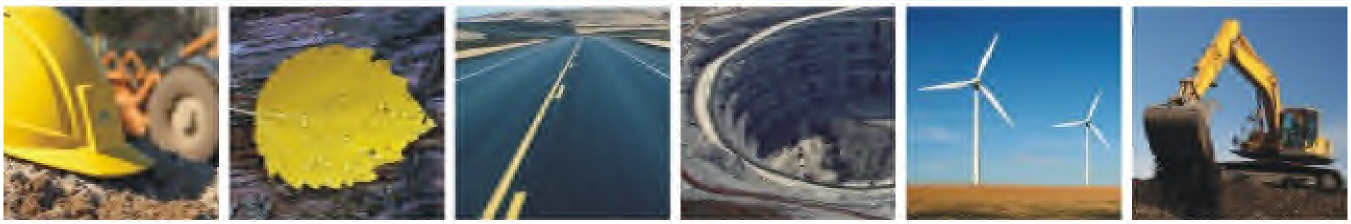
North American Tungsten Corporation Ltd

MACTUNG PROJECT(2008-0304): RESPONSE TO YESAB REQUEST FOR SUPPLEMENTARY INFORMATION DATED JANUARY 4, 2013



REPORT

OCTOBER 2013
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ACRONYMS & ABBREVIATIONS

ABA	Acid-Base Accounting
ARD/ML	Acid Rock Drainage/Metal Leaching
CCME	Canadian Council of Ministers of the Environment
COPCs	Contaminants of Potential Concern
DSTF	dry-stacked tailings facility
HC	Humidity Cell
HTC	Humidity Test Cell
ICP	Inductively Coupled Plasma
MMER	Metal Mining Effluent Regulations
NATC	North American Tungsten Corporation Ltd.
NP	Neutralization Potential
NPR	Net Potential Ratio
SFE	Shake Flask Extraction
WTP	Water Treatment Plant
WSC	Water Survey of Canada
YESAB	Yukon Environmental and Socio-economic Assessment Board

LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of North American Tungsten Corporation Ltd. (NATC) and their agents. EBA Engineering Consultants Ltd. does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than NATC, or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this report is subject to the terms and conditions stated in EBA's Services Agreement dated April 30, 2009.

1.0 INTRODUCTION

This document is Schedule 1 to NATC's detailed response of October 15, 2013, to YESAB's information requests of January 4, 2013.

NATC's response reflects the following:

1. On January 4, 2013, YESAB presented NATC with its requests for supplementary information in a document now filed online as "Mactung Mine Project YOR #2008-0304. Request for Supplementary Information Project Assessment 2008-0304, North American Tungsten Corporation Ltd."
2. Following meetings between NATC and YESAB and other intervening events, NATC outlined its approach to each of YESAB's information requests. The approach was presented to YESAB by a letter dated February 7, 2013, and is filed on the YESAB Online Registry (YOR #2008-0304-292-1).
3. Further, following meetings between NATC and YESAB, and in light of concerns expressed by communities and presented in YESAB's Draft Screening Report, NATC withdrew its proposal to construct approximately 36 km of new; all-Yukon road to the Project and so informed YESAB. The letter of February 7, 2013, is filed on the YESAB Online Registry (YOR #2008-0304-294-1).
4. On March 6, 2013, YESAB informed NATC by letter of its own position on each of the enumerated information requests. "Mactung Mine Project No. 2008-0304. NATC's Approach to Response to the Supplementary Information Request." (YOR #2008-0304-295-1)."
5. Working independently or through its consultants at EBA, NATC evidenced its commitment to Mactung by investing in a comprehensive program of science, engineering, and engagement in order to address YESAB's concerns and questions and advance the Project towards development.
6. The information contained in this document complements information provided by NATC over the past five years, from December, 2008, the date when NATC formally submitted the Mactung Project to YESAB.

The response document and all appendices have been included on the accompanying CD as digital pdf files (Appendix A & B).

