4**. Given that the BC FWG for total iron was not exceeded, except at WQ14 and WQ18 for the 95th percentile concentrations, the BC FWG of 1 mg/L total iron is proposed as applicable to Project area water bodies and not the Health Canada or CCME guidelines. WQ18 is on the Blackwater River and will not be affected by the Project.

5.3.3.3.2.5 Total Mercury

Total mercury occasionally exceeded the BC FWG usually associated with total suspended solids (TSS) elevated above detection (2 mg/L). A site-specific water quality objective is not proposed but recognition of occasional exceedances in background data needs to be taken into account in interpreting operations water quality monitoring results.

5.3.3.3.2.6 Total Zinc

The range in background total zinc concentrations at the baseline water quality stations is shown in **Figure 5.3.3-4**. Further information is included in **Appendix 5.1.2.2A**.

Figure 5.3.3-4 has had outliers removed from the graphed data to improve the display. Water quality was monitored at WQ10 and WQ7 on Davidson Creek. At both sites, the mean and 95th percentile background concentrations occasionally exceed the BC FWG. Additionally, the 95th percentile background concentrations occasionally exceed both the BC maximum and CCME guidelines for total zinc. Therefore, the Proponent suggests that the site-specific water quality objective for total zinc be set at a 30-day average of 0.01 mg/L, or alternatively, that the CCME guideline of 0.03 mg/L be used, with recognition that WQ4 (if included in the operational water quality monitoring plan) was naturally always above guidelines as shown in **Figure 5.3.3-4**.

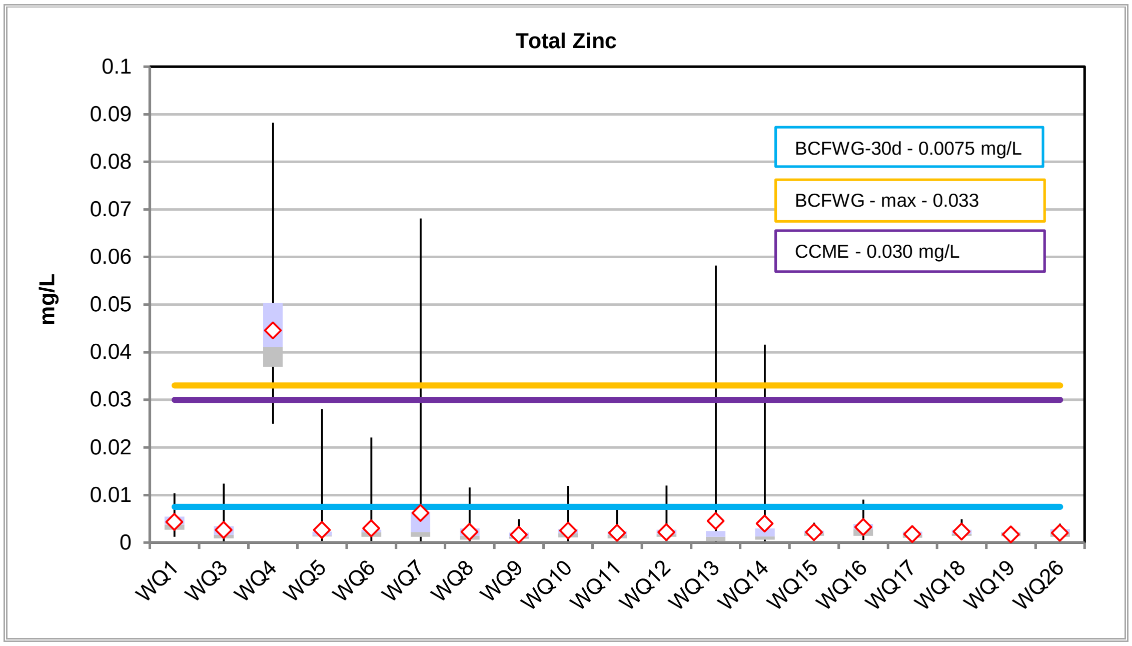


Figure 5.3.3-4: Range in Total Zinc Concentrations in Project Area Streams

5.3.3.3.3 Discharges during Construction Phase

Discharges during the approximate two-year construction phase will be controlled by seven sediment control ponds as shown in **Table 5.3.3-9**. Ponds have been sized according to BC Guidelines and flocculants tested and identified for use if required. Four of the ponds will discharge effluent to infiltrate permeable glaciofluvial deposits, which will further remove suspended solids and other contaminants. Three of the ponds will discharge to streams for the construction phase only, two to Davidson Creek and one to Creek 661. All discharges will meet *MMER* and provincial permit requirements.

Further details on the design and operation of the facilities can be found in the Construction Sediment and Erosion Control Plan (SECP) (**Section 12.2.1.18.4.1**) and the Mine Water Management Plan (MWAMP) (**Section 12.2.1.18.4.18**).

The exploration camp sewage treatment plant will be expanded and upgraded to include a rapid infiltration basin to mitigate against potential effects on Davidson Creek water quality. The upgraded sewage treatment system will operate through the operations and early closure phases as well. A second sewage treatment plant to serve to process plant will discharge to the TSF during operations. The design and operation of the sewage treatment systems is described in the Project Overview, **Section 2.2** and the Water Quality and Liquid Discharges Management Plan (WQLDMP), **Section 12.2.1.18.4.10**.

Table 5.3.3-9: Construction Sediment Control

Pond	General Area	Start of Construction	Discharge Strategy	Date of Decommissioning	Post Decommissioning Runoff Routing
SCP#1	Construction laydown and truck shop	Beginning of Year -2	Permeable glaciofluvial deposits	End of Year -2	To TSF Site C basin via West Ditch
SCP#2	Plant site	Beginning of Year -2	Permeable glaciofluvial deposits	End of Year -2	To TSF Site C basin via West Ditch
SCP#3	Camp	Beginning of Year -2	Permeable glaciofluvial deposits	N/A	N/A
SCP#4	Aggregate screening area	Beginning of Year -2	Permeable glaciofluvial deposits	N/A	N/A
SCP#5	East waste dump area	Late Year -2	Creek 661	End of Year -1	To TSF Site C basin via collection ditch
SCP#6	Downstream of Site C cofferdam	Late Year -2	Davidson Creek	End of Year -1	SCP is in TSF basin footprint
SCP#7	Downstream of Site D cofferdam	Late Year -2	Davidson Creek	End of Year -1	SCP becomes obsolete, structure is in place and can be used if needed

5.3.3.3.4 Information Source and Methods

The Goldsim™ mass balance model was used to produce quantitative water quality predictions at various locations and during all phases of mining, from construction through post-closure. Source terms were provided from geochemistry models of site features (e.g., open pit, NAG and overburden dumps), chemical testing (e.g., results of aging tests for tailings supernatant, cyanide destruction testing). Geochemistry source terms are discussed in the ML/ARD Characterization Report (**Section 5.1.3.1** and **Appendix 5.1.3.1A**). Potential effects from the transmission line and mine access road construction were not quantitatively modelled.

Background water quality for receiving water bodies was derived from baseline sampling conducted from March 2011 through June 2013; background water quality sampling continues.

The assumptions that were key to the development of the model are:

- Mixing for each model component is instantaneous and complete;
- Dissolved components remain in solution; and
- Mine components in the model turn on and shut off instantaneously as the model progresses between mine development phases although water quality of the TSF is carried through operations, closure and into post-closure.

Knight Piésold developed a water balance schedule for the mine site and watersheds for input into the mass balance water quality model. The schedule was divided into four phases for the purposes of modelling water quality, which are:

- Construction – Year -1;
- Operations – Years 1 through 17;
- Decommissioning/Closure – Years 18 to 35, and
- Post-closure – Years 35+.

The water quality parameters modelled are presented in **Table 5.3.3-10**. The modelled results were compared to relevant provincial and federal water quality guidelines (WQGs) and the proposed site-specific water quality objectives for cadmium developed by Lorax, dissolved aluminum, copper and zinc. Guidelines and standards for comparison with the model output data were determined by regulations, when applicable, and with respect to the most sensitive receptors in the downstream environment. The guidelines and standards are as follows:

- BC MOE water quality guidelines (approved and working) for the protection of freshwater aquatic life:
  - The Maximum Acceptable limits (Max); and
  - The 30-day Average limits (30-day average).
- CCME guideline for the protection of aquatic life (freshwater):
  - Long term (equivalent to MOE 30-day average); and
  - Short term (equivalent to MOE Max).
- Health Canada drinking water guidelines; and
- BC MOE wildlife guidelines.

TSS were not modelled because:

- During construction, sediment will be captured by sediment control ponds and discharges from ponds will meet *MMER* and provincial permit requirements;
- During operations and closure all site water will be captured (except for approximately 2 L/s groundwater seepage) and pumped back to the TSF; and
- At post-closure only TSF supernatant water filtered through Cell D wetland and seepage filtered through wetlands in the former ECD/water reservoir will be released to Davidson Creek.

Table 5.3.3-10: Water Quality Parameters Modelled in Goldsim™

	Parameter	
General parameters	Temperature	Nitrate-nitrogen
	pH	Nitrite-nitrogen
	Hardness as $CaCO_3$	Ammonia-nitrogen
	Total dissolved solids	
	Fluoride	
	Chloride	Sulphate
Metals – Total	Aluminum	Molybdenum
	Antimony	Mercury
	Arsenic	Nickel
	Barium	Potassium
	Beryllium	Selenium
	Boron	Silicon
	Cadmium	Silver
	Calcium	Sodium
	Chromium	Strontium
	Cobalt	Thallium
	Copper	Tin
	Iron	Titanium
	Lead	Uranium
	Lithium	Vanadium
	Magnesium	Zinc
	Manganese	
Metals – Dissolved	Aluminum	Iron
Cyanide	Total cyanide	Weak acid dissociable (WAD) cyanide

Note: $CaCO_3$ = calcium carbonate

Water quality modelling was conducted for a best estimate and a worst-case scenario with the following inputs as shown in **Table 5.3.3-11**.

The CN destruct (SO_2/air) data and the results from a neutralization experiment with potentially acid-generating (PAG) rock humidity cell test (HCT) leachate are included in **Appendix 5.1.3.1A**. Aged SO_2/air treated tailings laboratory data were used for the best estimate since operating tailings ponds typically have about 30 days retention time during which natural degradation of cyanide species and other contaminants (e.g., copper cyanide complex) occurs. Leachate from an acid generating humidity cell containing PAG1 waste rock was neutralized with lime to estimate contaminants in the PAG interstitial water that would remain in solution after neutralization to about pH 8 by the TSF tailings discharge. The annual discharge of tailings solution to the TSF will be about 22 Mm^3/y; given its very large volume and elevated alkalinity, the tailings solution will control the pond pH. The worst-case estimate does not consider the effects of neutralization of PAG rock interstitial water (i.e., assumes interstitial water in PAG waste rock is acidic with elevated metals).

Table 5.3.3-11: Modelled Scenarios

	Best Estimate	Worst Case	Comment
Tailings	SO_2/air with 39 day aging	SO_2/air w/o aging	–
PAG waste rock	Neutralization of PAG HCT average experiment results	Neutralization of PAG HCT 95th percentile experiment results	–
Constructed wetland at ECD and water reservoir (post-closure)	Wetland	No wetland	Wetlands in TSF C and D cells assumed for both cases
Background water quality (WQ 10)	Average monthly	95th Percentile monthly	–
Pit water quality	Annual estimate	Annual estimate	No degradation of CN species, nutrients or copper assumed in TSF supernatant transferred to pit at closure
Closure pit lake mixing	Complete	Complete	Stratified case less conservative
TSF interstitial water quality	Average	95th Percentile	–
Watershed model/streamflow	Average monthly	Average monthly	Winter 7dQ10, 7dQ20; 1:50 dry year
Site water balance	Average monthly	Average monthly	–
Rainfall Event	Average, 7dQ10, 7dQ20, 1:50 dry year	Average, 7dQ10, 7dQ20, 1:50 dry year	All but average for post closure only; Davidson Creek water flow controlled during operations and closure by IFN pumping
TSF Dam D downstream runoff/seepage quality	Monthly-Estimate	Monthly Estimate	–
TSF Dam D seepage discharged to Davidson Creek	2 L/s op/closure 55 L/s post-closure	3 L/s op/closure 83 L/s post-closure	Worst case assumed 50% higher

Note: PAG = potentially acid generating; TSF = tailings storage facility; ECD = environmental control dam; IFN = instream flow needs (for fish); L/s = litres per second; op = operations; w/o = without; d = day; Q_n = return period in years.

The CN destruct (SO_2/air) data and the results from a neutralization experiment with PAG rock HCT leachate are included in **Appendix 5.1.3.1A**. Aged SO_2/air treated tailings laboratory data were used for the best estimate since operating tailings ponds typically have about 30 days retention time during which natural degradation of cyanide species and other contaminants (e.g., copper cyanide complex disassociation) occurs. Leachate from an acid generating humidity cell containing PAG1 waste rock was neutralized with lime to estimate contaminants in the PAG interstitial water that would remain in solution after neutralization to about pH 8 by the mill tailings discharge. The annual discharge of tailings solution to the TSF will be about 22 Mm^3/y; given its very large volume and elevated alkalinity, the tailings solution will control the pond pH during operations. The worst-case estimate does not consider the effects of neutralization of PAG rock interstitial water (i.e., assumes interstitial water in PAG waste rock is acidic with elevated metals).

The effects of a constructed wetland in the former ECD/water reservoir in treating seepage from the TSF in post-closure were included in the best estimate but not the worst-case. In post-closure, the surface discharge from the TSF spillway would bypass the wetland to protect the structure during high flows. The wetland and TSF spillway discharges will combine in a plunge pool below the wetland in the former water reservoir. Water quality predictions at this point (Plunge Pool) represent Davidson Creek at the location closest to the TSF. Predictions are conservative as the proposed compliance point in Davidson Creek is below the access road crossing and the additional dilution provided by this catchment have not been included in the model. This compliance point location is proposed because mine plans include the potential for a contingency constructed wetland between the water reservoir wetland, plunge pool, and access road crossing. This downstream contingency wetland would be used to treat the post-closure TSF seepage or spillway discharge and be implemented if required, based on monitoring during closure. Additional seepage collection and treatment works could be implemented in this area as required. Note that compensation for the loss of fish habitat in Davidson Creek between the TSF dam and access road crossing has been included in the Fish Mitigation and Offsetting Plan (FMOP) presented in **Appendix 5.1.2.6C**.

Average background water quality of WQ8 (operations and closure when Tatelkuz Lake water is pumped to Davidson Creek and WQ10 (post closure when lake water pumping ceases) was used in the best estimate model and the 95th percentile for all parameters in the worst-case model.

Knight Piésold determined average monthly stream flows and site flows. In addition, 7dQ10 and 1:50 year dry flows were used to estimate potential water quality effects in extreme flow conditions. Potential effects of flood flows were not modelled since the TSF is designed to contain a maximum probable flood. TSF pond water quality was modelled and presented in **Table 5.3.3-14** and **Table 5.3.3-15**. Accidental release of TSF water could result in water quality in Davidson Creek becoming the water quality of the TSF in a very unlikely worst case release of a large volume of tailings pond supernatant.

The quality of runoff and seepage from the downstream Dam D shell was estimated based on the quantity of rock and overburden used in its construction and geochemical leaching data (**Section 5.1.3.1**, **Appendix 5.1.3.1A**).

Pit water quality was determined by a pit lake model (**Appendix 5.1.3.1A**) that did not consider degradation of CN species, nutrients or copper in TSF supernatant transferred to the pit during closure, bacterial sulphate reduction, adsorption or precipitation; all conservative assumptions.

Dam seepage is the unrecovered foundation seepage from the TSF that might bypass the ECD and reach Davidson Creek and was estimated by Knight Piésold using a Seep/w model (**Section 5.3.5**). A conservative value of 2 L/s unrecovered seepage was used for operations and closure in the best estimate and was increased by 50% to 3 L/s in the worst-case estimate. The water quality model assumed seepage would instantaneously appear in Davidson Creek downstream of the ECD without any attenuation. Seepage will not be collected and recycled in post-closure if of acceptable quality so the full 55 L/s estimated by Knight Piésold was assumed to reach Davidson Creek in post-closure, again with no path length attenuation. Sensitivity analyses conducted by Knight Piésold (discussed in **Section 5.3.5**) using conservative subsurface material permeabilities suggest seepage values could be higher than predicted. However the higher seepage rates are not expected and does not have a large effect on water quality predictions since concentrations are (for most parameters) governed by predicted quality in the TSF during each phase of mining and the background concentration of receiving waters; constructed wetlands are predicted to address the few remaining parameters of concern. Verification and adaptive management responses if required are discussed in **Section 5.3.3.5**.

<u>All</u> assumptions in the worst-case estimate listed above were combined into the model for that scenario. While individually the assumptions might be reasonable, combining them all in the worst-case model is very conservative.

For each time period, the modelled water quality locations were chosen to be coincident with the water balance model. A map of the modelled locations is provided in **Figure 5.3.3-2**. **Table 5.3.3-12** lists the nodes and locations, along with their rationale for inclusion in the model.

Table 5.3.3-12: Assessed Nodes

Hydrology Node	Water Quality Node	Status	Rationale
H2/Plunge Pool	WQ10	Primary	Davidson Creek; closest point to the Project where all contributing drainages are accounted for
4DC	WQ7	Primary	Mouth of Davidson Creek, midfield site
H5	WQ9	Primary	Integrates effects of Tatelkuz Lake and Davidson Creek on Chedakuz Creek
1-50569	WQ3	Secondary	Tributary of Creek 661; no potential Project effects assumed
H1	WQ5	Secondary	Site on Creek 661; no potential Project effects assumed
4-705	WQ12	Secondary	Near headwaters of Creek 705; first modelling node west of the project

Note: The groundwater seepage front is not forecast to reach Creek 661 for approximately 400 years at which time groundwater quality is expected to be at background

5.3.3.3.4.1 Schematic of Modelled Sources

Figure 5.3.3-5 and **Figure 5.3.3-6** provide schematics of the model site sources for operations and closure that show the interconnection of the various sources; the first year of the construction period (Year -2) was not modelled as the second year of construction (Year -1) involves more site disturbance and was taken to be the existing background since sediment ponds will meet TSF standards and very little mining not have commenced and the mill and TSF will not be operating. **Appendix 5.3.3B** provides a listing of inputs for the Goldsim™ model. The hydrology, groundwater, and geochemistry sections provide detailed discussions about derivation of the values used in the Goldsim™ model. A summary of model sources is provided in **Table 5.3.3-13**.

Table 5.3.3-13: Goldsim™ Model Input Sources Summary

Source	Data
Operations/Closure	
Site surface runoff	WQ10 background water quality
Open pit	Open pit water quality model results
Waste rock dumps	Infiltration: East dump and West dump infiltration concentration Runoff: East dump and West dump runoff concentration
Nitrogen species loading	Mining: ANFO use + Ferguson & Leask (1980) model; processing: 39-day tailings supernatant aging lab results
LGS	neutralization of PAG rock HCT leachate results
Lime treatment	neutralization of PAG rock test results
Landfill runoff	WQ10 background water quality
Landfill seepage	Literature
SO_2/air CN destruct	39-day tailings supernatant aging lab results
TSF	39-day tailings supernatant aging lab results
TSF dam runoff	WQ10 background water quality
TSF dam embankment / foundation seepage	Interstitial water: mix of aging test and waste rock in TSF
TSF tailings beach	39-day tailings supernatant aging lab results
Tatelkuz Lake water	WQ8
Post-Closure	
Site surface runoff	WQ10 background water quality
Open pit lake	Pit lake water quality model results, complete mixing scenario
Reclaimed dumps and stockpiles runoff	WQ10 background water quality
Reclaimed dumps and stockpiles seepage	East dump and West dump infiltration and runoff concentrations
Wetland treatment	Musselwhite 1997 – 2006 data; Sobolewsky (2013) data for Cd and Zn (**Appendix 2.6C**)
TSF discharge	Combination of TSF supernatant water quality and pit water quality; TSF supernatant aged and polished by beach wetlands
TSF Dam runoff	Based on dam composition; AMEC geochemistry tests results (**Appendix 5.1.3.1A**).
TSF dam embankment / foundation seepage	Concentration calculated based on the relative proportions of total waste rock and total tailings in TSF

Note: ANFO = ammonium nitrate/fuel oil; HCT = humidity cell tests; LGS = low-grade stockpile; PAG = potentially acid generating; TSF = tailings storage facility

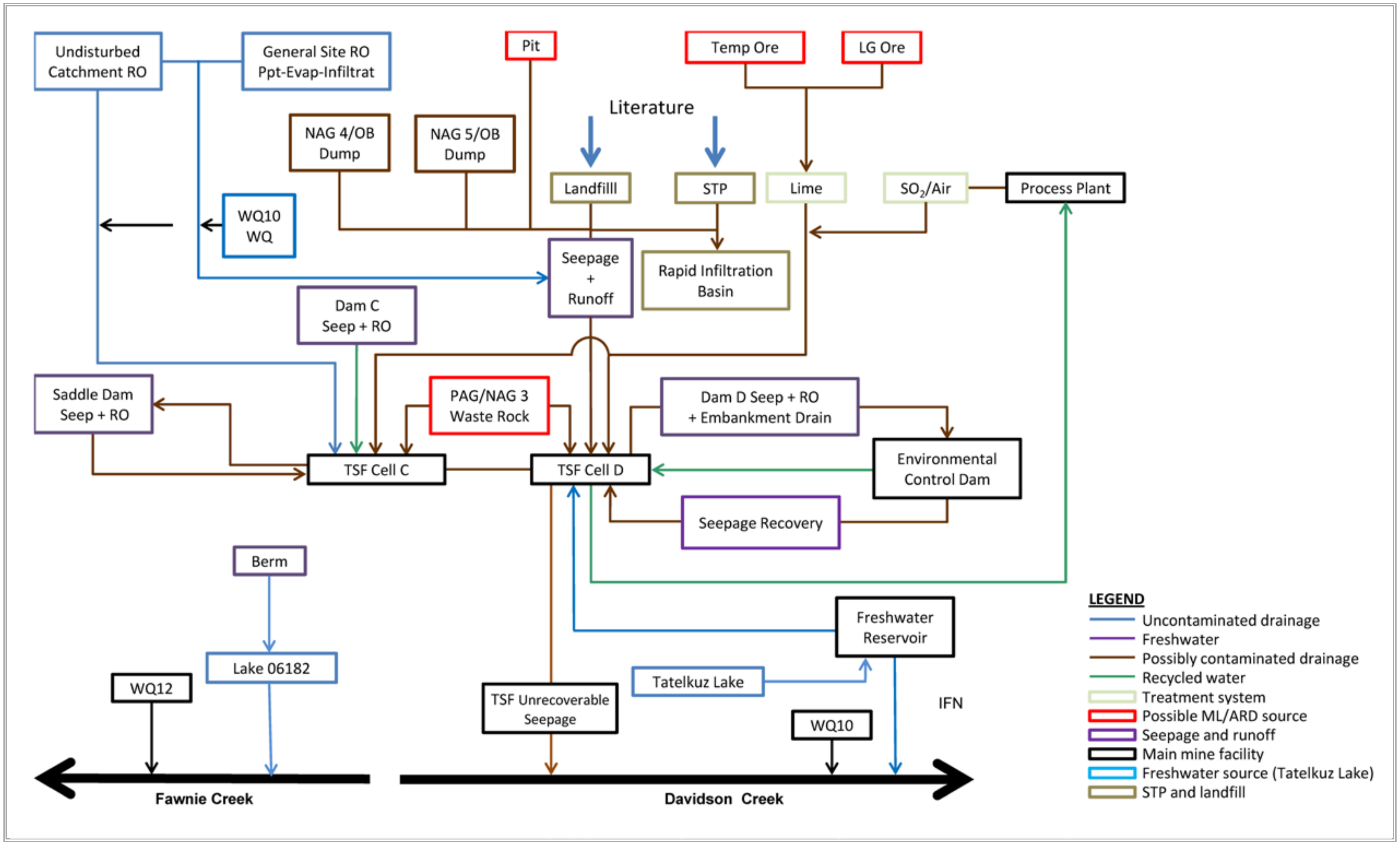


Figure 5.3.3-5: Operations/Closure Model Input and Output Schematic

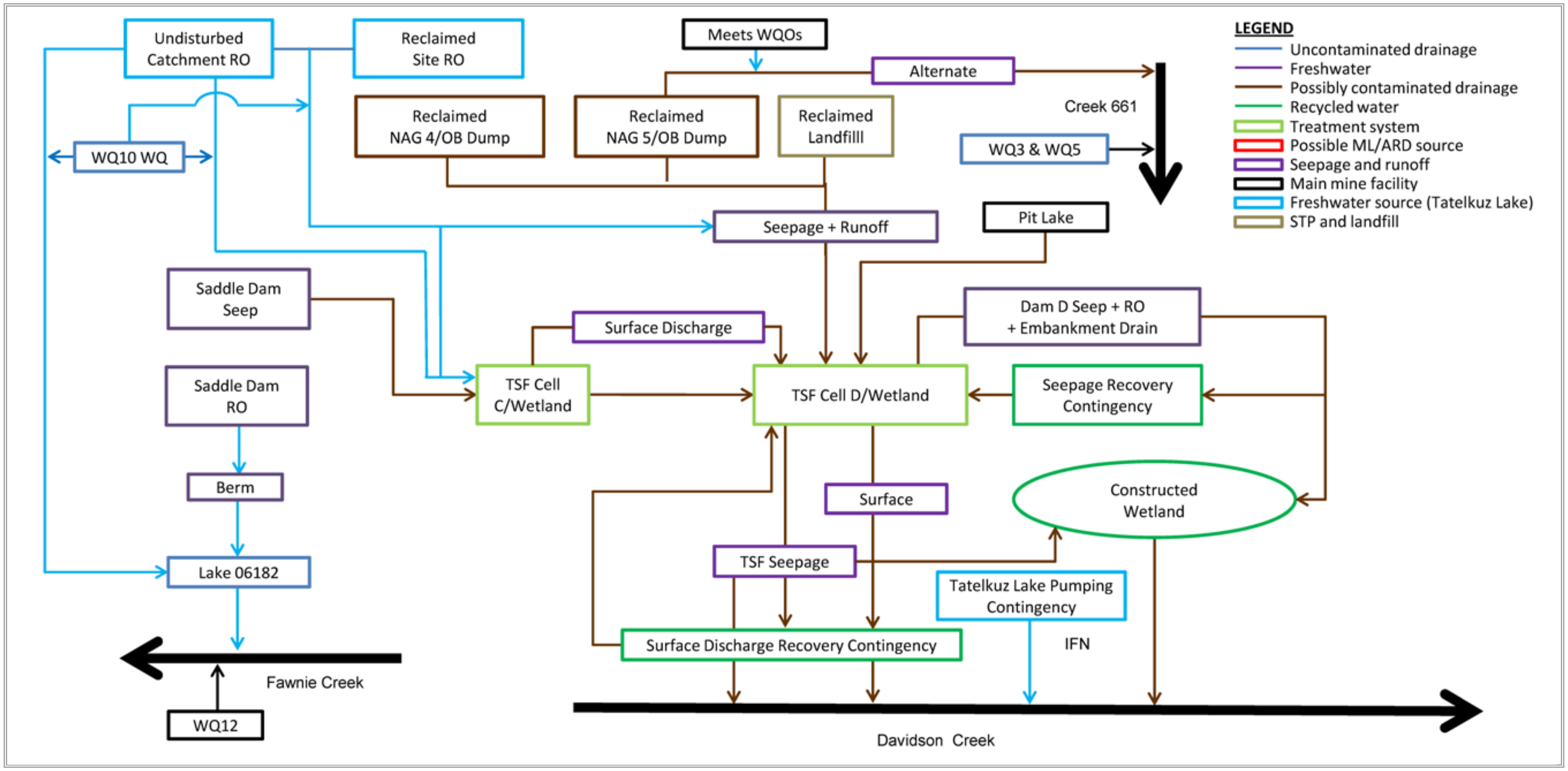


Figure 5.3.3-6: Post-Closure Model Input and Output Schematic

5.3.3.3.5 Predicted TSF Water Quality

The TSF is the main mixing and storage facility for water from all mine sources during the operations, closure, and post-closure phases. The TSF quality was modelled on a monthly basis, as were other modelled nodes. **Table 5.3.3-14** and **Table 5.3.3-15** provide summaries for best estimate and worst-case scenarios, respectively, for the last year of open pit mining (Year 14), the first full year of closure (Year 18), and the first full year of post-closure (Year 36). Year -1 is provided to show annual average and 95th percentile background concentrations at WQ10. Parameters listed are those for which there are water quality guidelines, and are discussed below. Results listed are annual averages calculated from the modelled monthly concentrations.

The TSF is designed to contain the probable maximum flood event. In the very unlikely event that the main dam (Dam D) overtopped and released a large volume of supernatant, the following tables indicate the possible concentration of listed parameters in Davidson Creek. Prior to overtopping TSF Site D supernatant could be pumped to Pond C or the open pit. Therefore, an overtopping scenario is extremely unlikely and would require that mining temporarily ceased during the time of flooding. Water captured in the pit would be pumped back to the TSF via the pit dewatering system when water levels returned to normal.

The current *MMER* Schedule 4 standards are not exceeded. BC protection of wildlife guideline for molybdenum (0.05 mg/L) is exceeded for best estimate and worst case for operations and closure, but other guidelines are met. The BC wildlife guideline is based on the assumption ruminants would drink water daily from a water source with molybdenum at the guideline concentration. Molybdenum levels in the Blackwater ore and waste are relatively low. Terrestrial wildlife is not expected to be attracted to the TSF during operations due to human activities and the presence of the soft tailings beach and would not drink from the pond on an ongoing basis. Estimates of TSF water quality for closure in particular are conservative as a layer of overburden will be placed over the PAG/NAG3 waste rock and the tailings to prevent upward diffusion of porewater. The tailings pond supernatant will be pumped to the pit to accelerated flooding. Therefore, the supernatant water quality is expected to approximate background (WQ10) quality very soon after reclamation. The actual molybdenum concentration at closure will determine whether any special management actions are required to prevent wildlife from drinking water from the TSF until water quality approaches background concentrations.

For most parameters, there are little differences between predictions for best estimate and worst case.

Table 5.3.3-14: TSF Summary Annual Average Water Quality Predictions: Best Estimate

Parameter	Unit	Construction Background Year -1	Operations Last Year of Open Pit Mining Year 13	Closure Pit Filling / TSF Pumping Year 18	Post-Closure Pit Overflow Year 36
pH	pH unit	7.6	9.1	8.5	7.6
Conductivity	mS/cm	78	284	195	78
TDS	mg/L	56	171	120	56
TSS	mg/L	2.5	5.7	4.4	2.5
Turbidity	mg/L	1.1	3.3	2.4	1.1
Total_hardness	mg $CaCO_3$/L	34	72	57	34
Total_alkalinity	mg/L	38	79	62	38
Fluoride	mg/L	0.050	0.10	0.082	0.050
Sulphate	mg/L	2.3	67	38	2.3
Chloride	mg/L	0.29	0.80	0.59	0.29
Ammonia	mg/L	0.019	1.8	0.097	0.020
Nitrate	mg/L	0.022	14	0.18	0.022
Nitrite	mg/L	0.003	0.33	0.013	0.003
TOC	mg/L	5.8	13	10	5.8
T_Aluminum	mg/L	0.099	0.27	0.083	0.083
T_Antimony	mg/L	0.000050	0.090	0.057	0.000052
T_Arsenic	mg/L	0.00053	0.012	0.0074	0.00047
T_Barium	mg/L	0.0072	0.075	0.050	0.0071
T_Beryllium	mg/L	0.00010	0.00020	0.00016	0.00010
T_Boron	mg/L	0.0012	0.038	0.024	0.0012
T_Cadmium	mg/L	0.000015	0.0050	0.0031	0.000015
T_Calcium	mg/L	10	36	19	10
T_Chromium	mg/L	0.00033	0.0018	0.0012	0.0003
T_Cobalt	mg/L	0.000028	0.090	0.057	0.000030
T_Copper	mg/L	0.00024	0.025	0.014	0.00024
T_Iron	mg/L	0.084	0.65	0.43	0.084
T_Lead	mg/L	0.0001	0.0018	0.00049	0.000067
T_Lithium	mg/L	0.0012	0.020	0.012	0.0012
T_Magnesium	mg/L	2.1	5.1	4.1	2.1
T_Manganese	mg/L	0.0044	0.51	0.32	0.0044
T_Mercury	mg/L	0.0000067	0.000017	0.000013	0.0000080
T_molybdenum	mg/L	0.00059	0.15	0.10	0.00059
T_Nickel	mg/L	0.00013	0.0053	0.0033	0.00013
T_Phosphorus	mg/L	0.013	0.10	0.043	0.013
T_Potassium	mg/L	0.50	98	62	0.50
T_Selenium	mg/L	0.00056	0.0014	0.0011	0.00060
T_Silicon	mg/L	6.0	10	8.9	6.0
T_Silver	mg/L	0.000050	0.000035	0.000033	0.000033
T_Sodium	mg/L	2.8	19.7	11.7	2.8
T_Strontium	mg/L	0.070	0.77	0.51	0.070
T_Thallium	mg/L	0.00005	0.00016	0.00011	0.00005
T_Tin	mg/L	0.00010	0.024	0.016	0.00010
T_Titanium	mg/L	0.0015	0.0040	0.0020	0.0015

Parameter	Unit	Construction Background Year -1	Operations Last Year of Open Pit Mining Year 13	Closure Pit Filling / TSF Pumping Year 18	Post-Closure Pit Overflow Year 36
T_Uranium	mg/L	0.00020	0.0031	0.0020	0.00020
T_Vanadium	mg/L	0.00020	0.00058	0.00033	0.00020
T_Zinc	mg/L	0.0022	0.12	0.069	0.0022
D_Aluminum	mg/L	0.060	0.25	0.067	0.060
D_Iron	mg/L	0.052	0.63	0.41	0.052
Cyanide_T	mg/L	ND	0.16	0.093	0.0000041
Cyanide_WAD	mg/L	ND	0.0081	0.0052	ND

Note: TDS = total dissolved solids; TSS = total suspended solids; TSF = tailings storage facility; LGS = low grade ore stockpile; T = total; D = dissolved; WAD = weak acid dissociable; ND = non detect
mg/L = milligram per litre; mS/cm = microSiemens per centimetre

Table 5.3.3-15: TSF Summary Annual Average Water Quality Predictions: Worst Case

Parameter	Unit	Construction Background Year -1	Operation Last Year of Open Pit Mining Year 13	Closure Pit Filling / TSF Pumping Year 18	Post-Closure Pit Overflow Year 36
pH	pH unit	7.7	9.1	8.5	7.6
Conductivity	mS/cm	84	231	145	78
TDS	mg/L	68	180	122	56
TSS	mg/L	3.3	6.5	4.7	2.5
Turbidity	mg/L	1.8	4.0	2.6	1.1
Total_hardness	mg $CaCO_3$/L	38	76	58	34
Total_alkalinity	mg/L	43	83	64	38
Fluoride	mg/L	0.058	0.11	0.085	0.050
Sulphate	mg/L	2.8	41	14	2.3
Chloride	mg/L	0.44	0.91	0.62	0.29
Ammonia	mg/L	0.021	1.8	0.010	0.011
Nitrate	mg/L	0.035	14	0.08	0.022
Nitrite	mg/L	0.004	0.33	0.010	0.003
TOC	mg/L	7.5	15	11	5.8
T_Aluminum	mg/L	0.161	0.45	0.102	0.083
T_Antimony	mg/L	0.000052	0.093	0.058	0.000054
T_Arsenic	mg/L	0.00067	0.012	0.0073	0.00048
T_Barium	mg/L	0.0080	0.079	0.051	0.0071
T_Beryllium	mg/L	0.00010	0.00020	0.00016	0.00010
T_Boron	mg/L	0.0015	0.040	0.024	0.0012
T_Cadmium	mg/L	0.000017	0.0054	0.0032	0.000016
T_Calcium	mg/L	11	51	20	10
T_Chromium	mg/L	0.00040	0.0019	0.0012	0.00033
T_Cobalt	mg/L	0.000042	0.093	0.058	0.000031
T_Copper	mg/L	0.00037	0.026	0.014	0.00024
T_Iron	mg/L	0.130	0.67	0.41	0.084
T_Lead	mg/L	0.0001	0.0047	0.00055	0.000067
T_Lithium	mg/L	0.0017	0.022	0.013	0.0012

Parameter	Unit	Construction Background Year -1	Operation Last Year of Open Pit Mining Year 13	Closure Pit Filling / TSF Pumping Year 18	Post-Closure Pit Overflow Year 36
T_Magnesium	mg/L	2.3	5.4	4.2	2.1
T_Manganese	mg/L	0.0078	0.54	0.33	0.0044
T_Mercury	mg/L	0.0000088	0.000017	0.000013	0.0000080
T_molybdenum	mg/L	0.00065	0.16	0.10	0.00060
T_Nickel	mg/L	0.00018	0.0056	0.0034	0.00013
T_Phosphorus	mg/L	0.022	0.10	0.040	0.013
T_Potassium	mg/L	0.52	101	63	0.51
T_Selenium	mg/L	0.00060	0.0015	0.0011	0.00060
T_Silicon	mg/L	6.4	11	9.0	6.0
T_Silver	mg/L	0.000053	0.000036	0.000033	0.000033
T_Sodium	mg/L	3.0	20.4	11.2	2.8
T_Strontium	mg/L	0.076	0.80	0.52	0.070
T_Thallium	mg/L	0.00005	0.00015	0.00010	0.000050
T_Tin	mg/L	0.00010	0.026	0.016	0.00010
T_Titanium	mg/L	0.0027	0.0048	0.0022	0.0015
T_Uranium	mg/L	0.00023	0.0032	0.0020	0.00020
T_Vanadium	mg/L	0.00033	0.00065	0.00034	0.00020
T_Zinc	mg/L	0.0038	0.14	0.072	0.0022
D_Aluminum	mg/L	0.077	0.42	0.078	0.060
D_Iron	mg/L	0.067	0.63	0.38	0.052
Cyanide_T	mg/L	ND	0.01	ND	ND
Cyanide_WAD	mg/L	ND	0.0075	0.0044	ND

Note: TDS = total dissolved solids; TSS = total suspended solids; TSF = tailings storage facility; LGS = low grade ore stockpile; T = total; D = dissolved; WAD = weak acid dissociable; ND = non detect
mg/L = milligram per litre; mS/cm = microSiemens per centimetre

5.3.3.3.6 Pit Lake Modelled Results

Once mining has been completed the pit will be flooded. It is forecast to fill and flow to the TSF Year 35 from the commencement of mine operation; the first full year of overflow will be 36. Two scenarios were modelled: complete mixing and stratified assuming mixing only in the top 30 m. **Table 5.3.3-16** provides modelling results. Only the complete mixing scenario was carried forward for post closure in the Goldsim™ surface water quality model, as the more conservative of the two scenarios. Results are compared to BC wildlife, as pit water will not discharge directly to any natural water bodies. **Appendix 5.1.3.1A** provides additional information.

