March 9, 2018

Mr. Ben Pierce
Superintendent, Environmental
Gibraltar Mines Limited
10251 Gibraltar Mine Road
McLeese Lake, BC
V0L 1P0

Dear Mr. Pierce,

Re: 2017 WQEA Report Addendum

In August 2017, Gibraltar Mine included a Water Quality Effects Assessment (WQEA) completed by Minnow Environmental Inc. (Minnow) as part of a Technical Assessment for an application to amend Permit PE-00416 for discharge of Gibraltar Mine effluent to the Fraser River at a rate of 0.285 m^3/s, a 50% increase over the currently permitted rate of 0.190 m^3/s. The WQEA (Minnow 2017) included the prediction of downstream concentrations of a number of analytes that were elevated in Gibraltar Mine effluent (relative to guidelines and/or upstream Fraser River water quality). Based on discussions during the November Technical Advisory Committee (TAC) meeting (November 9, 2017) and additional review of monitoring data, Minnow has prepared this Addendum to the 2017 WQEA report, investigating three items:

- the substantial decrease in nitrite concentrations reported in the Fraser River (post June 2015) based on data collected at the Federal/Provincial Long-Term Monitoring Station at Marguerite;
- the identification of Contaminants of Potential Concern (COPCs) for hardness-based guidelines; and
- trends in effluent COPC concentrations following inclusion of the 2017 monitoring period to determine if concentrations are still increasing.

Investigation of Fraser River Nitrite Concentrations

The WQEA (Minnow 2017) included the prediction of downstream concentrations of a number of analytes that were elevated in Gibraltar Mine effluent (relative to guidelines and/or upstream Fraser River water quality), including nitrite. The methodology relied on summary statistics calculated from Fraser River nitrite data over the period from 2009-2016 (Figure 1). The observation that concentrations of nitrite measured in water sampling conducted in 2015 and 2016 were much lower than predicted prompted an examination of available data. This examination identified an apparent substantial decrease in Fraser River (at Marguerite) nitrite concentrations following the result reported in April 2015 (Figure 1). The investigation reported herein provides a review of available data sources and changes in monitoring and/or laboratory methods that may have influenced the results.

Nitrite concentrations were retrieved for monitoring stations on the Fraser River (Marguerite, Hope) and the Nechako River (which enters the Fraser River in Prince George; EC/BCMOE long-term monitoring stations; CABIN database) and Metal Mining Effluent Regulations (MMER) reference and Gibraltar Wells stations (Gibraltar Mine). Results indicate that each of the federally monitored stations had a change in nitrite concentrations and detection limit in 2015, while the data from Gibraltar Mines has been consistent. The change for federal data is attributable to a change in laboratory (A. Yeow, Pers. Comm.). Specifically, prior to spring 2015, samples were submitted to Maxxam Analytics Ltd. located in Burnaby, BC. Following the switch, samples were submitted to ALS Environmental Inc., also in Burnaby, BC. ALS is also the laboratory that is used by the Gibraltar Mine, so it is understandable that recent monitoring data from Marguerite is similar to the routine monitoring conducted by the mine.

Maxxam Analytics in Burnaby uses a colorimetric method to determine nitrite concentrations in water. Conversely, ALS uses ion chromatography to analyze nitrate, nitrite, and nitrate+nitrite. Both methods are approved standard methods (APHA 1992a,b); however the BCMOE lab manual recommends using the colorimetric method for nitrite and nitrate+nitrite, and using ion chromatography for nitrate analysis (BCMOE 2015). Both the APHA methods and BCMOE lab manual nitrite methods have not been updated for some time (1992 and 2000, respectively), potentially missing advancements in technology (e.g., Michalski and Kurzyca 2006).

Nitrite concentrations at the federally monitored Nechako River and Marguerite (Fraser River) suggest that concentrations may be elevated within the Fraser River relative to tributaries that are joining the river (Figure 2). This is likely attributable to upstream municipal and industrial effluents entering the river in Prince George and Quesnel (i.e., pulp mill effluent, municipal sewage). Nitrite concentrations measured before and after the change in labs exhibited a similar pattern. Following the change in labs, the Nechako River measurements were consistently below the detection limit whereas nitrite concentrations at Marguerite were often detectable (Figure 2).

At this time, it is unclear whether data from before or after the laboratory change provide an accurate measure of nitrite in the Fraser River. Environment Canada is aware of the issue and is conducting an investigation, which includes submitting blind samples to both labs. They have noted a similar issue with total phosphorus (not a Gibraltar Mine COPC). Gibraltar Mine may wish to conduct a similar assessment using blind Certified Reference Material samples submitted to several laboratories. Outcomes from the investigations should indicate whether historical (pre-2015) nitrite data from Marguerite has been overestimated, or if more current (post-2015) Marguerite and Gibraltar Mine routine monitoring data have been underestimating nitrite concentrations. Once confirmed, the assessment of nitrite in relation to the WQEA will need to be revisited. If ion chromatography measurements are accurate, nitrite is no longer a COPC for the WQEA.

Analytes with Hardness Based Guidelines

The WQEA (Minnow 2017) included the identification of COPCs upon which to focus the assessment. One of the COPC identification methods involved screening Gibraltar Mine effluent against receiving environment water quality guidelines (BCMOE 2017a,b). For several metals (cadmium, copper, lead, manganese, nickel, silver, and zinc), these guidelines are based on concurrent hardness levels. Hardness is elevated in the effluent and thus the concurrent guidelines applied were accordingly high. Although there is a mechanistic basis for hardness amelioration of the potential effects of cationic metals due to competition from major cations (including calcium^{2+} and magnesium^{2+}) at uptake sites of exposed organisms (e.g., Di Toro et al. 2001), and both the metals and the co-occurring hardness would mix similarly in the receiving waters following discharge, discussion at the November TAC meeting indicated some surprise that copper was not identified as a COPC given that it had been identified as a COPC in previous assessment (e.g., Minnow 2015). As a result, the WQEA is expanded herein to consider the metals with hardness-based guidelines as potential COPCs with the application of more conservative hardness assumptions in effluent screening. Specifically, in cases where the guideline documents specify a maximum hardness to be applied to the guideline, that hardness was used to calculate applicable chronic or acute guidelines by which effluent data were screened (i.e., which were somewhat lower than the guidelines originally calculated and applied using effluent hardness).