2.0 RESPONSES TO INFORMATION REQUESTS

2.1 Tributary C Site Specific Hydrology

R1: Provide representative measurements of annual stream flow/volume distribution to describe the temporal and spatial variability of the Tributary C flow regime, including annual peak and low flows. The measurements should be sufficient to develop proper stage-discharge curves for the watercourse. At a minimum, during periods of flow, measurements should be taken on a monthly basis over one year and capture timing and flow information surrounding spring freshet, annual peak and winter low flow conditions.

Manual flow measurements have been collected on Tributary A and Tributary C from August 2006 to November 2012. As of December 2012, a total of 58 and 52 manual flow measurements have been collected from Tributary C and Tributary A, respectively. The flows evaluated for Tributary C prior to June 2009, were derived from Tributary A by a ratio of discrete flow measurements collected at similar times from both creeks (Figure R1-1). This method was validated as the flow rate agreed with the basin area ratio. On June 23, 2009, a hydrometric station was installed to continuously measure stages (water elevations) in Tributary C where a stage-discharge relationship was established to evaluate flows. The total upstream catchment area of the Tributary C hydrometric station was determined to be 24.5 km^2.

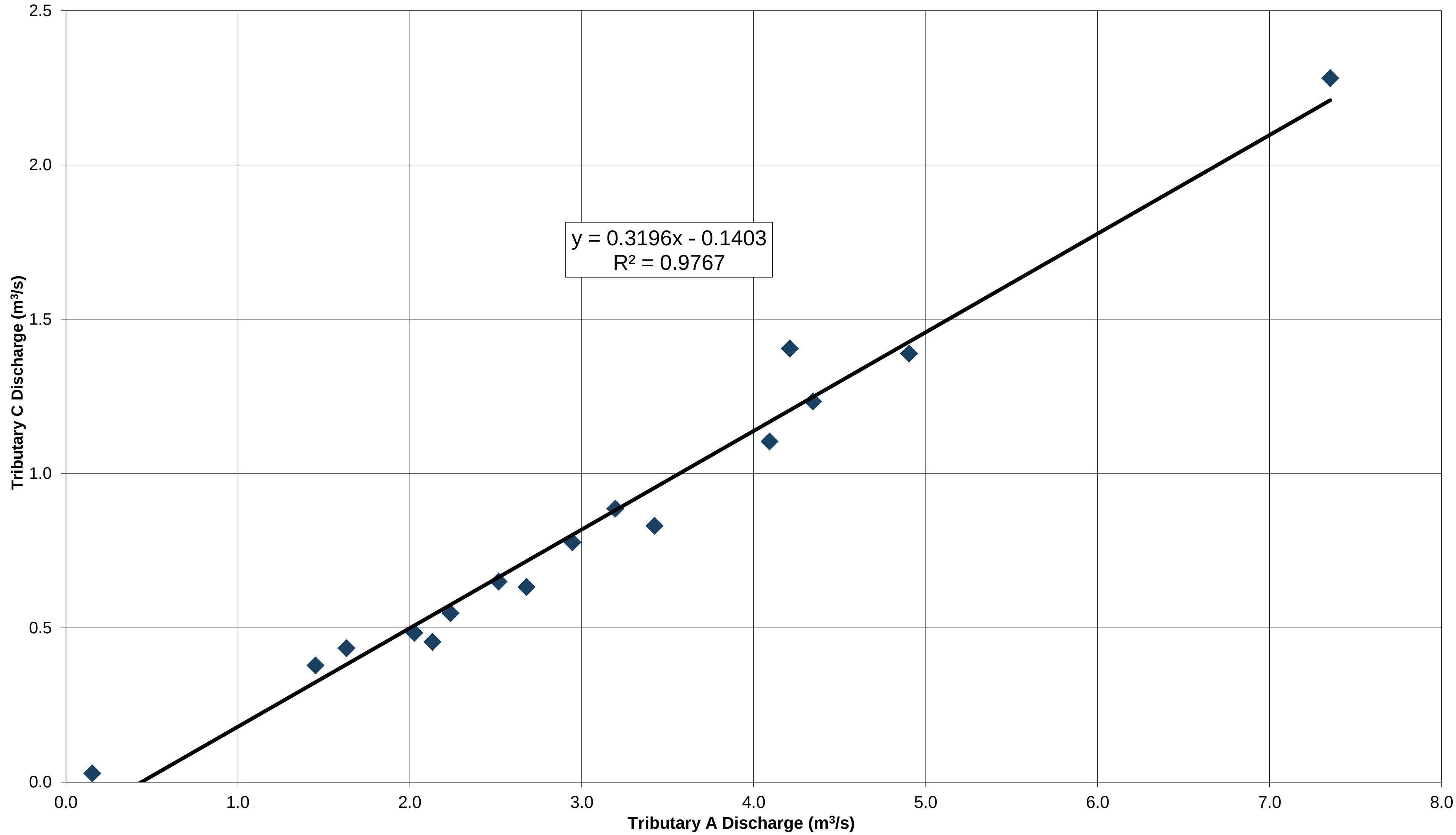
A hydrometric station continuously monitors the Hess River South Tributary stages at 15 minute intervals. Each stage is used to calculate the flow rate of the river based on the stage-discharge relationship developed for the Tributary C hydrometric station. The stage-discharge relationship for Tributary C is presented in Figure R1-2 and the calculated flows are plotted in Figure R1-3. Hollow circles represent manual flow measurements which were taken during site visits. The data indicate that a maximum peak instantaneous flow of 4.54 m^3/sec was recorded on June 7, 2012 and a winter low flow of 0.013 m^3/sec was recorded on April 16, 2012. Figure R1-3 summarizes all available data collected at Tributary C along with the historical trends and seasonal patterns. Peak flows occur in June with freshet and continuously reduce in volume thereafter until the next freshet in the following year. Over the winter period, precipitation is stored as snow and minimal surface runoff is released. Shallow groundwater discharges contribute to stream flow in the winter.

