APPENDIX 15-L
SEDIMENT QUALITY MODELLING

Memorandum

DATE:	January 31, 2013
TO:	Michael Henry and Chris Burns
FROM:	Kelsey Norlund, Lesley Shelley, and Brenda Bailey
SUBJECT:	KSM Project Sediment Loadings and Partitioning Coefficients

1. Introduction

Potential KSM Project-related chemical or physical changes to sediment quality during the operation phase were evaluated by modelling the sediment loading. Many streams and rivers in the baseline study area have naturally high sediment loads due to glacial origins. The KSM Project (the Project) design includes mitigation and management strategies to control total suspended solids (TSS) concentrations in diversions and discharge from the Project to meet regulatory limits (i.e., 15 mg/L). Predicted changes to sediment loading, defined as predicted changes in TSS concentrations, were used as a screening step to identify the potential for Project-related effects on sediment quality.

During the Project operation phase, TSS is likely to decrease as mine discharges are required by the Metal Mining Effluent Regulations (MMER; SOR/2002-222) and provincial discharge permits to meet stringent TSS limits. This memo evaluates potential physical and chemical changes to sediment for key receiving environments in Treaty Creek downstream of the Tailing Management Facility (TMF) and Sulphurets Creek downstream of the Mine Site. Potential effects on Teigen Creek, also located downstream of the TMF, were not assessed because there is no discharge to the creek during the operation phase and predictions regarding TSS content of water leaving the reclaimed TMF during the closure and post-closure phases would have a high level of uncertainty.

The objectives of this memorandum are:

1. to assess potential changes to sediment loading during the operation phase of the proposed Project;
2. to calculate the partitioning coefficients between sediment and the overlying water during baseline conditions for various metals; and
3. to identify the potential for Project-related effects on sediment quality.

2. Mass Loadings of Total Suspended Solids

2.1 Methodology

2.1.1 Treaty Creek

In order to assess the potential changes to sediment loading in Treaty Creek downstream of the TMF, baseline sediment loadings were calculated ("baseline scenario") and compared to the estimated sediment loadings during mining ("mine scenario"). The estimated total mass loading at TRC2 was determined from the sum of TSS mass loadings from all the input locations into Treaty Creek

(see Table 2.1-2). TSS loading at TRC2 was estimated using monthly average TSS concentrations measured during baseline water quality studies over four years (2007 through 2011; Appendix 14-A) and estimated stream flow rates at NTR1A, NTR2, TRC1B and catchment runoff to TRC2 (Appendix 13-X). Calculations for the baseline scenario included the concentration of natural TSS and the baseline flow rate for each location as follows:

$$Total\ load\ of\ TSS\ at\ TRC2\ (mg/month) = Q_i \times [TSS_{BG}]$$

where Q_i is the flow rate in L/month at any given sampling location and [TSS] is the concentration of TSS in mg/L at any given sampling location. The estimated TSS mass loading at TRC2 during the baseline scenario was determined from the sum of TSS mass loadings from the four locations into Treaty Creek.

The mine scenario for Treaty Creek was determined using a mass balance approach as described in Chapter 14. The mass loading calculation considered the average monthly flow rates for the four sites upstream of TRC2 (Table 2.1-1, baseline scenario locations), the catchment area to TRC2 as defined in Appendices 14-F and 14-G, the diversion water directed to North Treaty, and the flow rate from the TMF discharge for the 100 years after the start-up of the Process Plant (model year 0 through 100).

Table 2.1-1. Locations Used to Estimate the Change in Total Suspended Solids due to Mining Activities in Treaty Creek

Baseline Scenario Locations	Mine Scenario Locations
NTR1A	NTR1A
NTR2	NTR2
TRC1B	TRC1B
TRC2 Catchment	TRC2 Catchment Diversion water to North Treaty Creek Tailing Management Facility discharge

The background TSS at the four baseline scenario sites was assumed to be unchanged due to Project activities, therefore the same TSS concentrations were used for these sites in the mine scenario. Water diverted from the catchment area around the TMF was assumed to have a TSS of 20 mg/L during the winter months and 75 mg/L during the summer months based on the assumption that TSS in diversion water would be lower during the winter when there would be less flow. The TSS of the TMF discharge was assumed to meet the MMER (SOR/2002-222) requirements due to the use of floating clarifiers in the active flotation pond and, consequently, 15 mg/L TSS in the TMF discharge was used in the prediction of the TSS mass loadings to TRC2.

The total discharge from the catchment area was estimated in the water balance model (see Chapters 13 and 14) based on the model outputs that were developed using the software program Goldsim™ for the surface water quantity and quality analyses.

2.1.2 Sulphurets Creek

Sulphurets Creek is the receiving environment for discharge from the Water Treatment Plant (WTP) located upstream on Mitchell Creek and non-contact water that is diverted around the proposed Mine Site including the McTagg Twinned Diversion Tunnels and the Mitchell Diversion Tunnels.