Methods

Monthly mean hardness concentrations in effluent were always higher than the maximum applicable hardness values provided in guidance documentation, and so using the maximum applicable hardness values provided in guidance documentation was more conservative (Table 1). COPC tier I, II, and III identification, downstream water quality predictions, effluent loadings and cumulative loads were determined using the same methods as described in the WQEA. Hardness-based guideline screening of predicted downstream water quality was performed using the upstream median Fraser River hardness (64 mg/L). Use of the upstream Fraser River median hardness is also slightly more conservative than applying predicted downstream hardness after mixing has occurred.

Results

Under the more conservative hardness-based approach, total copper was the only additional analyte identified as a COPC (Tier II) due to the maximum monthly mean (0.0081 mg/L) and maximum concentration (0.024 mg/L) being within 20% of the maximum applicable chronic guideline (0.010 mg/L; Table 2). It should be noted that the maximum monthly mean and maximum effluent total copper concentrations were actually lower than their respective values in the Fraser River (0.022 and 0.037 mg/L, respectively; Table 2). In fact, all summary statistics for total copper indicated lower concentrations in effluent than in the Fraser River upstream of the effluent discharge (Table 2). In addition, 61% of monthly means and 16% of all total copper concentrations in the Fraser River exceeded the chronic and acute water quality guidelines, respectively (Table 4.1 of the WQEA). In contrast, only 2 (out of 145 samples) exceeded the chronic guideline in effluent, and none exceeded the acute guideline. No temporal trends were identified for total copper for either effluent of upstream Fraser River (Tables 3.3 and 4.2 of the WQEA), and so downstream predicted concentrations were made using the conventional summary statistics (Tables 3.2 and 4.1 of the WQEA).

The evaluation of the discharge of total copper to the Fraser River is complicated by the fact that upstream concentrations of total copper (at Marguerite) often exceed guidelines. Although predicted downstream total copper concentrations exceeded the chronic and acute water quality guidelines (based on median Fraser River hardness), this was due to the upstream median and 95th percentile Fraser River concentrations, respectively, exceeding these guidelines (Table 3). Under average case (median effluent quality), total copper was predicted to decrease slightly under all flow scenarios due to a lower median effluent total copper concentration compared to the receiving water (Table 3). Under the reasonable worst-case (95th percentile effluent quality), small discharge-induced increases above the upstream median – but not 95th percentile – copper concentration were predicted, ranging between 0.4 and 5.2% for the largest and smallest dilution ratios, respectively. For example, under likely flow scenarios (>800 m^3/s) and the median Fraser River concentration, less than 2.6% increases of total copper were predicted in the receiving water 100 m downstream of the discharge. However, hardness was predicted to increase under all mixing scenarios (Table 4), and so this small increase under the reasonable worst-case scenario is likely to be ameliorated, and not result in any discharge-induced effects to aquatic life in the receiving environment. Under extreme worst-case (maximum effluent concentration), water quality was also evaluated, although maximum effluent quality is, by definition, rare and of short duration (e.g., Figure 3). Under maximum effluent quality, water quality predictions were evaluated on the basis of acute guidelines, to be consistent with the short term nature of any effluent discharged with maximum concentrations. Under the median Fraser River total copper concentration (0.0031 mg/L), predicted downstream total copper concentrations (0.0032 to 0.0041 mg/L) were well below the acute guideline (0.0080 mg/L), indicating that discharge-induced acute effects to the receiving environment are highly unlikely most of the time. Under scenarios using 95th percentile upstream concentration (0.015 mg/L), slight discharge-induced exceedances were predicted for likely flow scenarios (>800 m^3/s), but were all less than 2.7% higher than upstream concentrations (Table 3). It should be noted that the maximum permit limit concentrations resulted in higher downstream discharge-related exceedances under likely flow scenarios (although increases were still less than 3.9%) compared to the observed maximum concentration. Given that hardness was predicted to increase under all scenarios (Table 4), the predicted, but likely small increases of total copper under the extreme worst-case scenario are likely to be ameliorated. Overall, discharge-induced exceedances of water quality guidelines are predicted to be rare (only under reasonable or extreme worst-case), and when they do occur, they are predicted to be relatively small compared to the upstream concentrations that are already in exceedance of water quality guidelines.

As expected, total copper effluent loadings increased by 50% as the effluent flow rate increased from 0.190 m^3/s to 0.285 m^3/s, and ranged between 0.00057 to 0.0019 g/s for the median and 95th percentile effluent concentration scenarios, respectively, at 0.285 m^3/s. Compared to the upstream loads at Marguerite (1.1 to 82 g/s for all scenarios and upstream concentrations; Table 5), the contribution of effluent to the total downstream loads should be less than 0.08% of the total loads for all reasonable worst-case scenarios (i.e., median Fraser River concentration, 95th percentile effluent concentration, >800 m^3/s flow rate; Table 6). The majority of total copper loads at Marguerite occurred upstream, whereby loads increased between 444% and 1,665% between Red Pass and Marguerite Stations (Table 5). Thus, compared to upstream sources, the additional total copper loads from effluent are small.