Table R1-1 summarizes mean monthly flows recorded for Tributary C and Table R1-2 summarizes mean monthly runoff (including base-flows) for the Tributary C catchment area (24.5 km^2). The data summarized in Tables R1-1 and R1-2 is based on both manual flow measurements and flows computed from hydrometric station stage data. Based on a total of seven monitoring years (2006 to 2012) a mean total annual runoff of 461 mm was calculated for Tributary C, where peak flows occur during freshet in June and winter low flows occur in April.

Table R1-1: Summary of Tributary C Mean Monthly Flows (m^3/sec)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2006							0.97	0.82	0.62			
2007							0.95	0.54	0.36			
2008					0.11*	1.52	1.03	0.81	0.73			
2009				0.03*	0.97*	0.89	0.67	0.85	0.68	0.24*	0.08*	0.10*
2010					1.71*	1.00	0.50	0.35	0.19	0.13	0.09*	0.05*
2011	0.08*			0.03*	0.42	1.22	0.58	0.52	0.35	0.21	0.12	0.08
2012	0.05	0.03	0.02	0.01	0.15	1.36	0.72	0.47	0.36	0.25	0.20	0.06
Average	0.06	0.03	0.02	0.02	0.67	1.20	0.77	0.62	0.47	0.21	0.12	0.07

Notes: Cells with an asterisk (*) indicate only a manual measurement was recorded
m^3/sec – cubic metres per second



NOTES

The ratio of Tributary C discharges to Tributary A discharges is used to determine Tributary C flows based on Tributary A flows. This method was used for the 2006 to 2008 Tributary C hydrographs. In 2009 the use of flow ratios was no longer required as a hydrometric station was installed in Tributary C.