The baseline mass loading for the receiving environment was calculated based on the inputs into Sulphurets Creek upstream of monitoring station SC2, similar to the approach used at Treaty Creek

(Section 2.1.1). Monthly average TSS concentrations were measured over four years (2007 through 2011) during baseline water quality studies at MC2, GC1, SC1, and catchment runoff to SC2 as defined in Appendices 14-F and 14-G, and were used in the baseline scenario calculation of TSS mass loadings. TSS input from Ted Morris Creek was not included in the assessment because it will not be affected by discharge or diverted water during mining activities and is assumed to remain unchanged during Project activities.

Estimated baseline stream discharge rates were used for each of the sampling locations (see Chapters 13 and 14). Calculations for the baseline scenario included the concentration of natural TSS (monthly average) and the baseline flow rate (monthly average) for each location as described in Section 2.1.1. The estimated total mass loading at SC2 was determined from the sum of TSS mass loadings from all the inputs locations into Sulphurets Creek (Table 2.1-2).

Table 2.1-2. Locations Used to Estimate the Change in Total Suspended Solids due to Mining Activities in Sulphurets Creek

Baseline Scenario Locations	Mine Scenario Locations
GC1	GC1
MC2	MC2
SC1	SC1
SC2 Catchment	SC2 Catchment McTagg Twinned Diversion Tunnels Mitchell Diversion Tunnels Water Treatment Plant

The mine scenario for Sulphurets Creek included estimates of TSS inputs from the same four locations as in the baseline scenario (Table 2.1-2), diverted water from the McTagg Twinned Diversion Tunnels and Mitchell Diversion Tunnels, and discharge from the WTP. For sites included in the baseline scenario, TSS was assumed to remain unchanged and the same TSS was used for these sites in the mine scenario. The diverted water was assumed to have a TSS of 20 mg/L during the winter months and 75 mg/L during the summer months based on the assumption that sediment loading from the diversions would be lower during the winter when there would be less flow. The TSS released from the WTP was assumed to meet the maximum allowable MMER (SOR/2002-222) requirement of 15 mg/L.

The total discharge from each catchment area was estimated in the water balance model (see Chapters 13 and 14) based on the model outputs that were developed using the software program Goldsim™ for the surface water quantity and quality analysis.

2.2 Results

2.2.1 Treaty Creek

During water quality baseline studies, the background TSS at TRC2 ranged from 5 to 14 mg/L during the winter months from November through April and ranged from 116 to 470 mg/L during the summer months (Appendix 14-A). The stream bed sediments in Treaty Creek were composed mainly of sand-sized particles with some silt, reflecting the high velocity of the creek and suggesting the fine tailing particulates that may be in the effluent discharged from the TMF will have minimal impact on the sediment in Treaty Creek (Chapter 15, Table 15.1-7).

The discharge from the TMF is expected to meet the maximum allowable MMER (SOR/2002-222) requirement of 15 mg/L TSS. The TSS content of diverted water will be controlled as required in consultation with relevant government agencies; therefore, the load of TSS during Project operation

compared to baseline TSS is predicted to remain consistent for the duration of mining. The maximum estimated concentrations of TSS at TRC2 during the Project operation phase was 470 mg/L during high flow rates in September, which is similar to background conditions (Table 2.2-1). Winter TSS concentrations are estimated to be within 3% of background conditions and summer TSS concentrations are expected to remain within 11% of background conditions. The total discharge from the upstream locations to TRC2 is anticipated to be within 11% of baseline conditions during the Project operation phase. There is no overall increase in sediment loadings expected at TRC2.

2.2.2 Sulphurets Creek

The background TSS at SC2 ranged from 9.8 to 28.3 mg/L during the winter months from November through April and ranged from 113.9 to 234.2 mg/L during the summer months (Appendix 14-A). The stream bed sediments in Sulphurets Creek were composed mainly of sand-sized particles, similar to Treaty Creek, reflecting the high velocity of the creek (Chapter 15, Table 15.1-7). The estimated concentration of TSS at SC2 in the mine scenario ranged from 7.5 to 22 mg/L during the winter months during the Project operation phase, which is within the range of observed background TSS concentrations (Table 2.2-2). The total TSS mass loading was estimated to be consistent with baseline conditions for the duration of mining.

The difference in total mass loading between the baseline and mine scenario during the winter months ranged from a decrease of 60% to an increase of 5% over baseline TSS load, with a 30% decrease on average over the entire winter (Table 2.2-2). In the summer, however, the concentration of TSS was estimated to range between 52 and 108 mg/L over the course of mining, which was lower than the observed baseline range of TSS at SC2. A decrease in total load by 30 to 70% is predicted during the summer months (Table 2.2-2). Overall, no increase in TSS loading is predicted during the Project operation phase.

The mass balance calculation approach used to estimate the change in TSS concentrations due to Project activities does not consider the loss of sediment between the upstream sampling locations and SC2; therefore, TSS concentrations may be overestimated if sediment deposition occurs between the upstream catchment sampling locations (GC1, MC2, or SC1) and SC2.

3. Sediment Partitioning Coefficients

3.1 Methodology

Partitioning coefficients (K_d) can be used to describe the relationship between the concentrations of dissolved metals in surface water and metals in stream bed sediments at the time of sample collection. Partitioning coefficients based solely on water and sediment concentrations of metals exclude information on mineral phases, sediment-pore water interactions and TSS-sediment interactions. While the K_d can oversimplify the complex relationship between these two environmental media, it can still be helpful in providing an indication of how metals may move from water to sediment.