Conclusion

While predicted copper concentrations 100 m downstream of the outfall exceed upstream concentrations under reasonable worst-case scenarios (95th percentile and maximum), under most conditions, effluent discharge will not increase total copper concentrations within the Fraser River. Predicted concentrations 100 m downstream of the point of effluent discharge also reflect a very small portion of the river. Under 800 m^3/s flow conditions within the Fraser River, once effluent (at 0.285 m^3/s) is fully mixed, it contributes 0.036% to the total volume of water within the river. This is reflected in the loading contributions of effluent to the river for total copper, which should be less than 0.08% under all reasonable worst-case scenarios. Overall, it is not expected that total copper concentrations in effluent will result in any additional influence on aquatic organisms (at the higher discharge rate) relative to the total copper concentrations currently present within the river, which are already above guidelines protective of aquatic life.

2017 Data for COPCs with Increasing Trends

Several COPCs had concentrations with increasing trends in effluent over the five-year period assessed for the WQEA (Minnow 2017). However, only nitrate+nitrite and sulphate had concentrations approaching effluent permit limits. To determine if increasing trends identified for these analytes in the WQEA continued, effluent quality data for 2017 was added to the data set. Nitrate+nitrite concentrations continued to increase in 2017 relative to previous years (Figure 4), however, the rate of increase was significantly slower than the increase observed for 2014 and 2015 (Table 7). The rate of increase was also slower in 2016 than in previous years (Figure 4, Table 7). Gibraltar Mine has implemented an explosives and nitrate management plan (Hemmera 2017), which may be having a positive effect on nitrate+nitrite concentrations, limiting further increase. Nitrate+nitrite concentrations in effluent should continue to be monitored by the mine. Under current permit conditions, the Gibraltar Mine is not allowed to discharge effluent if nitrate+nitrite conditions exceed 10 mg/L

Table 7: Statistical Comparison of NO3+NO2 Slopes Among Years

ANCOVA					Slope Comparison				
Terms	Interaction	n for Analysis	Outliers Removed	p-value (covariate interaction)	Year	Intercept	Slope	Slope p-value (vs. 2017)	% Difference in Slope vs 2017
Response: NO3+NO2 Covariate: Day Factor: Year	Day*Year	122	(3)	<0.001	2014	1.8	0.0151	<0.001	-650%
					2015	4.1	0.0059	0.025	-193%
					2016	6.6	0.0013	<0.001	35%
					2017	7.0	0.0020	-	-

Dissolved sulphate concentrations exhibited a step change in 2013, increasing from approximately 1,100 mg/L to 1,600 mg/L (Figure 4). Based on the data assessed through the end of 2016, the predicted 95th percentile was 1,638 mg/L (Minnow 2017). However, in 2017, sulphate concentrations increased again, with concentrations approaching and sometimes exceeding the 1,800 mg/L Permit Limit (Figure 4). It is unclear at this time if this represents another step change or a linear increase. Sulphate concentrations within the TSF have been modelled by SRK, with results indicating that an equilibrium has likely been reached for sulphate as it has approached its saturation point (SRK 2018). SRK is continuing to work on identifying the source of sulphate within the system and is also assessing trends. Monitoring of sulphate within the TSF will be required to determine if the predicted equilibrium is accurate. While concentrations of sulphate within the TSF may be increasing, predicted concentrations at the edge of the IDZ are still 10-fold lower than applicable water quality guidelines, and therefore would not be expected to harm aquatic organisms within the Fraser River.

Conclusions

Nitrite concentrations upon which the WQEA was based have been influenced by different laboratory methods used by two analytical companies. At this time, it is unclear which method provided accurate nitrite measurements and which was over- or under-estimating results. Once this information is determined, a further assessment of nitrite concentrations in effluent and the Fraser River may be required (i.e., if ion chromatography under-estimates nitrite concentrations, which may result in higher effluent nitrite concentrations). If ion chromatography results are accurate, nitrite is no longer a COPC for the WQEA.

The screening of analytes in effluent using maximum hardness values provided in water quality guidance documents resulted in the addition of total copper to the WQEA. Based on the Fraser River and effluent data sets assessed, upstream Fraser River total copper concentrations frequently exceeded the guideline. Conversely, effluent total copper concentrations rarely exceeded the chronic guideline, and did not exceed the acute guideline. Therefore, as effluent concentrations are typically lower than Fraser River concentrations (based on summary statistics), effluent would typically be expected to decrease the total copper concentration within the river downstream of the effluent discharge. While marginal increases in total copper concentrations may occur under reasonable worst-case scenarios, the probability of this occurring is low. Additionally, under median conditions, effluent would cause a slight dilution of total copper within the Fraser River (based on median concentrations of 0.0031 and 0.0020 mg/L in the Fraser River and effluent, respectively). As total copper concentrations within the River are already consistently above guidelines protective of aquatic life, it is not expected that an increase in Gibraltar Mines effluent discharge rate will result in further degradation of water quality. The guideline for copper is currently being revised by the BCMOE. Use of dissolved copper concentrations with consideration of modifying factors, the Biotic Ligand Model will provide a better basis for future copper evaluations.

Examination of the most recently available effluent data indicated that only two analytes with increasing trends had concentrations approaching effluent permit limits (i.e., nitrate+nitrite and sulphate). The annual increase in nitrate+nitrite concentrations decreased in 2016 and 2017 relative to 2014 and 2015 increases, likely the result of the implementation of the explosive and nitrogen management plan at the mine. Results of modelling (SRK 2018) indicate sulphate has reached its equilibrium and/or saturation point in the TSF, and therefore concentrations should not continue to increase. Ongoing monitoring of analytes with concentrations approaching permit limits will provide evidence if management methods are working and predictions are accurate, with an appropriate plan of action in place should concentrations continue to increase. Regardless, Gibraltar Mine is bound by permit limits, and if concentrations do continue to increase, effluent discharge must be stopped.