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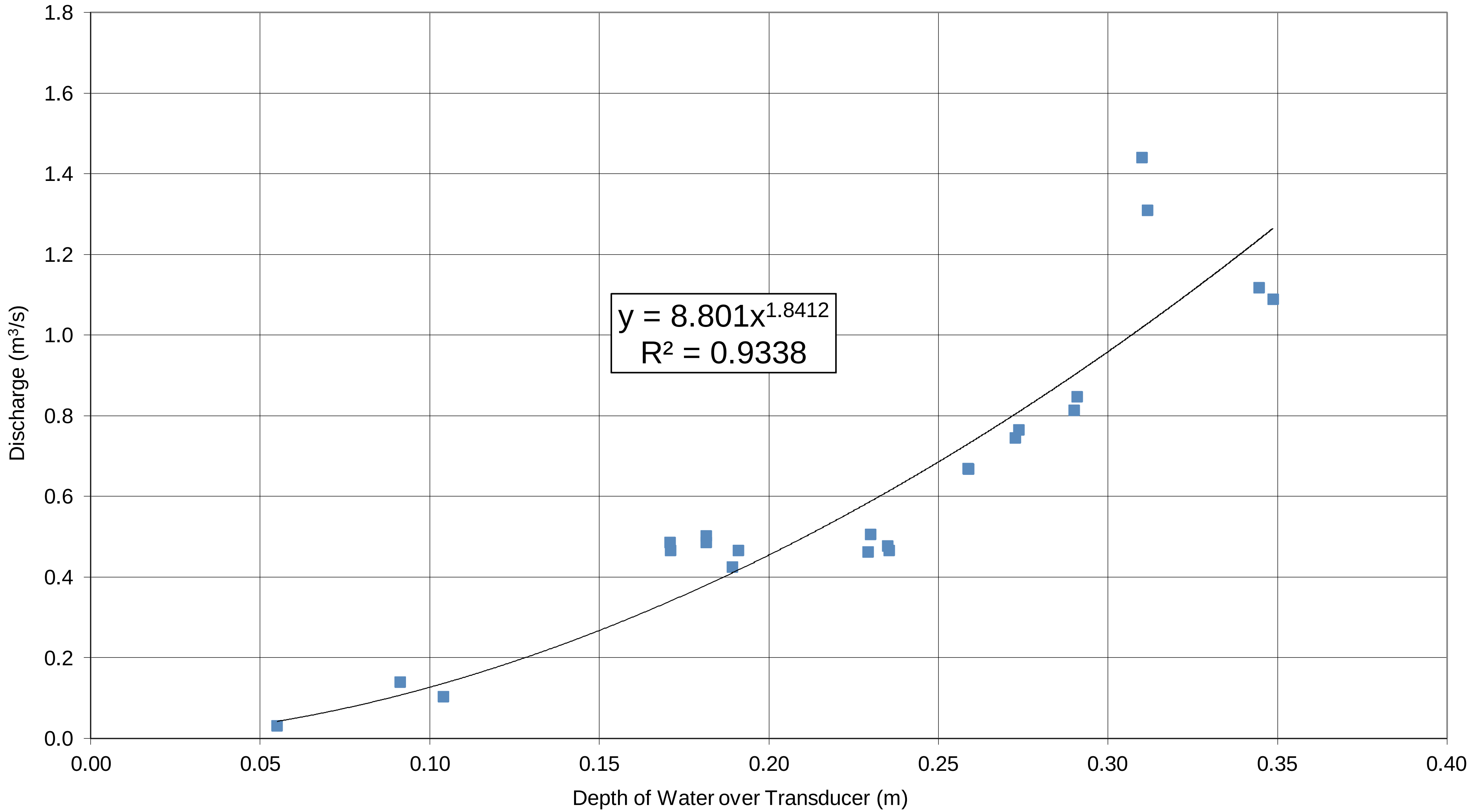
MACTUNG PROJECT
2012 HYDROLOGICAL STUDY

Ratio of Tributary C Discharges to Tributary A Discharges

PROJECT NO.	DWN	CKD	APVD	REV
W23101021.028	RED	JAS	JAS	0

OFFICE	DATE
EBA-VANC	January, 2013

Figure R1-1



NOTES

This stage-discharge relationship is based on data collected at the new hydrometric station location near the mouth of Tributary C.