For key receiving environments downstream of the TMF (NTR2, TRC2, STE3, and TEC2) or Water Storage Facility (WSF) / Water Treatment Plant discharges (SC2, SC3, UR1, and UR2), K_d values were calculated using baseline sediment and water chemistry data. For this purpose, only data collected during the November/December 2012 baseline sampling event was included, which consisted of the collection of three to five sediment samples and one water sample from each site. The November/December 2012 baseline data was selected because sediment and water quality samples were collected concurrently from the same sites during this sampling event. Sediment quality baseline data in previous years (2008 to 2010) often had higher detection limits, and are therefore excluded from K_d calculations.

Table 2.2-1. Estimated Total Suspended Solid Loadings for Baseline and Mine Scenarios for Treaty Creek (TRC2)

	Baseline Scenario			Mine Scenario				
Month	TSS (mg/L)	TRC2 Flow (L/month)	Monthly Load (kg)	Estimated TSS (mg/L)	Estimated Flow at TRC2 (L/month)	Estimate Monthly TSS Mass Load (kg)	Ratio of Mine Scenario to Baseline Scenario	Average Ratio of Mine Scenario to Baseline Scenario
January	4.3	7.11E+09	3.02E+04	7	7.13E+09	4.74E+04	1.57	**Winter = 0.97**
February	27.8	6.52E+09	1.79E+05	14	6.52E+09	9.12E+04	0.51	
March	2.6	6.64E+09	1.71E+04	8	6.67E+09	5.06E+04	2.96	
April	23.9	1.67E+10	3.94E+05	8	1.67E+10	1.31E+05	0.33	
May	106.5	6.00E+10	6.32E+06	116	6.02E+10	7.01E+06	1.11	
June	134.4	1.12E+11	1.48E+07	119	1.12E+11	1.33E+07	0.90	
July	153.8	1.14E+11	1.73E+07	119	1.19E+11	1.42E+07	0.82	**Summer = 0.89**
August	301.7	8.88E+10	2.65E+07	126	9.44E+10	1.19E+07	0.45	
September	410.6	6.28E+10	2.55E+07	470	6.48E+10	3.05E+07	1.19	
October	172.1	4.78E+10	8.14E+06	13	4.92E+10	6.61E+05	0.08	
November	6.5	2.08E+10	1.34E+05	5	2.09E+10	1.03E+05	0.77	
December	10	9.84E+09	9.74E+04	6	9.88E+09	5.62E+04	0.58	

Table 2.2-2. Estimated Total Suspended Solid (TSS) Loadings for Baseline and Mine Scenarios for Sulphuretts Creek (SC2)