Sincerely,
Minnow Environmental Inc.

Kevin Martens, B.Sc., R.P.Bio.
Senior Aquatic Ecologist

cc: Pierre Stecko, M.Sc., R.P.Bio.

<u>References</u>

Ayisha Yeow. Personal communication. Environment Canada Water Quality Monitoring and Surveillance, Environmental Monitoring Scientist. Email communication, November 27, 2017.

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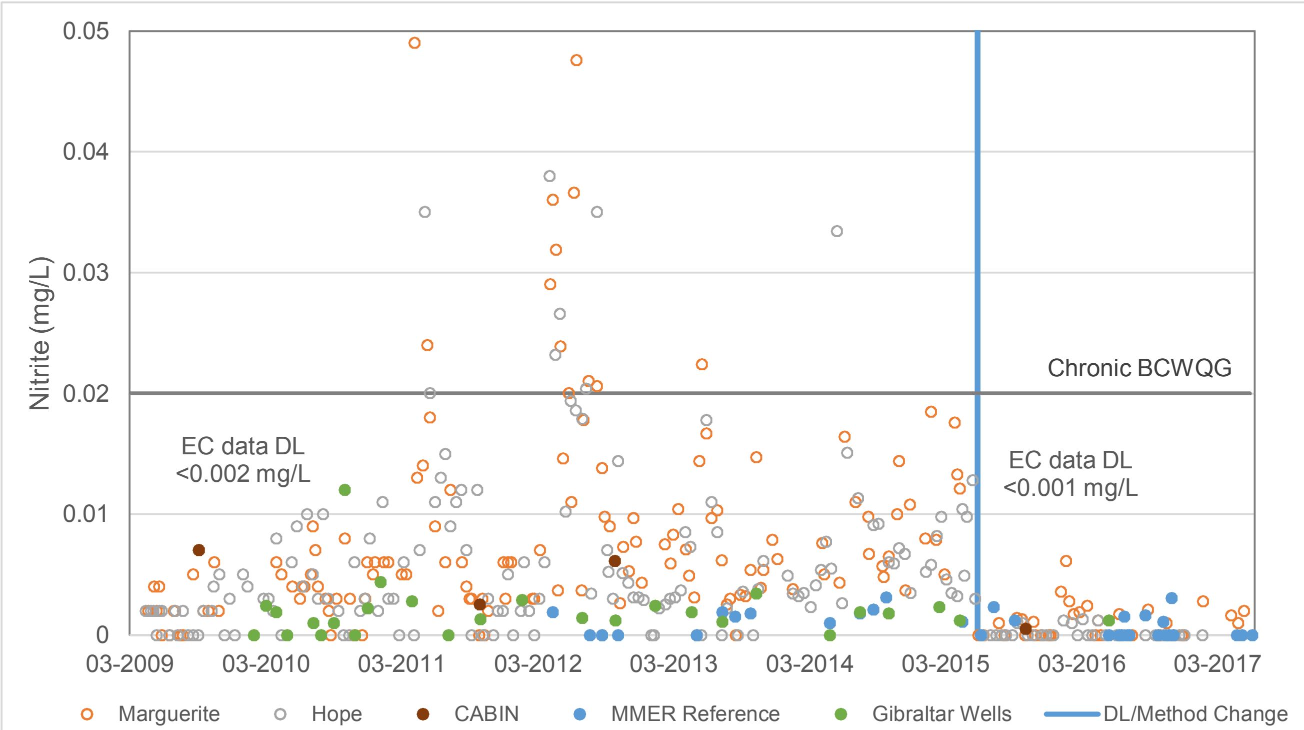


Figure 1: Fraser River Nitrite Concentrations Over Time From Various Monitoring Locations
Note: <DL values plotted as 0 along the x-axis to differentiate from other samples.