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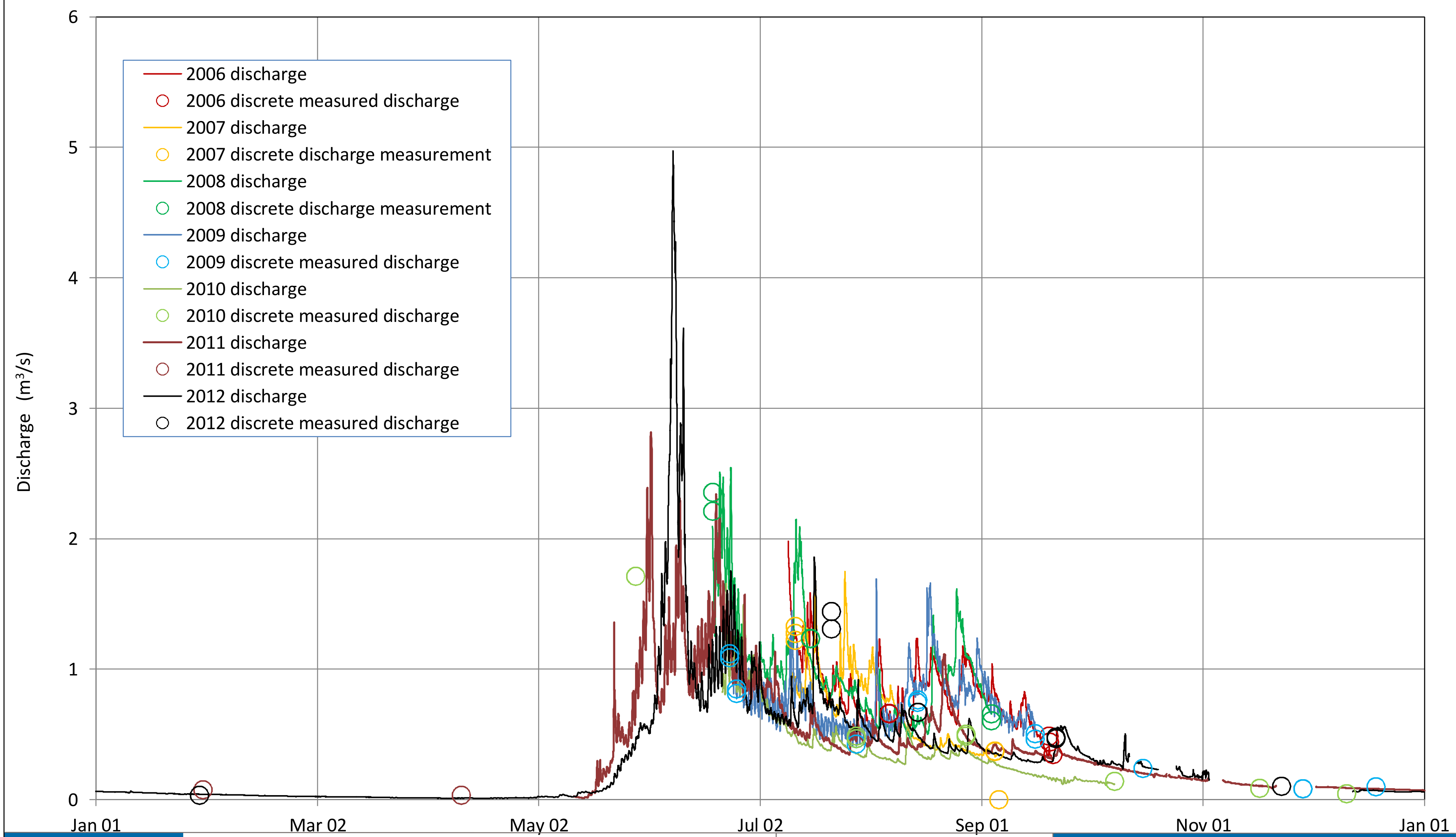
MACTUNG PROJECT
2013 HYDROLOGICAL STUDY