		Baseline Scenario			Mine Scenario			Ratio of Mine Scenario to Baseline Scenario
Year	Month	TSS (mg/L)	SC2 Flow (L/mon)	Monthly Load (kg)	Estimated TSS (mg/L)	Estimated Flow to SC2 (L/mon)	Estimated Monthly TSS Mass Load (kg)	
0 to 5	January	12.6	6.86E+09	8.64E+04	10	7.16E+09	6.93E+04	0.80
	February	10.5	5.93E+09	6.23E+04	9.1	6.08E+09	55327.3	0.89
	March	9.8	5.29E+09	5.16E+04	9.5	5.75E+09	54450.8	1.05
	April	28.3	7.27E+09	2.06E+05	20.9	8.46E+09	176011.5	0.86
	May	95.1	3.33E+10	3.16E+06	52	3.77E+10	1.95E+06	0.62
	June	192.3	7.21E+10	1.39E+07	82	7.41E+10	6.05E+06	0.44
	July	226.5	1.03E+11	2.33E+07	83	1.02E+11	8.53E+06	0.37
	August	234.2	1.05E+11	2.47E+07	108	1.05E+11	1.13E+07	0.46
	September	212.1	8.01E+10	1.70E+07	74	7.95E+10	5.92E+06	0.35
	October	113.9	2.95E+10	3.36E+06	78	3.13E+10	2.44E+06	0.73
	November	20.5	1.08E+10	2.21E+05	10.9	1.13E+10	123122.4	0.56
	December	26.3	6.09E+09	1.60E+05	11.6	6.08E+09	70704.5	0.44
5 to 10	January	12.6	6.86E+09	8.64E+04	9.2	6.62E+09	61114.3	0.71
	February	10.5	5.93E+09	6.23E+04	8.7	5.66E+09	49108.6	0.79
	March	9.8	5.29E+09	5.16E+04	8.8	5.16E+09	45511.5	0.88
	April	28.3	7.27E+09	2.06E+05	22.2	6.87E+09	152302.8	0.74
	May	95.1	3.33E+10	3.16E+06	54	3.52E+10	1.91E+06	0.60
	June	192.3	7.21E+10	1.39E+07	78	7.78E+10	6.10E+06	0.44
	July	226.5	1.03E+11	2.33E+07	81	1.06E+11	8.59E+06	0.37
	August	234.2	1.05E+11	2.47E+07	105	1.08E+11	1.13E+07	0.46
	September	212.1	8.01E+10	1.70E+07	75	7.86E+10	5.91E+06	0.35
	October	113.9	2.95E+10	3.36E+06	87	2.75E+10	2.38E+06	0.71
	November	20.5	1.08E+10	2.21E+05	10.6	1.04E+10	110607.3	0.50
	December	26.3	6.09E+09	1.60E+05	11.4	5.74E+09	65651.8	0.41
10 to 15	January	12.6	6.86E+09	8.64E+04	9.0	6.43E+09	58117.1	0.67
	February	10.5	5.93E+09	6.23E+04	8.5	5.51E+09	46638.5	0.75
	March	9.8	5.29E+09	5.16E+04	8.6	5.03E+09	43430.5	0.84
	April	28.3	7.27E+09	2.06E+05	22.2	6.79E+09	150816.3	0.73
	May	95.1	3.33E+10	3.16E+06	56	3.36E+10	1.87E+06	0.59
	June	192.3	7.21E+10	1.39E+07	77	7.86E+10	6.08E+06	0.44
	July	226.5	1.03E+11	2.33E+07	80	1.07E+11	8.57E+06	0.37
	August	234.2	1.05E+11	2.47E+07	104	1.09E+11	1.13E+07	0.46
	September	212.1	8.01E+10	1.70E+07	75	7.79E+10	5.88E+06	0.35
	October	113.9	2.95E+10	3.36E+06	82	2.94E+10	2.40E+06	0.71
	November	20.5	1.08E+10	2.21E+05	10.5	1.03E+10	108692.1	0.49
	December	26.3	6.09E+09	1.60E+05	11.4	5.79E+09	66146.8	0.41
15 to 20	January	12.6	6.86E+09	8.64E+04	8.8	6.20E+09	54627.3	0.63
	February	10.5	5.93E+09	6.23E+04	8.1	5.23E+09	42458.1	0.68
	March	9.8	5.29E+09	5.16E+04	8.3	4.81E+09	40035.0	0.78
	April	28.3	7.27E+09	2.06E+05	22.2	6.77E+09	150440.2	0.73
	May	95.1	3.33E+10	3.16E+06	56	3.33E+10	1.86E+06	0.59
	June	192.3	7.21E+10	1.39E+07	77	7.84E+10	6.07E+06	0.44
	July	226.5	1.03E+11	2.33E+07	80	1.07E+11	8.55E+06	0.37
	August	234.2	1.05E+11	2.47E+07	104	1.09E+11	1.13E+07	0.46
	September	212.1	8.01E+10	1.70E+07	75	7.80E+10	5.87E+06	0.35
	October	113.9	2.95E+10	3.36E+06	78	3.11E+10	2.42E+06	0.72
	November	20.5	1.08E+10	2.21E+05	10.6	1.05E+10	111294.3	0.50
	December	26.3	6.09E+09	1.60E+05	11.4	5.77E+09	65854.9	0.41
20 to 25	January	12.6	6.86E+09	8.64E+04	8.8	6.20E+09	54547.3	0.63
	February	10.5	5.93E+09	6.23E+04	8.1	5.23E+09	42399.4	0.68
	March	9.8	5.29E+09	5.16E+04	8.3	4.80E+09	39981.0	0.77
	April	28.3	7.27E+09	2.06E+05	22.2	6.77E+09	150373.3	0.73
	May	95.1	3.33E+10	3.16E+06	56	3.30E+10	1.86E+06	0.59

(continued)

Table 2.2-2. Estimated Total Suspended Solid (TSS) Loadings for Baseline and Mine Scenarios for Sulphuretts Creek (SC2) (continued)