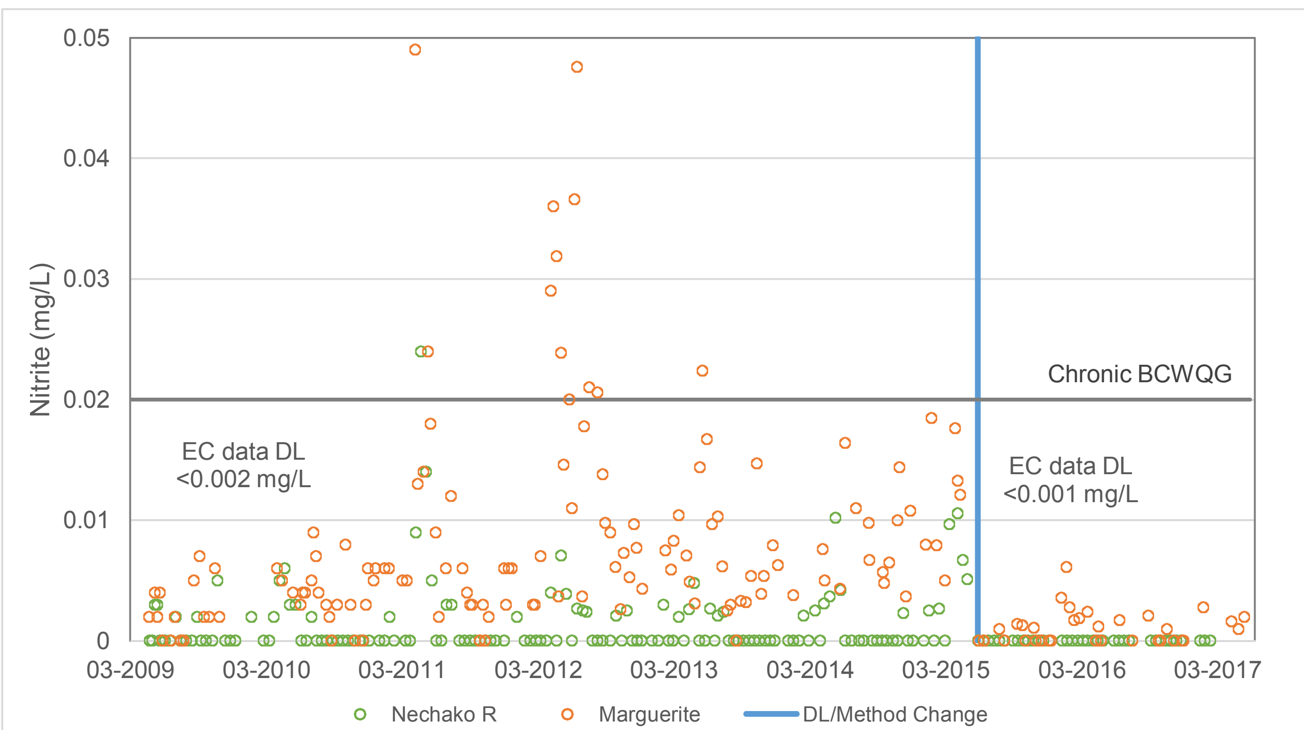


Figure 2: Nechako and Fraser River Nitrite Concentrations Over Time
Note: <DL values plotted as 0 along the x-axis to differentiate from other samples.

Table 1: Hardness-Based British Columbia and Canadian Water Quality Guidelines for the Protection of Aquatic Life

Analyte		Units	Water Quality Guidelines		Maximum Applicable Hardness (mg/L $CaCO_3$)		Maximum Applicable Guideline		Status and Source [1]
			Chronic	Acute	Chronic	Acute	Chronic	Acute	
Ions	Fluoride	mg/L	-	(-51.73 + 92.57(log(hardness))) x 0.01	-	385	-	1.9	A-B2017a
Dissolved Metals	Cadmium	mg/L	0.001 x e^(0.736(ln(hardness))-4.943)	0.001 x e^(1.03(ln(hardness))-5.274)	285	455	0.00046	0.0028	A-B2017a
Total Metals	Cadmium	mg/L	0.001 x 10^(0.83(log(hardness))-2.46)	0.001 x 10^(1.016(log(hardness))-1.71)	280	360	0.00037	0.0077	A-C2017
	Copper	mg/L	0.001 x 0.04 x hardness	0.001 x (0.094 x hardness + 2)	250	400	0.010	0.040	A-B2017a
	Lead	mg/L	0.001 x (3.31+ e^(1.273(ln(hardness))-4.704))	0.001 x e^(1.273(ln(hardness))-1.46)	360	360	0.020	0.42	A-B2017a
	Manganese	mg/L	0.0044 x hardness + 0.605	0.01102 x hardness + 0.54	450	259	2.6	3.4	A-B2017a
	Nickel	mg/L	0.025 if hardness ≤ 60mg/L 0.001 x e^(0.76(ln(hardness))+1.06); if hardness >60 to ≤180 mg/L 0.15 if hardness is ≥ 180 mg/L	-	NS	NS	0.15	-	W-B2017b
	Silver	mg/L	0.00005 if hardness ≤ 100 mg/L 0.0015 if hardness > 100 mg/L	0.0001 when hardness ≤ 100 mg/L 0.003 when hardness > 100 mg/L	NS	NS	0.0015	0.003	A-B2017a
	Zinc	mg/L	0.0075 if hardness < 90 0.001 x (7.5 + 0.75 x (hardness-90)); if hardness > 90	0.033 when hardness < 90 0.001 x (33 + 0.75 x (hardness-90)); when hardness > 90	330	500	0.19	0.34	A-B2017a

Note: NS = maximum applicable hardness not specified in guideline document

[1] A- = Approved; W- = Working; C2017 = CCME (2017); B2017a = BCMOE (2017a); B2017b = BCMOE (2017b)

Table 2: Screening of Contaminants of Potential Concern in Effluent Using the Maximum Applicable Hardness-Based Guidelines

Analyte		Units	Maximum Applicable Guideline [1]		Upstream Fraser River Summary Statistics					Effluent Summary Statistics				
					Monthly Means				All Data	Monthly Means				All Data
			Chronic	Acute	Mean	Median	95th Percentile	Maximum	Maximum	Mean	Median	95th Percentile	Maximum	Maximum
Ions	Fluoride	mg/L	-	1.9	ND [2]	ND	ND	ND	ND	0.59	0.59	0.76	0.84	1.1
Dissolved Metals	Cadmium	mg/L	0.00046	0.0028	0.000012	0.000012	0.000019	0.000019	0.000020	0.000012	0.000010	0.000017	0.000026	0.000043
Total Metals	Cadmium	mg/L	0.00037	0.0077	0.000052	0.000028	0.00016	0.00022	0.00039	0.000014	0.000012	0.000023	0.000025	0.000037
	Copper	mg/L	0.010	0.040	0.0049	0.0031	0.015	0.022	0.037	0.0023	0.0020	0.0066	0.0081	0.024
	Lead	mg/L	0.020	0.42	0.0012	0.00088	0.0037	0.0068	0.011	0.000059	0.00010	0.00012	0.00013	0.00021
	Manganese	mg/L	2.6	3.4	0.088	0.052	0.27	0.42	0.71	0.057	0.053	0.13	0.14	0.49
	Nickel	mg/L	0.15	-	0.0057	0.0034	0.018	0.026	0.044	0.0011	0.00094	0.0018	0.0018	0.0042
	Silver	mg/L	0.0015	0.003	0.000019	0.000012	0.000062	0.000082	0.00013	ND	ND	ND	ND	ND
	Zinc	mg/L	0.19	0.34	0.0084	0.0051	0.025	0.038	0.065	0.0051	<0.005	0.0058	0.0063	0.010

Exceeds chronic British Columbia Water Quality Guideline (BCMOE 2017) calculated using median upstream Fraser River hardness (64 mg/L)
Shading indicates value in exceedance of chronic guideline (indicates Tier I COPC in effluent)
Shading indicates value in exceedance of acute guideline (indicates Tier I COPC in effluent)
Shading indicates value within 20% of any guideline (indicates Tier II COPC in effluent)

[1] Calculated using maximum applicable hardness reported in guideline documentation.