5.3.3.3.7 Predicted Water Quality Results for Receiving Waters

Results were modelled for Davidson Creek and Creek 661 from Year -1 of mining (which was assumed to be baseline) through 10 years post-closure. The modelled nodes are listed in **Table 5.3.3-12** and shown in **Figure 5.3.3-2**. Only those parameters with BC guidelines or affecting guidelines (pH, hardness, and temperature) are discussed. Complete results for all parameters listed in **Table 5.3.3-10** are provided in graphic format (**Appendix 5.3.3B**, Annex A), and annual summary tables for mining Years -1, 16 (last full year of mining), and 36 (first full post-closure year) are provided in **Appendix 5.3.3B**, Annex B). Technical details regarding the Goldsim™ model, including details on source terms, are provided in **Appendix 5.3.3B**.

5.3.3.3.7.1 WQ3, WQ5, and WQ12

Site WQ3, on a tributary of Creek 661, and WQ5, on Creek 661, are downslope of the East NAG dump. However, all surface runoff and the majority of seepage from the dump will be captured and routed to the TSF. Any unrecovered seepage is predicted to take several decades to reach Creek 661. Therefore, baseline conditions will continue during the operations and closure phases. WQ12, on Creek 705, will not be affected, since all seepage from the TSF Site C West Dam will flow back toward the dam, due to a hydraulic barrier between the creek and the dam.

WQ3 is high up in the Creek 661 drainage basin and on a tributary. This site is likely to continue to be unaffected by groundwater seepage from the pit, TSF and East NAG5 dump at post closure because of the controls mentioned above.

Seepage from the East Dump, pit lake and TSF (very limited amount) might reach Creek 661 at WQ5 hundreds of years beyond closure according to MODFLOW modelling. Additional groundwater discussion can be found in **Section 5.3.6**. For the modelled time period (last year of construction to 10 years post closure), WQ5 is unlikely to be affected by seepage from the subject facilities due to the anticipated long travel times from sources to Creek 661 and the Goldsim model assumes background water quality will be maintained. Values for WQ3 and WQ5 are shown for completeness.

The possible long-term post-closure effects on Creek 661 are discussed below.

WQ12 on Creek 705 will not be affected since all seepage from the TSF Site C West Dam will flow back toward the dam due to a constructed hydraulic barrier between the creek and the dam. Site WQ12 will not be discussed further in **Section 5.3.3**.

Table 5.3.3-16: Modelled Pit Lake Results

Parameter	Unit	Mixing Case	Stratification Case	BC MOE Wildlife Guidelines
		Yr 35		Maximum
pH		7.9	7.9	
Alkalinity	mg/L $CaCO_3$	47.7	58.3	
Acidity	mg/L $CaCO_3$	0.1	0.1	
Sulphate	mg/L	9.6	8.2	
Chloride	mg/L	0.389	0.442	600
Fluoride	mg/L	0.064	0.071	1.5
Aluminum	mg/L	0.017	0.017	5
Antimony	mg/L	0.0106	0.0080	
Arsenic	mg/L	0.0035	0.0035	0.025
Barium	mg/L	0.0152	0.0143	
Beryllium	mg/L	0.00011	0.00013	
Boron	mg/L	0.0064	0.0057	5
Cadmium	mg/L	0.0007	0.0006	
Calcium	mg/L	13.0	15.7	
Chromium	mg/L	0.0006	0.0008	
Cobalt	mg/L	0.0108	0.0081	
Copper	mg/L	0.0030	0.0024	0.3
Iron	mg/L	0.126	0.116	
Lead	mg/L	0.0016	0.0018	0.1
Lithium	mg/L	0.0030	0.0027	
Magnesium	mg/L	2.65	3.25	
Manganese	mg/L	0.101	0.091	
Mercury	mg/L	0.000009	0.000010	0.0000125* - 0.00002*
Molybdenum	mg/L	0.0194	0.0150	0.05
Nickel	mg/L	0.0013	0.0012	
Phosphorus	mg/L	0.039	0.043	
Potassium	mg/L	12.054	9.244	
Selenium	mg/L	0.0006	0.0007	0.004
Silicon	mg/L	6.32	6.96	
Silver	mg/L	0.00005	0.00006	
Sodium	mg/L	5.151	5.347	
Strontium	mg/L	0.156	0.151	
Thallium	mg/L	0.00006	0.00006	
Tin	mg/L	0.0030	0.0022	
Titanium	mg/L	0.0019	0.0020	
Uranium	mg/L	0.0006	0.0005	
Vanadium	mg/L	0.0003	0.0003	
Zinc	mg/L	0.042	0.043	
Nitrate	mg/L	0.108	0.089	
Nitrite	mg/L	0.0068	0.0064	
Total Cyanide	mg/L	0.023	0.0169	
WAD Cyanide	mg/L	0.001	0.00094	
Ammonia	mg/L	0.0413	0.0406	

Note: * 30 days average concentration and depends on methyl mercury content, metal concentrations are dissolved; guidelines are for total metals

5.3.3.3.8 Long-term Post Closure Creek 661 WQ5 Water Quality

There will be no discharge to Creek 661 from the mine facilities during operations and closure. However, Creek 661 could eventually receive seepage from the pit lake, TSF and East Dump in post-closure although travel times predicted by the MODFLOW model (**Section 5.3.5**) are very long. The predicted median travel times for seepage from the pit lake, TSF and East Dump to reach Creek 661 are 218, 254 and 405 years respectively. The full predicted seepage flows would not reach the Creek from the mine site sources for even a longer time period. Over these century time frames, the concentration of contaminants in seepage from the mine sources should decrease substantially due to reduction in oxidation rate (e.g., shrinking waste rock particle core) and availability of readily leachable contaminants. This effect is illustrated in the modelling results discussed below for the East Dump. The possible impact of incomplete segregation of waste rock in the East Dump (i.e. the inadvertent mixing of other waste rock types besides NAG5) on water quality is also presented.

The expected attenuation (e.g. adsorption and exchange) of most metals in subsurface materials has been shown to be significant (**Appendix 5.1.3.1A, Annex 12**). Attenuation has not been considered in the modelling presented below. Biological processes that would reduce concentrations such as cyanide degradation and nitrification have also not been considered. These then are conservative assumptions in the model.

5.3.3.3.8.1 Mass Balance Model Assumptions

5.3.3.3.8.1.1 Water Quality

- Conservative mass balance spreadsheet model; Goldsim™ was not used due to the small number of input sources, but results will be identical with the same assumptions;
- Total metals concentrations used, except aluminum and TSF interstitial water (both dissolved). This is conservative for the pit lake and East Dump seepage as contaminants would be present only in dissolved form;
- Seepage flows to Creek 661 assumed the maximum predicted steady state over time and included (from Knight Piésold MODFLOW site groundwater model) (refer to **Section 5.3.6**) although it would take many centuries to reach these flows:
    - o pit lake 0.5 L/s;
    - o East Dump 1.7 L/s; and
    - o TSF 0.2 L/s;
- No long-term reduction of contaminants from sources (other than from the East Dump), attenuation or dispersion (conservative steady state);
- TSF interstitial water quality the median of five replicates after only 39-day aging (median used due to one very high outlier);
- Total CN, WAD CN, cyanate and thiocyanate set to mean background (WQ5 = <MDL) except for East Dump seepage where the concentrations were set to 0 as there is no cyanide contact with the waste rock in that dump;
- Cyanate and thiocyanate were set to 0.001 mg/L for pit lake seepage;

- Ca, Si and Na assays were unavailable for TSF seepage, therefore Creek 661 results were based on the pit lake and East Dump seepage effects only;
- Ammonia, nitrite, and nitrate for the East Dump were taken as the average of the mixed and stratification pit lake modelled cases as there were no humidity cell data for these parameters; and
- Mean background concentrations at WQ5 less than detection set at the detection limit.

5.3.3.3.8.1.2 Creek 661 Flows

Background flow in Creek 661 at 1:50 year lowest monthly flow (April) at 0.6 L/s from Knight Piésold's watershed model (refer to **Section 5.3.2** for further discussion on the watershed model).

5.3.3.3.8.2 Creek 661 Results

Table 5.3.3-17 lists long-term predictions for Creek 661, assuming seepage from the pit lake, East Dump and TSF reaches the Creek. For the East Dump, three scenarios were run: assuming complete segregation of waste rock so the dump is only comprised of NAG5 and overburden, incomplete segregation by 1% mixing of other waste rock types (PAG1, PAG2, NAG3, NAG4) and incomplete segregation by 3% mixing of other waste rock types. Incomplete 3% mixing of other waste rock types is equivalent to 1 Mt (about 3,500 truckloads) of non-NAG5 waste rock in the East Dump.

Table 5.3.3-17: Predicted Long-Term Post Closure Effects of Seepage on Creek 661

Parameter	Unit	Pit Lake @ 35 Years Mixing	East Dump (Yr 35 100% Segregation)	East Dump (Yr 35 1% Mixing)	East Dump (Yr 35 3% Mixing)	TSF Interstitial Water (Median)	Mean Background Creek 661 (WQ5)	Predicted Creek 661 Steady State (WQ5 - Yr 400 - 0% WR Mixing)	Predicted Creek 661 $T^{-1.2}$ Reduction (WQ5 - Yr 400 0% WR Mixing)	Predicted Creek 661 $T^{-1.2}$ Reduction (WQ5 - Yr 400 - 1% WR Mixing)	Predicted Creek 661 $T^{-1.2}$ Reduction (WQ5 - Yr 400 - 3% WR Mixing)	BC FWL or Site Specific Guidelines Max.	BC FWL or Site Specific Guidelines 30-d
Alkalinity	mg/L $CaCO_3$	47.7	63.2	63.3	63.5	59	18	52	3.16	3.17	3.17		
Acidity	mg/L $CaCO_3$	0.1	4.1	4.4	5.1	2		3	0.21	0.22	0.26		
Sulphate	mg/L	9.6	49.5	49.7	50.3	1300	0.9	137	2.47	2.49	2.51		
Aluminum	mg/L	0.017	0.22	0.24	0.29	0.031	0.15	0.2	0.01	0.01	0.01	0.12	site specific
Antimony	mg/L	0.0106	0.0053	0.0056	0.0062	0.049	0.00005	0.009	0.0003	0.0003	0.0003	0.02	
Arsenic	mg/L	0.0035	0.0155	0.0155	0.0153	0.016	0.0004	0.012	0.0008	0.0008	0.0008	0.005	
Barium	mg/L	0.015	0.008	0.008	0.008	0.046	0.004	0.01	0.0004	0.0004	0.0004	1	
Beryllium	mg/L	0.00011	0.0003	0.0003	0.0003	0.00002	0.0001	0.00021	0.00001	0.00001	0.00002		
Boron	mg/L	0.0064	0.02	0.021	0.021	0.026	0.001	0.015	0.001	0.001	0.0011	1.2	
Cadmium	mg/L	0.00074	0.0005	0.0008	0.0013	0.00007	0.00001	0.00034	0.00003	0.00004	0.00007	0.00006	site specific
Calcium	mg/L	13	38	38	38	-	4.8	26.2	1.9	1.9	1.9		
Chromium	mg/L	0.0006	0.0013	0.0013	0.0013	0.0005	0.0002	0.0009	0.00006	0.00006	0.00007	0.001	
Cobalt	mg/L	0.0108	0.0002	0.0004	0.0007	0.056	0.00006	0.0050	0.00001	0.00002	0.00003	0.004	
Copper	mg/L	0.003	0.0012	0.0015	0.0021	0.009	0.0004	0.0017	0.00006	0.00007	0.0001	0.0045	site specific
Iron	mg/L	0.13	0.12	0.12	0.12	2.7	0.17	0.33	0.006	0.006	0.006	1	0.351
Lead	mg/L	0.0016	0.00015	0.00531	0.01718	0.0003	0.00004	0.0003	0.00001	0.00027	0.00086	0.003	0.001
Lithium	mg/L	0.003	0.009	0.01	0.01	0.009	0.001	0.007	0.0005	0.0005	0.0005	0.014	
Magnesium	mg/L	2.7	1.77	1.79	1.82	2.4	1.4	2	0.09	0.09	0.09		
Manganese	mg/L	0.101	0.004	0.023	0.069	0.046	0.017	0.04	0.0002	0.0012	0.0034	0.64	
Mercury	mg/L	0.000009	0.00003	0.00003	0.00003	0.00001	0.00001	0.00002	0.000001	0.000001	0.000001	0.00002	
Molybdenum	mg/L	0.019	0.003	0.003	0.003	0.13	0.0001	0.013	0.0002	0.0002	0.0002	1	0.073
Nickel	mg/L	0.0013	0.0011	0.0013	0.0018	0.0024	0.0002	0.0010	0.00006	0.00007	0.00009	0.025	
Phosphorus	mg/L	0.039	0.6	0.6	0.61	0.039	0.02	0.38	0.03	0.03	0.03		
Potassium	mg/L	12.1	5.6	5.6	5.6	68.6	0.5	9.7	0.3	0.3	0.3		
Selenium	mg/L	0.0006	0.0007	0.0007	0.0007	0.001	0.0006	0.0007	0.00004	0.00004	0.00004	0.002	0.001
Silicon	mg/L	6.32	6.7	6.7	6.9	-	4.9	5.7	0.3	0.3	0.3		
Silver	mg/L	0.00005	0.00006	0.00007	0.00007	0.00004	0.00005	0.00006	0.000003	0.000003	0.000003	0.00005	
Sodium	mg/L	5.2	2.9	2.9	2.9	-	2.1	2.73	0.1	0.1	0.1		
Strontium	mg/L	0.156	0.18	0.17	0.17	0.57	0.03	0.17	0.01	0.01	0.01		
Thallium	mg/L	0.00006	0.00011	0.00012	0.00012	0.0003	0.00005	0.00010	0.00001	0.00001	0.00001	0.0003	
Tin	mg/L	0.003	0.0003	0.0003	0.0003	0.00013	0.0001	0.0003	0.00001	0.00001	0.00001		
Titanium	mg/L	0.0019	0.021	0.021	0.021	0.0002	0.003	0.014	0.001	0.001	0.001		
Uranium	mg/L	0.0006	0.0002	0.0002	0.0002	0.0048	0.0001	0.0006	0.00001	0.00001	0.00001	0.015	
Vanadium	mg/L	0.0003	0.002	0.002	0.002	0.00021	0.0003	0.001	0.0001	0.0001	0.0001	0.006	
Zinc	mg/L	0.042	0.008	0.049	0.143	0.004	0.003	0.008	0.0004	0.0025	0.0072	0.01	site specific
Ammonia	mg/L	0.041	0.041	0.041	0.041	4.4	0.02	0.39	0.32	0.33	0.33	0.42	
Nitrate	mg/L	0.108	0.099	0.099	0.099	0.6	0.023	0.12	0.12	0.12	0.12	3	
Nitrite	mg/L	0.007	0.007	0.007	0.007	0.3	0.003	0.026	0.026	0.026	0.026	0.02	
T. Cyanide	mg/L	0.0227	0	0	0	7.11	0	0.57	0.48	0.48	0.48		
WAD Cyanide	mg/L	0.0013	0	0	0	0.04	0	0.0038	0.0038	0.0029	0.0029	0.005	
Cyanate	mg/L	*0.001*	0	0	0	56	0	4.5	3.8	3.7	3.7		
Thiocyanate	mg/L	*0.001*	0	0	0	57	0	4.1	4.1	3.8	3.8		
	Guideline exceedance												

Note: (1) dissolved guideline; detectable cyanate and thiocyanate in E Dump and WQ5 background artifacts of analyses because no source exists in background

Results are presented assuming no long-term reduction of metal contaminants from the East Dump (i.e., steady Year 35 concentration) and then with a reduction in acidity, alkalinity, sulphate and metal concentrations over the approximately 400 years median travel time of seepage to Creek 661 as predicted by the following equation:

$$C_t = C_i * (T)^{-1/2}$$

Where:

C_t = concentration of contaminant at specified time

C_i = initial concentration (predicted peak concentration – year 10)

T = elapsed time in years from the predicted peak concentration (year 10)

Further discussion of the rationale for the assumed reduction in the East Dump seepage can be found in **Appendix 5.1.3.1A** under Creek 661. Concentrations of cyanide and nitrogen species were kept at steady state concentrations. As previously discussed, biological processes and chemical attenuation in the mine waste and in subsurface materials for seepage from the East Dump over the 400 years median travel time were not considered. Biological processes in particular would reduce cyanide and nitrogen species concentrations by the time the seepage reached Creek 661.

There are a few predicted exceedances with no attenuation assumed, based on the conservative assumptions made in the models (all concentrations in mg/L):

Complete Segregation (steady state Year 35 concentration)

Parameter	**Guideline or SSWQO**	**Predicted**
Aluminum	0.12	0.2
Arsenic	0.005	0.012
Cadmium	0.00006	0.00034
Cobalt	0.004	0.005
Silver	0.0005	0.0006
Nitrite	0.02	0.03
WAD CN	0.0067	0.005

Assuming very conservative steady state conditions, the predicted cobalt and silver, and guidelines concentrations are equal within the precision of the model. Other exceedances under steady state conditions, except Cd and to a lesser extent Al and As, are relatively near guidelines or objectives and will be lower by the time seepage reaches Creek 661 in the 100s of years due to dispersion, adsorption, and other degradation processes.

Acidity, alkalinity, sulphate and all metal parameters met guidelines after applying a reduction in East Dump seepage contaminant concentrations at a rate described by $t^{-1/2}$ over the 400 years travel time. Nitrite was not adjusted from the base case so still slightly exceeded the guideline. However nitrite is expected to meet guidelines due to nitrification, which was not modelled.

All parameters except nitrite met guidelines after 400 years of contaminant reduction in East Dump seepage assuming 1% incomplete segregation and mixing of other waste rock types in the East Dump. Cadmium very marginally exceeded the site-specific guideline after 400 years of contaminant reduction in East Dump seepage with 3% incomplete segregation and mixing of other waste rock types. Cadmium will be further reduced by attenuation and dispersion in the subsurface materials (refer to **Section 5.3.6** for further discussion of these mechanisms). The pit lake and TSF sources seepage concentrations were kept at steady state values and not reduced during their centuries long travel from the sources to Creek 661; therefore, concentrations in Creek 661 would be expected to be lower than the values shown. In addition, the seepage discharge during a 1:50 year lowest flow month would be lower than the steady state value obtained from the MODFLOW model (used in the calculations presented in **Table 5.3.3-17**) since the hydraulic gradient and seepage flow would decrease during a prolonged dry period. Taken together, the model results presented are conservative.

The conclusion then is that seepage from the mine will not significantly negatively affect Creek 661 water quality, i.e., guidelines and objectives will be met during all mine phases. Monitoring of seepage very near to the mine sources (e.g., toe seepage at the TSF Site D dam and East Dump and the pit lake while filling) and further down gradient will be conducted to confirm predictions. Ongoing testing will also be conducted during mining operations to ensure proper segregation of waste rock types occurs.

Contingency measures including groundwater recovery wells, Permeable Reactive Barrier's (PRBs) and treatment wetlands are available in the very unlikely event seepage is found to pose a potential water quality concern for Creek 661.

5.3.3.3.8.3 Extreme Dry Events Potential Effects on Davidson Creek

The winter (February) seven-day, ten-year and twenty-year return period precipitation (7Q10, 7Q20), and 1:50 dry year were modelled for both best estimate and worst-case scenarios for Davidson Creek. The 1:50 dry year was incorporated into the worst-case post-closure scenario for the first full year of TSF discharge (Year 36) and is listed for each parameter discussed in the post closure, worst-case scenario tables. Summary tables for 1:50, 7Q10, and 7Q20 predictions for both best estimate and worst-case scenarios for February of Year 36 are included in **Appendix 5.3.3C**. These scenarios only apply post-closure, since in-stream fish needs will be maintained during other mining phases. Results are discussed under each parameter.

The dry period results will vary relative to each other depending on whether the TSF discharge and seepage loadings to the plunge pool and WQ7 are lower or higher than the background loadings. If TSF discharge and seepage loadings are lower, less dilution at the plunge pool and WQ7, i.e., drier periods, will result in lower predicted concentrations the lower the background dilution or loading. Therefore, 7dQ20 and 1:50 predicted concentrations would be lower than 7dQ10. The reverse is true if the combined TSF discharge and loading is higher than background loading at the plunge pool and WQ7. For WQ9, the dry period flow reductions are different proportionally from those for Davidson Creek because of the storage effect of Tatelkuz Lake. Therefore, the relative difference in the predictions during dry periods (7dQ10, 7dQ20, and 1:50 year dry) did not necessarily follow those for Davidson Creek.

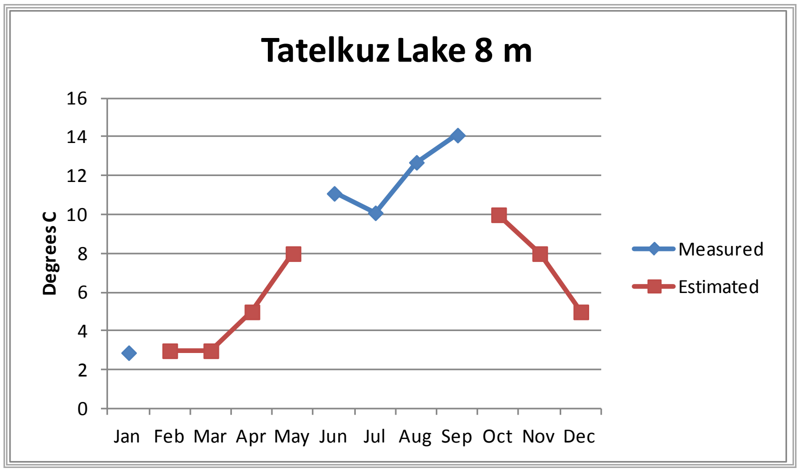
The Goldsim™ water quality model fully accounts for this complexity by using monthly flows predicted from the site hydrology model (Goldsim™-derived) and watershed model (both from Knight Piésold) to predict concentrations and therefore represents an accurate picture for the scenarios modelled.

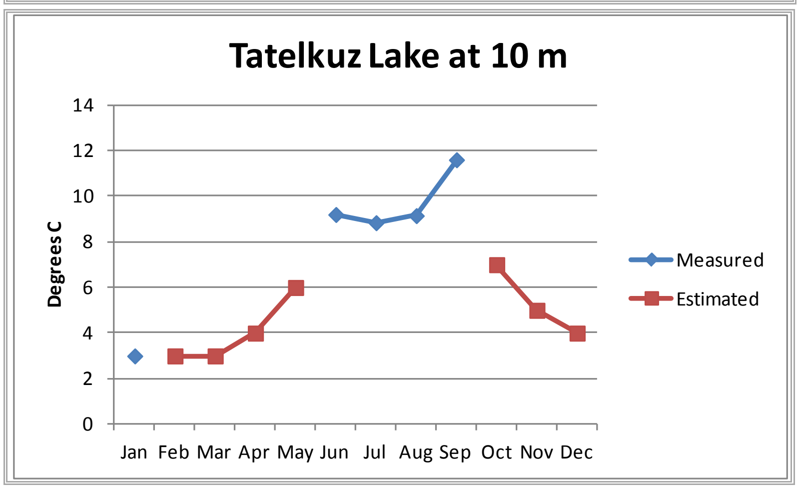
The general trend observed for dry period predictions is that 7dQ10 and 7dQ20 are approximately the same as the maxima for the 1:50 year predictions.

5.3.3.3.8.4 Potential Temperature Effects on Davidson Creek

5.3.3.3.8.4.1 Tatelkuz Lake

Tatelkuz Lake water is proposed as makeup water to maintain fish instream flow needs in Davidson Creek. To model temperature, an assumption was made, in consultation with Project engineers, about the depth of the water intake structure in Tatelkuz Lake. Three water intake depths were assessed: 8 m, 10 m, and 12 m. Alternatives were examined to predict effects on Davidson Creek monthly water temperatures during operations and closure when Tatelkuz Lake water will be discharged to the creek. Eleven monitoring results were used to reproduce monthly water temperatures at the design depths for the intake. The relationship between months of the year and temperatures in Tatelkuz Lake at 8 m, 10 m, and 12 m for which there are data are shown in **Figure 5.3.3-7**.





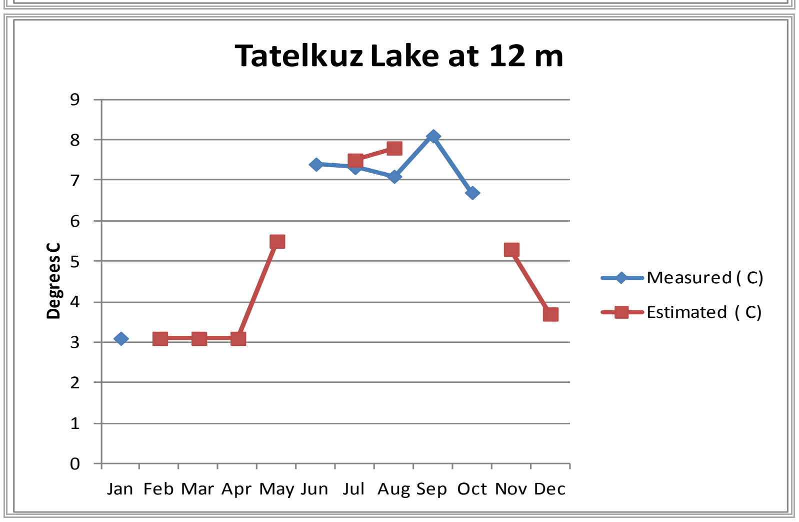


Figure 5.3.3-7: Monthly Temperatures in Tatelkuz Lake at 8 m, 10 m, and 12 m Depths

Based on the temperature lag response likely for the lake at depth and the fact that air temperatures at the approximate elevation of Tatelkuz Lake only begin to warm in April, the assumption was made that the temperature at 12 m depth would only begin to warm after April and during April at 8 m and 10 m. The average air temperature in April at the lower meteorological station at the Blackwater site was 2.8°C (**Appendix 5.1.1.1A**), or about the same as the measured temperature in Tatelkuz Lake at 12 m in January.

Table 5.3.3-18 shows the results.

Table 5.3.3-18: Measured and Estimated Average Monthly Temperature in Tatelkuz Lake at 8 m, 10 m, and 12 m Depths

Month	Temperature at 8 m (°C)	Temperature at 10 m (°C)	Temperature at 12 m (°C)
Jan	2.9	3	3.1
Feb	3	3	3.1
Mar	3	3	3.1
Apr	5	4	3.1
May	8	6	5.5
Jun	11.1	9.2	7.4
Jul	10.1	8.84	7.5
Aug	12.7	9.15	7.8
Sep	14.1	11.6	8.1
Oct	10	7	6.7
Nov	8	5	5.3
Dec	5	4	3.7

Note: 3.1: measured temperatures; 3.9: estimated temperatures

The monthly lake temperature profile was entered into the model.

5.3.3.3.8.4.2 Davidson Creek

Simultaneously, a relationship was developed for the changes in seasonal temperatures in Davidson Creek between WQ10, WQ26, and WQ7. These sites were chosen because they represent locations on Davidson Creek increasing distances from the proposed TSF Dam D: WQ10 just below, WQ26 about mid distance and WQ7 at the mouth of the creek. Temperature loggers were deployed in 2011, 2012, and 2013 during the spring to fall period and temperatures logged at one-hour intervals; for the remainder of the year only monthly spot measurements were available. There were no daily temperature data collected at WQ7, at the mouth of Davidson Creek and only monthly spot data available. **Figure 5.3.3-8** shows the measured temperature results.

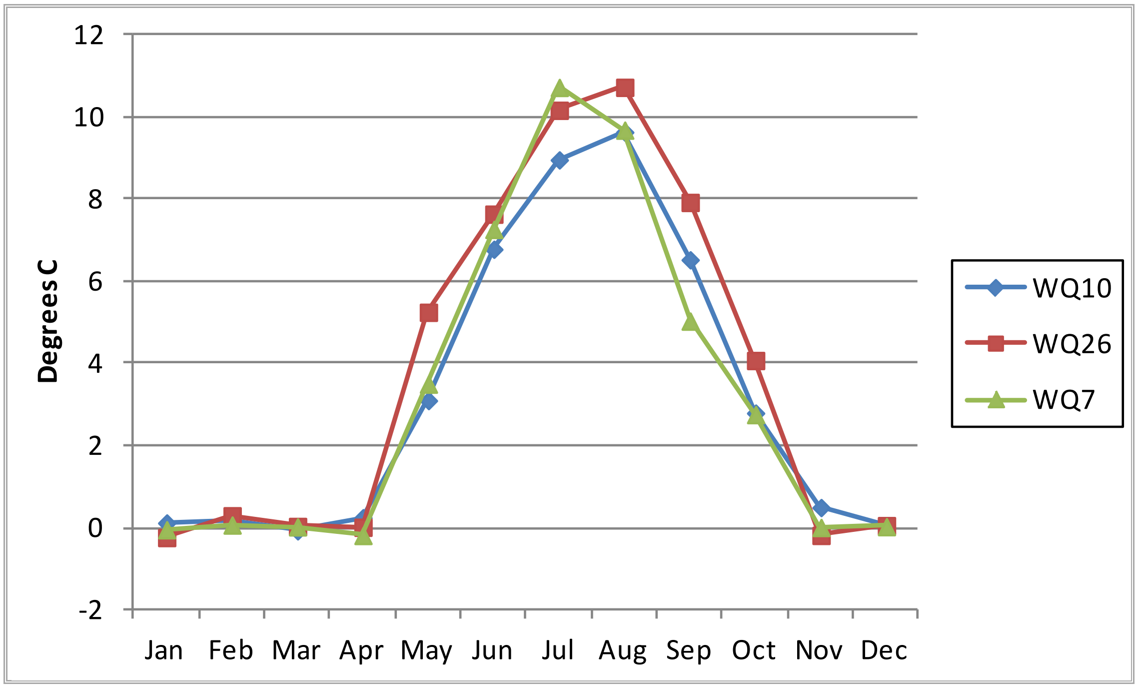


Figure 5.3.3-8: Measured Temperatures at Three Locations on Davidson Creek

The differences in temperatures between WQ10, WQ26, and WQ7 are shown in **Figure 5.3.3-9**. The values were calculated from a combination of monthly field measurements and averaged hourly temperatures for June through October at WQ10 and WQ26.

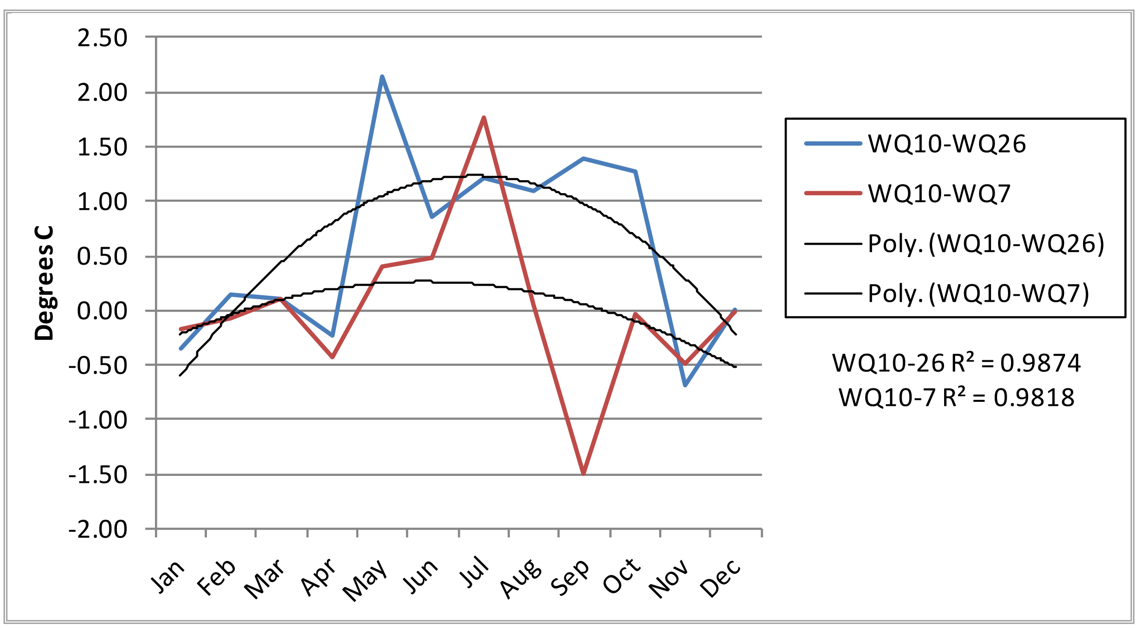


Figure 5.3.3-9: Monthly Temperature Differences between WQ10, WQ26, and WQ7

Polynomial regression equations were developed to smooth the data and are shown on the graphs. Correlation is relatively good on an annual basis, and the regression-derived seasonal differences in temperature among the three sites were input into the mass balance model. **Table 5.3.3-19** lists the measured and regression equation predicted differences.

Table 5.3.3-19: Measured and Regression Equation-Derived Temperature Differences among WQ10, WQ26, and WQ7

Month	Measured		Regression	
	WQ10-WQ26	**WQ10-WQ7**	**WQ10-WQ26**	**WQ10-WQ7**
Jan	-0.36	-0.17	-0.2	-0.5
Feb	0.15	-0.08	0.15	-0.1
Mar	0.11	0.10	0.5	0.2
Apr	-0.23	-0.43	0.8	0.25
May	2.15	0.40	1	0.3
Jun	0.85	0.48	1.2	0.3
Jul	1.21	1.77	1.3	0.25
Aug	1.09	0.05	1.2	0.2
Sep	1.40	-1.49	1	0.1
Oct	1.28	-0.04	0.7	-0.1
Nov	-0.68	-0.49	0.3	-0.3
Dec	0.01	-0.02	-0.2	-0.5

The mass balance model inputs were:

- Tatelkuz Lake measured and estimated temperature—assumed to be the operations/closure temperature at WQ10;
- Both measured and regression-derived temperature differences at WQ26 and WQ7 from WQ10 (for two scenarios);
- Instream flow needs at WQ10 derived from fish needs assessments; and
- Measured flows at WQ26 and WQ7 based on hourly datalogger stream heights and a watershed model derived by Knight Piésold (**Appendix 5.1.2.1C**).

Table 5.3.3-20 lists the flows used for modelling. The site water balance developed by Knight Piésold assumes no flow at WQ10 during operations and closure. Predicted results are listed in **Table 5.3.3-21**. Raw temperature data are available upon request.

Table 5.3.3-20: Davidson Creek Monthly Average Flows (L/s)

Month	Instream Flow Needs Davidson Creek	(Assumed) WQ10	Measured	
			WQ26	WQ7
Jan	125	0	21.1	35.2
Feb	125	0	16.0	32.8
Mar	125	0	18.7	38.8
Apr	125	0	77.6	107.2
May	570	0	127.5	139.3
Jun	560	0	90.3	83.8
Jul	240	0	48.4	49.8
Aug	150	0	33.7	39.6
Sep	115	0	26.7	37.3
Oct	115	0	29.3	45.3
Nov	115	0	32.1	47.8
Dec	125	0	26.2	39.2

Table 5.3.3-21 shows the pattern of predicted temperature changes based on measured monthly temperature differences and regression-derived temperature differences between WQ26 and WQ7. WQ10 remain the same for both scenarios and either could be used. The predicted differences between baseline (without the Project) and with the Project (operations and closure phases) are shown in. **Figure 5.3.3-10** graphs the results for measured monthly temperature relationships with 8 m, 10 m, and 12 m water intakes in Tatelkuz Lake.

There are no consistent differences between measure-derived and regression-derived predictions. The seasonal pattern is for higher temperatures in spring, fall, and winter and slightly lower temperatures in summer using Tatelkuz Lake water. A discussion on the implications for aquatic biota can be found in **Section 5.3.8**.

Davidson Creek and pumped Tatelkuz Lake water temperatures will be monitored during operations.