		Baseline Scenario			Mine Scenario			Ratio of Mine Scenario to Baseline Scenario
Year	Month	TSS (mg/L)	SC2 Flow (L/mon)	Monthly Load (kg)	Estimated TSS (mg/L)	Estimated Flow to SC2 (L/mon)	Estimated Monthly TSS Mass Load (kg)	
	June	192.3	7.21E+10	1.39E+07	77	7.84E+10	6.07E+06	0.44
	July	226.5	1.03E+11	2.33E+07	80	1.07E+11	8.54E+06	0.37
	August	234.2	1.05E+11	2.47E+07	104	1.09E+11	1.13E+07	0.46
	September	212.1	8.01E+10	1.70E+07	75	7.80E+10	5.86E+06	0.35
	October	113.9	2.95E+10	3.36E+06	78	3.11E+10	2.42E+06	0.72
	November	20.5	1.08E+10	2.21E+05	10.5	1.03E+10	107746.4	0.49
	December	26.3	6.09E+09	1.60E+05	11.4	5.77E+09	65829.6	0.41
25 to 30	January	12.6	6.86E+09	8.64E+04	8.7	6.06E+09	52480.1	0.61
	February	10.5	5.93E+09	6.23E+04	8.1	5.22E+09	42298.8	0.68
	March	9.8	5.29E+09	5.16E+04	8.3	4.80E+09	39877.8	0.77
	April	28.3	7.27E+09	2.06E+05	22.2	6.76E+09	150230.8	0.73
	May	95.1	3.33E+10	3.16E+06	56	3.29E+10	1.85E+06	0.59
	June	192.3	7.21E+10	1.39E+07	75	8.09E+10	6.09E+06	0.44
	July	226.5	1.03E+11	2.33E+07	79	1.09E+11	8.57E+06	0.37
	August	234.2	1.05E+11	2.47E+07	102	1.11E+11	1.13E+07	0.46
	September	212.1	8.01E+10	1.70E+07	75	7.79E+10	5.86E+06	0.34
	October	113.9	2.95E+10	3.36E+06	78	3.11E+10	2.42E+06	0.72
	November	20.5	1.08E+10	2.21E+05	10.5	1.04E+10	109424.5	0.50
	December	26.3	6.09E+09	1.60E+05	11.4	5.76E+09	65670.4	0.41
30 to 35	January	12.6	6.86E+09	8.64E+04	8.9	6.34E+09	56568.2	0.65
	February	10.5	5.93E+09	6.23E+04	8.2	5.32E+09	43802.0	0.70
	March	9.8	5.29E+09	5.16E+04	8.4	4.90E+09	41352.9	0.80
	April	28.3	7.27E+09	2.06E+05	22.2	6.76E+09	150172.3	0.73
	May	95.1	3.33E+10	3.16E+06	56	3.29E+10	1.85E+06	0.59
	June	192.3	7.21E+10	1.39E+07	75	8.15E+10	6.10E+06	0.44
	July	226.5	1.03E+11	2.33E+07	78	1.10E+11	8.58E+06	0.37
	August	234.2	1.05E+11	2.47E+07	101	1.12E+11	1.13E+07	0.46
	September	212.1	8.01E+10	1.70E+07	75	7.79E+10	5.86E+06	0.34
	October	113.9	2.95E+10	3.36E+06	78	3.09E+10	2.42E+06	0.72
	November	20.5	1.08E+10	2.21E+05	10.6	1.05E+10	110934.3	0.50
	December	26.3	6.09E+09	1.60E+05	11.4	5.76E+09	65647.7	0.41
35 to 40	January	12.6	6.86E+09	8.64E+04	8.9	6.34E+09	56568.2	0.65
	February	10.5	5.93E+09	6.23E+04	8.2	5.32E+09	43802.0	0.70
	March	9.8	5.29E+09	5.16E+04	8.4	4.90E+09	41352.9	0.80
	April	28.3	7.27E+09	2.06E+05	22.2	6.76E+09	150172.3	0.73
	May	95.1	3.33E+10	3.16E+06	56	3.29E+10	1.85E+06	0.59
	June	192.3	7.21E+10	1.39E+07	75	8.17E+10	6.10E+06	0.44
	July	226.5	1.03E+11	2.33E+07	78	1.10E+11	8.58E+06	0.37
	August	234.2	1.05E+11	2.47E+07	101	1.12E+11	1.13E+07	0.46
	September	212.1	8.01E+10	1.70E+07	75	7.79E+10	5.86E+06	0.34
	October	113.9	2.95E+10	3.36E+06	78	3.11E+10	2.42E+06	0.72
	November	20.5	1.08E+10	2.21E+05	10.6	1.04E+10	110157.0	0.50
	December	26.3	6.09E+09	1.60E+05	11.4	5.76E+09	65647.7	0.41
40 to 45	January	12.6	6.86E+09	8.64E+04	8.9	6.34E+09	56568.2	0.65
	February	10.5	5.93E+09	6.23E+04	8.2	5.32E+09	43802.0	0.70
	March	9.8	5.29E+09	5.16E+04	8.4	4.90E+09	41352.9	0.80
	April	28.3	7.27E+09	2.06E+05	22.2	6.76E+09	150172.3	0.73
	May	95.1	3.33E+10	3.16E+06	56	3.29E+10	1.85E+06	0.59
	June	192.3	7.21E+10	1.39E+07	75	8.16E+10	6.10E+06	0.44
	July	226.5	1.03E+11	2.33E+07	78	1.10E+11	8.58E+06	0.37
	August	234.2	1.05E+11	2.47E+07	102	1.11E+11	1.13E+07	0.46
	September	212.1	8.01E+10	1.70E+07	75	7.79E+10	5.86E+06	0.34

(continued)

Table 2.2-2. Estimated Total Suspended Solid (TSS) Loadings for Baseline and Mine Scenarios for Sulphuretts Creek (SC2) (completed)