Tributary C Stage-Discharge Relationship as of Nov. 22, 2012

PROJECT NO.	DWN	CKD	APVD	REV
W23101021.028	RED	SP	JAS	0

OFFICE	DATE
EBA-VANC	July 2013

Figure R1-2



NOTES

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2012 HYDROLOGICAL STUDY

Tributary C Discharge Hydrograph 2006 to 2012

PROJECT NO.	DWN	CKD	APVD	REV
W23101021.028	RED	JAS	JAS	0

OFFICE	DATE
EBA-VANC	January, 2013

Figure R1-3

Table R1-2: Summary of Mean Monthly Runoff and Percent Distribution for Tributary C

Month	Mean Monthly Flows (m^3/sec)	Mean Monthly Runoff (mm)	Monthly Distribution (%)
Jan	0.06	7	2
Feb	0.03	3	1
Mar	0.02	2	0
Apr	0.02	3	1
May	0.67	73	16
Jun	1.20	127	28
Jul	0.77	84	18
Aug	0.62	68	15
Sep	0.47	50	11
Oct	0.21	23	5
Nov	0.12	13	3
Dec	0.07	8	2
Mean Annual	0.36	461	100

Notes: Mean flows, mean runoffs and monthly distributions presented are based on partial records from Tributary C.

m^3/sec – cubic metres per second

mm – millimetres

% - percent

The proponent collected baseline data for Tributary C in order to evaluate runoff conditions at Mactung. The data were also used in the updated water balance presented in Response R8.

R2: Based on the flow information collected, characterize runoff conditions for the Tributary C catchment areas using runoff coefficients. Model and evaluate extreme flow conditions for both wet and dry events using these runoff coefficients and appropriate duration and return periods. (For additional information see "Proponents Guide: Water information Requirements for Quartz Mining Project Proposals" (YESAB, 2011)).

As summarized in Table R1-2, in Response R1, an average total annual runoff of 461 mm was used for the period from 2006 to 2012, based on the data from the Tributary C hydrometric monitoring program. Based on the precipitation analysis (Response R6), it was estimated that the total average annual precipitation for the same corresponding period (2006-2012) was approximately 734 mm.