Table 5.3.3-21: Baseline Temperatures in Davidson Creek and Predicted Changes with Tatelkuz Lake Water Addition – Operations and Closure (°C)

					Measured Temperature Relationship								Regression-Derived Temperature Relationship							
	WQ10				WQ26				WQ7				WQ26				WQ7			
		With Tatelkuz Lake				With Tatelkuz Lake				With Tatelkuz Lake				With Tatelkuz Lake				With Tatelkuz Lake		
Month	**Baseline**	**8 m Intake**	**10 m Intake**	**12 m Intake**	**Baseline**	**8 m Intake**	**10 m Intake**	**12 m Intake**	**Baseline**	**8 m Intake**	**10 m Intake**	**12 m Intake**	**Baseline**	**8 m Intake**	**10 m Intake**	**12 m Intake**	**Baseline**	**8 m Intake**	**10 m Intake**	**12 m Intake**
Jan	0.1	2.9	3.0	3.1	-0.2	2.4	2.5	2.7	-0.04	2.3	2.3	2.9	-0.2	2.9	3.0	2.7	-0.04	2.8	2.9	2.5
Feb	0.2	3.0	3.0	3.1	0.3	2.7	2.7	3.3	0.1	2.4	2.4	3.0	0.3	3.0	3.0	2.7	0.08	3.0	3.0	2.5
Mar	-0.1	3.0	3.0	3.1	0.03	2.6	2.6	3.2	0.0	2.3	2.3	3.2	0.0	3.1	3.1	2.7	0.03	3.0	3.0	2.4
Apr	0.3	5.0	4.0	3.1	0.0	3.1	2.5	2.9	-0.2	2.6	2.1	2.7	0.0	5.3	4.3	2.0	-0.2	5.1	4.1	1.9
May	3.1	8.0	6.0	5.5	5.3	7.5	5.9	7.6	3.5	7.1	5.5	5.9	2.7	8.2	6.2	4.3	3.5	8.1	6.1	4.6
Jun	6.8	11.1	9.2	7.4	7.6	10.6	9.0	8.3	7.3	10.6	8.9	7.9	6.4	11.3	9.4	7.0	7.3	11.1	9.2	7.0
Jul	9.0	10.1	8.8	7.5	10.2	10.1	9.1	8.7	10.7	10.2	9.2	9.3	9.7	10.3	9.1	7.5	10.7	10.1	8.9	7.4
Aug	9.6	12.7	9.2	7.8	10.7	12.3	9.4	8.9	9.7	12.1	9.3	7.8	10.1	12.9	9.4	7.8	9.7	12.7	9.2	8.0
Sep	6.5	14.1	11.6	8.1	7.9	12.9	10.9	9.5	5.0	11.9	10.0	6.6	7.4	14.3	11.8	7.5	5.0	14.1	11.6	8.0
Oct	2.8	10.0	7.0	6.7	4.1	8.8	6.4	8.0	2.8	8.0	5.8	6.7	-0.2	10.1	7.1	5.5	2.8	10.0	7.0	5.4
Nov	0.5	8.0	5.0	5.3	-0.2	6.2	3.9	4.6	0.02	5.7	3.5	4.8	0.3	8.1	5.1	4.3	0.02	7.9	4.9	3.9
Dec	0.1	5.0	4.0	3.7	0.1	4.1	3.3	3.7	0.04	3.8	3.1	3.7	0.1	5.0	4.0	3.1	0.04	4.9	3.9	2.8

Note: red = Estimated; blue = Based on averaged hourly data

Table 5.3.3-22: Predicted Differences between Background and Operations-Closure Temperatures in Davidson Creek

Estimated Temperature Differences w/ Tatelkuz Lake Water															
	Measured (ºC)									Regression (ºC)					
	WQ10			WQ26			WQ7			WQ26			WQ7		
Month	8 m Intake	10 m Intake	12 m Intake	8 m Intake	10 m Intake	12 m Intake	8 m Intake	10 m Intake	12 m Intake	8 m Intake	10 m Intake	12 m Intake	8 m Intake	10 m Intake	12 m Intake
Jan	2.8	2.9	3.0	2.7	2.8	2.9	2.3	2.4	2.5	3.1	3.2	3.3	2.8	2.9	3.0
Feb	2.9	2.9	3.0	2.4	2.4	2.4	2.3	2.3	2.4	2.7	2.7	2.8	2.9	2.9	3.0
Mar	3.1	3.1	3.2	2.6	2.6	2.6	2.3	2.3	2.3	3.0	3.0	3.1	3.0	3.0	3.1
Apr	4.7	3.7	2.8	3.1	2.5	2.0	2.8	2.3	2.1	5.3	4.3	3.4	5.1	4.1	3.4
May	4.9	2.9	2.4	2.2	0.6	-1.0	3.6	2.0	1.0	5.5	3.5	0.4	5.2	3.2	2.1
Jun	4.3	2.4	0.6	3.0	1.3	-0.7	3.3	1.7	-0.2	4.8	2.9	-0.1	3.9	2.0	0.2
Jul	1.1	-0.1	-1.5	-0.1	-1.1	-2.7	-0.5	-1.6	-3.3	0.6	-0.7	-2.5	0.3	-1.0	-3.2
Aug	3.1	-0.5	-1.8	1.6	-1.3	-3.0	2.4	-0.4	-1.7	2.8	-0.7	-2.7	1.5	-2.1	-1.8
Sep	7.6	5.1	1.6	5.0	3.0	-0.4	6.8	5.0	3.0	6.8	4.3	0.4	9.1	6.6	3.1
Oct	7.2	4.2	3.9	4.7	2.3	1.4	5.2	3.0	2.6	10.3	7.3	2.8	7.7	4.7	3.9
Nov	7.5	4.5	4.8	6.4	4.0	4.5	5.6	3.5	3.9	7.8	4.8	5.5	7.9	4.9	5.2
Dec	5.0	4.0	3.7	4.1	3.3	3.0	3.8	3.0	2.8	4.9	3.9	3.6	4.8	3.8	3.5

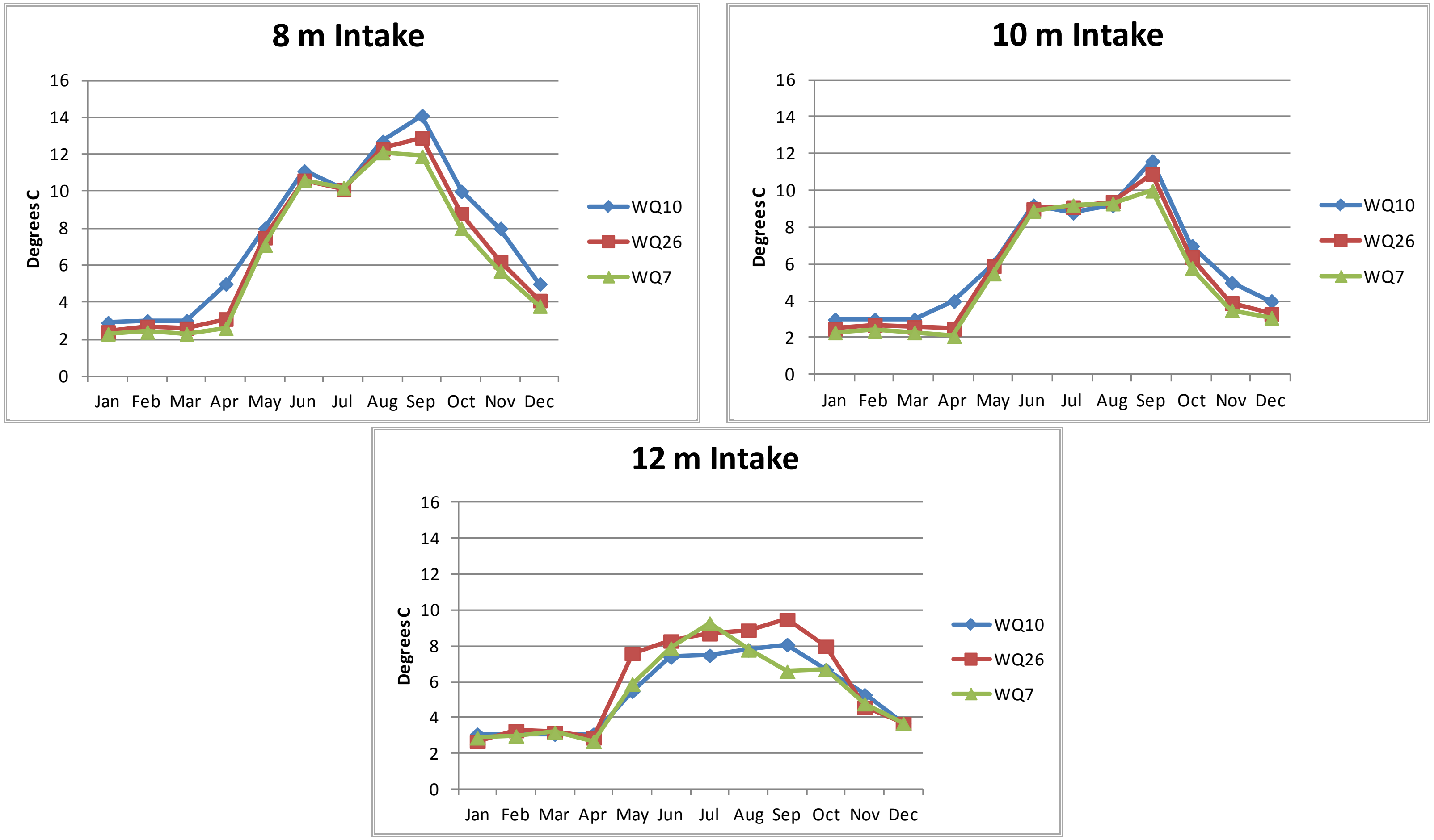


Figure 5.3.3-10: Predicted Monthly Temperature Comparisons in Davidson Creek with 8 m, 10 m and 12 m Water Intakes in Tatelkuz Lake

5.3.3.3.8.4.3 Post-Closure

At post-closure, water will no longer be pumped from Tatelkuz Lake. Davidson Creek in-stream fish needs will be met by discharge and seepage from the TSF, assuming monitoring verifies that the water quality predictions made for this assessment are correct, and water quality will be protective of freshwater aquatic life. Temperature of the discharged water will be governed by the combined surface water temperature of the post-closure pit lake and TSF. Water will likely be close to area lake temperatures throughout the year, moderated by TSF dam seepage (predicted to be 55 L/s). During May to early November in 2012 and May to early August in 2013 surface temperatures in Snake Lake were measured on a 15 minute basis. Daily averages from these data were used to determine averages and 95th percentiles; the remainder of the months (January through April, and December) were estimated. **Figure 5.3.3-11** is a plot of the results listed in the table below.

Month	Average	95th Percentile
Jan	1.2	1.5
Feb	4.0	4.5
Mar	6.0	6.5
Apr	8.0	9.3
May	11.1	13.4
Jun	14.7	17.7
Jul	18.2	20.6
Aug	18.6	20.8
Sep	13.4	15.49
Oct	6.1	9.59
Nov	1.5	1.92
Dec	0.5	0.6

1.2 Estimated
11.1 Measured

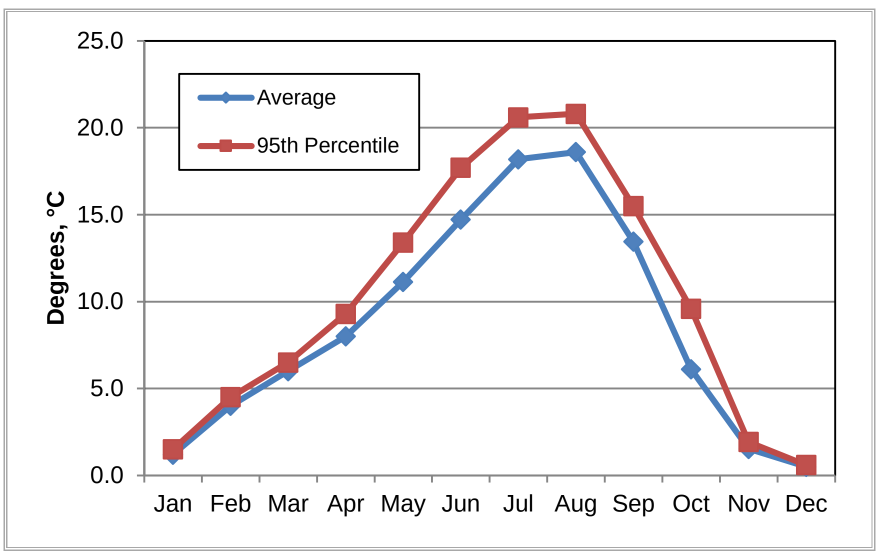


Figure 5.3.3-11: Measured and Estimated Snake Lake Surface Water Temperature

Groundwater well temperatures were obtained approximately quarterly from March 2011 through September 2013 at the Project camp. At the end of July 2013, water temperature samples were taken from 20 wells. The monthly spot temperatures from the camp wells, and the 95th percentile temperature measured at the end of July 2013, were plotted and interpolated, as shown in **Figure 5.3.3-12**; results listed in the table below.

Month	Average	95th Percentile
Jan	6.0	8.4
Feb	6.0	8.4
Mar	6.7	8.4
Apr	6.4	8.4
May	6.2	8.4
Jun	8.1	9.3
Jul	10.3	13.3
Aug	12.8	17.4
Sep	7.9	11.2
Oct	7.2	10.0
Nov	6.5	9.3
Dec	5.9	8.6

6.4 Estimated
6.15 Measured

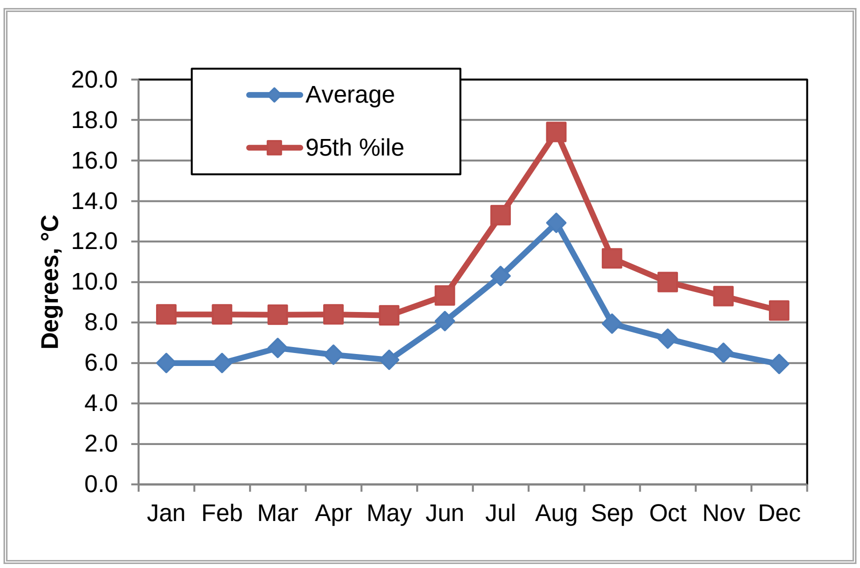


Figure 5.3.3-12: Measured and Estimated Groundwater Temperature at Project Site

Knight Piésold calculated the seepage from Dam D (using the SEEPW model) throughout mine life and post-closure to be 55 L/s. Knight Piésold also calculated the discharge from Dam D at post-closure using the site water balance model Goldsim™. The pit lake and TSF monthly surface water temperatures were assumed to be the same as area lake temperatures. Snake Lake has two years of spring – fall temperature data, and this lake was used as a proxy for discharge temperatures from the TSF; surface temperatures were estimated for other months and are not critical for upper lethal temperature estimates. A mass balance calculation was then made to estimate the temperature at the plunge pool downstream on Davidson Creek, which would be a combination of seepage and TSF discharge. Complete mixing was assumed. **Table 5.3.3-23** lists the results for average and 95th percentile Snake Lake and groundwater temperatures; only average estimated flows were available.

British Columbia Ministry of Environment (2001) provides temperature guidelines for salmonids (which include rainbow trout—the most common fish in Davidson Creek (**Section 5.3.8**). The guideline for the mean weekly maximum temperature is 19°C. Based on this analysis, the guideline will not be exceeded, even under worst case (95th percentile temperature predictions). Davidson Creek temperatures are forecast to be warmer than at present (baseline) or during operations and closure (predicted).

5.3.3.3.8.5 pH

In the summary tables that follow, Year -1 represents background, Year 16 is the last full year of ore processing, and Year 36 is the first full year of discharge from the TSF. Year 36 worst case used the 1:50 dry year flows for receiving water bodies; The basic flow assumption for the Goldsim™ model was that discharge and seepage from the TSF, and receiving environment background water quality during 7dQ10, 7dQ20, and a 1:50 dry year would stay the same as in the best estimate and worst-case scenarios. Receiving environment flows would be reduced based on calculations from Knight Piésold’s watershed model (**Appendix 5.1.2.1B**).

BC protection of freshwater aquatic life guidelines for pH is 6.5 to 9; CCME guidelines are the same. BC and Health Canada drinking water guidelines for pH are 6.5 to 8.5. There is no BC wildlife guideline. Since pH is the negative log of the hydrogen ion concentration and does not behave conservatively, the predicted results are only an approximation. However, given that alkalinity can be assumed to behave conservatively, and is forecast to change only slightly, the pH estimates are likely relatively close to what will occur.

Table 5.3.3-24 provides monthly pH summaries for the sites modelled for construction, the last year of mining, and the first full year of post-closure for best estimate values, and **Table 5.3.3-25** provides the same data for worst-case estimate values.

5.3.3.3.8.5.1 Best Estimate: Operations and Closure

5.3.3.3.8.5.1.1 WQ10

The pH at WQ10 will be driven by Tatelkuz Lake pH, because of the very small proportion of TSF seepage contributing to the water quality. The pH is predicted to remain at background (range of 7.5 to 8.0) throughout the operations and closure phases.

5.3.3.3.8.5.1.2 WQ7

The pH at WQ7 follows the same pattern as WQ10. It is expected to remain within the same range of background values (7.5 to 8.0) as WQ10.

Table 5.3.3-23: Calculated Davidson Creek Water Temperature (°C) at the Plunge Pool with TSF Discharge and Seepage – Best Estimate

Month	m^3/month	Discharge L/s	Seep L/s	% Discharge	% Seep	TSF Temp		GW Temp		Plunge Pool Temp		Davidson Creek at WQ10	
						Avg.	95^{th} %ile	Avg.	95^{th} %ile	Avg.	95^{th} %ile	Baseline	Operations/ Closure
Jan	139,592	52.1	55.8	48%	52%	1.2	1.5	6.0	8.4	3.7	5.1	0.02	0.13
Feb	112,759	46.6	55.8	46%	54%	4.0	4.5	6.0	8.4	5.1	6.6	0.04	0.15
Mar	160,917	60.1	55.8	52%	48%	6.0	6.5	6.7	8.4	6.4	7.4	0.04	-0.07
Apr	1,038,831	400.8	55.8	88%	12%	8.0	9.3	6.4	8.4	7.8	9.2	0.03	0.25
May	2,017,618	753.3	55.8	93%	7%	11.1	13.4	6.2	8.4	10.8	13.0	1.07	3.11
Jun	1,985,895	766.2	55.8	93%	7%	14.7	17.7	8.1	9.3	14.2	17.1	5.05	6.79
Jul	369,218	137.9	55.8	71%	29%	18.2	20.6	10.3	13.3	15.9	18.5	8.81	8.96
Aug	209,019	78	55.8	58%	42%	18.6	20.8	12.9	17.4	16.2	19.4	8.63	9.64
Sep	227,601	87.8	55.8	61%	39%	13.4	15.49	7.9	11.2	11.3	13.8	6.40	6.53
Oct	283,460	105.8	55.8	65%	35%	6.1	9.59	7.2	10.0	6.5	9.7	1.98	2.80
Nov	228,831	88.3	55.8	61%	39%	1.5	1.92	6.5	9.3	3.5	4.8	0.21	0.50
Dec	160,028	59.7	55.8	52%	48%	0.5	0.6	5.9	8.6	3.1	4.4	0.03	0.05

Note: TSF discharge and seepage estimates from Knight Piésold
TSF Temperature assumed to be Snake Lake surface temperature
1.2 Estimated 11.1 Measured 3.11 Calculated
Disch = discharge; Seep = seepage; temp = temperature (°C); L/s = litres per second; Avg. = average; 95^{th} %ile = 95^{th} percentile

5.3.3.3.8.5.1.3 WQ9

During operations and closure, the pH at WQ9 is predicted to average about 7.2, ranging from 6.9 to 8.04. The predicted pre-construction pH will be at background, or about 8.

5.3.3.3.8.5.2 Worst-Case: Operations and Closure

5.3.3.3.8.5.2.1 WQ10

The pH at WQ10 for worst case will remain in approximately the same range as for the best estimate, but will peak slightly higher at 8.2, still below the drinking water guideline of 8.5. The minimum forecast pH is 7.6, well above the BC and CCME 6.5 minimum aquatic guideline. Shaded cells on **Table 5.3.3-24** and subsequent tables are sites on Creek 661.

Table 5.3.3-24: Monthly Best Estimate pH for Modelled Sites: Construction, Operations/Closure, Post-Closure

NODES	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Year -1 (Background)												
H1/WQ5	7.57	7.36	7.36	7.15	6.99	7.02	7.27	7.46	7.51	7.13	7.36	7.38
1-505659/WQ3	7.57	7.81	7.82	7.79	7.40	7.40	7.57	7.74	7.68	7.68	7.65	7.68
H2/WQ10	7.57	7.86	7.95	7.94	7.66	7.86	7.89	7.99	7.84	7.82	7.79	7.74
1DC/WQ7	7.57	7.85	7.91	7.94	7.50	7.71	7.82	7.91	7.80	7.78	7.75	7.68
H7/WQ12	7.57	7.34	7.40	7.43	7.21	7.27	7.32	7.42	7.38	7.38	7.33	7.29
H5/WQ9	7.57	7.83	8.04	7.97	7.84	7.83	7.79	7.95	7.77	7.76	7.74	7.77
Year 16												
H1/WQ5	7.57	7.36	7.36	7.15	6.99	7.02	7.27	7.46	7.51	7.13	7.36	7.38
1-505659/WQ3	7.57	7.81	7.82	7.79	7.40	7.40	7.57	7.74	7.68	7.68	7.65	7.68
H2/WQ10	7.57	7.87	7.94	7.97	7.95	7.93	7.90	8.01	7.85	7.84	7.81	7.76
1DC/WQ7	7.64	7.92	7.98	7.99	7.76	7.81	7.84	7.97	7.88	7.85	7.82	7.77
H7/WQ12	7.57	7.35	7.40	7.42	7.21	7.27	7.32	7.43	7.38	7.38	7.33	7.28
H5/WQ9	6.91	7.16	7.36	7.65	7.18	7.09	7.14	7.21	7.27	7.26	7.33	7.15
Year 36												
H1/WQ5	7.57	7.36	7.36	7.15	6.99	7.02	7.27	7.46	7.51	7.13	7.36	7.38
1-505659/WQ3	7.57	7.81	7.82	7.79	7.40	7.40	7.57	7.74	7.68	7.68	7.65	7.68
H2/Plunge Pool	7.61	7.65	7.68	7.68	7.38	7.46	7.56	7.62	7.64	7.62	7.61	7.60
1DC/WQ7	7.64	7.73	7.75	7.76	7.38	7.46	7.58	7.68	7.69	7.66	7.66	7.64
H7/WQ12	7.57	7.35	7.40	7.42	7.21	7.27	7.32	7.43	7.38	7.38	7.33	7.28
H5/WQ9	7.58	7.83	7.97	7.93	7.79	7.80	7.81	7.94	7.79	7.78	7.76	7.75

Table 5.3.3-25: Monthly Worst-Case pH for Modelled Sites: Construction, Operations/Closure, Post-Closure

NODES	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Year -1 (Background)												
H1/WQ5	7.57	7.36	7.36	7.15	7.23	7.27	7.46	7.56	7.56	7.23	7.56	7.38
1-505659/WQ3	7.57	7.83	7.87	7.88	7.76	7.64	7.79	7.85	7.78	7.87	7.81	7.86
H2/WQ10	7.57	7.93	8.10	8.22	7.88	8.00	7.98	8.07	7.96	7.90	7.93	7.74
1DC/WQ7	7.57	7.90	8.04	8.19	7.67	7.87	7.93	7.99	7.91	7.88	7.90	7.77
H7/WQ12	7.57	7.44	7.53	7.68	7.38	7.40	7.41	7.48	7.46	7.51	7.44	7.29
H5/WQ9	7.57	7.89	8.23	8.17	7.98	8.01	7.91	7.97	7.91	7.87	7.84	7.84
Year 16												
H1/WQ5	7.57	7.36	7.36	7.15	7.23	7.27	7.46	7.56	7.56	7.23	7.56	7.38
1-505659/WQ3	7.57	7.83	7.87	7.88	7.76	7.64	7.79	7.85	7.78	7.87	7.81	7.86
H2/WQ10	7.57	7.94	8.09	8.24	8.15	8.07	8.00	8.09	7.97	7.91	7.95	7.76
1DC/WQ7	7.64	7.98	8.11	8.22	7.94	7.96	7.96	8.05	7.98	7.95	7.98	7.84
H7/WQ12	7.57	7.44	7.54	7.64	7.39	7.40	7.41	7.49	7.47	7.52	7.44	7.28
H5/WQ9	6.91	7.22	7.51	7.89	7.34	7.23	7.24	7.27	7.39	7.33	7.45	7.18
Year 36												
H1/WQ5	7.57	7.36	7.36	7.15	7.23	7.27	7.46	7.56	7.56	7.23	7.56	7.38
1-505659/WQ3	7.57	7.83	7.87	7.88	7.76	7.64	7.79	7.85	7.78	7.87	7.81	7.86
H2/Plunge Pool	7.60	7.74	7.77	7.46	7.39	7.55	7.66	7.64	7.70	7.70	7.66	7.59
1DC/WQ7	7.64	7.80	7.83	7.55	7.40	7.56	7.70	7.70	7.75	7.75	7.72	7.66
H7/WQ12	7.57	7.31	7.39	7.63	7.39	7.39	7.41	7.50	7.49	7.49	7.45	7.35
H5/WQ9	7.59	7.90	8.08	7.96	7.74	7.81	7.89	7.94	7.87	7.85	7.87	7.76

5.3.3.3.8.5.2.2 WQ7

During operations and closure, pH is forecast to vary between 7.6 and 8.2, or within the same range as for WQ10.

5.3.3.3.8.5.2.3 WQ9

The pH at WQ9 is forecast to vary between 6.9 and 8.0, or the same range as best estimate.

5.3.3.3.8.5.3 Best Estimate: Post-Closure

5.3.3.3.8.5.3.1 Plunge Pool

At post-closure, the pH of water at the plunge pool will be driven by discharge and seepage from the TSF. Overflow from the open pit lake will be a key determinant of discharge pH. The pH is forecast to be approximately 7.5, with some seasonal variability, but not to vary outside of the 7.4 to 7.7 range. Dry year and 10- and 20-year return period predictions for best estimate are within the same range.

5.3.3.3.8.5.3.2 WQ7

The post-closure pH at WQ7 is forecast to range between 7.4 and 7.7, and will be more influenced by the average background pH at WQ7, due to increased dilution from watershed inflow at this station relative to the plunge pool. Dry year and 10- and 20-year return period predictions for best estimate are near the top of the range, or about 7.7.

5.3.3.3.8.5.3.3 WQ9

At post-closure, the mean pH at WQ9 is forecast to increase to 7.8 from operation/closure phases pH, and range between 7.6 and 7.8. This is largely because of the background pH at WQ9. Dry year and 10- and 20-year return period predictions for best estimate are near the top of the range or about 7.8.

5.3.3.3.8.5.4 Worst Case – Post-Closure

5.3.3.3.8.5.4.1 Plunge Pool

For the worst case, the predicted maximum pH will drop to about 7.4 to 7.8. The pH predictions for 7dQ10 and 7dQ20 are in the same range as the 1:50 dry year predictions.

5.3.3.3.8.5.4.2 WQ7

At post-closure, due to the influence of TSF discharge, the mean pH is forecast to vary between 7.4 and 7.8. The 7dQ10 and 7dQ20 predictions are for pH of 7.7 to 7.8.

5.3.3.3.8.5.4.3 WQ9

At WQ9, pH is more influenced by Chedakuz Creek, and is predicted to increase to between 7.6 and 7.9, or slightly higher than the predicted best estimate, due to the use of 95th percentile background pH at WQ9. The 7dQ10 and 7dQ20 predictions are for pH of about 7.9.

5.3.3.3.8.6 Hardness

There are no BC or CCME hardness guidelines for protection of freshwater aquatic life. However, estimates of hardness are required to calculate the water quality guidelines for some metals. The acceptable level for drinking water is 80 mg to 100 mg $CaCO_3$/L; many areas of Canada naturally exceed this guideline.

Table 5.3.3-26 provides monthly hardness summaries for the sites modelled for construction, the last year of mining, and the first full year of post-closure for best estimate values, and **Table 5.3.3-27** provides the same data for worst-case estimate values.

Table 5.3.3-26: Monthly Best Estimate Hardness (mg $CaCO_3$/L) for Modelled Sites – Construction, Operations/Closure, Post-Closure

NODES	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Year -1 (Background)												
H1/WQ5	43.5	33.5	33.5	23.4	11.3	11.2	15.9	19.3	27.6	27.7	25.6	31.4
1-505659/WQ3	45.5	45.1	48.0	44.3	20.5	22.7	30.4	37.6	42.5	42.0	42.2	60.7
H2/WQ10	75.1	77.6	76.6	60.5	52.4	62.6	62.3	66.1	66.3	69.2	67.0	72.3
1DC/WQ7	68.4	70.2	71.5	58.2	36.2	52.6	54.8	57.1	59.9	61.3	59.1	65.0
H7/WQ12	22.8	23.6	24.2	21.6	17.5	16.6	18.3	20.4	22.6	22.6	21.6	23.0
H5/WQ9	75.8	73.9	75.7	68.2	52.6	54.0	56.7	64.3	66.2	65.9	66.6	73.3
Year 16												
H1/WQ5	43.5	33.5	33.5	23.4	11.3	11.2	15.9	19.3	27.6	27.7	25.6	31.4
1-505659/WQ3	45.5	45.1	48.0	44.3	20.5	22.7	30.4	37.6	42.5	42.0	42.2	60.7
H2/WQ10	77.3	79.5	79.5	64.8	71.1	67.4	63.7	68.0	67.8	72.3	70.0	74.9
1DC/WQ7	72.0	74.4	74.9	59.0	54.6	58.4	53.9	58.6	61.8	63.4	61.3	68.8
H7/WQ12	22.8	23.5	24.2	21.6	18.1	16.6	18.3	20.5	22.8	22.7	21.6	22.9
H5/WQ9	69.6	70.2	71.9	62.8	57.1	55.5	54.6	59.2	62.1	64.5	64.3	68.0
Year 36												
H1/WQ5	43.5	33.5	33.5	23.4	11.3	11.2	15.9	19.3	27.6	27.7	25.6	31.4
1-505659/WQ3	45.5	45.1	48.0	44.3	20.5	22.7	30.4	37.6	42.5	42.0	42.2	60.7
H2/Plunge Pool	49.8	51.6	50.6	42.3	27.3	29.6	35.2	40.2	44.1	41.9	43.3	45.1
1DC/WQ7	51.8	53.5	53.5	45.3	26.3	29.6	34.1	39.8	45.4	43.3	44.4	47.6
H7/WQ12	22.8	23.5	24.2	21.6	18.1	16.6	18.3	20.5	22.8	22.7	21.6	22.9
H5/WQ9	73.8	74.2	75.1	63.0	55.2	55.2	56.9	62.6	64.4	65.2	65.6	71.1

Table 5.3.3-27: Monthly Worst Case Estimate Hardness (mg $CaCO_3$/L) for Modelled Sites – Construction, Operations/Closure, Post-Closure

NODES	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Year -1 (Background)												
H1/WQ5	44.0	33.8	33.8	23.7	17.2	13.1	18.1	21.0	28.9	32.7	28.0	31.5
1-505659/WQ3	47.0	46.5	50.2	47.3	24.9	26.6	35.7	40.9	44.4	44.4	44.0	77.0
H2/WQ10	80.3	80.4	79.3	69.3	61.0	76.1	65.9	69.5	68.9	71.9	68.8	73.5
1DC/WQ7	74.3	73.1	74.6	65.5	42.3	86.1	58.3	60.1	62.2	66.0	62.1	67.7
H7/WQ12	23.0	23.8	24.8	23.8	22.4	18.5	19.6	22.4	24.5	26.2	23.3	23.2
H5/WQ9	79.0	75.9	79.1	74.7	61.5	62.9	63.1	67.8	70.2	71.1	68.0	76.0
Year 16												
H1/WQ5	44.0	33.8	33.8	23.7	17.2	13.1	18.1	21.0	28.9	32.7	28.0	31.5
1-505659/WQ3	47.0	46.5	50.2	47.3	24.9	26.6	35.7	40.9	44.4	44.4	44.0	77.0
H2/WQ10	82.4	82.3	82.0	74.1	83.0	81.9	67.2	71.4	70.4	74.4	71.5	76.2
1DC/WQ7	77.7	77.3	77.8	65.9	63.8	88.7	57.5	61.5	64.1	67.9	64.1	71.2
H7/WQ12	23.0	23.7	24.8	23.6	23.3	18.5	19.6	22.5	24.8	26.3	23.3	23.1
H5/WQ9	73.8	72.6	74.5	70.7	66.6	69.0	58.7	62.3	64.9	67.6	65.8	69.8
Year 36												
H1/WQ5	44.0	33.8	33.8	23.7	17.2	13.1	18.1	21.0	28.9	32.7	28.0	31.5
1-505659/WQ3	47.0	46.5	50.2	47.3	24.9	26.6	35.7	40.9	44.4	44.4	44.0	77.0
H2/Plunge Pool	50.8	54.3	53.1	29.3	21.2	27.5	38.8	41.9	47.3	47.4	46.4	46.5
1DC/WQ7	52.6	55.5	54.6	32.4	21.3	32.8	38.1	41.9	48.0	48.4	47.0	48.1
H7/WQ12	22.9	24.6	24.3	23.6	23.0	18.6	19.6	22.6	25.2	25.0	22.9	22.8
H5/WQ9	75.4	75.9	76.3	58.1	47.9	55.6	57.3	61.0	61.8	65.2	65.2	70.1

5.3.3.3.8.6.1 Best Estimate – Operations and Closure

5.3.3.3.8.6.1.1 WQ10

Baseline total hardness was assumed to be the same as the hardness at WQ8 (outlet to Tatelkuz Lake), since water at WQ10 during operations and closure will largely be Tatelkuz Lake water. Tatelkuz Lake water quality measurements were taken quarterly. Predicted hardness ranges from just over 52 mg to 79 mg $CaCO_3$/L, essentially the same as background.

5.3.3.3.8.6.1.2 WQ7

Water hardness at WQ7 is predicted to increase above background with the addition of slightly harder Tatelkuz Lake water during operations and closure up to 75 mg $CaCO_3$/L. Water will remain within the acceptable range for drinking.

5.3.3.3.8.6.1.3 WQ9

Water hardness is forecast to be approximately the same as background during operations and closure (53 to 72 mg $CaCO_3$/L).

5.3.3.3.8.6.2 Worst Case – Operations and Closure

5.3.3.3.8.6.2.1 WQ10

The 95th percentile hardness is somewhat higher than the mean, which affects guideline concentrations for parameters that are hardness-specific, such as cadmium, copper, lead, zinc. The predicted range is 61 to 83 mg $CaCO_3$/L.

5.3.3.3.8.6.2.2 WQ7

Similar to WQ10, the worst-case hardness for WQ7 will track background concentrations, which is somewhat higher due to using the 95th percentile hardness as a source term.

5.3.3.3.8.6.2.3 WQ9

The hardness concentrations at WQ9 are predicted to be similar to those for WQ7, tracking background hardness for lower Chedakuz Creek.

5.3.3.3.8.6.3 Best Estimate – Post-Closure

5.3.3.3.8.6.3.1 Plunge Pool

Total hardness concentrations at the plunge pool during post-closure are predicted to be lower than during the operations and closure phases. As with pH, the main influences will be overflow from the open pit lake, TSF discharge, and TSF seepage, since Tatelkuz Lake water will no longer be pumped after the TSF discharges. The required volume of water for in-stream flow needs for fish is predicted to be supplied by TSF discharge and seepage. The predicted range is 27 to 52 mg $CaCO_3$/L; 7dQ10 and 7dQ20 predictions are about 52 mg $CaCO_3$/L.

5.3.3.3.8.6.3.2 WQ7

At WQ7 at post-closure, hardness is predicted to range between 26 and 54 mg $CaCO_3$/L: within, the lower range of natural variation measured at the station. Dry year and 10- and 20-year winter return period low flows are also predicted to track worst case (95th percentile) background hardness, or near the top of the range.

5.3.3.3.8.6.3.3 WQ9

Water hardness is forecast to track background concentrations during post-closure, including for dry period flows.

5.3.3.3.8.6.4 Worst Case – Post-Closure

5.3.3.3.8.6.4.1 Plunge Pool

Hardness again tracks background concentrations, and will be below the drinking water aesthetic minimum. Low hardness water has no toxic effects, and therefore soft water is not a health concern. The predicted results for 7dQ10 and 7dQ20 also track background.

5.3.3.3.8.6.4.2 WQ7

The hardness pattern predicted at post-closure for the worst case is the same as for the best estimate, except for during the 1:50 dry year, when hardness is predicted to peak at about 65 mg $CaCO_3$/L, or about the mean hardness during operations and closure. The predicted results for 7dQ10 and 7dQ20 are the same as for average flows.

5.3.3.3.8.6.4.3 WQ9

Post-closure hardness at WQ9 will be similar to that for the best estimate, but slightly higher because 95th percentile background hardness concentrations were assumed. Similar to WQ7, the 1:50 dry year spike is higher, increasing from 77 to 79 mg $CaCO_3$/L, which is not significant, and well within the margin of error for the Goldsim™ model. The predicted results for 7dQ10 and 7dQ20 are the same as for average flows.

5.3.3.3.8.7 Total Dissolved Solids

BC and Health Canada guidelines for total dissolved solids in drinking water are 500 mg/L maximum. Predicted concentrations during all phases of mining and at all modelled sites range between 54 and 140 mg/L, or one-tenth to slightly more than one-quarter of the drinking water guidelines maximum.

5.3.3.3.8.8 Ammonia

The BC and CCME protection of freshwater aquatic life guidelines are pH and temperature dependent. The higher the pH and temperature, the lower is the guideline. For the range of measured and predicted temperatures and pH values at Davidson Creek, the total ammonia guideline will vary between 1.1 and 2.0 mg N/L. There are no ammonia guidelines for drinking water or wildlife protection.

Table 5.3.3-28 provides monthly ammonia summaries for the sites modelled for construction, the last year of mining, and the first full year of post-closure for best estimate values, and **Table 5.3.3-29** provides the same data for worst-case estimate values.