		Baseline Scenario			Mine Scenario			Ratio of Mine Scenario to Baseline Scenario
Year	Month	TSS (mg/L)	SC2 Flow (L/mon)	Monthly Load (kg)	Estimated TSS (mg/L)	Estimated Flow to SC2 (L/mon)	Estimated Monthly TSS Mass Load (kg)	
	October	113.9	2.95E+10	3.36E+06	78	3.11E+10	2.42E+06	0.72
	November	20.5	1.08E+10	2.21E+05	10.6	1.05E+10	110934.3	0.50
	December	26.3	6.09E+09	1.60E+05	11.4	5.76E+09	65647.7	0.41
45 to 50	January	12.6	6.86E+09	8.64E+04	8.9	6.34E+09	56568.2	0.65
	February	10.5	5.93E+09	6.23E+04	8.2	5.32E+09	43802.0	0.70
	March	9.8	5.29E+09	5.16E+04	8.4	4.90E+09	41352.9	0.80
	April	28.3	7.27E+09	2.06E+05	22.2	6.76E+09	150172.3	0.73
	May	95.1	3.33E+10	3.16E+06	56	3.29E+10	1.85E+06	0.59
	June	192.3	7.21E+10	1.39E+07	75	8.15E+10	6.10E+06	0.44
	July	226.5	1.03E+11	2.33E+07	78	1.09E+11	8.58E+06	0.37
	August	234.2	1.05E+11	2.47E+07	101	1.12E+11	1.13E+07	0.46
	September	212.1	8.01E+10	1.70E+07	75	7.79E+10	5.86E+06	0.34
	October	113.9	2.95E+10	3.36E+06	78	3.11E+10	2.42E+06	0.72
	November	20.5	1.08E+10	2.21E+05	10.6	1.04E+10	110157.0	0.50
	December	26.3	6.09E+09	1.60E+05	11.4	5.76E+09	65647.7	0.41
50 to 55	January	12.6	6.86E+09	8.64E+04	8.0	5.77E+09	46582.2	0.54
	February	10.5	5.93E+09	6.23E+04	7.5	4.99E+09	37696.1	0.60
	March	9.8	5.29E+09	5.16E+04	7.7	4.57E+09	35371.0	0.68
	April	28.3	7.27E+09	2.06E+05	22.3	6.43E+09	143735.5	0.70
	May	95.1	3.33E+10	3.16E+06	55	3.11E+10	1.71E+06	0.54
	June	192.3	7.21E+10	1.39E+07	79	7.22E+10	5.73E+06	0.41
	July	226.5	1.03E+11	2.33E+07	83	9.60E+10	7.91E+06	0.34
	August	234.2	1.05E+11	2.47E+07	109	9.80E+10	1.06E+07	0.43
	September	212.1	8.01E+10	1.70E+07	79	6.79E+10	5.36E+06	0.32
	October	113.9	2.95E+10	3.36E+06	89	2.48E+10	2.20E+06	0.65
	November	20.5	1.08E+10	2.21E+05	9.4	8.93E+09	84233.4	0.38
	December	26.3	6.09E+09	1.60E+05	10.5	5.09E+09	53749.5	0.34
55 to 65	January	12.6	6.86E+09	8.64E+04	8.9	6.20E+09	55226.9	0.64
	February	10.5	5.93E+09	6.23E+04	8.4	5.36E+09	45011.4	0.72
	March	9.8	5.29E+09	5.16E+04	8.6	4.93E+09	42589.2	0.82
	April	28.3	7.27E+09	2.06E+05	22.2	6.90E+09	152982.4	0.74
	May	95.1	3.33E+10	3.16E+06	56	3.31E+10	1.86E+06	0.59
	June	192.3	7.21E+10	1.39E+07	76	8.05E+10	6.10E+06	0.44
	July	226.5	1.03E+11	2.33E+07	79	1.10E+11	8.67E+06	0.37
	August	234.2	1.05E+11	2.47E+07	102	1.12E+11	1.14E+07	0.46
	September	212.1	8.01E+10	1.70E+07	79	7.38E+10	5.86E+06	0.35
	October	113.9	2.95E+10	3.36E+06	89	2.68E+10	2.39E+06	0.71
	November	20.5	1.08E+10	2.21E+05	10.4	9.84E+09	102543.3	0.46
	December	26.3	6.09E+09	1.60E+05	11.5	5.58E+09	63934.2	0.40
65 to 100	January	12.6	6.86E+09	8.64E+04	9.0	6.27E+09	56619.8	0.66
	February	10.5	5.93E+09	6.23E+04	8.5	5.41E+09	46100.9	0.74
	March	9.8	5.29E+09	5.16E+04	8.8	4.99E+09	43664.6	0.85
	April	28.3	7.27E+09	2.06E+05	22.2	6.97E+09	154414.6	0.75
	May	95.1	3.33E+10	3.16E+06	57	3.34E+10	1.89E+06	0.60
	June	192.3	7.21E+10	1.39E+07	75	8.17E+10	6.16E+06	0.44
	July	226.5	1.03E+11	2.33E+07	79	1.10E+11	8.67E+06	0.37
	August	234.2	1.05E+11	2.47E+07	102	1.12E+11	1.14E+07	0.46
	September	212.1	8.01E+10	1.70E+07	79	7.38E+10	5.86E+06	0.34
	October	113.9	2.95E+10	3.36E+06	89	2.68E+10	2.39E+06	0.71
	November	20.5	1.08E+10	2.21E+05	10.4	9.83E+09	102394.6	0.46
	December	26.3	6.09E+09	1.60E+05	11.5	5.58E+09	63848.0	0.40