Table 3: Predicted Total Copper Concentrations 100 m Downstream of the Outfall Based on Different Mixing Scenarios and Upstream and Effluent Copper Concentrations

Upstream Fraser River Concentration		Scenario	Fraser River Flow Rate	Dilution Ratio	Guidelines for Aquatic Life[1]		Units	Effluent Concentration			
					Chronic	Acute		Median	95th Percentile	Maximum	Permit Limit Maximum
							mg/L	0.0020	0.0066	0.024	0.030
Median	0.0031 mg/L	Scenario 1	7Q10 Low Flow (348 m^3/s)	20:1	0.0026	0.0080	mg/L	0.0031	**0.0033**	**0.0041**	**0.0044**
Median	0.0031 mg/L	Scenario 2	Minimum Flow (800 m^3/s)	42:1	0.0026	0.0080	mg/L	0.0031	**0.0032**	**0.0036**	**0.0038**
Median	0.0031 mg/L	Scenario 3	Median flow (1,821 m^3/s)	112:1	0.0026	0.0080	mg/L	0.0031	**0.0032**	**0.0033**	**0.0034**
Median	0.0031 mg/L	Scenario 4	7Q10 High Flow (5,473 m^3/s)	282:1	0.0026	0.0080	mg/L	0.0031	**0.0031**	**0.0032**	**0.0032**
95th Percentile	0.015 mg/L	Scenario 5	7Q10 Low Flow (348 m^3/s)	20:1	0.0026	0.0080	mg/L	0.015	0.015	**0.016**	**0.016**
95th Percentile	0.015 mg/L	Scenario 6	Minimum Flow (800 m^3/s)	42:1	0.0026	0.0080	mg/L	0.015	0.015	**0.016**	**0.016**
95th Percentile	0.015 mg/L	Scenario 7	Median flow (1,821 m^3/s)	112:1	0.0026	0.0080	mg/L	0.015	0.015	**0.015**	**0.015**
95th Percentile	0.015 mg/L	Scenario 8	7Q10 High Flow (5,473 m^3/s)	282:1	0.0026	0.0080	mg/L	0.015	0.015	**0.015**	**0.015**

Bold text - downstream Fraser River concentration greater than upstream Fraser River concentration

Exceeds chronic British Columbia Water Quality Guideline (BCMOE 2017). (blue shading)

Exceeds acute British Columbia Water Quality Guideline (BCMOE 2017). (green shading)

[1] Calculated using median upstream Fraser River hardness (64 mg/L).

Table 4: Predicted Hardness 100 m Downstream of the Outfall Based on Different Mixing Scenarios and Upstream and Effluent Hardness Concentrations.

Upstream Fraser River Concentration		Scenario	Fraser River Flow Rate	Dilution Ratio	Units	Effluent Concentration		
						Median	95th Percentile	Maximum
					mg/L	1,288	1,327	1,400
Median	64 mg/L	Scenario 1	7Q10 Low Flow (348 m^3/s)	20:1	mg/L	**122**	**124**	**127**
Median	64 mg/L	Scenario 2	Minimum Flow (800 m^3/s)	42:1	mg/L	**92**	**93**	**95**
Median	64 mg/L	Scenario 3	Median flow (1,821 m^3/s)	112:1	mg/L	**75**	**75**	**76**
Median	64 mg/L	Scenario 4	7Q10 High Flow (5,473 m^3/s)	282:1	mg/L	**68**	**68**	**69**
95th Percentile	79 mg/L	Scenario 5	7Q10 Low Flow (348 m^3/s)	20:1	mg/L	**137**	**139**	**142**
95th Percentile	79 mg/L	Scenario 6	Minimum Flow (800 m^3/s)	42:1	mg/L	**107**	**108**	**110**
95th Percentile	79 mg/L	Scenario 7	Median flow (1,821 m^3/s)	112:1	mg/L	**90**	**90**	**91**
95th Percentile	79 mg/L	Scenario 8	7Q10 High Flow (5,473 m^3/s)	282:1	mg/L	**83**	**84**	**84**

Bold text - downstream Fraser River concentration greater than upstream Fraser River concentration