5.3.3.3.8.8.1 Best Estimate – Operations and Closure

5.3.3.3.8.8.1.1 WQ10

During operations, the ammonia concentration is predicted to increase from the background concentration of less than approximately 0.02 to 0.03 mg N/L to a maximum of 0.08 mg N/L. This is due to both the use of ammonium-based explosives and oxidation of cyanide, which produces an intermediate product of ammonia. After closure, ammonia is predicted to stay at this maximum level until Year 36, when the TSF will begin to discharge. Ammonia should drop over time in the post closure period due to oxidation to nitrate but the Goldsim™ model makes no allowance for nitrification or denitrification and is therefore conservative.

5.3.3.3.8.8.1.2 WQ7

The predicted concentration of ammonia at WQ7 during operations and closure follows a similar pattern to WQ10, but the maximum predicted ammonia nitrogen concentration will be about 0.06 mg N/L, reflecting slight increase in dilution from the Davidson Creek watershed. Since the Goldsim™ model treated ammonia as conservative, whereas it will readily oxidize to nitrate, the measured concentrations of ammonia are expected to be less than those predicted.

5.3.3.3.8.8.1.3 WQ9

During mining, when flows in lower Chedakuz Creek before the confluence with Davidson Creek will be reduced slightly due to withdrawal of water from Tatelkuz Lake for mill process and in-stream fish needs in Davidson Creek, ammonia will vary between 0.014 and 0.024 mg N/L. At closure, when process make-up water is no longer needed, water withdrawal from Tatelkuz Lake will lessen somewhat, and the influence of background quality Chedakuz Creek water at WQ9 will increase with increased flows. By the end of mining, ammonia concentrations at WQ9 will peak at approximately 0.024 mg N/L, which is within the background range for the site. The change in effects on water quality is negligible, since ammonia is forecast to remain well below BC and CCME guidelines to protect freshwater aquatic life.

Table 5.3.3-28: Monthly Best Estimate Ammonia (mg N/L) for Modelled Sites – Construction, Operations/Closure, Post-Closure

NODES	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Year -1 (Background)												
H1/WQ5	0.020	0.020	0.020	0.020	0.021	0.020	0.020	0.020	0.020	0.020	0.015	0.020
1-505659/WQ3	0.020	0.015	0.020	0.020	0.020	0.101	0.020	0.020	0.020	0.020	0.020	0.020
H2/WQ10	0.020	0.015	0.020	0.025	0.020	0.020	0.030	0.020	0.020	0.020	0.015	0.020
1DC/WQ7	0.020	0.015	0.020	0.023	0.020	0.020	0.027	0.022	0.024	0.020	0.015	0.020
H7/WQ12	0.020	0.016	0.020	0.020	0.021	0.020	0.020	0.020	0.020	0.023	0.017	0.027
H5/WQ9	0.020	0.015	0.020	0.020	0.021	0.020	0.020	0.020	0.020	0.020	0.015	0.020
Year 16												
H1/WQ5	0.020	0.020	0.020	0.020	0.021	0.020	0.020	0.020	0.020	0.020	0.015	0.020
1-505659/WQ3	0.020	0.015	0.020	0.020	0.020	0.101	0.020	0.020	0.020	0.020	0.020	0.020
H2/WQ10	0.078	0.067	0.078	0.083	0.033	0.033	0.060	0.068	0.081	0.083	0.076	0.078
1DC/WQ7	0.061	0.053	0.060	0.046	0.029	0.030	0.049	0.055	0.063	0.059	0.052	0.059
H7/WQ12	0.020	0.016	0.020	0.020	0.021	0.020	0.020	0.020	0.020	0.023	0.017	0.027
H5/WQ9	0.018	0.014	0.018	0.023	0.019	0.018	0.024	0.018	0.019	0.019	0.014	0.018
Year 36												
H1/WQ5	0.020	0.020	0.020	0.020	0.021	0.020	0.020	0.020	0.020	0.020	0.015	0.020
1-505659/WQ3	0.020	0.015	0.020	0.020	0.020	0.101	0.020	0.020	0.020	0.020	0.020	0.020
H2/Plunge Pool	0.297	0.299	0.283	0.155	0.091	0.099	0.187	0.264	0.246	0.214	0.246	0.278
1DC/WQ7	0.240	0.240	0.228	0.124	0.083	0.091	0.156	0.212	0.205	0.178	0.195	0.223
H7/WQ12	0.020	0.016	0.020	0.020	0.021	0.020	0.020	0.020	0.020	0.023	0.017	0.027
H5/WQ9	0.046	0.038	0.042	0.040	0.034	0.033	0.042	0.047	0.043	0.045	0.036	0.044

Table 5.3.3-29: Monthly Worst Case Ammonia (mg N/L) for Modelled Sites – Construction, Operations/Closure, Post-Closure

NODES	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Year -1 (Background)												
H1/WQ5	0.020	0.020	0.020	0.020	0.030	0.020	0.020	0.020	0.020	0.020	0.020	0.020
1-505659/WQ3	0.020	0.020	0.020	0.020	0.020	0.670	0.020	0.020	0.020	0.020	0.030	0.020
H2/WQ10	0.020	0.020	0.020	0.036	0.023	0.020	0.039	0.020	0.020	0.020	0.020	0.020
1DC/WQ7	0.020	0.020	0.020	0.030	0.022	0.020	0.035	0.023	0.028	0.020	0.020	0.020
H7/WQ12	0.020	0.020	0.020	0.020	0.027	0.020	0.020	0.020	0.020	0.027	0.020	0.027
H5/WQ9	0.020	0.020	0.020	0.020	0.030	0.020	0.020	0.020	0.020	0.020	0.020	0.020
Year 16												
H1/WQ5	0.020	0.020	0.020	0.020	0.030	0.020	0.020	0.020	0.020	0.020	0.020	0.020
1-505659/WQ3	0.020	0.020	0.020	0.020	0.020	0.670	0.020	0.020	0.020	0.020	0.030	0.020
H2/WQ10	0.084	0.078	0.084	0.102	0.034	0.034	0.074	0.074	0.088	0.090	0.088	0.084
1DC/WQ7	0.065	0.063	0.065	0.054	0.030	0.031	0.058	0.060	0.071	0.063	0.061	0.063
H7/WQ12	0.020	0.020	0.020	0.020	0.026	0.020	0.020	0.020	0.020	0.027	0.020	0.027
H5/WQ9	0.018	0.018	0.018	0.031	0.021	0.018	0.030	0.019	0.019	0.019	0.019	0.018
Year 36												
H1/WQ5	0.020	0.020	0.020	0.020	0.030	0.020	0.020	0.020	0.020	0.020	0.020	0.020
1-505659/WQ3	0.020	0.020	0.020	0.020	0.020	0.670	0.020	0.020	0.020	0.020	0.030	0.020
H2/Plunge Pool	0.644	0.501	0.469	0.273	0.164	0.187	0.439	0.464	0.430	0.401	0.446	0.478
1DC/WQ7	0.583	0.453	0.433	0.248	0.150	0.177	0.382	0.416	0.379	0.372	0.421	0.438
H7/WQ12	0.020	0.020	0.020	0.020	0.026	0.020	0.020	0.020	0.020	0.025	0.020	0.025
H5/WQ9	0.142	0.102	0.100	0.118	0.088	0.096	0.144	0.154	0.161	0.139	0.113	0.114

5.3.3.3.8.8.2 Worst-Case – Operations and Closure

5.3.3.3.8.8.2.1 WQ10

Using the worst-case conditions discussed in **Table 5.3.3-11**, ammonia could vary between 0.08 and just over 0.10 mg N/L during operations. Ammonia will slowly increase in the TSF during the LOM due to destruction of cyanide and the use of ammonium-based explosives. While ammonia will oxidize (nitrification) in the TSF, the Goldsim™ model made no provision for oxidation (or denitrification), and is therefore conservative. At closure, ammonia is predicted reach a maximum of just over 0.1 mg N/L.

5.3.3.3.8.8.2.2 WQ7

Ammonia at WQ7 is predicted to increase during operations to a maximum of 0.07 mg N/L, due to the influence of the TSF and a minimum of the detection limit (0.02 mg N/L). Peak concentrations will be slightly higher than the best estimate, because of the higher assumed background concentrations.

5.3.3.3.8.8.2.3 WQ9

Ammonia at WQ9 is predicted to track background during operations and closure, at 0.03 mg N/L during operations and closure.

5.3.3.3.8.8.3 Best Estimate – Post-Closure

5.3.3.3.8.8.3.1 Plunge Pool

With the greater influence of tailings supernatant and open pit lake water, the total ammonia at the plunge pool is predicted to increase from a minimum of 0.09 mg N/L to a maximum of 0.3 mg N/L, still well below guidelines. February best estimate prediction for 7dQ10 and 7dQ20 is 0.36 mg N/L.

5.3.3.3.8.8.3.2 WQ7

The same pattern of increasing concentrations is exhibited by ammonia at WQ7, with minimums about 0.09 mg N/L and maximums of about 0.24 mg N/L, reflecting the lessening influence of the TSF discharge further downstream. February best estimate 1:50 dry year prediction is for 0.31 mg N/L, 7dQ10 0.37 mg N/L and for 7dQ20 0.30 mg N/L.

5.3.3.3.8.8.3.3 WQ9

The pattern at WQ9 is similar to WQ7, except that the range is forecast to be between 0.033 and 0.047 mg N/L because of the effects of Chedakuz Creek. February best estimate 1:50 dry year prediction is for 0.07 mg N/L, 7dQ10 0.10 mg N/L and for 7dQ20 0.06 mg N/L.

5.3.3.3.8.8.4 Worst-Case – Post-Closure

5.3.3.3.8.8.4.1 Plunge Pool

Under the worst-case scenario, ammonia is predicted to increase to a maximum of about 0.6 mg N/L in the 1:50 dry year maximum, and to always stay above 0.16 mg N/L. The predicted 7dQ10 and 7dQ20 results are slightly lower than the highest 1:50 year predictions.

5.3.3.3.8.8.4.2 WQ7

Under the influence of TSF discharge post-closure, ammonia is predicted to increase to between 0.15 and 0.58 mg N/L, with a mean of about 0.28 mg N/L. The 1:50 dry year maximum is forecast to be 0.58 mg N/L. The predicted 7dQ10 and 7dQ20 results are 0.45 mg N/L, respectively. These worst-case concentrations are still below the pH- and temperature-adjusted guidelines for ammonia, and will likely never be reached due to the overly conservative assumptions used to arrive at the predictions.

5.3.3.3.8.8.4.3 WQ9

At WQ9, the worst-case ammonia concentrations are predicted to vary between 0.09 and 0.16 mg N/L, well below guidelines. The 1:50 year maximum is predicted to be 0.16 mg N/L, also well below guidelines for the average pH and temperatures in Chedakuz Creek. The predicted 7dQ10 and 7dQ20 results are between 0.09 and 0.13 mg N/L.

5.3.3.3.8.8.5 Ammonia Summary

Ammonia is predicted to remain below BC FWG and CCME aquatic guidelines at WQ10 / plunge pool, WQ7 and WQ9 for all mining phases.

5.3.3.3.8.9 Nitrate and Nitrite

The BC and CCME protection of freshwater aquatic life guidelines for nitrate are 3 mg N/L for the 30-day average. The BC and Health Canada nitrate guidelines for drinking water are 10 mg N/L. The BC protection of freshwater aquatic life guideline for nitrite is 0.02 mg N/L; the CCME guideline is 0.06 mg N/L. The drinking water guideline is 1 mg N/L. There is no BC wildlife guideline. During operations Project nitrate and nitrite sources will include blasting residues and oxidation of cyanide residue remaining after CN destruct. **Table 5.3.3-14** and **Table 5.3.3-15** list predicted TSF water quality during operations, closure and post closure for best estimate and worst-case scenarios. All three N compounds (nitrate, nitrite, and ammonia) are elevated above background in the TSF, but there is a very small amount of seepage to Davidson Creek during operations and closure. By post closure when the TSF discharges nitrate and nitrite are predicted to be below BC FWG.

5.3.3.3.8.9.1 WQ10, Plunge Pool, WQ7, and WQ9

Nitrate and nitrite concentrations are predicted to be at or near background concentrations at these modelled sites for all mining phases and both best estimate. For worst-case scenarios, which do not include any reduction in nitrate and nitrite in wetlands downstream of the TSF, both nitrate and nitrite are predicted to be somewhat elevated above background, but, except for January nitrite, remain below guidelines. However, nitrite is expected to meet guidelines during all months even for the worst case conditions since the model does not include denitrification or removal of nitrogen compounds in wetlands.

5.3.3.3.8.10 Fluoride

The BC protection of freshwater aquatic life guideline for fluoride is hardness-based. For the hardness range predicted for the Project, the BC guideline is between 1 and 2 mg/L. The drinking water guideline is 1.5 mg/L.

The Project will not contribute any significant amount of fluoride to either Davidson Creek or Chedakuz Creek, and concentrations are predicted to remain below the CCME guideline for all modelled locations and mining phases.

5.3.3.3.8.11 Chloride

The BC and CCME protection of freshwater aquatic life guidelines for chloride are 150 mg/L, and for drinking water, 250 mg/L. The BC wildlife guideline is 600 mg/L.

Chloride guideline limits will never be approached during any phase of mining at any of the modelled locations, and are forecast to remain around background concentrations, between 0.2 and 0.8 mg/L.

5.3.3.3.8.12 Sulphate

The BC protection of freshwater aquatic life guideline for sulphate is hardness based. Based on the these criteria, the sulphate guideline during operations and closure (driven by Tatelkuz Lake water hardness) is about 300 mg/L, and at post-closure, with predicted softer water, about 200 mg/L; there is no CCME sulphate guideline for protection of aquatic life. The drinking water guideline is 500 mg/L; there is no BC wildlife guideline.

Water Hardness (mg/L)	Sulphate Guideline (mg/L)
0 to 30	128
31 to 75	218
76 to 180	309
181 to 250	429
>250	Site specific

Table 5.3.3-30 provides monthly sulphate summaries for the sites modelled for construction, the last year of mining, and the first full year of post-closure for best estimate values, and **Table 5.3.3-31** provides the same data for worst-case estimate values.

Table 5.3.3-30: Monthly Best Estimate Sulphate (mg/L) for Modelled Sites – Construction, Operations/Closure, Post-Closure

NODES	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Year -1 (Background)												
H1/WQ5	2	2	2	1	1	1	1	1	1	1	1	1
1-505659/WQ3	2	2	2	2	2	1	1	1	1	2	1	4
H2/WQ10	4	4	4	4	3	3	3	4	4	4	4	4
1DC/WQ7	4	4	4	3	3	3	3	3	3	3	3	3
H7/WQ12	2	1	2	1	1	1	1	1	1	1	1	1
H5/WQ9	5	5	5	4	4	3	3	4	4	4	4	5
Year 16												
H1/WQ5	2	2	2	1	1	1	1	1	1	1	1	1
1-505659/WQ3	2	2	2	2	2	1	1	1	1	2	1	4
H2/WQ10	23	21	23	22	8	8	13	19	23	24	23	22
1DC/WQ7	17	16	17	10	6	6	10	14	16	15	15	16
H7/WQ12	2	1	2	1	1	1	1	1	1	1	1	1
H5/WQ9	4	4	4	4	4	3	3	3	3	3	4	4
Year 36												
H1/WQ5	2	2	2	1	1	1	1	1	1	1	1	1
1-505659/WQ3	2	2	2	2	2	1	1	1	1	2	1	4
H2/Plunge Pool	246	262	246	117	66	77	165	224	206	177	204	231
1DC/WQ7	196	209	195	90	59	70	135	176	167	145	159	182
H7/WQ12	2	1	2	1	1	1	1	1	1	1	1	1
H5/WQ9	27	25	24	19	16	16	20	28	24	26	22	25

Table 5.3.3-31: Monthly Worst-Case Sulphate (mg/L) for Modelled Sites – Construction, Operations/Closure, Post-Closure

NODES	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Year -1 (Background)												
H1/WQ5	2	2	2	1	4	1	1	1	1	1	1	1
1-505659/WQ3	2	2	2	2	3	2	1	1	2	2	1	6
H2/WQ10	5	5	4	4	5	4	3	4	4	4	4	4
1DC/WQ7	4	4	4	4	4	4	3	4	3	4	3	4
H7/WQ12	2	2	2	2	2	3	1	1	1	1	1	1
H5/WQ9	5	5	5	5	5	4	3	4	4	4	4	6
Year 16												
H1/WQ5	2	2	2	1	4	1	1	1	1	1	1	1
1-505659/WQ3	2	2	2	2	3	2	1	1	2	2	1	6
H2/WQ10	24	22	24	23	10	9	13	21	24	25	24	23
1DC/WQ7	18	17	17	11	8	7	10	15	17	16	16	17
H7/WQ12	2	2	2	2	2	3	1	1	1	1	1	1
H5/WQ9	4	4	4	4	5	4	3	4	4	4	4	4
Year 36												
H1/WQ5	2	2	2	1	4	1	1	1	1	1	1	1
1-505659/WQ3	2	2	2	2	3	2	1	1	2	2	1	6
H2/Plunge Pool	300	320	299	155	84	95	229	274	267	249	271	292
1DC/WQ7	271	288	276	140	76	90	198	244	232	230	256	266
H7/WQ12	2	2	2	2	2	3	1	1	1	1	1	1
H5/WQ9	63	59	57	58	42	45	65	86	94	80	63	64

5.3.3.3.8.12.1 Best Estimate – Operations and Closure

5.3.3.3.8.12.1.1 WQ10

The sulphate concentration at WQ10 is predicted to rise above background (mean value of 4 mg/L) to a maximum of about 24 mg/L, and with seasonal variations between 8 mg/L and maximum.

5.3.3.3.8.12.1.2 WQ7

The predicted sulphate concentrations at WQ7 are similar to those for WQ10, ranging from 3 to 17 mg/L.

5.3.3.3.8.12.1.3 WQ9

During operations and closure, sulphate concentrations at WQ9 are predicted to remain at background of 3 to 5 mg/L.

5.3.3.3.8.12.2 Worst-Case – Operations and Closure

Under the worst-case scenario, sulphate at WQ10 is predicted to increase during operations to a maximum of about 25 mg/L, and stay at that level through the closure period. Sulphate concentrations will range from a minimum of about 5 mg/L to a maximum of about 25 mg/L, with an average concentration of about 15 mg/L.

5.3.3.3.8.12.2.1 WQ7

Sulphate concentrations at WQ10 are predicted to mirror those for the best estimate scenario during operations and closure.

5.3.3.3.8.12.2.2 WQ9

During operations and closure, the worst-case scenario sulphate concentrations are predicted to remain at background.

5.3.3.3.8.12.3 Best Estimate – Post-Closure

5.3.3.3.8.12.3.1 Plunge Pool

Sulphate is predicted to increase at the plunge pool after closure, principally due to the input from TSF seepage. Concentration might range between 66 and 262 mg/L, above the 200 mg/L BC guideline. The source of the sulphate is almost entirely the TSF seepage. The 1:50 year best estimate prediction for February (the month with the highest predicted concentration) is 301 mg/L, for 7dQ10 and 7dQ20 305 mg/L. The model prediction is very conservative, since it does not account for natural sulphate reduction of the seepage in the TSF, subsurface materials, and wetlands (bacterial sulphate reduction) which would be significant, from 40% to over 80% in constructed wetlands alone (Kadlec and Knight, 1996). Since these processes are not included in the model, the actual sulphate in the plunge pool in post-closure is expected to meet the water quality guideline.

5.3.3.3.8.12.3.2 WQ7

Similar to the plunge pool, sulphate concentration is predicted to increase post-closure to just over the BC guideline values of 200 mg/L in February, based on the predicted hardness at the site. As above, the actual sulphate concentration at WQ7 in post-closure is expected to meet the water quality guideline. Predictions for the 1:50 dry year, 7dQ10, and 7dQ20 are, respectively, 264, 260, and 262 mg/L.

5.3.3.3.8.12.3.3 WQ9

Post-closure sulphate concentrations at WQ9 are predicted to increase to a peak of about 27 mg/L, due to the influence of elevated sulphate above background in Davidson Creek. Predictions for the 1:50 dry year, 7dQ10, and 7dQ20 are, respectively, 49, 67, and 43 mg/L. The apparent anomaly of higher 7dQ10 than 1:50 and 7dQ20 is due to the lesser influence of Davidson Creek vs. Chedakuz Creek with the slightly lower 1:50 and 7dQ20 flows.

5.3.3.3.8.12.4 Worst-Case – Post-Closure

5.3.3.3.8.12.4.1 Plunge Pool

Assuming no reduction of sulphate in the TSF, subsurface materials, or wetlands, post-closure sulphate concentrations are predicted to increase to a maximum of 320 mg/L for the 1:50 dry year peak concentration, and to range between about 75 mg/L and 326 mg/L. The predicted 7dQ10 and 7dQ20 results are respectively, 324 and 325 mg/L. The hardness-adjusted BC protection of aquatic life guideline is 200 mg/L, as previously discussed. This scenario assumes that PAG rock will not be effectively neutralized in the TSF, which is the main purpose for submerging this rock in the TSF. Therefore, sulphate from this source is not limited by gypsum solubility. Moreover, as above, natural sulphate reduction processes were not modelled so the actual sulphate concentration at plunge pool in post-closure is expected to meet the water quality guideline.

5.3.3.3.8.12.4.2 WQ7

The worst-case prediction for sulphate during post-closure is for concentrations to vary between 76 and 288 mg/L, except in a 1:50 dry year, when sulphate is predicted to increase to a maximum of 289 mg/L. The predicted 7dQ10 and 7dQ20 predicts are 285 and 286 mg/L, respectively. The increase at WQ7 is driven by the predicted increase at the plunge pool. As above, the actual sulphate concentration at WQ7 in post-closure is expected to meet the water quality guideline.

5.3.3.3.8.12.4.3 WQ9

The worst-case sulphate concentrations at WQ9 are predicted to peak at about 94 mg/L, due to the assumption of 95th percentile background in Davidson Creek and the influence of Davidson Creek. For the 1:50 dry year, a maximum of 59 mg/L is predicted. The predicted 7dQ10 and 7dQ20 sulphate concentrations at WQ9 are, respectively, 75 and 51 mg/L. The lower concentrations are due to less influence, proportionally, from Davidson Creek at the lower flows.

5.3.3.3.8.12.5 Sulphate Summary

Sulphate is only predicted to potentially exceed the BC FWG at post closure at the plunge pool and WQ7 using conservative assumptions of no sulphate reduction in the TSF, subsurface materials or wetlands. Sulphate reduction is expected to significantly reduce sulphate in Davidson Creek; monitoring will be conducted during operations and closure to confirm this prediction.

The source of the sulphate is almost entirely the TSF seepage. Should sulphate be predicted to exceed guidelines in post closure, additional wetland treatment downstream of the operations freshwater reservoir area is an option for post closure or the seepage could continue to be recycled to the TSF for further treatment in the TSF wetland or to a biological treatment plant.

As previously discussed the model prediction is conservative, since it does not account for natural sulphate reduction of the seepage in the TSF, subsurface materials and wetlands (bacterial sulphate reduction) which would be significant, from 40% to over 80% in constructed wetlands (Kadlec and Knight, 1996). Since these processes are not included in the model, the actual sulphate in the plunge pool in post-closure is expected to meet the water quality guideline.

5.3.3.3.8.13 Total Organic Carbon

The BC chlorinated drinking water guideline for total organic carbon is 4 mg/L (for other or no disinfection, there is no guideline), and the BC guideline for the protection of freshwater aquatic life is ±20% of background. The chlorinated drinking water guideline is universally exceeded by up to four times in background concentrations measured at Project area streams, but this might only become problematic if surface water is used as a source of drinking water and chlorinated. At present, well or bottled water is used by residents in the area. The effects from the Project on total organic carbon (TOC) are forecast to stay within the range of background variation under both best estimate and worst-case scenarios.

5.3.3.3.8.14 Total Aluminum

CCME has a long-term guideline for total aluminum to protect aquatic life of 0.1 mg/L; BC's guideline is based on dissolved aluminum (discussed in the next section). BC's wildlife guideline is 5 mg/L for total aluminum.

The background total aluminum concentration in Tatelkuz Lake and Davidson Creek ranges from 0.05 to 0.38 mg/L, and the CCME guideline is exceeded more frequently than it is met. Total aluminum is sensitive to total suspended solids levels because sediment typically has considerable aluminum content, as a result of the earth's crust being approximately 75% aluminosilicate minerals. Aluminum readily complexes to aluminum oxyhydroxides, which are not biologically available.

Table 5.3.3-32 provides monthly total aluminum summaries for the sites modelled for construction, the last year of mining, and the first full year of post-closure for best estimate values, and **Table 5.3.3-33** provides the same data for worst-case estimate values.

Table 5.3.3-32: Monthly Best Estimate Total Aluminum (mg/L) for Modelled Sites – Construction, Operations/Closure, Post-Closure

NODES	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Year -1 (Background)												
H1/WQ5	0.057	0.112	0.112	0.167	0.314	0.202	0.136	0.072	0.054	0.056	0.067	0.100
1-505659/WQ3	0.032	0.093	0.030	0.078	0.250	0.114	0.080	0.078	0.075	0.032	0.029	0.026
H2/WQ10	0.014	0.003	0.007	0.021	0.136	0.047	0.055	0.017	0.039	0.013	0.057	0.137
1DC/WQ7	0.026	0.019	0.010	0.031	0.359	0.112	0.079	0.039	0.033	0.017	0.047	0.130
H7/WQ12	0.052	0.039	0.168	0.161	0.185	0.105	0.097	0.092	0.060	0.056	0.042	0.082
H5/WQ9	0.038	0.019	0.024	0.100	0.157	0.073	0.050	0.024	0.019	0.023	0.030	0.015
Year 16												
H1/WQ5	0.057	0.112	0.112	0.167	0.314	0.202	0.136	0.072	0.054	0.056	0.067	0.100
1-505659/WQ3	0.032	0.093	0.030	0.078	0.250	0.114	0.080	0.078	0.075	0.032	0.029	0.026
H2/WQ10	0.013	0.002	0.007	0.011	0.022	0.030	0.052	0.011	0.034	0.010	0.059	0.145
1DC/WQ7	0.023	0.014	0.009	0.032	0.205	0.086	0.083	0.036	0.031	0.016	0.049	0.138
H7/WQ12	0.052	0.039	0.161	0.143	0.173	0.105	0.096	0.094	0.060	0.057	0.043	0.084
H5/WQ9	0.021	0.009	0.012	0.039	0.085	0.047	0.051	0.017	0.027	0.014	0.046	0.093
Year 36												
H1/WQ5	0.057	0.112	0.112	0.167	0.314	0.202	0.136	0.072	0.054	0.056	0.067	0.100
1-505659/WQ3	0.032	0.093	0.030	0.078	0.250	0.114	0.080	0.078	0.075	0.032	0.029	0.026
H2/Plunge Pool	0.028	0.023	0.029	0.058	0.201	0.117	0.072	0.051	0.052	0.041	0.037	0.031
1DC/WQ7	0.032	0.027	0.026	0.055	0.247	0.131	0.089	0.059	0.046	0.038	0.036	0.051
H7/WQ12	0.052	0.039	0.161	0.143	0.173	0.105	0.096	0.094	0.060	0.057	0.043	0.084
H5/WQ9	0.028	0.013	0.017	0.053	0.116	0.065	0.056	0.023	0.029	0.020	0.043	0.071

Table 5.3.3-33: Monthly Worst-Case Total Aluminum (mg/L) for Modelled Sites – Construction, Operations/Closure, Post-Closure

NODES	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Year -1 (Background)												
H1/WQ5	0.057	0.112	0.112	0.167	0.596	0.258	0.189	0.087	0.056	0.074	0.068	0.100
1-505659/WQ3	0.043	0.157	0.035	0.128	0.575	0.156	0.104	0.123	0.101	0.034	0.031	0.033
H2/WQ10	0.018	0.003	0.016	0.038	0.263	0.090	0.094	0.020	0.067	0.016	0.108	0.137
1DC/WQ7	0.036	0.021	0.016	0.059	0.717	0.263	0.133	0.052	0.051	0.021	0.079	0.176
H7/WQ12	0.060	0.054	0.201	0.331	0.425	0.155	0.142	0.129	0.060	0.068	0.053	0.082
H5/WQ9	0.071	0.030	0.042	0.139	0.208	0.119	0.087	0.031	0.020	0.024	0.042	0.020
Year 16												
H1/WQ5	0.057	0.112	0.112	0.167	0.596	0.258	0.189	0.087	0.056	0.074	0.068	0.100
1-505659/WQ3	0.043	0.157	0.035	0.128	0.575	0.156	0.104	0.123	0.101	0.034	0.031	0.033
H2/WQ10	0.016	0.002	0.016	0.018	0.039	0.066	0.090	0.012	0.058	0.011	0.115	0.146
1DC/WQ7	0.032	0.016	0.016	0.062	0.409	0.211	0.141	0.048	0.047	0.019	0.083	0.175
H7/WQ12	0.060	0.055	0.195	0.290	0.390	0.156	0.141	0.131	0.061	0.069	0.053	0.084
H5/WQ9	0.034	0.013	0.023	0.058	0.135	0.094	0.087	0.022	0.041	0.015	0.083	0.099
Year 36												
H1/WQ5	0.057	0.112	0.112	0.167	0.596	0.258	0.189	0.087	0.056	0.074	0.068	0.100
1-505659/WQ3	0.043	0.157	0.035	0.128	0.575	0.156	0.104	0.123	0.101	0.034	0.031	0.033
H2/Plunge Pool	0.016	0.010	0.037	0.457	0.384	0.184	0.085	0.041	0.072	0.030	0.020	0.015
1DC/WQ7	0.021	0.015	0.035	0.421	0.463	0.215	0.111	0.050	0.066	0.030	0.021	0.035
H7/WQ12	0.045	0.021	0.317	0.287	0.393	0.156	0.141	0.134	0.061	0.062	0.043	0.064
H5/WQ9	0.031	0.012	0.026	0.201	0.284	0.145	0.096	0.028	0.055	0.020	0.076	0.091

5.3.3.3.8.15 Dissolved Aluminum

The BC guideline to protect freshwater aquatic life is 0.05 mg/L when the pH is above 6.5. The drinking water guideline is 0.2 mg/L. A site-specific water quality object is proposed as dissolved aluminum naturally exceeds the guideline routinely based on the three years of water quality monitoring conducted.

To ensure receiving environment limits are rarely, if ever, over the dissolved aluminum site objective, the proponent is proposing to use 0.12 mg/L (10% over the mean value at WQ10) for the 30-day average guideline, and 0.25 mg/L (the 95th percentile value for WQ10) for the maximum grab guideline. WQ10 is the water quality monitoring site closest to the TSF, and is considered the most representative of background water quality in the portion of upper Davidson Creek below Project construction.

Table 5.3.3-34 provides monthly dissolved aluminum summaries for the sites modelled for construction, the last year of mining, and the first full year of post-closure for best estimate values, and **Table 5.3.3-35** provides the same data for worst-case estimate values.

5.3.3.3.8.15.1 Best Estimate – Operations and Closure

5.3.3.3.8.15.1.1 WQ10

The background concentration of dissolved aluminum at WQ10 ranges from 0.01 to 0.23 mg/L; highest mean monthly concentration is 0.079 mg/L. The average aluminum concentration at WQ8, at the outlet of Tatelkuz Lake, is about 0.01 mg/L, and this is the predicted concentration at WQ10 during operations and closure, when Tatelkuz Lake water is pumped to Davidson Creek. The limited amount of seepage input from the TSF is not predicted to measurably affect background concentrations during operations and closure.

5.3.3.3.8.15.1.2 WQ7

The predicted concentrations for WQ7 during operations and closure is driven by the average background concentration of dissolved aluminum at the site, which ranges up to 0.17 mg/L. With the influence of Tatelkuz Lake water, dissolved aluminum is predicted to peak at 0.124 mg/L or approximately at the proposed site-specific water quality objective of 0.13 mg/L.

5.3.3.3.8.15.1.3 WQ9

Dissolved aluminum is predicted to track background concentrations at WQ9 throughout the operations and closure period, and to stay below the BC average guideline for the protection of freshwater aquatic life.

Table 5.3.3-34: Monthly Best Estimate Dissolved Aluminum (mg/L) for Modelled Sites – Construction, Operations/Closure, Post-Closure

NODES	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Year -1 (Background)												
H1/WQ5	0.047	0.098	0.098	0.149	0.225	0.180	0.112	0.062	0.038	0.045	0.061	0.063
1-505659/WQ3	0.009	0.007	0.011	0.015	0.147	0.091	0.045	0.026	0.015	0.015	0.015	0.007
H2/WQ10	0.003	0.003	0.003	0.006	0.079	0.024	0.009	0.008	0.004	0.005	0.005	0.004
1DC/WQ7	0.004	0.004	0.004	0.010	0.124	0.060	0.021	0.013	0.007	0.008	0.007	0.006
H7/WQ12	0.032	0.021	0.019	0.067	0.123	0.074	0.063	0.042	0.032	0.034	0.033	0.032
H5/WQ9	0.002	0.002	0.002	0.020	0.048	0.029	0.017	0.006	0.005	0.005	0.004	0.003
Year 16												
H1/WQ5	0.047	0.098	0.098	0.149	0.225	0.180	0.112	0.062	0.038	0.045	0.061	0.063
1-505659/WQ3	0.009	0.007	0.011	0.015	0.147	0.091	0.045	0.026	0.015	0.015	0.015	0.007
H2/WQ10	0.002	0.002	0.002	0.002	0.007	0.010	0.006	0.005	0.003	0.002	0.002	0.002
1DC/WQ7	0.004	0.004	0.003	0.011	0.059	0.042	0.022	0.011	0.006	0.007	0.006	0.005
H7/WQ12	0.032	0.021	0.019	0.060	0.116	0.073	0.062	0.042	0.033	0.034	0.034	0.032
H5/WQ9	0.002	0.002	0.002	0.008	0.025	0.019	0.011	0.006	0.003	0.003	0.003	0.002
Year 36												
H1/WQ5	0.047	0.098	0.098	0.149	0.225	0.180	0.112	0.062	0.038	0.045	0.061	0.063
1-505659/WQ3	0.009	0.007	0.011	0.015	0.147	0.091	0.045	0.026	0.015	0.015	0.015	0.007
H2/Plunge Pool	0.021	0.018	0.022	0.037	0.128	0.088	0.052	0.034	0.027	0.031	0.028	0.024
1DC/WQ7	0.018	0.016	0.018	0.032	0.133	0.093	0.054	0.031	0.024	0.028	0.025	0.021
H7/WQ12	0.032	0.021	0.019	0.060	0.116	0.073	0.062	0.042	0.033	0.034	0.034	0.032
H5/WQ9	0.004	0.003	0.004	0.014	0.048	0.033	0.017	0.009	0.006	0.007	0.005	0.005

Table 5.3.3-35: Monthly Worst-Case Dissolved Aluminum (mg/L) for Modelled Sites – Construction, Operations/Closure, Post-Closure

NODES	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Year -1 (Background)												
H1/WQ5	0.047	0.098	0.098	0.149	0.256	0.218	0.155	0.075	0.043	0.058	0.062	0.063
1-505659/WQ3	0.012	0.011	0.013	0.019	0.219	0.129	0.062	0.032	0.016	0.016	0.018	0.010
H2/WQ10	0.003	0.003	0.003	0.009	0.100	0.036	0.015	0.011	0.005	0.006	0.005	0.004
1DC/WQ7	0.005	0.006	0.004	0.016	0.151	0.124	0.034	0.016	0.007	0.011	0.008	0.006
H7/WQ12	0.038	0.022	0.020	0.093	0.179	0.089	0.086	0.051	0.034	0.045	0.037	0.032
H5/WQ9	0.003	0.002	0.002	0.030	0.066	0.047	0.029	0.010	0.005	0.007	0.004	0.003
Year 16												
H1/WQ5	0.047	0.098	0.098	0.149	0.256	0.218	0.155	0.075	0.043	0.058	0.062	0.063
1-505659/WQ3	0.012	0.011	0.013	0.019	0.219	0.129	0.062	0.032	0.016	0.016	0.018	0.010
H2/WQ10	0.003	0.002	0.003	0.003	0.010	0.018	0.010	0.008	0.004	0.003	0.003	0.003
1DC/WQ7	0.004	0.005	0.003	0.017	0.072	0.093	0.036	0.015	0.007	0.009	0.006	0.005
H7/WQ12	0.038	0.022	0.020	0.082	0.168	0.088	0.085	0.052	0.034	0.046	0.037	0.032
H5/WQ9	0.002	0.002	0.002	0.012	0.034	0.035	0.018	0.009	0.004	0.004	0.003	0.002
Year 36												
H1/WQ5	0.047	0.098	0.098	0.149	0.256	0.218	0.155	0.075	0.043	0.058	0.062	0.063
1-505659/WQ3	0.012	0.011	0.013	0.019	0.219	0.129	0.062	0.032	0.016	0.016	0.018	0.010
H2/Plunge Pool	0.012	0.009	0.016	0.181	0.198	0.128	0.042	0.028	0.015	0.023	0.017	0.012
1DC/WQ7	0.011	0.010	0.016	0.166	0.199	0.141	0.050	0.028	0.014	0.023	0.017	0.012
H7/WQ12	0.023	0.010	0.012	0.081	0.169	0.084	0.084	0.052	0.034	0.039	0.030	0.025
H5/WQ9	0.004	0.003	0.005	0.072	0.116	0.081	0.026	0.015	0.008	0.010	0.006	0.005

5.3.3.3.8.15.2 Worst-Case – Operations and Closure

5.3.3.3.8.15.2.1 WQ10

Predicted dissolved aluminum concentrations at WQ10 will track similar to background through the operations and closure period. The assumed 95th percentile background concentrations range from a minimum of 0.003 mg/L to a peak of 0.15 mg/L.

5.3.3.3.8.15.2.2 WQ7

Dissolved aluminum is predicted to vary between the detection limit and 0.15 mg/L at WQ7 during operations and closure, but generally remain below the maximum background concentration of 0.175 mg/L.

5.3.3.3.8.15.2.3 WQ9

Dissolved aluminum concentrations at WQ9 for the worst-case prediction are forecast to peak at 0.066 mg/L, which is the background peak.