To calculate K_d for each metal at each sampling site, the following equation was used:

$$K_d = log\left(\frac{mean\ sediment\ metal\ concentration}{water\ metal\ concentration}\right)$$

The K_d was only calculated when both the mean sediment and water metal concentrations were above detection limits. A number of metals (beryllium, barium, cobalt, copper, iron, lead, mercury, phosphorus, silver, thallium, tin, titanium, vanadium, and zinc) were below detection limits in the water at the four sites downstream of the TMF and have therefore been excluded from analysis. Similarly, beryllium, bismuth, chromium, iron, lead, mercury, phosphorus, silver, tin, titanium, and vanadium were excluded at the four sites downstream of the Mine Site since they were below detection limits in the water sample. Sodium was also excluded since the concentration was lower than detection limits in sediment samples.

3.2 Results

Results are summarized in Table 3.2-1 for sampling sites downstream of the TMF and WSF/WTP discharges. The K_d was positive for each metal suggesting that, at the time of sampling, sediment was a sink for dissolved metals (i.e., gradient for metal movement from water to sediment). The K_d for a metal was often similar between sampling sites downstream of the TMF or Mine Site, even though the underlying sediment and water chemistry differed. However, it is unknown whether this relationship varies with seasons or inter-annually.

The use of the K_d values for predictive purposes has limited value since it oversimplifies the complex relationships between sediment and water metal chemistry and does not incorporate movement of metals between other compartments such as TSS or sediment pore water. Based on the K_d from baseline studies, it is likely that the sediment metal concentrations will follow water concentrations (i.e., if water concentrations go down, sediment concentrations will also go down and vice versa).

4. Potential Changes to Sediment Quality

Total suspended solids were used as a proxy for predicted sediment quality changes at the proposed Project site. Overall, TSS loadings are expected to remain the same or decrease in both the Treaty Creek and Sulphurets Creek. The concentration of TSS is anticipated to remain within 11% of natural background conditions in Treaty Creek. In Sulphurets Creek, the TSS concentrations are anticipated to decrease on average by 30% in the winter during the low-flow season and by approximately 52% in the summer months during high-flow season. Partitioning coefficients were calculated to establish the baseline relationship between the concentrations of dissolved metals in surface water and metals in stream bed sediments in receiving environments downstream of the TMF and Mine Site WTP. Uncertainty associated with the K_d predictions limits its use to predict potential changes to the sediment quality, and therefore, only TSS was used in the predictive calculations. Changes in sediment loadings (i.e., changes in TSS concentrations) are not anticipated to affect sediment quality. Monitoring of the sediment in Treaty and Sulphurets creeks, as described in the Aquatic Effects Monitoring Plan, will be used to monitor sediment quality over time.

Table 3.2-1. Calculation of Baseline Sediment-Water Partitioning Coefficient (K_d) for Key Areas Downstream of Discharge Points

	Downstream of TMF Discharge												
	NTR2 Site			NTR2 Site			STE3			TEC2			All 4 Sites	
Metal	Sediment Concentration	Water Concentration	NTR2 $LogK_d$	Sediment Concentration	Water Concentration	TRC2 $LogK_d$	Sediment Concentration	Water Concentration	STE3 $LogK_d$	Sediment Concentration	Water Concentration	TEC2 $LogK_d$	$LogK_d$ Mean	$LogK_d$ SD
Aluminum (Al)-Total	21900	0.0053	6.62	15133	0.0036	6.62	20800	0.0055	6.58	20433	0.0049	6.62	6.61	0.02
Antimony (Sb)-Total	0.3833	<0.0001	n/a	2.360	0.00032	3.87	0.4900	<0.0001	n/a	0.3433	<0.0001	n/a	n/a	n/a
Arsenic (As)-Total	8.27	<0.0001	n/a	22.40	0.00021	5.03	9.073	0.00010	4.96	7.013	0.00011	4.80	4.93	0.11
Barium (Ba)-Total	109.9	0.0204	3.73	64.47	0.0315	3.31	75.23	0.0220	3.53	99.43	0.0185	3.73	3.53	0.20
Cadmium (Cd)-Total	0.2317	<0.00001	n/a	0.9240	0.000027	4.53	0.2577	<0.00001	n/a	0.2107	<0.00001	n/a	n/a	n/a
Calcium (Ca)-Total	2757	16.5	2.22	12800	48.4	2.42	2953	32.8	1.95	4020	22.9	2.24	2.21	0.19
Chromium (Cr)-Total	95.27	0.00021	5.66	31.57	0.00011	5.46	109.0	0.00021	5.72	95.07	0.00020	5.68	5.63	0.12
Lithium (Li)-Total	39.13	0.00060	4.81	23.77	0.00077	4.49	36.67	<0.005	n/a	29.8	0.00063	4.67	4.66	0.16
Magnesium (Mg)-Total	16633	3.64	3.66	11400	8.21	3.14	17000	6.62	3.41	15867	5.72	3.44	3.41	0.21
Manganese (Mn)-Total	514	0.000368	6.15	742.3	0.0141	4.72	449.3	0.00172	5.42	466.3	0.00155	5.48	5.44	0.58
Molybdenum (Mo)-Total	1.293	0.000424	3.48	2.237	0.00144	3.19	1.320	0.000468	3.45	0.8867	0.000338	3.42	3.39	0.13
Nickel (Ni)-Total	115.7	<0.005	n/a	43.17	0.00113	4.58	126.7	0.00055	5.36	117	0.00051	5.36	5.10	0.45
Potassium (K)-Total	1307	0.263	3.70	413.3	0.298	3.14	1043	0.262	3.60	1023	0.268	3.58	3.51	0.25
Selenium (Se)-Total	0.540	0.00077	2.85	1.280	0.00066	3.29	0.590	0.00099	2.78	0.410	0.00050	2.91	2.96	0.23
Strontium (Sr)-Total	30.13	0.176	2.23	63.87	0.381	2.22	34.33	0.347	2.00	32.67	0.190	2.24	2.17	0.12
Uranium (U)-Total	0.166	<0.00001	n/a	0.386	0.000080	3.68	0.1477	0.000020	3.87	0.1713	0.000014	4.09	3.88	0.20