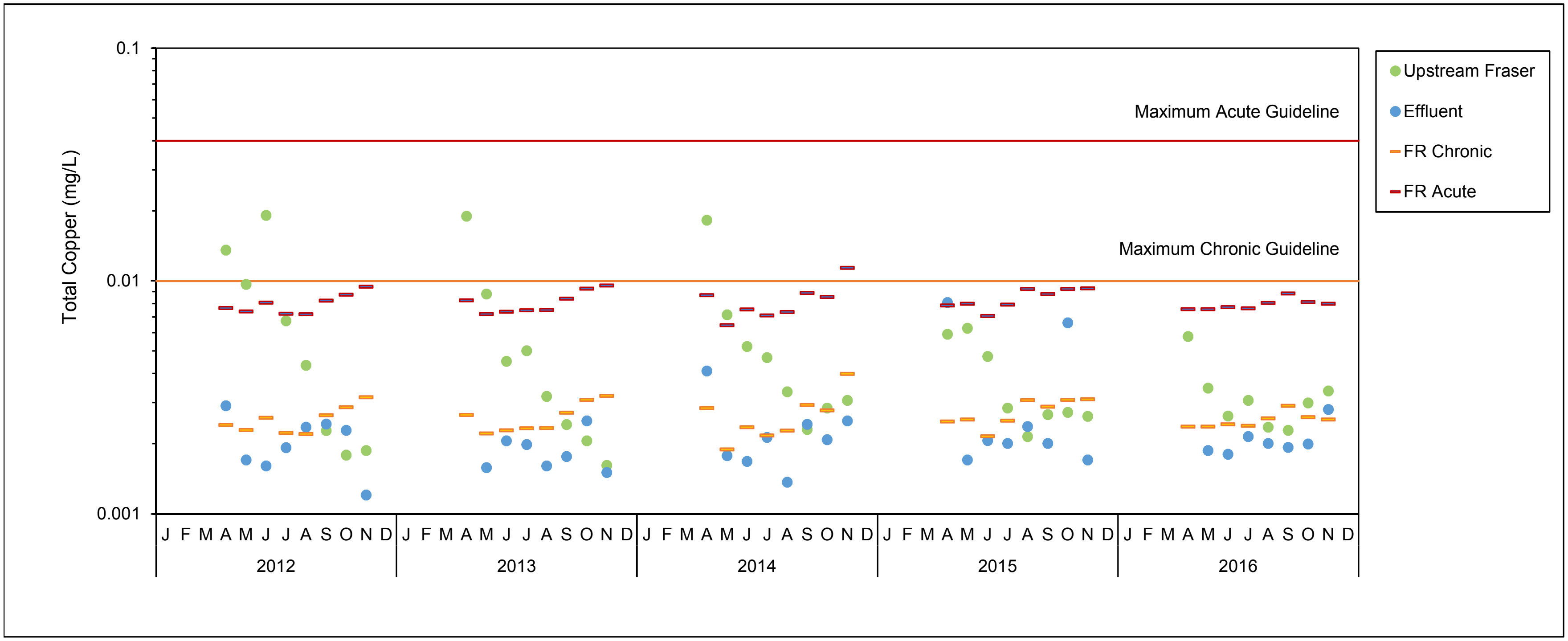


Figure 3: Temporal Variation of Total Copper (Monthly Means) and Concurrent Hardness-Based Guidelines in Effluent and Upstream Fraser River (FR) Water (Log Scale, April to November), 2012 to 2016.

Note: Missing Fraser River hardness data for May 2015 and November 2016 were substituted with the median hardness for 2012-2016 (April to November). For effluent, the minimum concurrent hardness exceeded the maximum applicable hardness, and so the maximum applicable hardness-based guideline was displayed (Table 1).

Table 5: Total Copper Instantaneous Loads and Percent Change at Marguerite Compared to Upstream at Red Pass, Fraser River

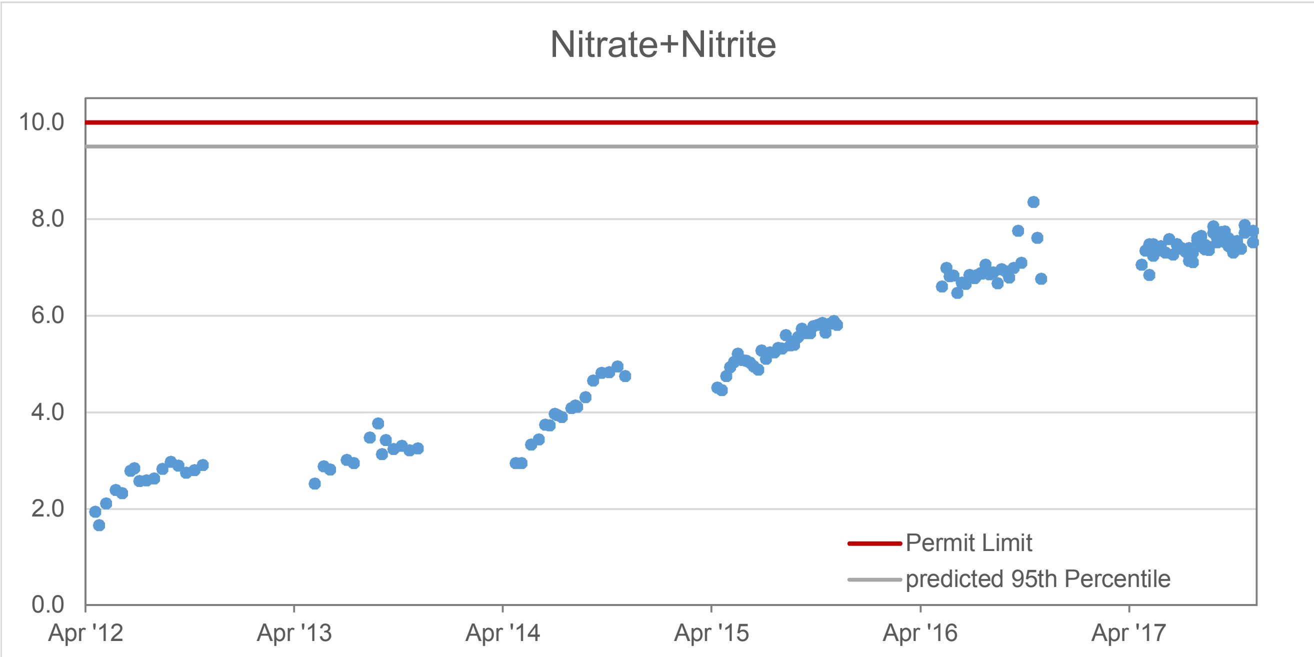
Summary Statistic	Scenario	Fraser River Flow Rate	Units	Red Pass	Marguerite	% Change [1]
Median (0.00057 mg/L for Red Pass, 0.0031 mg/L for Marguerite)	Scenario 1	7Q10 Low Flow (348 m^3/s)	g/s	0.20	1.1	444%
	Scenario 2	Minimum Flow (800 m^3/s)	g/s	0.46	2.5	
	Scenario 3	Median flow (1,821 m^3/s)	g/s	1.0	5.6	
	Scenario 4	7Q10 High Flow (5,473 m^3/s)	g/s	3.1	17	
95th Percentile (0.00085 mg/L for Red Pass, 0.015 mg/L for Marguerite)	Scenario 5	7Q10 Low Flow (348 m^3/s)	g/s	0.30	5.2	1,665%
	Scenario 6	Minimum Flow (800 m^3/s)	g/s	0.68	12	
	Scenario 7	Median flow (1,821 m^3/s)	g/s	1.5	27	
	Scenario 8	7Q10 High Flow (5,473 m^3/s)	g/s	4.7	82	