5.3.3.3.8.15.3 Best Estimate – Post-Closure

5.3.3.3.8.15.3.1 Plunge Pool

Dissolved aluminum concentrations at post-closure are predicted to increase above both the average and maximum BC guidelines (0.05 and 0.10 mg/L, respectively) to 0.128 mg/L, but remain well below the maximum background dissolved aluminum concentrations, which reach seasonal maximums of 0.23 mg/L, driven by the natural catchment at the plunge pool. The best estimate 1:50, 7dQ10 and 7dQ20 predictions were made for February when the background dissolved aluminum concentrations are relatively low compared to background, at 0.02 mg/L and not representative of the highest average concentrations.

5.3.3.3.8.15.3.2 WQ7

Post-closure, dissolved aluminum is predicted to increase at WQ7, as at WQ10, as Tatelkuz Lake water will no longer be an influence; but, as with WQ10, the wetland is expected to reduce dissolved aluminum concentrations. However, with the greater influence of high background dissolved aluminum in Davidson Creek, the decrease is expected to be less. Dissolved aluminum at WQ7 in the post-closure phase, at a predicted 0.133 mg/L, is still predicted to remain well below the background maximum of 0.17 mg/L. The best estimate 1:50, 7dQ10 and 7dQ20 results are similar to WQ10 at 0.018 mg/L, and for the same reason.

5.3.3.3.8.15.3.3 WQ9

Dissolved aluminum is predicted to track background concentrations at WQ9 during post-closure, and to remain below the BC average guideline.

5.3.3.3.8.15.4 Worst-Case – Post-Closure

5.3.3.3.8.15.4.1 Plunge Pool

Dissolved aluminum concentrations at the plunge pool are predicted to stay well within the range of background variation (from the detection limit of 0.002 mg/L to about 0.198 mg/L), whereas the background 95th percentile concentrations were greater than 0.7 mg/L. As previously discussed, 7dQ10 and 7dQ20 low flow predicted concentrations are not representative of worst case. This applies equally to WQ7 and WQ9.

5.3.3.3.8.15.4.2 WQ7

Dissolved aluminum is forecast to remain within the background range, and stay well below the peak background concentration of 0.34 mg/L, reaching a maximum of 0.199 mg/L, except in the 1:50 dry year, when the maximum is forecast to reach 0.22 mg/L.

5.3.3.3.8.15.4.3 WQ9

Dissolved aluminum is forecast to track background concentrations, varying between the detection limit of 0.002 mg/L and 0.06 mg/L, except in the 1:50 dry year, when the peak is forecast to reach 0.08 mg/L.

5.3.3.3.8.15.5 Dissolved Aluminum Summary

During operations, closure, and post-closure, dissolved aluminum is predicted to exceed BC FWG due entirely to high background measured mean and 95th percentile concentrations at WQ10, WQ7, and WQ9 during some months. Site-specific objectives have been proposed to address the elevated background aluminum concentration issue.

5.3.3.3.8.16 Total Antimony

The BC working guideline for the protection of freshwater aquatic life for antimony uses the Ontario guideline of a long-term average of 0.02 mg/L. There is no CCME aquatic life guideline for antimony. The drinking water guideline is 0.006 mg/L; there is no BC wildlife guideline.

Total antimony is predicted to remain an order of magnitude below drinking water guidelines at WQ10/plunge pool, WQ7 and WQ9 during all mining phases for both best- and worst-case estimates.

5.3.3.3.8.17 Total Arsenic

The BC and CCME protection of freshwater aquatic life guidelines for total arsenic are 0.005 mg/L. The drinking water guideline is 0.010 mg/L. The BC wildlife guideline is 0.025 mg/L.

Table 5.3.3-36 provides monthly total arsenic summaries for the sites modelled for construction, the last year of mining, and the first full year of post-closure for best estimate values, and **Table 5.3.3-37** provides the same data for worst-case estimate values.

5.3.3.3.8.17.1 Best Estimate – Operations and Closure

5.3.3.3.8.17.1.1 WQ10

Modelled arsenic follows background concentrations for the operations and closure period, with maximum concentrations at about 20% of the guideline concentration limit.

5.3.3.3.8.17.1.2 WQ7

The predicted arsenic concentrations at WQ7 mirror those at WQ10.

5.3.3.3.8.17.1.3 WQ9

Total arsenic is predicted to track background throughout operations and closure (mean 0.0005 mg/L).

5.3.3.3.8.17.2 Worst-Case – Operations and Closure

5.3.3.3.8.17.2.1 WQ10

During operations and closure, total arsenic is predicted to track background concentrations.

5.3.3.3.8.17.2.2 WQ7

Predictions at WQ7 mirror those at WQ10.

5.3.3.3.8.17.2.3 WQ9

During operations, when there will be slightly less flow in Chedakuz Creek, total arsenic is predicted to peak at 0.0011 mg/L. At closure, when Chedakuz Creek flows increase, peaks are predicted to drop to 0.0005 mg/L, or 10% of the BC and CCME protection of freshwater aquatic life guidelines.

Table 5.3.3-36: Monthly Best Estimate Total Arsenic (mg/L) for Modelled Sites – Construction, Operations/Closure, Post-Closure

NODES	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Year -1 (Background)												
H1/WQ5	0.0011	0.0014	0.0014	0.0017	0.0003	0.0003	0.0004	0.0004	0.0003	0.0003	0.0003	0.0003
1-505659/WQ3	0.0011	0.0012	0.0012	0.0017	0.0005	0.0005	0.0008	0.0011	0.0011	0.0010	0.0011	0.0008
H2/WQ10	0.0011	0.0004	0.0005	0.0008	0.0005	0.0004	0.0004	0.0005	0.0004	0.0004	0.0005	0.0006
1DC/WQ7	0.0011	0.0004	0.0005	0.0006	0.0006	0.0004	0.0005	0.0005	0.0004	0.0004	0.0005	0.0005
H7/WQ12	0.0011	0.0002	0.0004	0.0008	0.0002	0.0002	0.0003	0.0003	0.0003	0.0002	0.0002	0.0003
H5/WQ9	0.0011	0.0005	0.0005	0.0005	0.0005	0.0005	0.0006	0.0007	0.0006	0.0005	0.0005	0.0005
Year 16												
H1/WQ5	0.0011	0.0014	0.0014	0.0017	0.0003	0.0003	0.0004	0.0004	0.0003	0.0003	0.0003	0.0003
1-505659/WQ3	0.0011	0.0012	0.0012	0.0017	0.0005	0.0005	0.0008	0.0011	0.0011	0.0010	0.0011	0.0008
H2/WQ10	0.0013	0.0006	0.0007	0.0010	0.0006	0.0005	0.0006	0.0007	0.0006	0.0006	0.0007	0.0008
1DC/WQ7	0.0012	0.0006	0.0006	0.0006	0.0006	0.0004	0.0006	0.0007	0.0006	0.0006	0.0006	0.0007
H7/WQ12	0.0011	0.0002	0.0004	0.0008	0.0003	0.0002	0.0003	0.0003	0.0002	0.0002	0.0002	0.0003
H5/WQ9	0.0010	0.0004	0.0004	0.0006	0.0005	0.0004	0.0005	0.0005	0.0004	0.0004	0.0005	0.0005
Year 36												
H1/WQ5	0.0011	0.0014	0.0014	0.0017	0.0003	0.0003	0.0004	0.0004	0.0003	0.0003	0.0003	0.0003
1-505659/WQ3	0.0011	0.0012	0.0012	0.0017	0.0005	0.0005	0.0008	0.0011	0.0011	0.0010	0.0011	0.0008
H2/Plunge Pool	0.0015	0.0015	0.0014	0.0010	0.0007	0.0007	0.0011	0.0013	0.0012	0.0011	0.0012	0.0013
1DC/WQ7	0.0014	0.0012	0.0012	0.0008	0.0007	0.0007	0.0010	0.0012	0.0011	0.0010	0.0010	0.0011
H7/WQ12	0.0011	0.0002	0.0004	0.0008	0.0003	0.0002	0.0003	0.0003	0.0002	0.0002	0.0002	0.0003
H5/WQ9	0.0011	0.0006	0.0006	0.0007	0.0006	0.0005	0.0006	0.0007	0.0006	0.0006	0.0006	0.0006

Table 5.3.3-37: Monthly Worst-Case Total Arsenic (mg/L) for Modelled Sites – Construction, Operations/Closure, Post-Closure

NODES	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Year -1 (Background)												
H1/WQ5	0.0011	0.0014	0.0014	0.0017	0.0005	0.0004	0.0005	0.0004	0.0003	0.0004	0.0004	0.0003
1-505659/WQ3	0.0011	0.0013	0.0012	0.0023	0.0009	0.0006	0.0009	0.0011	0.0011	0.0011	0.0011	0.0011
H2/WQ10	0.0011	0.0005	0.0005	0.0017	0.0009	0.0005	0.0005	0.0005	0.0004	0.0004	0.0005	0.0006
1DC/WQ7	0.0011	0.0005	0.0005	0.0012	0.0010	0.0006	0.0005	0.0005	0.0004	0.0004	0.0005	0.0006
H7/WQ12	0.0011	0.0002	0.0005	0.0012	0.0004	0.0004	0.0004	0.0004	0.0003	0.0002	0.0002	0.0003
H5/WQ9	0.0011	0.0006	0.0005	0.0007	0.0006	0.0006	0.0007	0.0007	0.0007	0.0006	0.0006	0.0005
Year 16												
H1/WQ5	0.0011	0.0014	0.0014	0.0017	0.0005	0.0004	0.0005	0.0004	0.0003	0.0004	0.0004	0.0003
1-505659/WQ3	0.0011	0.0013	0.0012	0.0023	0.0009	0.0006	0.0009	0.0011	0.0011	0.0011	0.0011	0.0011
H2/WQ10	0.0013	0.0007	0.0007	0.0019	0.0010	0.0006	0.0006	0.0007	0.0006	0.0007	0.0007	0.0008
1DC/WQ7	0.0013	0.0007	0.0006	0.0010	0.0010	0.0006	0.0006	0.0007	0.0006	0.0006	0.0007	0.0008
H7/WQ12	0.0011	0.0002	0.0004	0.0012	0.0004	0.0004	0.0004	0.0004	0.0002	0.0002	0.0002	0.0003
H5/WQ9	0.0010	0.0005	0.0005	0.0013	0.0007	0.0005	0.0005	0.0005	0.0005	0.0004	0.0005	0.0005
Year 36												
H1/WQ5	0.0011	0.0014	0.0014	0.0017	0.0005	0.0004	0.0005	0.0004	0.0003	0.0004	0.0004	0.0003
1-505659/WQ3	0.0011	0.0013	0.0012	0.0023	0.0009	0.0006	0.0009	0.0011	0.0011	0.0011	0.0011	0.0011
H2/Plunge Pool	0.0016	0.0017	0.0019	0.0013	0.0009	0.0008	0.0014	0.0015	0.0015	0.0014	0.0015	0.0015
1DC/WQ7	0.0016	0.0016	0.0018	0.0013	0.0009	0.0008	0.0013	0.0014	0.0014	0.0013	0.0014	0.0015
H7/WQ12	0.0011	0.0003	0.0008	0.0012	0.0004	0.0004	0.0004	0.0004	0.0002	0.0002	0.0002	0.0004
H5/WQ9	0.0012	0.0007	0.0007	0.0013	0.0008	0.0007	0.0008	0.0008	0.0008	0.0008	0.0007	0.0008

5.3.3.3.8.17.3 Best Estimate – Post-Closure

5.3.3.3.8.17.3.1 Plunge Pool

Arsenic concentrations peak at about 0.0015 mg/L and range down to background well below the guideline at maximum predicted concentrations. Dry return period flows (1:50, 7dQ10, 7dQ20) are predicted to be slightly higher at 0.0016 mg/L.

5.3.3.3.8.17.3.2 WQ7

Total arsenic concentrations mirror those at the plunge pool.

5.3.3.3.8.17.3.3 WQ9

Total arsenic is predicted to track background throughout post-closure (mean 0.0005 mg/L). Dry return period flows are predicted to be slightly higher at 0.0006 to 0.0007 mg/L.

5.3.3.3.8.17.4 Worst-Case – Post-Closure

5.3.3.3.8.17.4.1 Plunge Pool

Post-closure, total arsenic is predicted to peak just above the 95th percentile background concentration of 0.0012 mg/L, at a maximum of 0.0019 mg/L; well below 0.005 mg/L, which is the BC protection guidelines for freshwater aquatic life. Dry return period results (7dQ10 and 7dQ20) are predicted to be slightly lower than the maximum, at 0.0017 mg/L due to a slightly lower background concentration in February.

5.3.3.3.8.17.4.2 WQ7

Post-closure, total arsenic at WQ7 is forecast to increase to a peak of 0.0018 mg/L, which is the 1:50 dry year maximum. The BC protection of freshwater aquatic life guideline is 0.005 mg/L. The 7dQ10 and 7dQ20 predicted concentrations are both 0.0016 mg/L.

5.3.3.3.8.17.4.3 WQ9

Post-closure, total arsenic at WQ9 is predicted to track background, varying from the detection limit (0.0001 mg/L) to a maximum of 0.0013 mg/L. The 1:50 dry year maximum concentration is predicted to be 0.0015 mg/L. The 7dQ10 and 7dQ20 predicted concentrations are about 0.0008 mg/L

5.3.3.3.8.17.5 Total Arsenic Summary

Total arsenic is predicted to remain below the BC FWG and CCME aquatic guideline at WQ10/plunge pool, WQ7 and WQ9 during all mine phases for best and worst-case estimates.

5.3.3.3.8.18 Barium

The BC protection of freshwater aquatic life guideline for barium is 1 mg/L, as is the drinking water guideline; there are no CCME freshwater aquatic or BC wildlife guidelines.

Barium concentrations at all sites during all mining phases are predicted to remain within guidelines under both the best estimate and worst-case scenarios. Concentrations rise slightly above background under the worst case, up to a maximum of 0.022 mg/L.

5.3.3.3.8.19 Beryllium

The BC protection of freshwater aquatic life maximum is 0.0053 mg/L. There are no CCME or BC protection of wildlife guidelines.

Beryllium is forecast to stay within background concentrations at all sites during all phases of mining, which is at or below the detection limit of 0.0001 mg/L.

5.3.3.3.8.20 Boron

The BC protection of freshwater aquatic life guideline for boron is 1.2 mg/L. The drinking water and BC protection of wildlife guideline is 5 mg/L.

Under the best estimate scenario, boron is predicted to remain at background concentrations of about 0.002 mg/L, rising to a maximum of 0.012 mg/L for the worst-case assumptions.

5.3.3.3.8.21 Total Cadmium

The BC protection of freshwater aquatic life guideline is based on hardness according to the following equation:

$$10^{(0.86[\log\{hardness\}]-3.2)}$$

The current guideline is based on 1972 data, and is under review by BC MOE.

The 2012 CCME cadmium guideline is based on the following equation:

$$10^{(0.83[\log\{hardness\}]-2.46)}$$

Based on anecdotal information from BC MOE, the new federal guideline will likely not be followed by BC.

The Proponent commissioned Lorax to develop a site water quality objective (SPO) for total cadmium. This objective was designed to be fully protective of rainbow trout (the predominant fish in Davidson Creek). The Lorax SPO guideline (**Appendix 5.3.3A**) is also based on hardness, per the following equation:

$$0.1 \times 10^{(0.83[\log\{hardness\}]-1.649)}$$

The Lorax WQO results in the following guidelines for a range of water hardness, with BC and CCME guidelines added for comparison:

Table 5.3.3-38: Range of Water Hardness Guidelines

Hardness (mg $CaCO_3$)/L	Lorax Cd WQO (µg Cd/L)	BC Guideline (µg Cd/L)	CCME 2012 Guideline (µg Cd/L)
50	0.06	0.02	0.10
100	0.10	0.03	0.18
200	0.18	0.06	0.32
300	0.26	0.09	0.42

Table 5.3.3-39 provides monthly total cadmium summaries for the sites modelled for construction, the last year of mining, and the first full year of post-closure for best estimate values, and **Table 5.3.3-40** provides the same data for worst-case estimate values.

5.3.3.3.8.21.1 Best Estimate – Operations and Closure

5.3.3.3.8.21.1.1 WQ10

Predicted best estimate total cadmium concentrations at WQ10 are at approximately background concentrations, and below the current BC guideline. Predicted concentrations are well below the Lorax WQO and CCME guidelines.

5.3.3.3.8.21.1.2 WQ7

Predicted total cadmium concentrations at WQ7 mirror those at WQ10.

5.3.3.3.8.21.1.3 WQ9

Total cadmium is predicted to track background at WQ9 throughout operations and closure (a mean below detection limits of 0.000015 mg/L).

5.3.3.3.8.21.2 Worst-Case – Operations and Closure

5.3.3.3.8.21.2.1 WQ10

Total cadmium is predicted to stay within the range of background 95th percentile concentrations during operations and closure, and to remain below the current BC guideline, the Lorax WQO, and the CCME guideline.

5.3.3.3.8.21.2.2 WQ7

Worst-case total cadmium is predicted to stay within the background range for cadmium, but to increase to 0.00005 mg/L, due to high background, or approximately twice the current BC protection of freshwater aquatic life guideline. Predicted concentration maximums will remain below the WQO of about 0.00006 mg/L during operations and closure.

5.3.3.3.8.21.2.3 WQ9

Similar to WQ7, total cadmium is predicted to range from between background to an increase maximum of 0.000033 mg/L.

Table 5.3.3-39: Monthly Best Estimate Total Cadmium (mg/L) for Modelled Sites – Construction, Operations/Closure, Post Closure

NODES	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Year -1 (Background)												
H1/WQ5	0.000105	0.000060	0.000060	0.000015	0.000017	0.000015	0.000015	0.000015	0.000015	0.000015	0.000020	0.000031
1-505659/WQ3	0.000024	0.000015	0.000015	0.000015	0.000021	0.000015	0.000015	0.000015	0.000016	0.000015	0.000015	0.000015
H2/WQ10	0.000015	0.000015	0.000015	0.000015	0.000017	0.000015	0.000015	0.000015	0.000015	0.000015	0.000015	0.000015
1DC/WQ7	0.000015	0.000041	0.000015	0.000015	0.000020	0.000019	0.000015	0.000015	0.000016	0.000015	0.000015	0.000018
H7/WQ12	0.000015	0.000015	0.000021	0.000015	0.000022	0.000025	0.000020	0.000021	0.000015	0.000015	0.000015	0.000015
H5/WQ9	0.000015	0.000015	0.000015	0.000015	0.000025	0.000016	0.000015	0.000015	0.000015	0.000015	0.000015	0.000015
Year 16												
H1/WQ5	0.000105	0.000060	0.000060	0.000015	0.000017	0.000015	0.000015	0.000015	0.000015	0.000015	0.000020	0.000031
1-505659/WQ3	0.000024	0.000015	0.000015	0.000015	0.000021	0.000015	0.000015	0.000015	0.000016	0.000015	0.000015	0.000015
H2/WQ10	0.000016	0.000016	0.000016	0.000016	0.000017	0.000015	0.000015	0.000016	0.000016	0.000016	0.000016	0.000016
1DC/WQ7	0.000016	0.000034	0.000016	0.000015	0.000019	0.000019	0.000015	0.000015	0.000016	0.000016	0.000016	0.000018
H7/WQ12	0.000015	0.000015	0.000020	0.000015	0.000023	0.000026	0.000021	0.000020	0.000015	0.000015	0.000015	0.000015
H5/WQ9	0.000014	0.000016	0.000014	0.000014	0.000018	0.000014	0.000014	0.000014	0.000014	0.000014	0.000014	0.000014
Year 36												
H1/WQ5	0.000105	0.000060	0.000060	0.000015	0.000017	0.000015	0.000015	0.000015	0.000015	0.000015	0.000020	0.000031
1-505659/WQ3	0.000024	0.000015	0.000015	0.000015	0.000021	0.000015	0.000015	0.000015	0.000016	0.000015	0.000015	0.000015
H2/Plunge Pool	0.000011	0.000011	0.000011	0.000013	0.000015	0.000014	0.000013	0.000012	0.000012	0.000012	0.000012	0.000011
1DC/WQ7	0.000012	0.000026	0.000012	0.000014	0.000016	0.000016	0.000013	0.000012	0.000013	0.000013	0.000013	0.000014
H7/WQ12	0.000015	0.000015	0.000020	0.000015	0.000023	0.000026	0.000021	0.000020	0.000015	0.000015	0.000015	0.000015
H5/WQ9	0.000015	0.000016	0.000015	0.000015	0.000019	0.000015	0.000015	0.000015	0.000015	0.000015	0.000015	0.000015

Table 5.3.3-40: Monthly Worst Case Total Cadmium (mg/L) for Modelled Sites – Construction, Operations/Closure, Post-Closure

NODES	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Year -1 (Background)												
H1/WQ5	0.000105	0.000060	0.000060	0.000015	0.000029	0.000015	0.000015	0.000015	0.000015	0.000015	0.000025	0.000031
1-505659/WQ3	0.000032	0.000015	0.000015	0.000015	0.000045	0.000015	0.000015	0.000015	0.000017	0.000015	0.000015	0.000015
H2/WQ10	0.000015	0.000015	0.000015	0.000015	0.000028	0.000015	0.000015	0.000015	0.000015	0.000015	0.000015	0.000015
1DC/WQ7	0.000016	0.000051	0.000015	0.000015	0.000034	0.000047	0.000015	0.000015	0.000017	0.000015	0.000015	0.000021
H7/WQ12	0.000015	0.000015	0.000022	0.000015	0.000045	0.000045	0.000031	0.000032	0.000015	0.000015	0.000015	0.000015
H5/WQ9	0.000015	0.000015	0.000015	0.000015	0.000058	0.000021	0.000015	0.000015	0.000015	0.000015	0.000015	0.000015
Year 16												
H1/WQ5	0.000105	0.000060	0.000060	0.000015	0.000029	0.000015	0.000015	0.000015	0.000015	0.000015	0.000025	0.000031
1-505659/WQ3	0.000032	0.000015	0.000015	0.000015	0.000045	0.000015	0.000015	0.000015	0.000017	0.000015	0.000015	0.000015
H2/WQ10	0.000016	0.000016	0.000016	0.000016	0.000024	0.000015	0.000015	0.000016	0.000016	0.000016	0.000016	0.000016
1DC/WQ7	0.000016	0.000041	0.000016	0.000015	0.000029	0.000041	0.000015	0.000016	0.000017	0.000016	0.000016	0.000020
H7/WQ12	0.000015	0.000015	0.000021	0.000015	0.000046	0.000047	0.000032	0.000030	0.000015	0.000015	0.000015	0.000015
H5/WQ9	0.000014	0.000017	0.000014	0.000014	0.000033	0.000019	0.000014	0.000014	0.000014	0.000014	0.000014	0.000014
Year 36												
H1/WQ5	0.000105	0.000060	0.000060	0.000015	0.000029	0.000015	0.000015	0.000015	0.000015	0.000015	0.000025	0.000031
1-505659/WQ3	0.000032	0.000015	0.000015	0.000015	0.000045	0.000015	0.000015	0.000015	0.000017	0.000015	0.000015	0.000015
H2/Plunge Pool	0.000012	0.000011	0.000011	0.000027	0.000023	0.000015	0.000013	0.000012	0.000011	0.000012	0.000011	0.000011
1DC/WQ7	0.000013	0.000021	0.000011	0.000026	0.000024	0.000022	0.000013	0.000012	0.000013	0.000012	0.000012	0.000013
H7/WQ12	0.000015	0.000015	0.000031	0.000015	0.000046	0.000052	0.000033	0.000030	0.000015	0.000015	0.000015	0.000015
H5/WQ9	0.000015	0.000016	0.000014	0.000019	0.000030	0.000019	0.000014	0.000014	0.000014	0.000014	0.000014	0.000015

5.3.3.3.8.21.3 Best Estimate – Post-Closure

5.3.3.3.8.21.3.1 Plunge Pool

Concentrations of total cadmium are predicted to be below the current BC guideline, except where background concentrations naturally exceed this guideline. The Lorax WQO and CCME guidelines are predicted to not be exceeded. The dry return period flows are predicted to remain below the BC guideline.

5.3.3.3.8.21.3.2 WQ7

Predicted concentrations of total cadmium at WQ7 mirror those at WQ10, including the dry return period flows.

5.3.3.3.8.21.3.3 WQ9

Total cadmium is predicted to track background at WQ9 throughout operations and closure (a mean below the detection limit of 0.000015 mg/L), including the dry return period flows.

5.3.3.3.8.21.4 Worst Case – Post Closure

5.3.3.3.8.21.4.1 Plunge Pool

Post-closure, including discharge from the TSF and increased seepage flows, and assuming no wetland polishing, total cadmium concentrations are predicted to be within the background 95th percentile variation (assumed to be WQ10). Maximum total cadmium is predicted to peak above the current BC guideline, due to high background, but to remain below the Lorax WQO, and well below the CCME guideline, at 0.000027 mg/L. The dry return period flow predictions for cadmium are lower than the maximum due to lower background concentrations in February when the winter low flows occur.

5.3.3.3.8.21.4.2 WQ7

Post-closure, except for the 1:50 dry year, peak cadmium concentrations are predicted to drop to 0.000024 mg/L. Dry return period predicted concentrations are slightly lower than the predicted maximum at 0.00002 mg/L.

5.3.3.3.8.21.4.3 WQ9

Post-closure, under the worst-case scenario, cadmium concentrations are forecast to generally remain under the current BC guideline, and well within the range of background concentrations, with a maximum of 0.00003 mg/L. Predicted dry return period concentrations are the same as for WQ7.

5.3.3.3.8.21.5 Total Cadmium Summary

During operations and closure total cadmium is predicted to track mean background at all sites under the best estimate scenario and within the background range for 95th percentile worst-case scenario. Predicted exceedances of the current BC FWG are due to high background concentrations. Predictions for post closure are similar and exceedances are driven by high background concentrations. For this reason a site specific water quality objective is proposed. The proposed Lorax WQO is not predicted to be exceeded.

5.3.3.3.8.22 Total Chromium

Most chromium in streams and lakes with well oxygenated waters is in the Cr^{6+} form, and therefore total chromium analyzed by assay labs routinely approximates the Cr^{6+} concentration. The BC and CCME protection of freshwater aquatic life average guideline for Cr^{6+} is 0.001 mg/L. The drinking water guideline is 0.05 mg/L; there is no BC wildlife guideline.

There is no anomalous chromium in the Project's ore and area streams and lakes all have low to undetectable concentrations of chromium. Chromium concentrations in Davidson Creek are predicted to follow background for all mining phases and for both best estimate and worst-case scenarios.

5.3.3.3.8.23 Total Cobalt

The BC protection of freshwater aquatic life guideline for total cobalt is 0.004 mg/L. There are no CCME aquatic life, BC wildlife, or drinking water guidelines.

Table 5.3.3-41 provides monthly total cobalt summaries for the sites modelled for construction, the last year of mining, and the first full year of post-closure for best estimate values, and **Table 5.3.3-42** provides the same data for worst-case estimate values.

Total cobalt is predicted to remain 5 to 100 times below BC FWG at all sites during all mining phases for both best and worst-case estimates.

5.3.3.3.8.24 Total Copper

The BC protection of freshwater aquatic life guideline for total copper varies with hardness, based on the following equation for hardness >50 mg/L:

$$0.04 \times (\text{mean hardness})$$

For hardness <50 mg $CaCO_3$/L the BC guideline is 0.002 mg/L. For the average hardness of Tatelkuz Lake water, the BC guideline is approximately 0.003 mg/L. The CCME aquatic life guideline is fixed at 0.002 mg/L. The drinking water guideline is 1 mg/L, and the BC wildlife guideline is 0.3 mg/L. Because of high background, particularly in Davidson Creek, a site-specific water quality objective of 0.0045 mg/L 30-d average is proposed, but noting that 95th percentiles may exceed this WQO by over two times. Monitoring during the operations and closure period will result in a better concentration distribution prediction and the site-specific water quality objective can be reviewed with that information.

Table 5.3.3-43 provides monthly total copper summaries for the sites modelled for construction, the last year of mining, and the first full year of post-closure for best estimate values, and **Table 5.3.3-44** provides the same data for worst-case estimate values.

5.3.3.3.8.24.1 Best Estimate – Operations and Closure

5.3.3.3.8.24.1.1 WQ10

Predicted total copper concentrations are controlled by background levels, with seasonal spikes above the federal guideline; it is predicted that the provincial, hardness-adjusted guideline will not be exceeded.

5.3.3.3.8.24.1.2 WQ7

Total copper is predicted to peak at 0.0017 mg/L at WQ7 during operations and closure, ranging down to just above the detection limit (0.0002 mg/L).

5.3.3.3.8.24.1.3 WQ9

Total copper at WQ9 is predicted to range between the detection limit and 0.0007 mg/L during operations. The periodic peaks are due to increases in background water concentrations (such as in October). Total copper at WQ9 is predicted to remain below both CCME and BC protection of freshwater aquatic guidelines.

5.3.3.3.8.24.2 Worst Case – Operations and Closure

5.3.3.3.8.24.2.1 WQ10

For the worst-case scenario, total copper is predicted to stay within the background 95th percentile range, with a maximum value (0.0033 mg/L) that exceed both the CCME (0.002 mg/L) and the BC hardness-adjusted guideline of about 0.003 mg/L due to high background. The mean total copper concentration is predicted to remain below 0.001 mg/L during operations and closure. Peak predicted concentrations will be below the BC protection of aquatic life maximum hardness-adjusted guideline of approximately 0.009 mg/L.

5.3.3.3.8.24.2.2 WQ7

For the worst-case scenario, total copper at WQ7 is forecast to stay below the 95th percentile (0.01 mg/L in June) but above provincial and federal protection of aquatic life guidelines at a predicted 0.008 mg/L.

5.3.3.3.8.24.2.3 WQ9

For the worst-case scenario, total copper during operations and closure is forecast to track background and to peak just above the CCME guideline, at 0.0027 mg/L.

Table 5.3.3-41: Monthly Best Estimate Total Cobalt (mg/L) for Modelled Sites – Construction, Operations/Closure, Post-Closure

NODES	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Year -1 (Background)												
H1/WQ5	0.000060	0.000055	0.000055	0.000050	0.000107	0.000038	0.000025	0.000025	0.000025	0.000030	0.000030	0.000050
1-505659/WQ3	0.000020	0.000040	0.000020	0.000055	0.000122	0.000047	0.000025	0.000045	0.000040	0.000020	0.000020	0.000030
H2/WQ10	0.000020	0.000020	0.000021	0.000035	0.000042	0.000032	0.000035	0.000025	0.000029	0.000025	0.000042	0.000066
1DC/WQ7	0.000036	0.000030	0.000027	0.000041	0.000132	0.000053	0.000039	0.000034	0.000039	0.000028	0.000047	0.000082
H7/WQ12	0.000027	0.000046	0.000089	0.000064	0.000036	0.000028	0.000027	0.000030	0.000032	0.000030	0.000027	0.000040
H5/WQ9	0.000035	0.000025	0.000035	0.000073	0.000064	0.000050	0.000035	0.000035	0.000030	0.000030	0.000045	0.000030
Year 16												
H1/WQ5	0.000060	0.000055	0.000055	0.000050	0.000107	0.000038	0.000025	0.000025	0.000025	0.000030	0.000030	0.000050
1-505659/WQ3	0.000020	0.000040	0.000020	0.000055	0.000122	0.000047	0.000025	0.000045	0.000040	0.000020	0.000020	0.000030
H2/WQ10	0.000784	0.000711	0.000784	0.000776	0.000200	0.000198	0.000436	0.000663	0.000833	0.000855	0.000848	0.000834
1DC/WQ7	0.000566	0.000530	0.000556	0.000347	0.000209	0.000176	0.000327	0.000468	0.000562	0.000539	0.000530	0.000590
H7/WQ12	0.000027	0.000047	0.000088	0.000058	0.000035	0.000028	0.000028	0.000030	0.000032	0.000030	0.000027	0.000041
H5/WQ9	0.000025	0.000021	0.000024	0.000047	0.000046	0.000036	0.000033	0.000027	0.000029	0.000025	0.000043	0.000053
Year 36												
H1/WQ5	0.000060	0.000055	0.000055	0.000050	0.000107	0.000038	0.000025	0.000025	0.000025	0.000030	0.000030	0.000050
1-505659/WQ3	0.000020	0.000040	0.000020	0.000055	0.000122	0.000047	0.000025	0.000045	0.000040	0.000020	0.000020	0.000030
H2/Plunge Pool	0.000578	0.000615	0.000581	0.000289	0.000190	0.000207	0.000401	0.000530	0.000488	0.000422	0.000483	0.000545
1DC/WQ7	0.000472	0.000497	0.000467	0.000233	0.000195	0.000197	0.000338	0.000427	0.000404	0.000350	0.000389	0.000451
H7/WQ12	0.000027	0.000047	0.000088	0.000058	0.000035	0.000028	0.000028	0.000030	0.000032	0.000030	0.000027	0.000041
H5/WQ9	0.000080	0.000071	0.000074	0.000084	0.000078	0.000070	0.000074	0.000085	0.000077	0.000079	0.000086	0.000095

Table 5.3.3-42: Monthly Worst-Case Total Cobalt (mg/L) for Modelled Sites – Construction, Operations/Closure, Post-Closure

NODES	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Year -1 (Background)												
H1/WQ5	0.000060	0.000055	0.000055	0.000050	0.000400	0.000050	0.000030	0.000030	0.000030	0.000030	0.000030	0.000050
1-505659/WQ3	0.000020	0.000060	0.000020	0.000090	0.000450	0.000070	0.000030	0.000070	0.000050	0.000020	0.000020	0.000040
H2/WQ10	0.000020	0.000020	0.000023	0.000050	0.000112	0.000070	0.000049	0.000030	0.000039	0.000029	0.000065	0.000066
1DC/WQ7	0.000044	0.000036	0.000030	0.000050	0.000315	0.000129	0.000059	0.000039	0.000050	0.000033	0.000063	0.000110
H7/WQ12	0.000027	0.000050	0.000165	0.000098	0.000084	0.000039	0.000032	0.000038	0.000035	0.000030	0.000027	0.000040
H5/WQ9	0.000040	0.000030	0.000050	0.000080	0.000110	0.000070	0.000050	0.000040	0.000030	0.000030	0.000050	0.000030
Year 16												
H1/WQ5	0.000060	0.000055	0.000055	0.000050	0.000400	0.000050	0.000030	0.000030	0.000030	0.000030	0.000030	0.000050
1-505659/WQ3	0.000020	0.000060	0.000020	0.000090	0.000450	0.000070	0.000030	0.000070	0.000050	0.000020	0.000020	0.000040
H2/WQ10	0.000809	0.000733	0.000809	0.000813	0.000265	0.000242	0.000463	0.000689	0.000869	0.000886	0.000898	0.000858
1DC/WQ7	0.000589	0.000550	0.000573	0.000362	0.000350	0.000249	0.000357	0.000487	0.000590	0.000561	0.000562	0.000629
H7/WQ12	0.000027	0.000050	0.000166	0.000088	0.000078	0.000040	0.000032	0.000037	0.000035	0.000030	0.000027	0.000041
H5/WQ9	0.000027	0.000023	0.000029	0.000057	0.000106	0.000069	0.000047	0.000032	0.000035	0.000028	0.000059	0.000056
Year 36												
H1/WQ5	0.000060	0.000055	0.000055	0.000050	0.000400	0.000050	0.000030	0.000030	0.000030	0.000030	0.000030	0.000050
1-505659/WQ3	0.000020	0.000060	0.000020	0.000090	0.000450	0.000070	0.000030	0.000070	0.000050	0.000020	0.000020	0.000040
H2/Plunge Pool	0.000700	0.000752	0.000707	0.000455	0.000273	0.000259	0.000551	0.000644	0.000625	0.000582	0.000635	0.000682
1DC/WQ7	0.000641	0.000682	0.000654	0.000415	0.000298	0.000260	0.000488	0.000580	0.000552	0.000541	0.000602	0.000638
H7/WQ12	0.000024	0.000026	0.000131	0.000087	0.000078	0.000041	0.000033	0.000037	0.000034	0.000030	0.000025	0.000035
H5/WQ9	0.000160	0.000149	0.000151	0.000199	0.000199	0.000161	0.000188	0.000218	0.000239	0.000202	0.000189	0.000188

Table 5.3.3-43: Monthly Best Estimate Total Copper (mg/L) for Modelled Sites – Construction, Operations/Closure, Post-Closure

NODES	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Year -1 (Background)												
H1/WQ5	0.00050	0.00060	0.00060	0.00070	0.00053	0.00035	0.00045	0.00025	0.00020	0.00015	0.00015	0.00050
1-505659/WQ3	0.00370	0.00010	0.00010	0.00025	0.00063	0.00039	0.00035	0.00015	0.00015	0.00010	0.00015	0.00015
H2/WQ10	0.00019	0.00019	0.00028	0.00039	0.00067	0.00025	0.00035	0.00049	0.00025	0.00218	0.00016	0.00047
1DC/WQ7	0.00019	0.00047	0.00026	0.00034	0.00079	0.00166	0.00039	0.00041	0.00025	0.00141	0.00015	0.00046
H7/WQ12	0.00035	0.00043	0.00029	0.00040	0.00038	0.00020	0.00085	0.00016	0.00023	0.00019	0.00013	0.00019
H5/WQ9	0.00025	0.00025	0.00022	0.00043	0.00066	0.00033	0.00045	0.00025	0.00025	0.00020	0.00020	0.00020
Year 16												
H1/WQ5	0.00050	0.00060	0.00060	0.00070	0.00053	0.00035	0.00045	0.00025	0.00020	0.00015	0.00015	0.00050
1-505659/WQ3	0.00370	0.00010	0.00010	0.00025	0.00063	0.00039	0.00035	0.00015	0.00015	0.00010	0.00015	0.00015
H2/WQ10	0.00033	0.00032	0.00043	0.00056	0.00075	0.00027	0.00042	0.00061	0.00039	0.00251	0.00029	0.00063
1DC/WQ7	0.00029	0.00048	0.00037	0.00039	0.00080	0.00139	0.00044	0.00049	0.00034	0.00160	0.00023	0.00057
H7/WQ12	0.00035	0.00044	0.00028	0.00042	0.00036	0.00020	0.00083	0.00017	0.00023	0.00020	0.00013	0.00019
H5/WQ9	0.00020	0.00022	0.00025	0.00041	0.00065	0.00039	0.00035	0.00037	0.00023	0.00147	0.00016	0.00036
Year 36												
H1/WQ5	0.00050	0.00060	0.00060	0.00070	0.00053	0.00035	0.00045	0.00025	0.00020	0.00015	0.00015	0.00050
1-505659/WQ3	0.00370	0.00010	0.00010	0.00025	0.00063	0.00039	0.00035	0.00015	0.00015	0.00010	0.00015	0.00015
H2/Plunge Pool	0.00178	0.00188	0.00179	0.00098	0.00080	0.00076	0.00134	0.00167	0.00154	0.00133	0.00153	0.00170
1DC/WQ7	0.00145	0.00168	0.00147	0.00081	0.00081	0.00117	0.00118	0.00136	0.00129	0.00111	0.00122	0.00143
H7/WQ12	0.00035	0.00044	0.00028	0.00042	0.00036	0.00020	0.00083	0.00017	0.00023	0.00020	0.00013	0.00019
H5/WQ9	0.00037	0.00038	0.00038	0.00050	0.00072	0.00045	0.00050	0.00051	0.00038	0.00127	0.00030	0.00046

Table 5.3.3-44: Monthly Worst-Case Total Copper (mg/L) for Modelled Sites – Construction, Operations/Closure, Post-Closure

NODES	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Year -1 (Background)												
H1/WQ5	0.00050	0.00060	0.00060	0.00070	0.00100	0.00060	0.00050	0.00040	0.00030	0.00020	0.00020	0.00050
1-505659/WQ3	0.00730	0.00010	0.00010	0.00040	0.00110	0.00070	0.00040	0.00020	0.00020	0.00010	0.00020	0.00020
H2/WQ10	0.00028	0.00029	0.00038	0.00058	0.00256	0.00061	0.00041	0.00087	0.00029	0.00407	0.00021	0.00047
1DC/WQ7	0.00029	0.00061	0.00035	0.00047	0.00214	0.00825	0.00045	0.00072	0.00033	0.00261	0.00021	0.00061
H7/WQ12	0.00057	0.00047	0.00031	0.00058	0.00057	0.00041	0.00155	0.00022	0.00035	0.00019	0.00017	0.00019
H5/WQ9	0.00030	0.00040	0.00030	0.00060	0.00190	0.00070	0.00060	0.00040	0.00040	0.00020	0.00030	0.00030
Year 16												
H1/WQ5	0.00050	0.00060	0.00060	0.00070	0.00100	0.00060	0.00050	0.00040	0.00030	0.00020	0.00020	0.00050
1-505659/WQ3	0.00730	0.00010	0.00010	0.00040	0.00110	0.00070	0.00040	0.00020	0.00020	0.00010	0.00020	0.00020
H2/WQ10	0.00048	0.00046	0.00058	0.00077	0.00333	0.00064	0.00049	0.00105	0.00049	0.00464	0.00039	0.00068
1DC/WQ7	0.00043	0.00065	0.00050	0.00049	0.00282	0.00675	0.00053	0.00084	0.00046	0.00293	0.00032	0.00073
H7/WQ12	0.00057	0.00048	0.00030	0.00058	0.00054	0.00041	0.00150	0.00023	0.00037	0.00020	0.00017	0.00019
H5/WQ9	0.00027	0.00033	0.00033	0.00056	0.00252	0.00137	0.00043	0.00064	0.00031	0.00270	0.00022	0.00041
Year 36												
H1/WQ5	0.00050	0.00060	0.00060	0.00070	0.00100	0.00060	0.00050	0.00040	0.00030	0.00020	0.00020	0.00050
1-505659/WQ3	0.00730	0.00010	0.00010	0.00040	0.00110	0.00070	0.00040	0.00020	0.00020	0.00010	0.00020	0.00020
H2/Plunge Pool	0.00213	0.00227	0.00221	0.00169	0.00122	0.00114	0.00179	0.00200	0.00193	0.00176	0.00199	0.00209
1DC/WQ7	0.00196	0.00216	0.00206	0.00156	0.00127	0.00275	0.00163	0.00182	0.00173	0.00164	0.00189	0.00198
H7/WQ12	0.00040	0.00018	0.00054	0.00058	0.00054	0.00038	0.00148	0.00024	0.00041	0.00020	0.00015	0.00018
H5/WQ9	0.00066	0.00068	0.00070	0.00098	0.00202	0.00165	0.00082	0.00113	0.00088	0.00266	0.00062	0.00079

5.3.3.3.8.24.3 Best Estimate – Post-Closure

5.3.3.3.8.24.3.1 Plunge Pool

Post-closure the hardness will be closer to that of Davidson Creek; therefore, the BC guidelines will be lower, with the 30-day average guideline being 0.002 mg/L. Maximum predicted concentrations peak at 0.00188 mg/L in the month of January, approximately at the BC guideline, but mean concentrations will be about 0.001 mg/L. Maximum concentrations will be well below the maximum grab, hardness-adjusted, BC guideline for total copper of about 0.009 mg/L. Dry return period concentrations are predicted to reach 0.0022 mg/L.