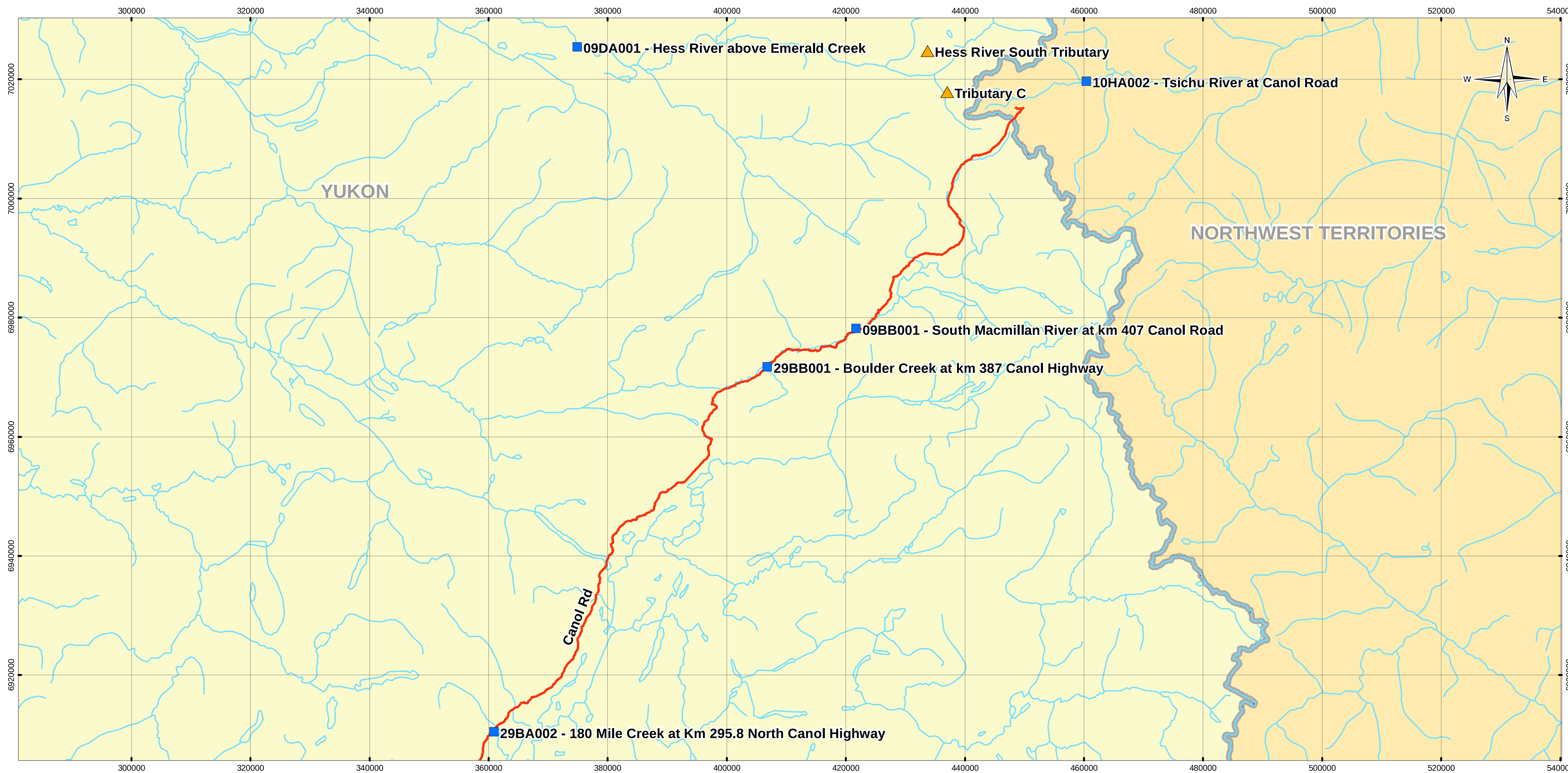
A runoff coefficient is defined as the total reported runoff divided by the corresponding precipitation. A catchment with a smaller runoff coefficient exhibits greater losses (i.e., evapotranspiration and infiltration) than a watershed with a much larger runoff coefficient. Based on the evaluated total runoff and precipitation, it was found that Tributary C has an annual runoff coefficient of 0.63.

A regional analysis was conducted to provide confidence in baseline hydrological trends and to evaluate extreme flow conditions. Historical hydrometric data were obtained from the Water Survey of Canada (WSC) and Yukon Environment to supplement the hydrological regime of the Tributary C. A total of five regional stations within a 200 km radius from Tributary C were investigated. Figure R2-1 illustrates the location of the five regional stations and Table R2-1 provides information on the stations including the period of record and distance away from Tributary C.

Table R2-1: Local and Regional Hydrometric Stations Information

Station No.	Name	Latitude	Longitude	Distance from Site (km)	Area (km^2)	Average Basin Elev. (m asl)	Period of Record
Local	Tributary C	63° 17' 04"	130° 15' 23"	1 km W	24.5	1805	2006 - 2012
Local	Hess River South Tributary	63° 18' 45"	130° 19' 31"	5 km NW	340	1730	2008 - 2012
09DA001[1]	Hess River above Emerald Creek	63° 20' 10"	131° 30' 00"	58 km NW	4840	1330	1977 - 1996
09BB001[1]	South Macmillan River at km 407 Canol Road	62° 55' 30"	130° 32' 30"	45 km SW	997	1420	1975 - 1996
29BB001[2]	Boulder Creek at km 387 Canol Highway	62° 51' 50"	130° 49' 55"	50 km SW	84.1	1171	1983 - 1991
29BA002[2]	180 Mile Creek at Km 295.8 North Canol Highway	62° 18' 00"	131° 41' 00"	130 km SW	83.1	1100	1983 - 1993
10HA002[1]	Tsichu River at Canol Road	63° 18' 14"	129° 47' 24"	25 km E	219	1345	1975 - 1992