	Downstream of WSF/WTP Discharge												
	SC2			SC3			UR1			UR2			All 4 Sites	
Metal	Sediment Concentration	Water Concentration	STE3 $LogK_d$	Sediment Concentration	Water Concentration	NTR2 $LogK_d$	Sediment Concentration	Water Concentration	NTR2 $LogK_d$	Sediment Concentration	Water Concentration	NTR2 $LogK_d$	$LogK_d$ Mean	$LogK_d$ SD
Aluminum (Al)-Total	12500	0.0458	5.44	12960	0.0525	5.39	14900	0.0387	5.59	13600	0.0223	5.79	5.55	0.18
Antimony (Sb)-Total	2.45	0.00055	3.65	2.578	0.00052	3.70	2.017	0.00095	3.33	1.047	0.00042	3.40	3.52	0.18
Arsenic (As)-Total	15.1	<0.0001	n/a	15.90	<0.0001	n/a	15.60	0.00010	5.19	10.11	0.00020	4.70	4.95	0.35
Barium (Ba)-Total	95.4	0.0408	3.37	84.22	0.0410	3.31	75.10	0.0370	3.31	86.78	0.0392	3.35	3.33	0.03
Cadmium (Cd)-Total	0.819	0.00171	2.68	0.9948	0.00115	2.94	0.9880	0.000633	3.19	0.5680	0.000220	3.41	3.06	0.32
Calcium (Ca)-Total	11500	69.0	2.22	11520	64.0	2.26	13500	48.1	2.45	8115	36.7	2.34	2.32	0.10
Cobalt (Co)-Total	11.0	0.00249	3.65	12.36	0.00182	3.83	12.43	0.00097	4.11	11.73	0.00025	4.67	4.06	0.45
Copper (Cu)-Total	116	0.00457	4.40	106.8	0.00361	4.47	88.03	0.00281	4.50	56.31	0.00226	4.40	4.44	0.05
Lithium (Li)-Total	10.6	0.00207	3.71	11.22	0.00161	3.84	17.60	0.00153	4.06	11.45	0.00086	4.12	3.93	0.19
Magnesium (Mg)-Total	9373	5.61	3.22	9862	5.28	3.27	12300	4.97	3.39	10900	3.05	3.55	3.36	0.15
Manganese (Mn)-Total	618	0.301	3.31	785.4	0.215	3.56	719.7	0.117	3.79	527.9	0.0304	4.24	3.73	0.39
Molybdenum (Mo)-Total	5.46	0.00250	3.34	6.994	0.00237	3.47	2.537	0.00182	3.14	1.624	0.00278	2.77	3.18	0.31
Nickel (Ni)-Total	14.1	0.00203	3.84	19.74	0.00165	4.08	34.60	0.00110	4.50	25.88	<0.005	n/a	4.14	0.33
Potassium (K)-Total	1183	1.87	2.80	946.0	1.76	2.73	796.7	1.14	2.84	929.2	1.22	2.88	2.81	0.06
Selenium (Se)-Total	3.05	0.00220	3.14	2.104	0.00202	3.02	1.663	0.00139	3.08	0.8983	0.00083	3.03	3.07	0.06
Strontium (Sr)-Total	50.4	0.392	2.11	51.16	0.359	2.15	62.10	0.310	2.30	43.25	0.209	2.32	2.22	0.10
Thallium (Tl)-Total	0.081	0.000013	3.79	0.0950	0.000011	3.94	0.0967	<0.0001	n/a	0.0687	<0.00001	n/a	3.87	0.10
Uranium (U)-Total	0.500	0.000320	3.19	0.5388	0.000305	3.25	0.3723	0.000182	3.31	0.4673	0.000319	3.17	3.23	0.06
Zinc (Zn)-Total	109	0.0853	3.11	124.4	0.0515	3.38	124.0	0.0277	3.65	87.60	0.0134	3.82	3.49	0.31

n/a = not applicable, shaded cells indicate samples where metal concentrations were below detection limits

Dissolved metals in water in mg/L

Sediment metal concentrations in mg/kg dry weight