5.3.3.3.8.24.3.2 WQ7

Predicted total copper concentrations at WQ7 range from a maximum of about 0.0017 mg/L down to about 0.0008 mg/L. The decrease compared to the plunge pool is due to dilution from the Davidson Creek watershed; this effect is larger at WQ7 than at the plunge pool. Dry return period concentrations are predicted to reach the BC guideline of 0.002 mg/L

5.3.3.3.8.24.3.3 WQ9

Post-closure copper concentrations are predicted to be similar to those at operations, averaging the same as background but peaking at about 0.0013 mg/L, or slightly lower than during operations and closure, showing the limited influence of Davidson Creek water quality on Chedakuz Creek. Dry return period maximums are predicted to be lower than the peak due to lesser influence of Davidson Creek relative to Chedakuz Creek and reach 0.0006 mg/L.

5.3.3.3.8.24.4 Worst Case – Post Closure

5.3.3.3.8.24.4.1 Plunge Pool

Post-closure, the TSF will be reclaimed and tailings beaches covered with overburden. This will reduce the amount of copper loading in the supernatant water, and is predicted to result in lower copper concentrations at the plunge pool. Total copper is predicted to peak at about 0.0023 mg/L, and vary between this maximum and 0.009 mg/L. The high maximum concentration is caused by the maximum background copper value at WQ10 of 0.036 mg/L in June, which raised the 95th percentile concentration used. Dry return period predicted concentrations are 0.0023 mg/L.

5.3.3.3.8.24.4.2 WQ7

Post-closure, under the worst-case scenario, copper is predicted to reach a maximum of 0.0028 mg/L in June driven by the high 95th percentile background concentration. This predicted concentration is well below the proposed site-specific water quality objective. Dry return period predicted concentrations, at 0.0022 mg/L, are lower due to February background copper concentrations being lower.

5.3.3.3.8.24.4.3 WQ9

Post-closure, under the worst-case scenario, total copper concentrations are predicted to peak at the hardness-adjusted BC guideline of about 0.0025 mg/L. The 1:50 dry year is not predicted to exceed the hardness-adjusted guideline, as the guideline limit will increase slightly to 0.0032 mg/L, due to the slightly greater influence of Chedakuz Creek water compared to Davidson Creek. Dry return period predicted concentrations only reach 0.0008 mg/L due to lower background copper at the winter low flow month of February.

5.3.3.3.8.24.5 Total Copper Summary

During operations, closure and post closure, WQ10 is predicted to spike above the CCME guideline due to elevated background concentrations (and above the BC hardness-adjusted 30-d guideline for worst-case predictions). WQ7 and WQ9 are predicted to remain below or just above the CCME guideline.

Because of natural background exceedances of total copper a site-specific water quality objective of 0.0045 mg/L, 30-day average, is proposed.

Monitoring during operations will be used to determine whether these predictions are approached in the closure period. If so, additional wetlands passive treatment capacity could be considered for use at post closure.

5.3.3.3.8.25 Total Iron

The BC protection of aquatic life maximum guideline is 1 mg/L; there is no average guideline. The CCME protection of aquatic life guideline is 0.3 mg/L. The drinking water guideline (based on aesthetics) is 0.3 mg/L. There is no BC wildlife guideline.

Table 5.3.3-45 provides total iron monthly summaries for the sites modelled for construction, the last year of mining and the first full year of post closure for best estimate values and **Table 5.3.3-46** provides the same data for worst-case estimate values.

Table 5.3.3-45: Monthly Best Estimate Total Iron (mg/L) for Modelled Sites – Construction, Operations/Closure, Post-Closure

NODES	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Year -1 (Background)												
H1/WQ5	0.37	0.30	0.30	0.22	0.22	0.11	0.13	0.12	0.13	0.12	0.14	0.22
1-505659/WQ3	0.08	0.18	0.08	0.20	0.27	0.14	0.13	0.17	0.14	0.09	0.09	0.14
H2/WQ10	0.03	0.02	0.02	0.05	0.15	0.06	0.10	0.04	0.08	0.04	0.11	0.22
1DC/WQ7	0.09	0.07	0.05	0.11	0.40	0.12	0.12	0.09	0.11	0.08	0.13	0.26
H7/WQ12	0.22	0.33	0.42	0.25	0.18	0.13	0.14	0.18	0.21	0.25	0.13	0.19
H5/WQ9	0.16	0.13	0.14	0.28	0.23	0.14	0.16	0.16	0.19	0.21	0.19	0.13
Year 16												
H1/WQ5	0.37	0.30	0.30	0.22	0.22	0.11	0.13	0.12	0.13	0.12	0.14	0.22
1-505659/WQ3	0.08	0.18	0.08	0.20	0.27	0.14	0.13	0.17	0.14	0.09	0.09	0.14
H2/WQ10	0.07	0.05	0.06	0.08	0.11	0.06	0.12	0.07	0.11	0.07	0.15	0.27
1DC/WQ7	0.10	0.08	0.07	0.15	0.28	0.11	0.14	0.11	0.13	0.10	0.16	0.28
H7/WQ12	0.22	0.33	0.42	0.23	0.18	0.13	0.14	0.19	0.21	0.25	0.13	0.19
H5/WQ9	0.07	0.06	0.06	0.13	0.15	0.08	0.11	0.08	0.11	0.09	0.13	0.19
Year 36												
H1/WQ5	0.37	0.30	0.30	0.22	0.22	0.11	0.13	0.12	0.13	0.12	0.14	0.22
1-505659/WQ3	0.08	0.18	0.08	0.20	0.27	0.14	0.13	0.17	0.14	0.09	0.09	0.14
H2/Plunge Pool	0.04	0.04	0.04	0.07	0.15	0.10	0.07	0.06	0.05	0.06	0.05	0.04
1DC/WQ7	0.07	0.06	0.06	0.09	0.21	0.11	0.09	0.09	0.07	0.08	0.08	0.10
H7/WQ12	0.22	0.33	0.42	0.23	0.18	0.13	0.14	0.19	0.21	0.25	0.13	0.19
H5/WQ9	0.10	0.08	0.09	0.15	0.17	0.10	0.13	0.10	0.13	0.11	0.14	0.17

Table 5.3.3-46: Monthly Worst Case Total Iron (mg/L) for Modelled Sites – Construction, Operations/Closure, Post-Closure

NODES	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Year -1 (Background)												
H1/WQ5	0.37	0.30	0.30	0.22	0.50	0.14	0.14	0.13	0.14	0.12	0.14	0.22
1-505659/WQ3	0.09	0.28	0.08	0.32	0.64	0.17	0.15	0.23	0.17	0.09	0.09	0.19
H2/WQ10	0.04	0.02	0.04	0.11	0.50	0.14	0.17	0.04	0.12	0.04	0.18	0.22
1DC/WQ7	0.11	0.08	0.07	0.15	0.98	0.29	0.19	0.10	0.14	0.09	0.20	0.34
H7/WQ12	0.28	0.41	0.63	0.45	0.36	0.21	0.17	0.26	0.27	0.39	0.15	0.19
H5/WQ9	0.19	0.13	0.20	0.34	0.29	0.15	0.21	0.16	0.23	0.23	0.20	0.13
Year 16												
H1/WQ5	0.37	0.30	0.30	0.22	0.50	0.14	0.14	0.13	0.14	0.12	0.14	0.22
1-505659/WQ3	0.09	0.28	0.08	0.32	0.64	0.17	0.15	0.23	0.17	0.09	0.09	0.19
H2/WQ10	0.08	0.06	0.08	0.15	0.45	0.14	0.19	0.07	0.16	0.07	0.23	0.27
1DC/WQ7	0.12	0.09	0.09	0.19	0.78	0.26	0.22	0.12	0.17	0.11	0.23	0.35
H7/WQ12	0.28	0.41	0.63	0.39	0.35	0.21	0.17	0.27	0.28	0.39	0.15	0.19
H5/WQ9	0.09	0.06	0.09	0.18	0.40	0.14	0.17	0.08	0.15	0.10	0.19	0.20
Year 36												
H1/WQ5	0.37	0.30	0.30	0.22	0.50	0.14	0.14	0.13	0.14	0.12	0.14	0.22
1-505659/WQ3	0.09	0.28	0.08	0.32	0.64	0.17	0.15	0.23	0.17	0.09	0.09	0.19
H2/Plunge Pool	0.03	0.03	0.05	0.39	0.29	0.12	0.07	0.05	0.05	0.05	0.04	0.03
1DC/WQ7	0.05	0.05	0.06	0.37	0.41	0.16	0.10	0.07	0.06	0.06	0.05	0.08
H7/WQ12	0.20	0.17	0.61	0.39	0.35	0.22	0.18	0.27	0.30	0.33	0.12	0.15
H5/WQ9	0.08	0.06	0.09	0.26	0.40	0.14	0.15	0.07	0.12	0.08	0.16	0.17

5.3.3.3.8.25.1 Best Estimate – Operations and Closure

5.3.3.3.8.25.1.1 WQ10

The predicted total iron concentration is driven by background and never exceeds the CCME/drinking water guideline.

5.3.3.3.8.25.1.2 WQ7

The predicted mean total iron concentration during operations and closure is 0.1 mg/L, and total iron is predicted to peak at 0.4 mg/L, because of high background total iron.

5.3.3.3.8.25.1.3 WQ9

Total iron is predicted to average the same as background (0.1 mg/L), and peak at 0.28 mg/L during operations and closure. Slight increase in peaks after closure is due to the greater influence of lower Chedakuz Creek.

5.3.3.3.8.25.2 Worst Case – Operations and Closure

5.3.3.3.8.25.2.1 WQ10

Total iron is predicted to track background concentrations during operations and closure. The 95th percentile background total iron peaks at about 0.50 mg/L, above the CCME guideline, but below the BC guideline.

5.3.3.3.8.25.2.2 WQ7

During operations and closure, under the worst-case scenario, total iron at WQ7 is predicted to increase to a peak of 0.98 mg/L under influence of the Project, which is less than the background peak of 1.5 mg/L.

5.3.3.3.8.25.2.3 WQ9

During operations and closure, under the worst-case scenario, total iron at WQ9 is forecast to peak at 0.4 mg/L, or above the 95th percentile background.

5.3.3.3.8.25.3 Best Estimate – Post-Closure

5.3.3.3.8.25.3.1 Plunge Pool

Total iron is predicted to be driven by background levels in the post-closure phase, and to remain below CCME and drinking water guidelines, peaking at about 0.15 mg/L, approximately 50% background without project effects of the Project. This is due principally to the polishing effects of the proposed wetlands to be constructed at closure. Dry period predicted concentrations are in the 0.04 mg/L range.

5.3.3.3.8.25.3.2 WQ7

The predicted pattern for total iron at WQ7 mirrors that at the plunge pool. Dry return period concentrations are in the 0.06 mg/L range.

5.3.3.3.8.25.3.3 WQ9

Predicted total iron at WQ9 for the post-closure period (including dry return periods) tracks background.

5.3.3.3.8.25.4 Worst Case – Post Closure

5.3.3.3.8.25.4.1 Plunge Pool

The predicted worst-case total iron concentrations for the plunge pool indicate that total iron will remain well within background variation, and peak below the CCME guideline of 0.3 mg/L due to high background. The mean concentration is predicted to be similar to those for the operations and closure phases. Dry return period concentration predictions are lower at 0.04 mg/L due to lower background concentrations in February.

5.3.3.3.8.25.4.2 WQ7

Post-closure, under the worst-case scenario, total iron is forecast to drop to a maximum of 0.35 mg/L, due to the influence of discharge from the reclaimed TSF, with the exception of the 1:50 dry year, where total iron is forecast to peak at 1 mg/L and below 95th percentile background concentrations of 1.5 mg/L. Dry return period concentrations predictions are similar to the Plunge Pool.

5.3.3.3.8.25.4.3 WQ9

Post-closure, under the worst-case scenario, total iron concentrations at WQ9 are predicted to increase to a maximum of 0.4 mg/L; the 1:50 dry year maximum is forecast to be slightly higher, at 0.45 mg/L. Dry return period predicted concentrations are up to 0.08 mg/L which is just below background.

5.3.3.3.8.25.5 Total Iron Summary

Total iron is predicted to track background at all sites. Natural background can exceed federal and BC guidelines, particularly for 95th percentile values. The BC FWG is proposed, but it is noted that this guideline is occasionally exceeded in background samples.

5.3.3.3.8.26 Dissolved Iron

The BC protection of freshwater aquatic life guideline for dissolved iron is 0.350 mg/L; there is no CCME, drinking water, or BC wildlife guidelines for dissolved iron.

Dissolved iron is predicted to remain below guidelines at all stations during all mining phases for both best estimate and worst-case scenarios.

5.3.3.3.8.27 Total Lead

The BC and CCME protection of freshwater aquatic life guidelines for total lead are hardness-based; at the hardness ranges predicted for operations and closure, this is approximately 0.002 mg/L. Post-closure, hardness is predicted to drop, and the guideline would also drop to average 0.0012 mg/L. The BC guideline for drinking water is 0.01 mg/L, and for wildlife is 0.1 mg/L.

During all phases of mining, for both the best estimate and worst-case scenarios, total lead will remain at or near background concentrations and well below guidelines.

5.3.3.3.8.28 Total Lithium

The BC protection of freshwater aquatic life guideline for lithium is based on Michigan Great Lakes guidelines, with levels set at 0.014 mg/L for secondary chronic, and 0.096 mg/L for final chronic. There is no CCME guideline for lithium, nor drinking water or protection of wildlife guidelines.

There is no source of lithium in the Blackwater deposit, and lithium is forecast to stay at background throughout all phases of mining.

5.3.3.3.8.29 Total Manganese

The BC protection of freshwater aquatic life guideline for manganese is hardness-based; for the hardness range predicted during operations and closure, this is approximately 0.9 mg/L, and will be 0.8 mg/L post-closure. The drinking water guideline is set at 0.050 mg/L, based on aesthetics. There is no BC wildlife guideline.

Background manganese peaks just above the drinking water guideline on average and above for the 95th percentile. Manganese is forecast to track background during all phases of mining.

5.3.3.3.8.30 Total Mercury

The BC protection of freshwater aquatic life and protection of wildlife guideline for total mercury is 0.02 µg/L. The CCME aquatic guideline is 0.1 µg/L, or five times higher. The drinking water guideline is 1 µg/L.

Mercury is forecast to track background for all phases of mining. Recognition of occasional background exceedances of the guideline will be required in interpreting mine monitoring results.

5.3.3.3.8.31 Total Molybdenum

The BC protection of freshwater aquatic life guideline for total molybdenum is 1 mg/L; the CCME freshwater aquatic guideline is 0.073 mg/L. The drinking water guideline is 0.25 mg/L, and the BC wildlife guideline is 0.05 mg/L.

Molybdenum is forecast to remain at or below background in Davidson and Chedakuz creeks during all phases of mining.

5.3.3.3.8.32 Total Nickel

The BC and CCME protection of freshwater aquatic life guideline for total nickel is hardness-based. At the predicted hardness of Davidson Creek water at operations and closure, the guideline is approximately 0.065 mg/L. Post-closure, as hardness is predicted to drop, the guideline will also drop to about 0.025 mg/L. There is no drinking water or BC protection of wildlife guidelines for total nickel.

Nickel is forecast to track background throughout all phases of mining.

5.3.3.3.8.33 Total Selenium

The BC protection of freshwater aquatic life guideline for selenium is 0.002 mg/L; the CCME freshwater aquatic guideline is 0.001 mg/L. The drinking water guideline is 0.010 mg/L, and the provincial wildlife guideline is 0.004 mg/L.

Table 5.3.3-47 provides monthly total selenium summaries for the sites modelled for construction, the last year of mining, and the first full year of post-closure for best estimate values, and **Table 5.3.3-48** provides the same data for worst-case estimate values.

Table 5.3.3-47: Monthly Best Estimate Total Selenium (mg/L) for Modelled Sites – Construction, Operations/Closure, Post Closure

NODES	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Year -1 (Background)												
H1/WQ5	0.0006	0.0003	0.0003	0.0001	0.0004	0.0004	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006
1-505659/WQ3	0.0006	0.0006	0.0006	0.0003	0.0004	0.0004	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006
H2/WQ10	0.0006	0.0006	0.0006	0.0004	0.0004	0.0004	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006
1DC/WQ7	0.0006	0.0006	0.0006	0.0004	0.0004	0.0004	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006
H7/WQ12	0.0006	0.0006	0.0006	0.0004	0.0003	0.0003	0.0005	0.0005	0.0006	0.0006	0.0006	0.0006
H5/WQ9	0.0006	0.0006	0.0006	0.0004	0.0004	0.0004	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006
Year 16												
H1/WQ5	0.0006	0.0003	0.0003	0.0001	0.0004	0.0004	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006
1-505659/WQ3	0.0006	0.0006	0.0006	0.0003	0.0004	0.0004	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006
H2/WQ10	0.0006	0.0006	0.0006	0.0004	0.0004	0.0004	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006
1DC/WQ7	0.0006	0.0006	0.0006	0.0004	0.0004	0.0004	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006
H7/WQ12	0.0006	0.0006	0.0006	0.0003	0.0003	0.0003	0.0005	0.0005	0.0006	0.0006	0.0006	0.0006
H5/WQ9	0.0005	0.0005	0.0006	0.0004	0.0004	0.0004	0.0005	0.0005	0.0006	0.0006	0.0006	0.0006
Year 36												
H1/WQ5	0.0006	0.0003	0.0003	0.0001	0.0004	0.0004	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006
1-505659/WQ3	0.0006	0.0006	0.0006	0.0003	0.0004	0.0004	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006
H2/Plunge Pool	0.0006	0.0006	0.0006	0.0006	0.0005	0.0005	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006
1DC/WQ7	0.0006	0.0006	0.0006	0.0005	0.0005	0.0005	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006
H7/WQ12	0.0006	0.0006	0.0006	0.0003	0.0003	0.0003	0.0005	0.0005	0.0006	0.0006	0.0006	0.0006
H5/WQ9	0.0006	0.0006	0.0006	0.0004	0.0004	0.0004	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006

Table 5.3.3-48: Monthly Worst Case Total Selenium (mg/L) for Modelled Sites – Construction, Operations/Closure, Post Closure

NODES	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Year -1 (Background)												
H1/WQ5	0.0006	0.0003	0.0003	0.0001	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006
1-505659/WQ3	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006
H2/WQ10	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006
1DC/WQ7	0.0006	0.0006	0.0006	0.0006	0.0006	0.0007	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006
H7/WQ12	0.0006	0.0006	0.0006	0.0005	0.0004	0.0004	0.0005	0.0005	0.0006	0.0006	0.0006	0.0006
H5/WQ9	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006
Year 16												
H1/WQ5	0.0006	0.0003	0.0003	0.0001	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006
1-505659/WQ3	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006
H2/WQ10	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006
1DC/WQ7	0.0006	0.0006	0.0006	0.0006	0.0006	0.0007	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006
H7/WQ12	0.0006	0.0006	0.0006	0.0004	0.0004	0.0004	0.0005	0.0005	0.0006	0.0006	0.0006	0.0006
H5/WQ9	0.0005	0.0005	0.0006	0.0006	0.0005	0.0005	0.0005	0.0005	0.0006	0.0006	0.0006	0.0006
Year 36												
H1/WQ5	0.0006	0.0003	0.0003	0.0001	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006
1-505659/WQ3	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006
H2/Plunge Pool	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006
1DC/WQ7	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006
H7/WQ12	0.0006	0.0006	0.0006	0.0004	0.0004	0.0004	0.0005	0.0005	0.0006	0.0006	0.0006	0.0006
H5/WQ9	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006

5.3.3.3.8.33.1 Best Estimate – Operations and Closure

5.3.3.3.8.33.1.1 WQ10

Predicted total selenium concentration tracks background during operations and closure, which is below the detection limit. The detection limit decreased during the monitoring period from 0.0006 to 0.0001 mg/L. Total selenium background concentrations ranged from 0.0003 to 0.0005 mg/L (below detection for earlier samples). Total selenium is forecast to track background through all mining phases at all sites modelled in Davidson and Chedakuz creeks.

5.3.3.3.8.33.1.2 WQ7

Predicted total selenium concentrations at WQ7 mirror those at WQ10.

5.3.3.3.8.33.1.3 WQ9

Total selenium is predicted to remain at background concentrations at WQ9, which represent the detection limit for selenium.

5.3.3.3.8.33.2 Worst Case – Operations and Closure

Since selenium concentrations were always below detection limits, both the best estimate and worst-case predictions are the same.

5.3.3.3.8.33.3 Best Estimate and Worst Case – Post-Closure

The predictions for post-closure are the same as for operations and closure.

5.3.3.3.8.33.4 Total Selenium Summary

All sites background concentrations are well below provincial and federal guidelines and are forecast to track background through all mining phases.

5.3.3.3.8.34 Total Silver

For water hardness less than 100 mg $CaCO_3$/L (which applies to Project-area water bodies), the BC protection of freshwater aquatic life guideline for total silver is 0.05 µg/L, which is the same as the method detection limit. The CCME freshwater aquatic guideline is 0.1 µg/L. There are no drinking water or wildlife guidelines for silver.

Total silver is forecast to remain at or below background for all mining phases for both best estimate and worst-case scenarios.

5.3.3.3.8.35 Total Sodium

There is no protection of freshwater aquatic life guidelines for sodium, only a drinking water guideline of 200 mg/L based on aesthetics.

All background and predicted concentrations of sodium during all phases of mining are a small fraction of the guideline.

5.3.3.3.8.36 Total Thallium

The BC protection of freshwater aquatic guideline for total thallium is 0.0003 mg/L. The CCME freshwater aquatic guideline is 0.0008 mg/L. There are no drinking water or BC wildlife guidelines for Thallium.

Total thallium is predicted to remain below guidelines during all phases of mining in Davidson and Chedakuz creeks, tracking background concentrations during operations and closure, and rising slightly higher than background post-closure to a maximum of 0.0002 mg/L.

5.3.3.3.8.37 Total Uranium

There is no BC or CCME protection of freshwater aquatic guidelines for uranium. The drinking water guideline is 0.020 mg/L; there is no BC wildlife guideline.

Total uranium is forecast to remain at least two orders of magnitude below the drinking water guideline during operations and closure, and over an order of magnitude below the drinking water guideline when the TSF discharges post-closure.

5.3.3.3.8.38 Total Vanadium

There is no BC protection of freshwater aquatic life approved guideline for vanadium; the Ontario guideline is 0.006 mg/L, which was adopted as a BC working guideline. There is no CCME freshwater aquatic guideline for total vanadium, drinking water, or BC wildlife guidelines.

Vanadium is forecast to remain at background through all phase of mining in Davidson and Chedakuz creeks.

5.3.3.3.8.39 Total Zinc

The BC protection of freshwater aquatic life guideline for zinc is hardness-based. Below water hardness of 90 mg $CaCO_3$/L, the guideline is 0.0075 mg/L, which applies to Project-area water bodies. The CCME freshwater aquatic guideline is 0.03 mg/L. The drinking water guideline is 5 mg/L. There is no BC wildlife guideline. A site-specific water quality objective of 0.01 mg/L, 30-day average concentration is proposed to account for elevated background total zinc concentrations.

Table 5.3.3-49 provides monthly total zinc summaries for the sites modelled for construction, the last year of mining, and the first full year of post-closure for best estimate values, and **Table 5.3.3-50** provides the same data for worst-case estimate values.

5.3.3.3.8.39.1 Best Estimate – Operations and Closure

5.3.3.3.8.39.1.1 WQ10

During operations and closure, zinc is forecast to track background, which, at maximum, is just below the BC protection of freshwater aquatic life guideline concentration.

5.3.3.3.8.39.1.2 WQ7

During operations and closure, the predicted total zinc at WQ7 tracks background. However, due to high background concentrations, total zinc is predicted to peak at about 0.018 mg/L; annual average total zinc concentrations at 0.004 mg/L are predicted to remain below the BC protection of freshwater aquatic life guideline of 0.0075 mg/L.

5.3.3.3.8.39.1.3 WQ9

WQ9 total zinc is predicted to peak at 0.003 mg/L during operations, and range at closure to between 0.001 and 0.0035 mg/L.

5.3.3.3.8.39.2 Worst Case – Operations and Closure

5.3.3.3.8.39.2.1 WQ10

During operations and closure, total zinc is forecast to track background and to peak at 0.012 mg/L; above the BC protection of freshwater aquatic life guideline, but below the CCME and BC maximum guidelines. The peaks are coincident with and driven by background concentrations.

5.3.3.3.8.39.2.2 WQ7

Under the worst-case scenario during operations and closure, total zinc at WQ7 is predicted to increase to a peak of 0.043 mg/L, due to the higher 95th percentile background zinc concentrations, but to stay within background variation, and well below background peaks.

5.3.3.3.8.39.2.3 WQ9

Under the worst-case scenario during operations and closure, total zinc at WQ9 is forecast to peak slightly above the BC guideline value of 0.0075 mg/L at 0.0083 mg/L, and have minimum concentrations at the detection limit. Peaks are above background, and result from the influence of Davidson Creek water.

Table 5.3.3-49: Monthly Best Estimate Total Zinc (mg/L) for Modelled Sites – Construction, Operations/Closure, Post-Closure

NODES	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Year -1 (Background)												
H1/WQ5	0.0281	0.0150	0.0150	0.0020	0.0025	0.0014	0.0014	0.0020	0.0012	0.0015	0.0016	0.0014
1-505659/WQ3	0.0074	0.0025	0.0031	0.0014	0.0038	0.0025	0.0010	0.0012	0.0006	0.0016	0.0023	0.0009
H2/WQ10	0.0015	0.0021	0.0017	0.0017	0.0031	0.0015	0.0009	0.0052	0.0005	0.0066	0.0011	0.0007
1DC/WQ7	0.0068	0.0183	0.0026	0.0014	0.0039	0.0065	0.0012	0.0054	0.0007	0.0046	0.0046	0.0031
H7/WQ12	0.0039	0.0023	0.0034	0.0021	0.0027	0.0016	0.0019	0.0023	0.0026	0.0020	0.0014	0.0017
H5/WQ9	0.0015	0.0023	0.0027	0.0018	0.0026	0.0010	0.0008	0.0009	0.0006	0.0015	0.0013	0.0007
Year 16												
H1/WQ5	0.0281	0.0150	0.0150	0.0020	0.0025	0.0014	0.0014	0.0020	0.0012	0.0015	0.0016	0.0014
1-505659/WQ3	0.0074	0.0025	0.0031	0.0014	0.0038	0.0025	0.0010	0.0012	0.0006	0.0016	0.0023	0.0009
H2/WQ10	0.0015	0.0018	0.0017	0.0018	0.0031	0.0014	0.0009	0.0052	0.0006	0.0072	0.0010	0.0008
1DC/WQ7	0.0057	0.0133	0.0024	0.0013	0.0036	0.0054	0.0012	0.0054	0.0007	0.0049	0.0046	0.0027
H7/WQ12	0.0039	0.0023	0.0033	0.0022	0.0025	0.0016	0.0019	0.0023	0.0025	0.0020	0.0014	0.0017
H5/WQ9	0.0019	0.0032	0.0019	0.0016	0.0027	0.0017	0.0008	0.0034	0.0005	0.0047	0.0014	0.0009
Year 36												
H1/WQ5	0.0281	0.0150	0.0150	0.0020	0.0025	0.0014	0.0014	0.0020	0.0012	0.0015	0.0016	0.0014
1-505659/WQ3	0.0074	0.0025	0.0031	0.0014	0.0038	0.0025	0.0010	0.0012	0.0006	0.0016	0.0023	0.0009
H2/Plunge Pool	0.0011	0.0020	0.0012	0.0015	0.0024	0.0021	0.0013	0.0016	0.0010	0.0013	0.0013	0.0009
1DC/WQ7	0.0040	0.0107	0.0018	0.0014	0.0027	0.0037	0.0015	0.0025	0.0010	0.0013	0.0032	0.0021
H7/WQ12	0.0039	0.0023	0.0033	0.0022	0.0025	0.0016	0.0019	0.0023	0.0025	0.0020	0.0014	0.0017
H5/WQ9	0.0018	0.0029	0.0022	0.0017	0.0028	0.0017	0.0009	0.0029	0.0006	0.0039	0.0014	0.0008

Table 5.3.3-50: Monthly Worst Case Total Zinc (mg/L) for Modelled Sites – Construction, Operations/Closure, Post-Closure

NODES	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Year -1 (Background)												
H1/WQ5	0.0281	0.0150	0.0150	0.0020	0.0046	0.0027	0.0014	0.0030	0.0016	0.0025	0.0018	0.0014
1-505659/WQ3	0.0124	0.0044	0.0038	0.0022	0.0095	0.0098	0.0013	0.0015	0.0007	0.0027	0.0029	0.0011
H2/WQ10	0.0016	0.0037	0.0021	0.0030	0.0058	0.0050	0.0012	0.0070	0.0005	0.0107	0.0015	0.0007
1DC/WQ7	0.0087	0.0292	0.0038	0.0025	0.0092	0.0429	0.0018	0.0082	0.0008	0.0075	0.0081	0.0052
H7/WQ12	0.0041	0.0029	0.0046	0.0028	0.0090	0.0033	0.0023	0.0035	0.0035	0.0026	0.0015	0.0017
H5/WQ9	0.0019	0.0037	0.0039	0.0021	0.0049	0.0015	0.0010	0.0009	0.0007	0.0025	0.0014	0.0008
Year 16												
H1/WQ5	0.0281	0.0150	0.0150	0.0020	0.0046	0.0027	0.0014	0.0030	0.0016	0.0025	0.0018	0.0014
1-505659/WQ3	0.0124	0.0044	0.0038	0.0022	0.0095	0.0098	0.0013	0.0015	0.0007	0.0027	0.0029	0.0011
H2/WQ10	0.0015	0.0030	0.0020	0.0032	0.0060	0.0047	0.0012	0.0070	0.0006	0.0115	0.0015	0.0008
1DC/WQ7	0.0072	0.0213	0.0035	0.0023	0.0082	0.0351	0.0020	0.0083	0.0009	0.0079	0.0082	0.0043
H7/WQ12	0.0041	0.0029	0.0045	0.0028	0.0083	0.0033	0.0023	0.0035	0.0036	0.0027	0.0015	0.0017
H5/WQ9	0.0022	0.0052	0.0026	0.0027	0.0054	0.0073	0.0011	0.0047	0.0006	0.0076	0.0020	0.0011
Year 36												
H1/WQ5	0.0281	0.0150	0.0150	0.0020	0.0046	0.0027	0.0014	0.0030	0.0016	0.0025	0.0018	0.0014
1-505659/WQ3	0.0124	0.0044	0.0038	0.0022	0.0095	0.0098	0.0013	0.0015	0.0007	0.0027	0.0029	0.0011
H2/Plunge Pool	0.0007	0.0018	0.0010	0.0035	0.0056	0.0024	0.0029	0.0014	0.0005	0.0013	0.0012	0.0005
1DC/WQ7	0.0026	0.0089	0.0015	0.0033	0.0063	0.0107	0.0031	0.0025	0.0006	0.0014	0.0022	0.0015
H7/WQ12	0.0061	0.0032	0.0055	0.0028	0.0084	0.0031	0.0023	0.0036	0.0036	0.0027	0.0015	0.0027
H5/WQ9	0.0018	0.0043	0.0024	0.0030	0.0060	0.0071	0.0018	0.0044	0.0006	0.0063	0.0016	0.0009

5.3.3.3.8.39.3 Best Estimate – Post-Closure

5.3.3.3.8.39.3.1 Plunge Pool

Total zinc concentrations are predicted to track background and stay well below the BC FWG. Dry return period predicted concentrations are in the 0.001 to 0.002 mg/L range.

5.3.3.3.8.39.3.2 WQ7

Predicted results for WQ7 peak at 0.011 mg/L, about 25% of background peaks. Dry return period predicted concentrations range from 0.006 to 0.007 mg/L.

5.3.3.3.8.39.3.3 WQ9

Post-closure, total zinc at WQ9 is predicted to range between 0.001 and 0.003 mg/L, which is at peak background concentrations of 0.003 mg/L, but still below the BC average guideline. Dry return period predicted concentrations are about 0.003 mg/L.

5.3.3.3.8.39.4 Worst Case – Post-Closure

5.3.3.3.8.39.4.1 Plunge Pool

Post-closure, total zinc concentrations at the plunge pool are forecast to remain below the BC protection of freshwater aquatic life guidelines, due to the increased influence of TSF seepage. TSF seepage is forecast to have relatively low zinc concentrations post-closure after reclamation has been completed. Dry return period predicted concentrations will also remain well below the BC guideline.

5.3.3.3.8.39.4.2 WQ7

Post-closure under the worst-case scenario, zinc is predicted to initially peak at 0.03 mg/L, but rapidly drop to 0.011 mg/L and remain at that concentration; 95th percentile background peaks are 0.13 mg/L zinc. Dry return period predicted concentrations are predicted to peak at 0.010 mg/L.