[1] Percent change = 100 x (Marguerite Load - Red Pass Load) / Red Pass Load. Since the same flow rate is used to estimate loadings for both stations, the % change are identical for all flow scenarios.

Table 6: Percent of Total Downstream Fraser River Loads of Total Copper Attributable to Effluent Discharge Under Different Flow Scenarios, Gibraltar Mine [1]

Upstream Fraser River Load Scenario	Flow Scenario	Fraser River Flow Rate	Effluent Loading Scenario			
			Median		95th Percentile	
			0.190 m^3/s	0.285 m^3/s	0.190 m^3/s	0.285 m^3/s
Median	Scenario 1	7Q10 Low Flow (348 m^3/s)	0.035%	0.053%	0.12%	0.17%
	Scenario 2	Minimum Flow (800 m^3/s)	0.015%	0.023%	0.051%	0.076%
	Scenario 3	Median flow (1,821 m^3/s)	0.0067%	0.010%	0.022%	0.033%
	Scenario 4	7Q10 High Flow (5,473 m^3/s)	0.0022%	0.0034%	0.0074%	0.011%
95th Percentile	Scenario 5	7Q10 Low Flow (348 m^3/s)	0.0073%	0.011%	0.024%	0.036%
	Scenario 6	Minimum Flow (800 m^3/s)	0.0032%	0.0047%	0.010%	0.016%
	Scenario 7	Median flow (1,821 m^3/s)	0.00139%	0.0021%	0.0046%	0.0069%
	Scenario 8	7Q10 High Flow (5,473 m^3/s)	0.00046%	0.00069%	0.0015%	0.0023%

[1] Percent Loading = 100 x Effluent Loading / (Effluent Loading + Marguerite Loading)



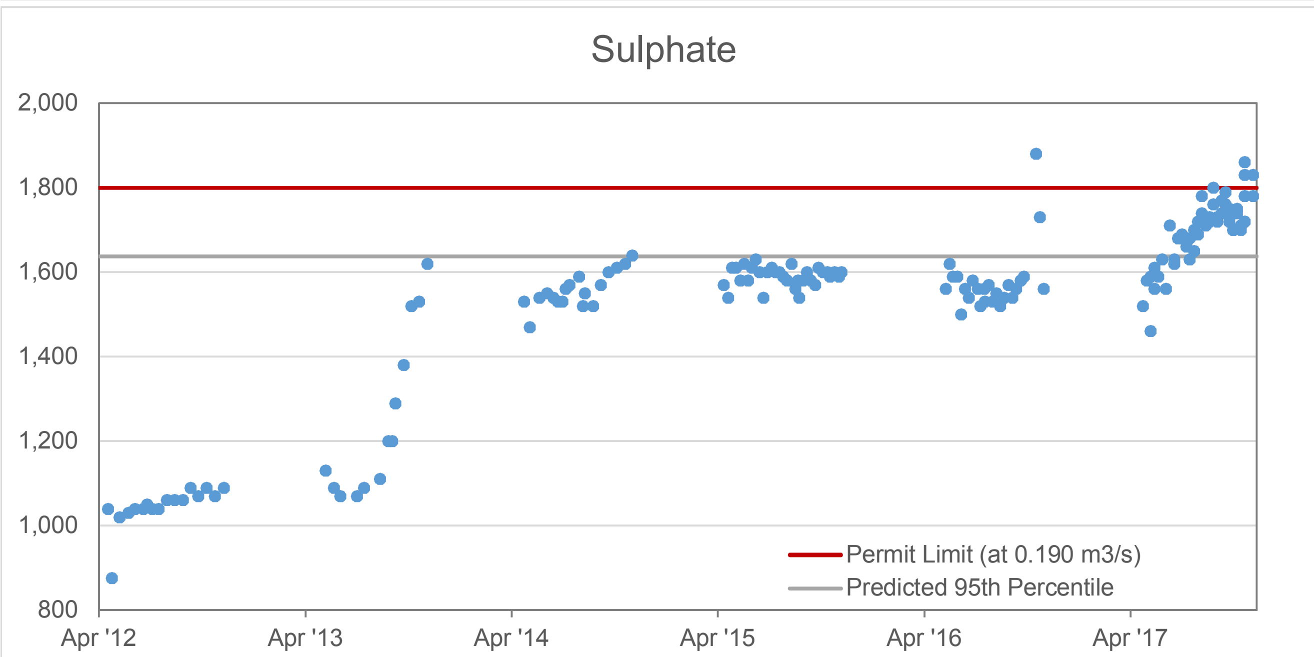


Figure 4: Concentrations of Nitrate+Nitrite and Sulphate in Effluent, 2012 to 2017