5.3.3.3.8.39.4.3 WQ9

Post-closure under the worst-case scenario, total zinc concentrations at WQ9 will continue to peak at, or slightly below, the BC protection of freshwater aquatic life guideline. All predicted worst-case predictions, including dry return period concentrations, are below the 95th percentile background concentrations and below the BC guideline.

5.3.3.3.8.40 Total Zinc Summary

During operations and closure, total zinc is predicted to track background. Since the mean background at WQ7 is above the BC FWG, guideline exceedances will occur at this site. Under the worst-case scenario for operations and closure WQ10, WQ7 and WQ9, while tracking background, are all predicted to exceed the BC FWG. At post-closure, total zinc concentrations are again predicted to track background and best estimate predictions are for WQ7 are above the

BC FWG. Under the worst-case scenario at post closure, the plunge pool is predicted to remain below the BC FWG, WQ7 to be above BC FWG and WQ9 to peak slightly above the guideline.

A site-specific water quality objective of 0.01 mg/L, 30-day average concentration is proposed to account for elevated background total zinc concentrations. This objective is still one-third of the CCME guideline.

5.3.3.3.8.41 Total Cyanide

Health Canada's drinking water guideline for total cyanide is 0.20 mg/L. The BC protection of aquatic life guidelines are based on weak acid dissociable (WAD) cyanide (CN).

Table 5.3.3-51 provides monthly total cyanide summaries for the sites modelled for construction, the last year of mining, and the first full year of post-closure for best estimate values, and **Table 5.3.3-52** provides the same data for worst-case estimate values.

Total cyanide is forecast to remain below the Health Canada drinking water guideline for both best estimate and worst-case scenarios at all site modelled for all mining phases.

5.3.3.3.8.42 Weak Acid Dissociable Cyanide

The BC and CCME protection of freshwater aquatic life guidelines for WAD CN are 0.005 mg/L. There are no drinking water or BC wildlife guidelines for WAD CN.

Table 5.3.3-53 provides monthly WAD CN summaries for the sites modelled for construction, the last year of mining, and the first full year of post-closure for best estimate values, and **Table 5.3.3-54** provides the same data for worst-case estimate values.

Table 5.3.3-51: Monthly Best Estimate Total Cyanide (mg/L) for Modelled Sites – Construction, Operations/Closure, Post-Closure

NODES	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Year -1												
H1/WQ5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1-505659/WQ3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
H2/WQ10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1DC/WQ7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
H7/WQ12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
H5/WQ9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Year 16												
H1/WQ5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1-505659/WQ3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
H2/WQ10	0.09774	0.08840	0.09774	0.09463	0.02166	0.02134	0.05124	0.08163	0.10274	0.10611	0.10274	0.09774
1DC/WQ7	0.06824	0.06431	0.06779	0.03866	0.01480	0.01632	0.03660	0.05542	0.06688	0.06527	0.06144	0.06499
H7/WQ12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
H5/WQ9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Year 36												
H1/WQ5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1-505659/WQ3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
H2/Plunge Pool	0.01079	0.01152	0.01081	0.00509	0.00286	0.00335	0.00725	0.00982	0.00902	0.00775	0.00894	0.01014
1DC/WQ7	0.00857	0.00913	0.00854	0.00389	0.00252	0.00303	0.00591	0.00770	0.00728	0.00631	0.00697	0.00795
H7/WQ12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
H5/WQ9	0.00099	0.00093	0.00089	0.00065	0.00056	0.00057	0.00076	0.00106	0.00091	0.00101	0.00082	0.00093

Note: ND = non detect

Table 5.3.3-52: Monthly Worst Case Total Cyanide (mg/L) for Modelled Sites – Construction, Operations/Closure, Post-Closure

NODES	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Year -1												
H1/WQ5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1-505659/WQ3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
H2/WQ10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1DC/WQ7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
H7/WQ12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
H5/WQ9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Year 16												
H1/WQ5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1-505659/WQ3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
H2/WQ10	0.10159	0.09188	0.10159	0.09836	0.02252	0.02218	0.05326	0.08485	0.10679	0.11029	0.10679	0.10159
1DC/WQ7	0.07093	0.06684	0.07047	0.04018	0.01538	0.01697	0.03804	0.05761	0.06952	0.06784	0.06386	0.06755
H7/WQ12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
H5/WQ9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Year 36												
H1/WQ5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1-505659/WQ3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
H2/Plunge Pool	0.01318	0.01409	0.01315	0.00677	0.00363	0.00419	0.01006	0.01204	0.01173	0.01091	0.01192	0.01283
1DC/WQ7	0.01180	0.01254	0.01198	0.00607	0.00328	0.00392	0.00864	0.01064	0.01011	0.00999	0.01114	0.01160
H7/WQ12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
H5/WQ9	0.00259	0.00241	0.00234	0.00239	0.00167	0.00189	0.00274	0.00363	0.00399	0.00340	0.00261	0.00264

Note: ND = non detect

Table 5.3.3-53: Monthly Best Estimate Weak Acid Dissociable Cyanide (mg/L) for Modelled Sites – Construction, Operations/Closure, Post-Closure

NODES	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Year -1												
H1/WQ5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1-505659/WQ3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
H2/WQ10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1DC/WQ7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
H7/WQ12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
H5/WQ9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Year 16												
H1/WQ5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1-505659/WQ3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
H2/WQ10	0.00066	0.00059	0.00066	0.00063	0.00015	0.00014	0.00034	0.00055	0.00069	0.00071	0.00069	0.00066
1DC/WQ7	0.00046	0.00043	0.00045	0.00026	0.00010	0.00011	0.00025	0.00037	0.00045	0.00044	0.00041	0.00044
H7/WQ12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
H5/WQ9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Year 36												
H1/WQ5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1-505659/WQ3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
H2/Plunge Pool	0.00397	0.00424	0.00398	0.00188	0.00105	0.00123	0.00267	0.00362	0.00332	0.00285	0.00329	0.00374
1DC/WQ7	0.00316	0.00336	0.00315	0.00143	0.00093	0.00111	0.00218	0.00284	0.00268	0.00232	0.00257	0.00293
H7/WQ12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
H5/WQ9	0.00037	0.00034	0.00033	0.00024	0.00021	0.00021	0.00028	0.00039	0.00034	0.00037	0.00030	0.00034

Note: ND=non detect

Table 5.3.3-54: Monthly Worst Case Weak Acid Dissociable Cyanide (mg/L) for Modelled Sites – Construction, Operations/Closure, Post-Closure

NODES	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Year -1												
H1/WQ5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1-505659/WQ3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
H2/WQ10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1DC/WQ7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
H7/WQ12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
H5/WQ9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Year 16												
H1/WQ5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1-505659/WQ3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
H2/WQ10	0.00104	0.00094	0.00104	0.00101	0.00023	0.00023	0.00054	0.00087	0.00109	0.00113	0.00109	0.00104
1DC/WQ7	0.00072	0.00068	0.00072	0.00041	0.00016	0.00017	0.00039	0.00059	0.00071	0.00069	0.00065	0.00069
H7/WQ12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
H5/WQ9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Year 36												
H1/WQ5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1-505659/WQ3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
H2/Plunge Pool	0.00486	0.00519	0.00484	0.00249	0.00134	0.00153	0.00370	0.00444	0.00432	0.00402	0.00439	0.00473
1DC/WQ7	0.00435	0.00462	0.00441	0.00224	0.00121	0.00144	0.00318	0.00392	0.00373	0.00368	0.00410	0.00427
H7/WQ12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
H5/WQ9	0.00095	0.00089	0.00086	0.00088	0.00062	0.00069	0.00101	0.00134	0.00147	0.00125	0.00096	0.00097

Note: ND=non detect

5.3.3.3.8.42.1 Best Estimate – Operations and Closure

For all water quality sites and all mine phases, and for both best estimate and worst-case scenarios, background WAD CN was set at zero for modelling. This was done for two reasons: first, the BC FWG is at the detection limit for WAD CN and therefore any predictions would be confounded by the detection limit issue, and, second, there is no plausible natural source of cyanide in the subject water bodies.

5.3.3.3.8.42.1.1 WQ10

WAD CN concentrations reach a predicted (calculated) maximum of less than 50% of the guideline.

5.3.3.3.8.42.1.2 WQ7

The predicted (calculated) concentrations of WAD CN at WQ7 mirror those at WQ10, but at lower concentrations, due to increased dilution lower in the watershed.

5.3.3.3.8.42.1.3 WQ9

WAD CN at WQ9 is predicted to follow a similar pattern to total CN during operations and closure, i.e., to remain below detection limits.

5.3.3.3.8.42.2 Worst Case – Operations and Closure

5.3.3.3.8.42.2.1 WQ10

WAD CN is forecast to increase during operations up to a maximum of 0.0011 mg/L (calculated), assuming receiving waters have no cyanide. WAD CN is assumed to stay within that range through the closure period.

5.3.3.3.8.42.2.2 WQ7

Under the worst-case scenario, WAD CN is predicted to rise during operations to a maximum of 0.0007 mg/L (calculated), and stays at that concentration through closure, again assuming background WAD CN is zero.

5.3.3.3.8.42.2.3 WQ9

During operations and closure under the worst-case scenario, WAD CN at WQ9 is forecast to remain at background, or undetectable.

5.3.3.3.8.42.3 Best Estimate – Post Closure

5.3.3.3.8.42.3.1 Plunge Pool

With discharge from the TSF, WAD CN is predicted to increase to a maximum of 0.004 mg/L, and vary seasonally down to 0.001 mg/L (calculated concentrations). This prediction is very conservative, and concentrations are expected to be lower due to degradation and attenuation, as discussed in the next section. Dry return period predicted concentrations may reach 0.005 mg/L. This is a conservative prediction and does not take into account degradation of WAD CN over time.

5.3.3.3.8.42.3.2 WQ7

Post-closure, with discharge from the TSF, WAD CN is predicted to increase to a maximum of 0.0034 mg/L (calculated), and vary seasonally down to below 0.001 mg/L. This prediction is very conservative, and concentrations are expected to be lower due to degradation and attenuation, as discussed in the next section. Dry return period predicted concentrations may reach 0.004 mg/L, again without any allowance for degradation over time.

5.3.3.3.8.42.3.3 WQ9

Post-closure, when the TSF will be discharging, WAD CN is predicted to increase slightly but remain well below detection at WQ9. Dry return period predicted concentrations are similar.

5.3.3.3.8.42.4 Worst Case – Post-Closure

5.3.3.3.8.42.4.1 Plunge Pool

Post-closure, with the TSF providing almost all of the flow at the plunge pool, under the worst-case scenario, WAD CN is forecast to vary between 0.001 and 0.005 mg/L (calculated) on a seasonal basis. It is expected that monitoring during closure will indicate WAD CN will not increase to those peaks, and will more nearly match values for the best estimate case, i.e., remain undetectable at current method detection limits. Dry return period predicted concentrations may peak at 0.005 mg/L.

5.3.3.3.8.42.4.2 WQ7

Post-closure under the worst-case scenario, WAD CN is forecast to mirror the plunge pool, but to peak at 0.0047 mg/L (calculated) or nearly at the guideline. Dry return period predictions are similar.

5.3.3.3.8.42.4.3 WQ9

Post-closure under the worst-case scenario, WAD CN is forecast to peak slightly above background, to a concentration of 0.0005 mg/L (below the detection limit). Under the 1:50 dry year scenario, WAD CN at WQ9 is forecast to peak at just under 0.0018 mg/L (calculated, assuming zero background WAD CN). Dry return period predictions are up to 0.0008 mg/L (calculated).

5.3.3.3.8.42.5 WAD CN Summary

WAD CN is forecast to remain below BC FWG at all sites in all mining phases for both the best estimate and worst-case scenario. WAD CN should remain below detection at all sites until the method detection limit drops below the current 0.005 mg/L.

5.3.3.3.8.42.6 Degradation and Attenuation of Weak Acid Dissociable Cyanide in Tailings Interstitial Water

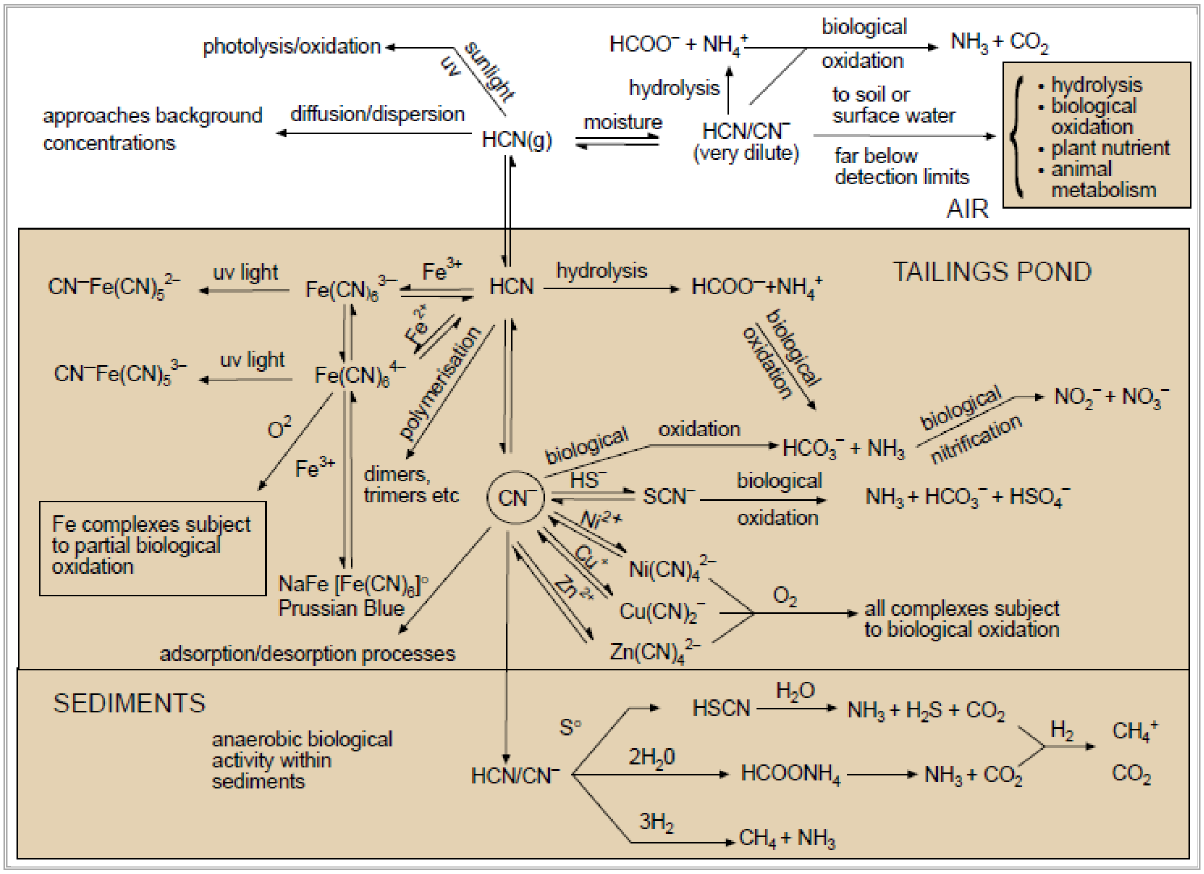
Analyses of interstitial water in SO_2/air-treated tailings after 39 days of aging found an average of 0.05 mg/L WAD CN. This interstitial water concentration is expected to decrease further while traveling through subsurface sands and gravels and upon emerging as seepage downstream of TSF Dam D.

Within the pond environment, cyanide will degrade through several mechanisms, including volatilization of hydrogen cyanide (HCN), photodegradation of metal-CN complexes, and biological oxidation and adsorption processes (Smith and Mudder, 1991; **Figure 5.3.3-13**). Within tailings interstitial water, cyanide may be further degraded through oxidation and hydrolysis reactions, as well as precipitation of insoluble mixed ferri/ferro-cyanides in suboxic porewaters (Jambor et al., 2009).

To illustrate, **Figure 5.3.3-14** shows sodium concentrations in the operating Musselwhite gold mine in Ontario (roughly the same latitude as Blackwater) TSF supernatant and in finger drains at the toe of the TSF dam. Assuming sodium behaves in a conservative manner and is a suitable tracer for seepage, results indicate that seepage from the Musselwhite TSF reached the dam finger drains by about 2002.

Figure 5.3.3-15 shows WAD CN concentrations for the same two sites at Musselwhite. Interpretation of data for the finger drains was limited by the lower analytical detection limits used prior to 2007. The WAD CN concentrations in the TSF dam finger drains are substantially lower than in the TSF supernatant, demonstrating degradation and attenuation of WAD CN within the tailings and via seepage travel through the dam. The mean WAD CN in the TSF supernatant from 2007 to 2013 was 0.036 mg/L, compared to 0.004 mg/L in the finger drains. The 95th percentiles for the TSF supernatant and finger drains WAD CN concentrations over the same time period were 0.118 and 0.009 mg/L, respectively. WAD CN was reduced by about an order of magnitude from the Musselwhite TSF supernatant to the finger drains. The mean concentration of 0.004 mg/L WAD CN is below the applicable BC water quality objective for aquatic life of 0.005 mg/L, while the 95th percentile was somewhat above.

Dilution by TSD Dam D runoff, and the catchment between the dam and compliance point at the Project, would further reduce WAD CN concentrations in seepage. WAD CN in the seepage from the Project TSF may meet the BC water quality objective without treatment in wetlands downstream of TSF Dam D. Seepage quality will be monitored during mine operations and into closure, so that wetlands could be constructed or seepage recycle continued post-closure if required.



Source: Smith and Mudder, 1991

Figure 5.3.3-13: Cyanide Cycling Mechanisms

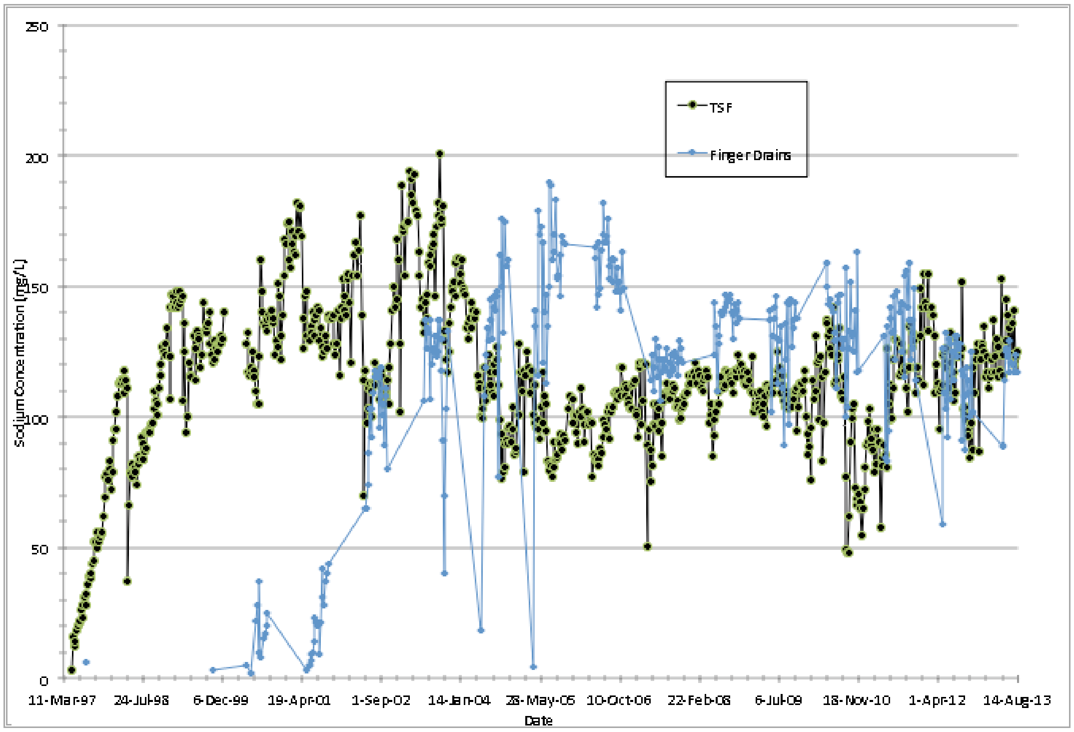


Figure 5.3.3-14: Sodium in Musselwhite TSF and Finger Drains

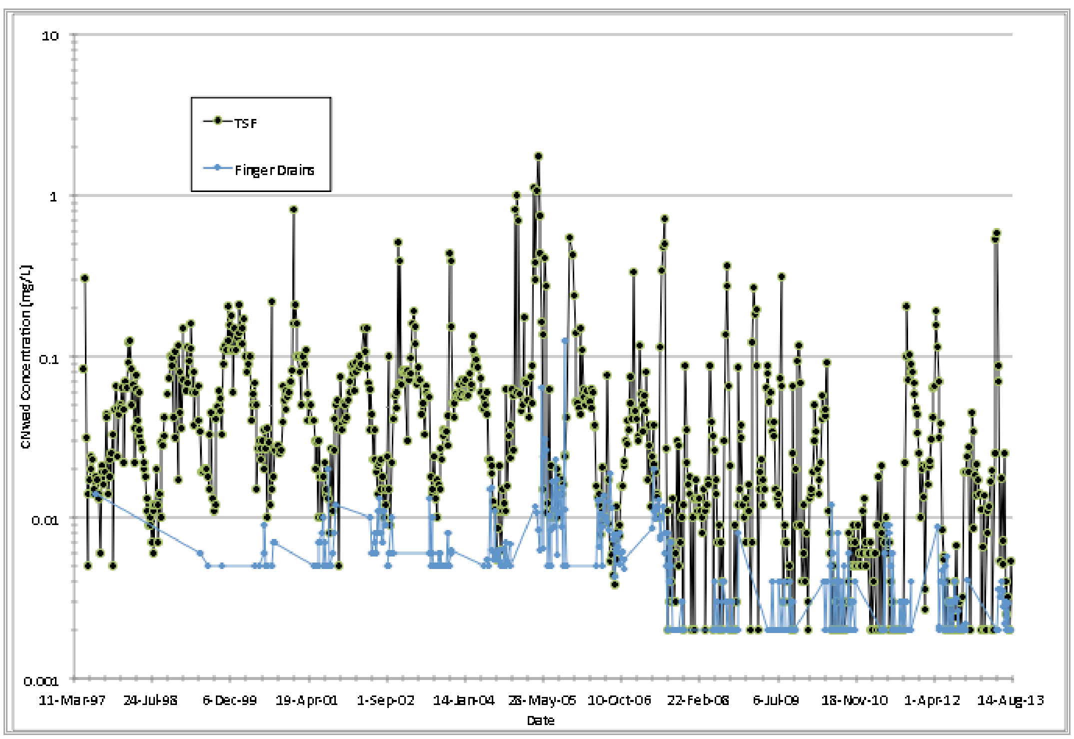


Figure 5.3.3-15: CNwad in Musselwhite TSF and Finger Drains

5.3.3.3.9 Summary of Surface Water Quality Predictions

All parameters are predicted to meet BC FWG and CCME, except where background concentrations are naturally above these guidelines. Because Health Canada drinking water guidelines are higher than protection of aquatic life, these latter guidelines will be met as well, again, except where background concentrations have exceedances. BC protection of wildlife guidelines will all be met with the exception of molybdenum in the TSF during operations, which may be marginally exceeded under the conservative assumptions modelled. The restricted access of wildlife to the TSF will ensure any exposures are not significant.

An exception to this generality is sulphate, which under the conservative assumption of no reduction in the TSF or wetlands at post closure, could potentially exceed BC FWG, hardness-adjusted guideline for both modelled scenarios. Predicted exceedances are at the Plunge Pool and WQ7; WQ9 in Chedakuz Creek remains below the guideline. With natural reduction of sulphate in the TSF, subsurface materials and wetlands sulphate is expected to meet water quality objectives during all mine phases.

Based on background water quality, dissolved aluminum, total cadmium, total copper, and total zinc will require site-specific water quality objectives. Background total iron occasionally exceeded CCME and drinking water guidelines (0.300 mg/L). Background total mercury occasionally exceed BC FWG.

No Project-caused exceedances are predicted at WQ10/plunge pool (equivalent location to the ECD) during any phase (except as noted), thus assuring downstream water quality guidelines that are not naturally exceeded will be met. Sites at the mouth of Davidson Creek (WQ7) and on Chedakuz Creek downstream of Davidson Creek mouth (WQ9) were also modelled, confirming this result. Chedakuz Creek discharges to the Nechako Reservoir 42 km stream thalweg distance downstream from the Chedakuz and Davidson Creek junction; any effects from the proposed Project would not be measurable at the mouth of Chedakuz Creek and would be well within natural variations in water quality parameters.

A water intake will be placed in Tatelkuz Lake to withdraw water for process makeup and instream flow needs for fish in Davidson Creek. The seasonal temperature pattern for Davidson Creek when Tatelkuz Lake water is pumped to maintain IFN is for higher temperatures in spring, fall, and winter and slightly lower temperatures in summer. At post closure when flows in Davidson Creek are composed mostly of flows from TSF discharge and seepage plus a variable amount from the watershed (depending on the location on the creek), temperatures are forecast to be higher for all seasons in Davidson Creek but not to reach the upper temperature guideline for rainbow trout. A discussion on the implications of predicted temperature changes for aquatic biota can be found in **Section 5.3.8**.

Davidson Creek water temperature assessment for operations and closure, when Tatelkuz Lake water will be drawn from 12 m depth, is forecast to be higher in winter and lower in summer, based on long-term temperature profiles in Tatelkuz Lake, and temperature logger data and spot measurements for Davidson Creek conducted from summer of 2011 through fall of 2013. Post-closure, water will no longer be pumped from Tatelkuz Lake, and Davidson Creek water will be maintained at in-stream fish needs flow levels by discharge and seepage from the TSF.

5.3.3.3.10 Mitigation Measures

5.3.3.3.10.1 Mitigation Inherent in Design

Conceptual management of mine water is discussed in **Section 2.2** and in the MWAMP, **Section 12.2.1.18.4.18**.

Numerous design elements were developed to achieve the objectives of the site wide water management plan which are:

- to treat potentially high-concentration waste streams before discharge to the TSF:
  - Recycle cyanide to the extent practical within the mill;
  - Destruct residual cyanide in process plant discharge by SO_2/air treatment; and
  - Route low grade and temporary ore stockpile runoff through a lime treatment plant.
- to isolate contact water to the site and provide for no discharge of surface water from the TSF during operations and closure:
  - Construction erosion prevention and control through minimizing disturbance and sediment control ponds at strategic locations;
  - Two-pond TSF to permanently store process plant tailings and PAG and NAG3 waste rock;
  - Recycle tailings supernatant back to the process plant;
  - Seepage control for all TSF dams including a hydraulic barrier by the TSF Site C West Dam;
  - Pump station on Tatelkuz Lake, pipeline and freshwater reservoir to supply the process plant, flood PAG rock in TSF (if required during dry periods) and instream flow needs for Davidson Creek;
  - Site contact water drainage containment;
  - Segregation and sub aqueous disposal of PAG and NAG3 waste rock (refer to **Section 12.2.1.18.4.17**);
  - Constructed wetlands in the reclaimed TSF ponds to polish supernatant water and in the former ECD and water reservoir in post-closure; and
  - NAG tailings and till cover of process tailings and PAG waste rock on closure to limit contact of interstitial water with supernatant on closure.

5.3.3.3.10.1.1 Construction

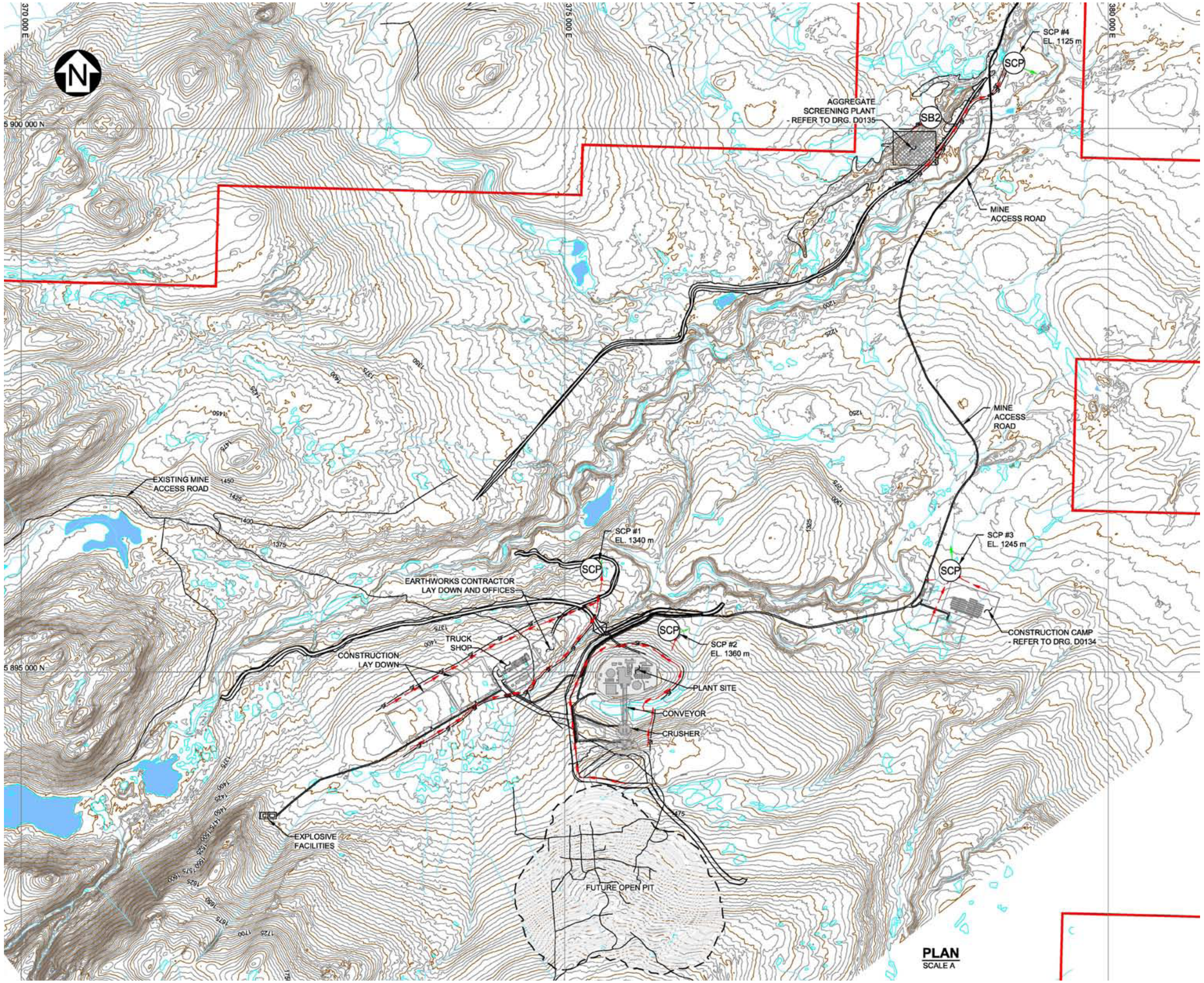
Prior to construction of Dam C, potential erosion and sedimentation from site preparation will be controlled. This will be accomplished by means of sediment control ponds that will be constructed prior to major clearing of the plant site area, and dams downstream of the TSF where other control facilities are not in place. A conceptual design is discussed in **Section 2.2** and

Section 12.2.1.18.4.1, and in the Knight Piésold SECP (**Appendix 2.2A-5**); a detailed design will be developed and submitted as support for application for the *Environmental Management Act* effluent permit required to operate the pond. To limit erosion from disturbed areas, construction management and erosion and sediment control plans, and conceptual plans were developed as provided in **Section 12.2.1.18.4.1** The SECP will include constructing sediment control facilities such as diversion and collection ditches and sediment control ponds and implementing BMPs prior to surface disturbance. Flocculent addition systems will also be established as contingency measures for sediment ponds that will discharge directly to surface waters prior to operating the ponds.

The sediment control ponds will be designed according to BC guidelines to remove suspended sediment. During storm events, water will discharge after settling over a spillway and for Pond 1 through Pond 4 will infiltrate into glaciofluvial surficial materials. Only Pond 5 to Pond 7 will have direct discharges to receiving streams. For ponds with direct discharges to streams, should daily turbidity and weekly TSS monitoring indicate discharge TSS is greater than 10% above Davidson Creek and Creek 661 background TSS, flocculants will be added. Provision for flocculant addition and mixing will be built into the design of the sediment control ponds.

Construction of the power line, water supply pipeline, new road alignment, and airstrip will follow construction BMPs, with the expectation that erosion and sedimentation into receiving waters will be strictly controlled, and that no significant effects from these activities will result. Construction activities will be monitored, and any erosion addressed at source and/or controlled near source with silt fences, hay bales, or other mitigation measures, as appropriate.

Figure 5.3.3-16 and **Figure 5.3.3-17** show the proposed location of the sediment control pond. **Table 5.3.3-9** lists sediment control ponds.



CLIENT: newgold	DWN BY: MY	PROJECT	Blackwater Gold Project	DATE: November 2013
	CHK'D BY: BO			PROJECT NO: VE52277
AMEC Environment & Infrastructure 4445 Lougheed, Suite 600, Burnaby, B.C., V5C 0E4 Tel. 604-294-3811 Fax 604-294-4664	DATUM: N/A	TITLE	Construction Sediment Control Pond 1	REV. NO.: A
amec	PROJECTION: N/A			FIGURE No. 5.3.3-16
	SCALE: N/A			

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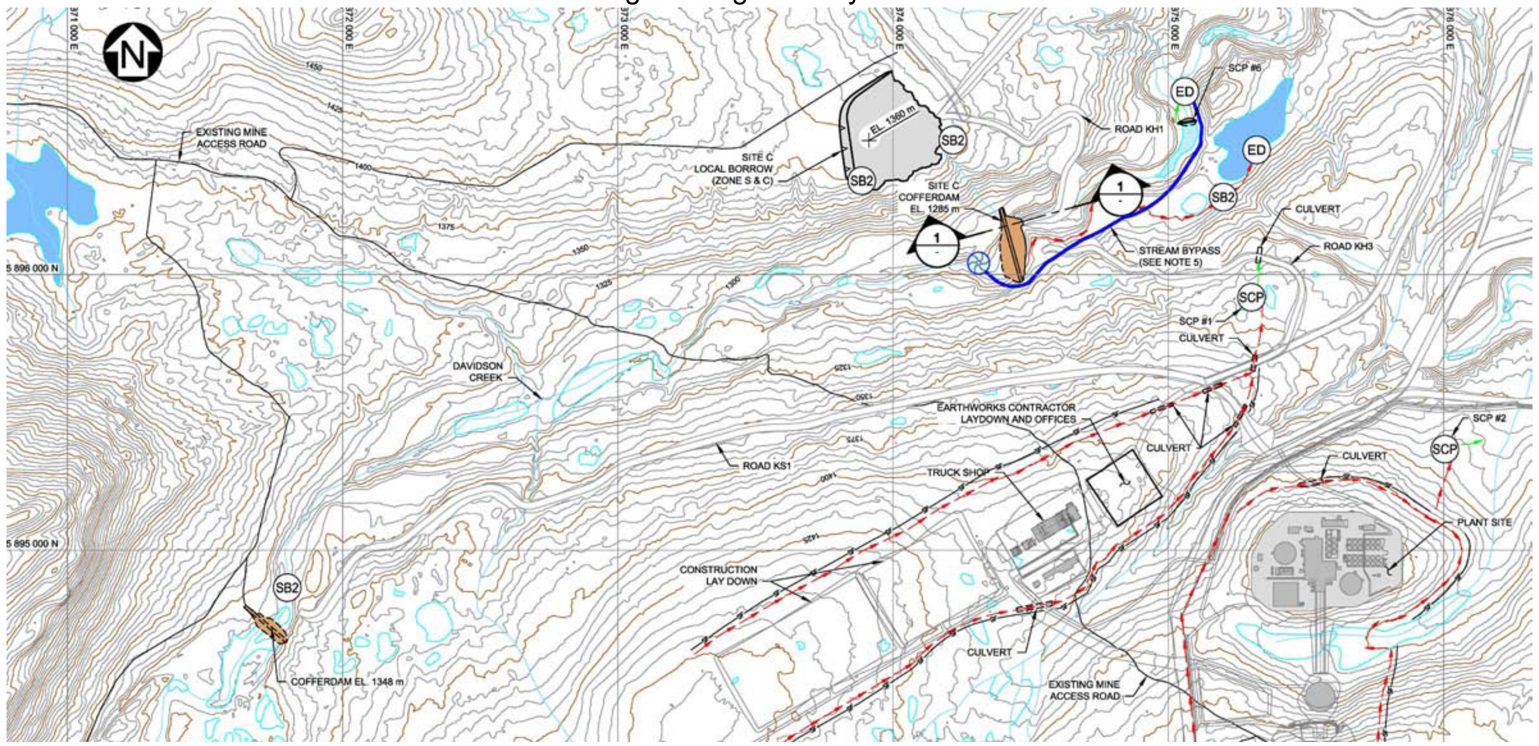
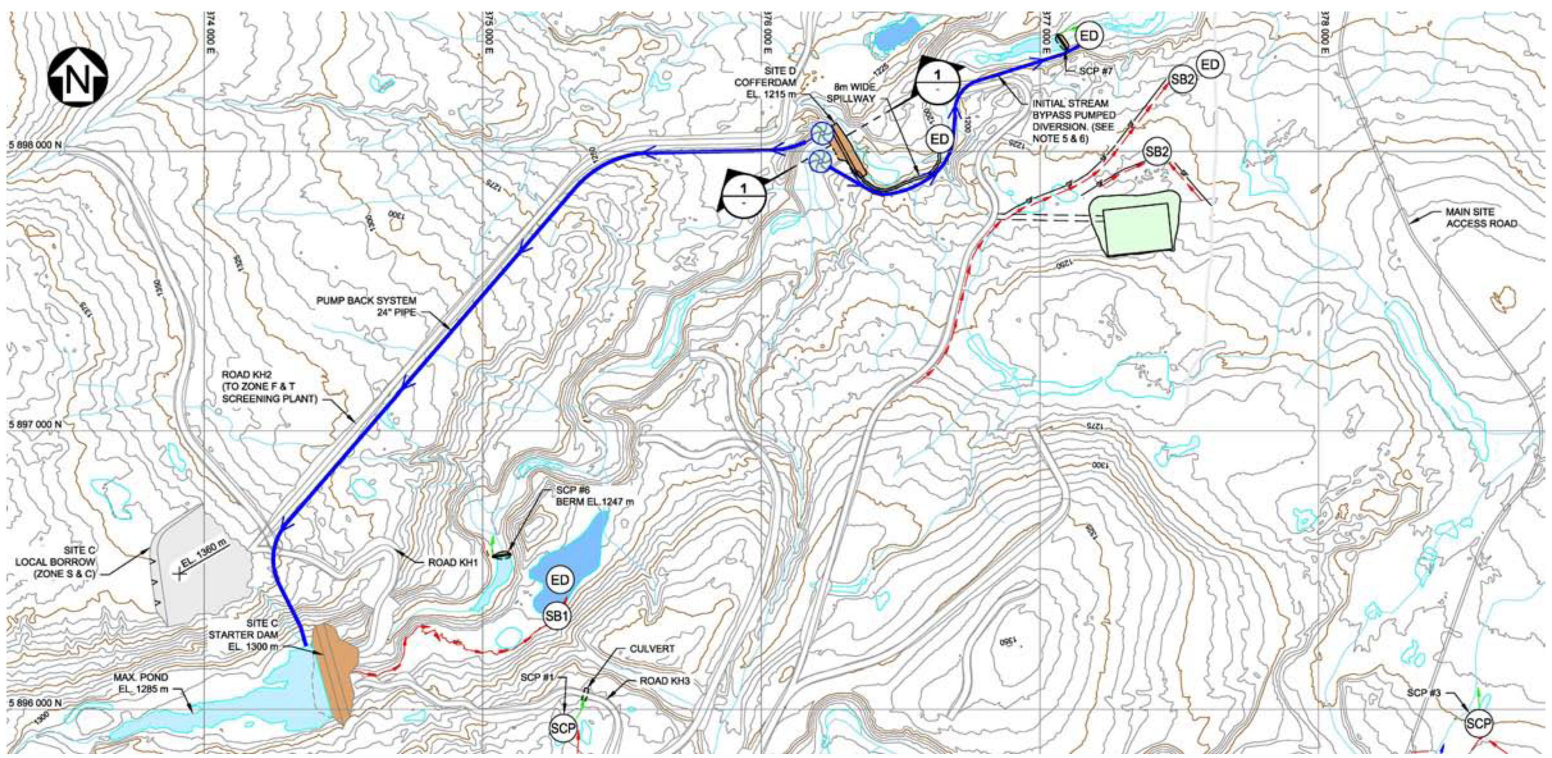
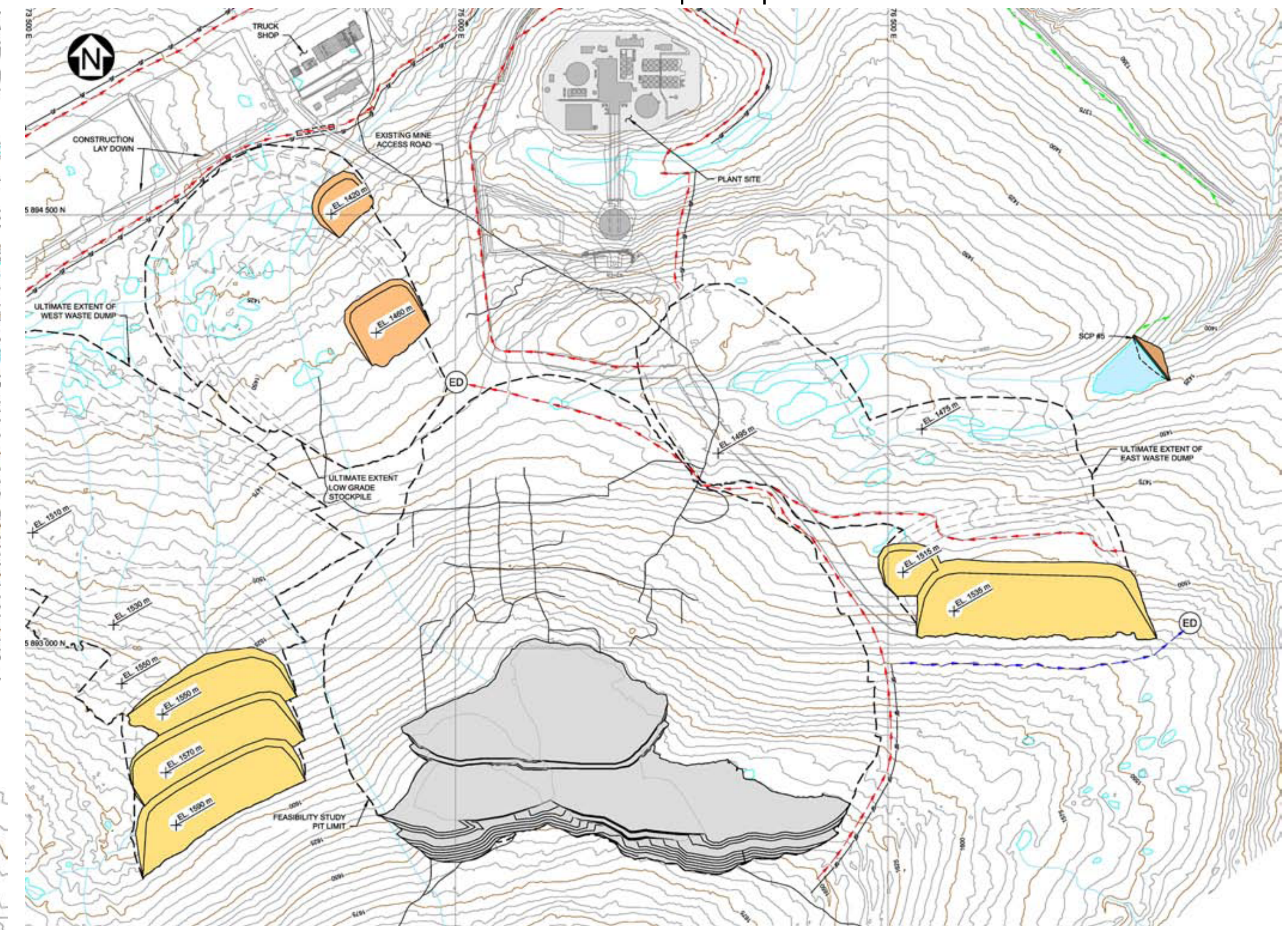
Tailings Storage Facility Site C Cofferdam



Tailings Storage Facility Site D Cofferdam



Waste Dumps & Open Pit



CLIENT: newgold		DWN BY: MY	PROJECT	Blackwater Gold Project	DATE: November 2013
		CHK'D BY: BO			PROJECT NO: VE52420
AMEC Environment & Infrastructure 4445 Lougheed, Suite 600, Burnaby, B.C., V5C 0E4 Tel. 604-294-3811 Fax 604-294-4664	amec	DATUM: N/A	TITLE	Construction Sediment Control Pond 2	REV. NO.: A
		PROJECTION: N/A			FIGURE No. 5.3.3-17
		SCALE: N/A			

Y:\GIS\Projects\VE\VE52095_Richfield_Blackwater\Mapping\09_water-quality\EIA\09-200-005_sediment_TSF.ai

Table 5.3.3-55: Additional Contingency Mitigation Measures

Issue	Additional Mitigation Scenarios
Dam D shell unexpected metal leaching	Drainage from the TSF Dam D shell will be monitored and captured in the ECD and returned to the TSF during operations and closure until the pit lake is full. The actual leaching characteristics of material placed in the downstream TSF Dam D shell will be known by the time the pit lake overflows. As a further contingency, TSF dam runoff and seepage could continue to be recycled to the TSF or be treated in an additional downstream wetland.
East and West Waste Rock Dumps metal leaching	Overburden comprises a significant portion of the East and West Dumps from year 2 of construction to year 7 of operations (59% average for East Dump and 43% average for West Dump). Therefore, overburden is available to encapsulate any improperly placed PAG or NAG3 waste in the dam shell during those years. Dump drainage will be monitored during operations and into closure to confirm the effectiveness of management plans. If required a thick overburden cover could be placed on one or both of the waste rock dumps to significantly reduce oxygen and water infiltration. In addition, drainage from the dumps could be treated in wetlands or by active chemical treatment or discharged at depth into the anoxic zone of the pit lake at closure.
Waste segregation	If additional PAG and NAG3 waste rock than forecast is generated and requires disposal in the TSF, the TSF dam(s) would be raised and the site water balance will be adjusted to ensure the material is flooded. Should treatment in the TSF prove less effective than predicted, additional water management contingency plans are available including discharge of the supernatant at depth into the anoxic zone of the pit lake, addition of nutrients (biological treatment) or through a chemical (e.g., lime) treatment plant at closure.
TSF operational pond capacity	The TSF operational pond capacity is sufficient to manage a reasonable range of surplus water conditions. Water levels will be monitored to ensure that the water balance assumptions are accurate and that an operational surface water discharge from the TSF does not occur until post-closure. As a contingency, non-contact surface water diversions can be created to divert runoff around the TSF ponds, and the TSF dams can be raised more frequently, if required.
Contingency water management	Should treatment in the TSF prove less effective than predicted, additional water management contingency plans are available including discharge of the supernatant at depth into the anoxic zone of the pit lake, addition of nutrients (biological treatment) or through a chemical (e.g., lime) treatment plant at closure.
Selenium or mercury bioaccumulation post closure	Should selenium or mercury bioaccumulation prove problematic other treatment options such as in-pit or in TSF pond treatment for sequestering of selenium and/or mercury in the solid (precipitated) phase, or recycle of water to the pit and addition of nutrients if necessary could be considered.

Note: PAG = potentially acid generating; NAG3 = non-acid-generating, high zinc neutral leaching

5.3.3.3.10.1.2 Operation

The key mitigation strategy for preventing impacts to Davidson Creek water quality during operations will be a no surface water discharge design for the TSF. The main dam (Dam D) is anticipated to produce up to 55 L/s seepage comprising foundation and embankment seepage. However, an additional dam (ECD) will be constructed downstream of the main TSF dam and will capture almost all of this seepage, only an estimated 2 L/s seepage might reach Davidson Creek, with the balance being pumped back to the TSF. This represents 96% efficiency in recovering seepage.

On the west side of the TSF, a saddle dam and seepage recovery pond will be constructed within the Davidson Creek watershed that will be designed to prevent seepage from this dam flowing into the headwaters of Creek 705. In addition, a hydraulic barrier will be established to the west of the saddle dam to force any seepage east into the TSF.

East of the East dump (comprising NAG5 waste rock and overburden), a collection ditch will be constructed to capture runoff and seepage from the dump and route it to the TSF, therefore avoiding any contact water reaching the headwaters of Creek 661 during the operations phase (any unrecovered seepage has a very long travel time). Based on monitoring results indicating BC FWG are met, runoff and seepage from the East dump may be allowed to flow to Creek 661.

Down slope monitoring wells will be installed to monitor seepage from waste management structures so that corrective action, such as recovery wells or ditches and pump back systems, can be initiated should predictions prove incorrect and seepage be higher and/or of poorer quality than expected.

Site contact water will be routed to the TSF, and water that flows to the ECD will be pumped back to the TSF.

After Year 3 of operations, TSF Cell C will be partially reclaimed. Seepage from Cell C will be naturally captured in Cell D.

5.3.3.3.10.1.3 Closure

During closure water management will essentially be the same as during operations. No surface water will be discharged from the TSF, and all site contact water except minimal seepage will be captured. TSF Cell D and Dam D will be reclaimed, and water in Cell D will be pumped to the open pit to facilitate filling. Reclamation of Cell D will consist of spigotting oxide tailings on top of the processed tailings during the last years of mill operations, followed by placement of an overburden cover on top of the oxide tailings. A 30 cm layer of overburden will also be placed over the submerged PAG and NAG3 waste rock in the TSF. This will serve to isolate the underlying tailings and waste rock from the supernatant, and surface water will take on background chemistry concentrations.

5.3.3.3.10.1.4 Post-Closure

At approximately Year 35 (first full year 36), the TSF will discharge to Davidson Creek. At that time pit lake water will mix with supernatant water in the TSF.

Surface water at the time of discharge from the TSF is expected to be very near receiving environment quality (provincial and federal guidelines or site-specific objectives). Wetlands will be constructed in Pond C and Pond D during the closure period and are expected to polish water based on data from the former Musselwhite Gold Mine in northern Ontario with approximately the same climate regime as the Project. A wetland will be constructed downstream of the Environmental Control Dam and water reservoir as previously discussed to polish seepage. As a contingency, an additional wetland could be constructed between the water reservoir and the mine access road crossing (compliance point) to provide further polishing.

5.3.3.3.10.2 Additional Mitigation – Triggers for Adaptive Management

Any additional mitigation will be completed in response to monitoring, and will be integrated into adaptive management practices at the site. In principle, triggers will consist of increasing trends in surface or groundwater quality concentrations that begin to approach BC FWG or site-specific water quality objectives.

Potential additional mitigation measures are outlined in the Mine Waste Management Plan (MWMP) (**Section 12.2.1.18.4.17**) and the MWAMP (**Section 12.2.1.18.4.18**) and are listed below for reference.

5.3.3.3.10.3 Effectiveness of Mitigation

Table 5.3.3-56 provides ratings for effectiveness of mitigation measures to avoid or reduce potential effects on surface water quality of mine site development, detailed in the above sections.

Table 5.3.3-56: Mitigation Measures and Effectiveness of Mitigation to Avoid or Reduce Potential Effects on Surface Water Quality of Mine Site Development

Likely Environmental Effect	Project Phase	Mitigation/Enhancement Measure	Effectiveness of Mitigation Rating
Surface water quality	Construction, Operations, Closure, Post-Closure	Recycle cyanide to the extent practical within the mill	High
		Destruct residual cyanide in process plant discharge by SO_2/air treatment	High
		Route low grade and temporary ore stockpile runoff through a lime treatment plant	High
		Construction erosion prevention and control through minimizing disturbance and sediment control ponds at strategic locations	High
		Two-pond TSF to permanently store process plant tailings and PAG and NAG3 waste rock	High
		Recycle tailings supernatant back to the process plant	High
		Seepage control for all TSF dams including a hydraulic barrier by the TSF Site C West Dam	High
		Pump station on Tatelkuz Lake, pipeline and freshwater reservoir to supply the process plant, flood PAG rock in TSF (if required during dry periods) and instream flow needs for Davidson Creek	High
		Site contact water drainage containment	High

Likely Environmental Effect	Project Phase	Mitigation/Enhancement Measure	Effectiveness of Mitigation Rating
		Segregation and sub aqueous disposal of PAG and NAG3 waste rock (refer to **Section 12.2.1.18.4.17**)	High
		Constructed wetlands in the reclaimed TSF ponds to polish supernatant water and in the former ECD and water reservoir in post-closure	High
		NAG tailings and till cover of process tailings and PAG waste rock on closure to limit contact of interstitial water with supernatant on closure	High
	Construction	Prior to construction of Dam C, potential erosion and sedimentation from site preparation will be controlled. This will be accomplished by means of sediment control ponds that will be constructed prior to major clearing of the plant site area, and dams downstream of the TSF where other control facilities are not in place. The SECP will include constructing sediment control facilities such as diversion and collection ditches and sediment control ponds and implementing BMPs prior to surface disturbance. Flocculent addition systems will also be established as contingency measures for sediment ponds that will discharge directly to surface waters prior to operating the ponds.	High
		A detailed design will be developed and submitted as support for application for the *Environmental Management Act* effluent permit required to operate the pond	High
		Construction of the power line, water supply pipeline, new road alignment, and airstrip will follow construction BMPs, with the expectation that erosion and sedimentation into receiving waters will be strictly controlled, and that no significant effects from these activities will result	High
		Construction activities will be monitored, and any erosion addressed at source and/or controlled near source with silt fences, hay bales, or other mitigation measures, as appropriate	High
		To limit erosion from disturbed areas, construction management and erosion and sediment control plans, and conceptual plans were developed as provided in **Section 12.2.1.18.4.1**	High
		The sediment control ponds will be designed according to BC guidelines to remove suspended sediment.	High
	Operations	During storm events, water will discharge after settling over a spillway and for Pond 1 through Pond 4 will infiltrate into glaciofluvial surficial materials	High

Likely Environmental Effect	Project Phase	Mitigation/Enhancement Measure	Effectiveness of Mitigation Rating
		Only Pond 5 to Pond 7 will have direct discharges to receiving streams	High
		For ponds with direct discharges to streams, should daily turbidity and weekly TSS monitoring indicate discharge TSS is greater than 10% above Davidson Creek and Creek 661 background TSS, flocculants will be added	High
		Provision for flocculant addition and mixing will be built into the design of the sediment control ponds	High
Additional Contingency Mitigation Measures			
Dam D shell unexpected metal leaching	Operations, Closure	Drainage from the TSF Dam D shell will be monitored and captured in the ECD and returned to the TSF during operations and closure until the pit lake is full	High
		As a further contingency, TSF dam runoff and seepage could continue to be recycled to the TSF or be treated in an additional downstream wetland	High
East and west waste rock dumps metal leaching	Operations, Closure	Dump drainage will be monitored during operations and into closure to confirm the effectiveness of management plans	High
		If required a thick overburden cover could be placed on one or both of the waste rock dumps to significantly reduce oxygen and water infiltration	High
		In addition, drainage from the dumps could be treated in wetlands or by active chemical treatment or discharged at depth into the anoxic zone of the pit lake at closure	High
Waste segregation	Operations, Closure	If additional PAG and NAG3 waste rock than forecast is generated and requires disposal in the TSF, the TSF dam(s) would be raised and the site water balance will be adjusted to ensure the material is flooded	High
	Closure	Should treatment in the TSF prove less effective than predicted, additional water management contingency plans are available including discharge of the supernatant at depth into the anoxic zone of the pit lake, addition of nutrients (biological treatment) or through a chemical (e.g., lime) treatment plant at closure	Moderate
TSF operational pond capacity	Operations	Water levels will be monitored to ensure that the water balance assumptions are accurate and that an operational surface water discharge from the TSF does not occur until post-closure	High

Likely Environmental Effect	Project Phase	Mitigation/Enhancement Measure	Effectiveness of Mitigation Rating
		As a contingency, non-contact surface water diversions can be created to divert runoff around the TSF ponds, and the TSF dams can be raised more frequently, if required	High
Contingency water management	Closure	Should treatment in the TSF prove less effective than predicted, additional water management contingency plans are available including discharge of the supernatant at depth into the anoxic zone of the pit lake, addition of nutrients (biological treatment) or through a chemical (e.g., lime) treatment plant at closure	Moderate
Selenium or mercury bioaccumulation post closure	Operations	Should selenium or mercury bioaccumulation prove problematic other treatment options such as in-pit or in TSF pond treatment for sequestering of selenium and/or mercury in the solid (precipitated) phase, or recycle of water to the pit and addition of nutrients if necessary could be considered	Moderate
Surface water quality	Operations	No surface water will be discharged to the TSF	High
		An additional dam (ECD) will be constructed downstream of the main TSF dam and will capture almost all seepage	High
		On the west side of the TSF, a saddle dam and seepage recovery pond will be constructed within the Davidson Creek watershed that will be designed to prevent seepage from this dam flowing into the headwaters of Creek 705	High
		A hydraulic barrier will be established to the west of the saddle dam to force any seepage east into the TSF	High
		East of the East dump (comprising NAG5 waste rock and overburden), a collection ditch will be constructed to capture runoff and seepage from the dump and route it to the TSF	High
		Down slope monitoring wells will be installed to monitor seepage from waste management structures	High
		Site contact water will be routed to the TSF, and water that flows to the ECD will be pumped back to the TSF	High
	Closure	No surface water will be discharged from the TSF	High
		All site contact water except minimal seepage will be captured	High
		TSF Cell D and Dam D will be reclaimed	High
		Water in Cell D will be pumped to the open pit to facilitate filling	High

Likely Environmental Effect	Project Phase	Mitigation/Enhancement Measure	Effectiveness of Mitigation Rating
		Reclamation of Cell D will consist of spigotting oxide tailings on top of the processed tailings during the last years of mill operations, followed by placement of an overburden cover on top of the oxide tailings	High
		A 30 cm layer of overburden will be placed over the submerged PAG and NAG3 waste rock in the TSF	High
	Post-Closure	Construct wetlands in TSF Site C and D after closure as part of water treatment	High
		Construct a wetland at the ECD site after closure as part of seepage water treatment	High
		As a contingency, and if required, construct a wetland in the water reservoir area below the ECD on closure if further polishing of TSF discharge water and seepage is required	High

Note: cm = centimetre; ECD = Environmental Control Dam; NAG = non-acid generating; PAG = potentially acid generating; TSF = Tailings Storage Facility

In summary, low success rating means mitigation has not been proven successful, moderate success rating means mitigation has been proven successful elsewhere, and high success rating means mitigation has been proven effective. High success ratings have been applied above to mitigation measures that have been proven effective at other mine sites. Where there is some question of the degree of success of mitigation (i.e., for alternate treatment options provided as contingencies) a rating of moderate has been applied.

5.3.3.4 Residual Project Effects and their Significance

5.3.3.4.1 Residual Project Effects

5.3.3.4.1.1 Definition of Effects Criterion and Certainty of Predictions

Residual effects here refer to changes in water quality in receiving water bodies above water quality guidelines or site-specific water quality objectives after mitigation that can reasonably be ascribed to the Project and not a result of natural background guideline exceedances. Three years of background water monitoring have provided data on receiving environment water chemistry. Certainty is high that predictions for the receiving environment are conservative. Some uncertainty still exists with projections of site and receiving water quality. However, a worst-case scenario was modelled which included conservative individual assumptions that taken together represent an unlikely scenario. The project design involves routing all contact water to the TSF during operations and early closure with no surface water discharge. Seepage estimates are based on extensive geotechnical investigations and assessment and it is assumed that all seepage that might reach fractured bedrock ultimately discharges to Davidson Creek upstream of the access road crossing. Surface discharges to Davidson Creek will not occur until well after mine closure providing ample time to confirm predictions and implement contingency measures as required.

Finally, a program of site, surface, and groundwater water chemistry and of environmental effects monitoring will be instituted to commence at mine construction to provide feedback on predictions. Should monitoring results indicate unexpected concentrations of parameters of concern or increasing trends, proactive adaptive management will be put in place to correct effects or reverse trends. Additional contingency measures are discussed in **Table 5.3.3-55** and the MWAMP (**Section 12.2.1.18.4.18**). Taken together the above measures provide for a high level of environmental protection.

5.3.3.4.1.2 Construction

No residual effects are expected during the construction phase, given the mitigation and management measures to be used (**Sections 2.2 and 5.3.3.3.10.1.1**).

5.3.3.4.1.3 Operations and Closure

There will be a residual effect on seasonal temperature in Davidson Creek from addition of Tatelkuz Lake water (**Section 5.3.3.3.8.4**). Tatelkuz Lake water (based on seasonal temperature measurements) will be warmer in winter and cooler in summer. The expected effect of this change on fish is discussed in **Section 5.3.8**.

A few parameters are over guidelines, but well within background. These parameters are listed in **Table 5.3.3-57**.

While above guidelines these parameters are not considered to cause any effects, as they do not exceed natural background levels. Parameters for which site-specific guidelines will be sought were previously discussed, and are:

- Dissolved aluminum;
- Total cadmium (2006 BC FWG);
- Total copper;
- Total iron (BC FWG, not CCME); and
- Total zinc.

Mercury occasionally naturally spikes above BC FWG and this will have to be taken into account when evaluating results from mine site monitoring.

Table 5.3.3-57: Potential Exceedances of Guidelines Due to High Background at Operations and Closure

Guideline	Station	Parameter	Scenario
Drinking water	WQ10, WQ7, WQ9	TOC[1]	Best estimate, worst case
CCME	WQ10, WQ7, WQ9	Total aluminum	Best estimate, worst case
BC FWG	WQ7 WQ10, WQ7, WQ9	Dissolved aluminum	Best estimate Worst case
BC FWG	WQ7, WQ9	Total cadmium	Worst case
CCME BC FWG, CCME	WQ10 WQ10,WQ9 (CCME only)	Total copper	Best estimate Worst case
CCME, drinking water	WQ7 WQ9, WQ10	Total iron	Best estimate, worst case Worst case
Drinking water (aesthetics)	WQ10, WQ7, WQ9	Total manganese	Best estimate, worst case
BC FWG	WQ7	Total mercury	Worst case
BC FWG	WQ7 WQ10, WQ7, WQ9	Total zinc	Best estimate Worst case

Note: [1] 4 mg/L guideline exceeded; applies to chlorinated water
BC FWG: BC Protection of Freshwater Aquatic Life Guideline, 30-d average

5.3.3.4.1.4 Post-Closure

Table 5.3.3-58 lists post-closure parameters that might be within background yet exceed guidelines (sulphate is discussed in **Section 5.3.3.1.2**).

5.3.3.4.1.5 Suspended Sediment

Once the access road realignment, water supply pipeline, power line, and airstrip are constructed, any unused disturbance will be reclaimed. An erosion and sediment control plan has been developed for the mine site construction and operation. Erosion and sedimentation are not expected, but facilities will be monitored to ensure there is limited erosion (refer to SECP, **Section 12.2.1.18.4.1**). Reclamation will mitigate erosion issues once the mine closes (see **Section 2.6**). The mine site will be monitored for approximately 35 years after the cessation of operations to ensure reclamation measures are effective.

Table 5.3.3-58: Potential Exceedances of Guidelines Due to High Background at Post-Closure

Guideline	Station	Parameter	Scenario
Drinking water	Plunge pool, WQ7, WQ9	TOC[1]	Best estimate, worst case
CCME	Plunge pool, WQ7, WQ9	Total aluminum	Best estimate, worst case
BC FWG	Plunge pool, WQ7 Plunge pool, WQ7, WQ9	Dissolved aluminum	Best estimate Worst case
BC FWG (2006)	Plunge pool, WQ7 Plunge pool, WQ7, WQ9	Total cadmium	Best estimate Worst case
BC FWG	WQ7	Total chromium	Worst case
BC FWG, CCME	Plunge pool Plunge pool, WQ7	Total copper	Best estimate Worst case
CCME, drinking water	WQ7 Plunge pool, WQ7, WQ9	Total iron	Best estimate Worst case
Drinking water (aesthetics)	Plunge pool, WQ7, WQ9	Total manganese	Best estimate, worst case
BC FWG	WQ7	Total zinc	Best estimate, worst case

Note: (1) 4 mg/L guideline exceeded; applies to chlorinated water
BC FWG: BC Protection of Freshwater Aquatic Life Guideline, 30-d average

5.3.3.4.2 Significance of Residual Project Effects

There are limited residual effects predicted for water quality after mitigation, since mitigation is built into the design of the Project. Residual effects relate to potential exceedances of water quality guidelines, and are parameter-specific. While there are exceedances predicted according to the model, they are almost all driven by background concentrations above guidelines, and are therefore, not considered residual. The possible exception is sulphate on the mine site at post closure, and TSS in water bodies crossed by access roads.

As discussed, post-closure sulphate at the plunge pool and WQ7 is predicted by the model to exceed the BC protection of freshwater aquatic life hardness-adjusted guideline by 10 to 50 mg/L above the 200 mg/L guideline. This prediction is the same for the best estimate and worst-case scenarios, but is based on the assumption of no natural sulphate reduction in the TSF, subsurface materials, in the wetlands, or downstream of Dam D. However, with the expected natural sulphate reduction, sulphate is expected to remain within the hardness-adjusted BC guideline. Moreover, monitoring conducted during the operating and extended closure periods will be used to verify this prediction and implement any contingency measures as required. Confidence in predictions is moderate to high. For erosion from access roads (TSS), proven best practices to mitigate erosion will be followed throughout the mine life. For sulphate, known mechanisms to reduce sulphate will be operating in the TSF and downstream wetlands.

Given natural attenuation of sulphate the probability (likelihood) of guideline exceedance is low.

The significance uncertainty is low for sulphate, because concentrations are well above the detection limit and the magnitude of predicted exceedances is low.

The significance of residual Project effects on water quality is listed in **Table 5.3.3-59**. Categories are defined in **Section 4.3.5**.

Table 5.3.3-59: Significance of Residual Project Effects on Water Quality

Categories for Significance Determination	Project Phase		
	Construction	Operations/Closure	Post-Closure
Context	n/a	n/a	low
Magnitude	n/a	n/a	low
Geographic Extent	n/a	n/a	local
Duration	n/a	n/a	chronic
Frequency	n/a	n/a	periodic
Reversibility	n/a	n/a	yes
Likelihood Determination	n/a	n/a	moderate – high
Statement of the level of Confidence for likelihood	n/a	n/a	moderate – high
Significance Determination	n/a	n/a	not significant – minor
Statement of the level of Confidence for Significance	n/a	n/a	moderate – high

5.3.3.5 Cumulative Effects

Logging has occurred in the watersheds where the Project is located. Logging typically leads to increased TSS in streams and potentially changes in nutrient concentrations of nutrients are washed more rapidly from the exposed soils after logging. Since logging occurred prior to water quality monitoring at the site, any effects are already included in the baseline data collected.

A ranch is located near the mouth of Davidson Creek and could potentially be having some effect on both Davidson and lower Chedakuz creeks. As the ranch was in operation before water monitoring commenced for the Project, it is not possible to separate any effects ranch operation may have on water quality of the subject creeks. Effects could include nutrient addition from cattle manure and sedimentation from cattle entering either creek. Since BC FWGs for these parameters were not exceeded at any of the monitoring sites close to the ranch, any effects that might possibly be occurring are not above concentrations considered potentially harmful to aquatic life.

Exploration activities for the Project resulted in land disturbance, which could potentially have affected water quality in adjacent streams. The Proponent developed and successfully implemented approved environmental management plans for their exploration license. Access trails and drill pads require reclamation under the license, which is carried out usually within a year or less of completion of site disturbance. Reclamation activities are inspected periodically by MEM and have been found to be satisfactory. Water quality monitoring from 2011 through 2013 has not indicated any increases in TSS that could be correlated with adjacent tote trails, exploration roads, or drill pads. Therefore, there is unlikely to be any water quality cumulative effects from exploration activities that pre-date Project construction.

In the RSA, the principal users of the FSR are, and will continue to be, forest companies. Cumulative effects could occur from dust deposition in streams crossed by the shared roads. Dust deposition in fish-bearing waters, if extreme, could possibly lead to sediment accumulation, which could negatively affect fish habitat. In practice, dust will be fine and be carried away from the road area and slowly sediment out of the water column. With dust controls in place (e.g., road dressing), contributions from traffic dust to sediment in crossed streams are expected to be minor compared to watershed sediment export upstream of the road crossing. Changes in sediment quantity and TSS from road dust will be unmeasurable, and in any case, inseparable from upstream changes.

Pacific Northern Gas Ltd. is proposing a natural gas transmission pipeline between Summit Lake, BC, and Kitimat, BC. The Project at the time of writing of this report was in the pre-application phase of the BC environmental assessment process. Based on the information provided in the pre-application, the gas line would cross the Stellako River, which would also be crossed by the proposed transmission line. With best management practices proposed for construction of the transmission line and the ability to site transmission towers well away from water crossings, no sedimentation into the Stellako River is anticipated by transmission line construction and therefore, no cumulative effect combined with the gas pipeline proposal.

Possible ranching activities effects on Davidson and Chedakuz creeks pre-dating the Project are already factored into the background monitoring results.

There are no other possible sources in the LSA (Project proposed watersheds) or RSA (including the Kluskus FSR and proposed transmission line) that could contribute residual effects outside of the background range for measured parameters. A former proposed mine project, Chu Moly, was withdrawn from the assessment process. There is extensive exploration activity in the RSA but no projects that have entered the project approval process and thus it is unknown whether any future mining or other project could be developed prior to closure of the Blackwater Mine. Therefore, there will be no significant cumulative effects from the Project and other sources of contamination on water quality.

The significance of residual Project effects on water quality is listed in **Table 5.3.3-60**.

Categories are defined in **Section 4.3.5**.

Table 5.3.3-60: Significance of Cumulative Project Effects on Water Quality

Categories for Significance Determination	Project Phase		
	Construction	**Operations/Closure**	**Post-Closure**
Context	n/a	n/a	low
Magnitude	n/a	n/a	low
Geographic Extent	n/a	n/a	regional
Duration	n/a	n/a	chronic
Frequency	n/a	n/a	periodic
Likelihood Determination	n/a	n/a	moderate
Statement of the level of Confidence for likelihood	n/a	n/a	high
Significance Determination	n/a	n/a	not significant – minor
Statement of the level of Confidence for Significance	n/a	n/a	high

5.3.3.6 Limitations

The assessment of water quality potential effects was based on empirical data and quantitative modelling results. However, all source terms derived from empirical data were subject to some uncertainly. Several models were used to provide inputs to the Goldsim™ water quality model, which in themselves had some uncertainty. In general, source models used conservative assumptions. These source models included:

- A pit lake water quality prediction model;
- PHREEQC for chemical equilibrium of open pit pH;
- SEEPW for tailings seepage;
- MODFLOW for general groundwater flows at the mine site;
- Goldsim™ for mine site hydrology; and
- Site-wide watershed model (developed by Knight Piésold) for watershed water balance.

Overall certainty is high (estimated at >90%) for the best estimate water quality effects model, and worst case assumptions were combined into a separate model scenario, but monitoring of surface water quality trends will be required to determine the accuracy of predictions, particularly for parameters that are naturally near or above BC FWG.

5.3.3.7 Conclusions

All parameters with BC FWG, CCME protection of aquatic life, BC/Health Canada drinking water guidelines and BC protection of wildlife guidelines were modelled and discussed in this report. Additional parameters were modelled including all those for which there were data from tests but are not reported herein. **Table 5.3.3-10** lists all the parameters input into the Goldsim™ model;

additional results are available upon request. The time step for the Goldsim™ model was monthly to account for seasonal variation in precipitation and runoff, and monthly changes in the mining schedule.

The last year of construction (assumed to represent baseline conditions), operations, closure and post closure were modelled. Operations and closure were grouped for evaluation because the fundamental water management at the Blackwater Mine will not change during the approximately 18-year closure period when the pit lake is filling.

Best estimate and worst-case scenarios were modelled as outlined in **Table 5.3.3-11**. Best estimate scenarios used mean results from test and background monitoring as representing the expected case over the monthly increments. Worst case used 95th percentile data if available, and assumed no neutralization of submerged PAG rock and no aging of SO_2/air destructed tailings. For the pit lake the predicted model results were increased by 1.5 times for worst case as an estimate because the PHREEQC model inputs used single entries and not a range of data; the complete pit lake mixing model was used as the more conservative for key parameters than the stratified model.

Dry years, including 7dQ10, 7dQ20 and 1:50 year dry years, were modelled at post closure best estimate and worst case. Dry year scenarios do not apply to operations and closure since Davidson Creek flows will be maintained by pumping water from Tatelkuz Lake to maintain IFN.

The general trend observed for dry period predictions is that 7dQ10 and 7dQ20 are approximately the same as the maxima for the 1:50 year predictions. This general rule did not hold for parameters such as dissolved aluminum whose peak background concentrations did not occur during the winter low flow minimum (February based on the Knight Piésold watershed model).

Sites off Davidson Creek and lower Chedakuz Creek will not be affected by the proposed mine's operations (Fawnie Creek and tributaries and Turtle Creek). Creek 661 may be affected from sediment control pond discharge during construction, but should be protected from the planned implementation of sediment and erosion control, (refer to SECP, **Section 12.2.1.18.4.1** for further discussion). Several hundred years after mine closure the groundwater plume from the East NAG Dump, closed open pit and closed TSF may reach Creek 661 (refer to **Section 5.3.5** for an analysis). Conservative modelling indicates the plume should meet surface water objectives when it discharges to the creek.

Predicted concentrations in Davidson Creek (WQ10/plunge pool and WQ7) and lower Chedakuz Creek (WQ9) are generally within natural annual variation. With the exception of background parameters above guidelines and possibly sulphate under the post closure worst-case scenario, all parameters are predicted to remain below all guidelines. A few parameters will require site-specific objectives due to natural background exceedances. These are total aluminum (for CCME); dissolved aluminum (for BC FWG); total cadmium (assuming the to-be-announced BC guideline is not substantially higher than the current hardness-unadjusted 0.017 µg/L); total copper; total iron (CCME) and total zinc. Recognition of occasional background exceedances of the BC FWG for total mercury in Davidson Creek, or a site-specific guideline to cover exceedances is also required.

A potential exception is dissolved sulphate. Predicted exceedances for dissolved sulphur are relatively small, and assume no sulphate reduction in the TSF, subsurface materials, or wetlands, and are therefore high. Sulphate is expected to meet guidelines.

The in-pond wetland for TSF Cell C will be constructed after three years of mining, and therefore there will be up to 15 years of monitoring to verify the wetlands are effective in lowering sulphate concentrations. Monitoring of TSF water, including water associated with PAG waste rock in the TSF, will also occur over the life of mine.

The overall design of the water management system to cluster mine facilities around the TSF, to prevent surface water discharges during operations and early closure, and to minimize seepage releases results in a robust system with general low environmental risk. Moreover, contingency measures are available as outlined in this section and the MWAMP (**Section 12.2.1.18.4.18**) to address conditions different from those modelled.

The proposed Project will not have significant effects on water quality due principally to the design providing for no surface discharge and collection and recycle of the vast majority of seepage during operations and early closure. During construction, sediment control ponds will limit or eliminate off site sediment transport. Reclamation after closure is designed to ensure water discharged from the TSF meets water quality guidelines. Residual cumulative effects would be limited to dust from combined users of the Kluskus-Ootsa FSR. Mitigation through dust control is expected to result in no significant effect on water bodies crossed by the FSR. Significance of residual cumulative effects on water quality is assessed to be not significant.