Notes: [1] Data from Water Survey of Canada
[2] Data from Hydrometric Manual 2005, Yukon Environment, Government of Yukon
km – kilometres
km^2 – square kilometres
m asl – metres above mean sea level



LEGEND

- Local Hydrometric Station
- Regional Hydrometric Station
- Major Road
- Watercourse
- Territorial Boundary
- Yukon
- Northwest Territories

NOTES
Base data source: Yukon Geomatics

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Hydrometric Station Locations

PROJECTION	DATUM	CLIENT
UTM Zone 9	NAD83	NORTH AMERICAN TUNGSTEN CORPORATION LTD

Scale: 1:650,000
10 5 0 10
Kilometres

FILE NO.
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PROJECT NO.	DWN	CKD	APVD	REV
W23101211.004	MEZ	MAN	MAN	0

OFFICE	DATE
EBA-VANC	August 23, 2013

Figure R2-1

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Of the selected hydrometric stations, none has a concurrent period of record similar to Tributary C. All five regional stations have larger catchment areas and they are located at lower elevations. Table R2-2 summarizes recorded average monthly runoffs for the selected regional stations and estimated monthly runoffs for Tributary C based on the local hydrometric program at Site.

Table R2-2: Summary of Mean Monthly Runoffs (mm)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
09BB001	6	4	4	4	83	204	133	78	58	35	15	9	633
09DA001	6	4	4	5	73	155	91	65	48	28	12	8	500
29BA002					138	124	61	40	38				
29BB001					187	114	45	36	45				
10HA002	3	2	2	2	40	204	121	60	42	22	10	5	515
Regional	5	4	3	4	104	160	90	56	46	29	12	7	521
Trib. C	7	3	2	3	73	127	84	68	50	23	13	8	461

Notes: Period of records are not concurrent
Blank cells indicate data were not available
mm – millimetres

As summarized in Table R2-2 the regional hydrometric stations have a similar seasonal pattern. The difference in mean annual runoff of the regional hydrometric stations and the runoff on Tributary C is approximately 12%. Flows recorded at the stations are seasonally distinct and associated with temperature conditions. The highest flows tend to occur in June with freshet and continuously decline thereafter until freshet the following year. Over the winter period, flows decrease in volume as precipitation is stored as snow. Minimal surface runoff is released and mostly base-flow (shallow groundwater discharge) contributes to stream flow. Based on the historical regional and local data presented in Table R2-2, winter base flows range between 2 and 8 mm/month.

A frequency analysis was conducted for three selected WSC stations to evaluate total annual wet and dry runoff. The two Yukon Environment stations (29BA001 and 29BA002) were omitted from the total annual wet and dry analysis as they are missing data during winter conditions. Wet and dry annual runoffs for the two year through 1000-year return periods were calculated using the HYFRAN commercial software (version 1.1). HYFRAN is a software package used for the statistical analysis of data, including generating probability distributions. Historical peak flow data was used to construct a frequency distribution (Table R2-3) where it was found that the Log-Normal distribution provided a good fit to the data.

Table R2-3: Annual Runoff Frequency Analysis for Selected Regional Stations (mm)

Return Period	Regional Stations					
	09BB001		09DA001		10HA002	
Mean Elev.	1420 m asl		1330 m asl		1345 m asl	
Condition	Wet	Dry	Wet	Dry	Wet	Dry
1,000	892	378	770	329	804	241
200	848	420	714	351	755	285
100	827	440	688	363	731	307
50	805	463	662	376	705	330
20	770	497	624	396	666	366
10	740	527	592	416	632	398
5	703	563	557	441	591	438
2	633	633	495	495	514	514

Notes: mm – millimetres

m asl – metres above mean sea level

As regional average runoff conditions were evaluated to differ by 12% from observed runoff conditions in Tributary C, this 12% difference was applied to the average results of the frequency analysis to evaluate total annual wet and dry runoffs for Tributary C. Table R2-4 summarizes the total annual runoff for a range of return periods at Tributary C and Table R2-5 summarizes monthly distributions for a range of return periods.

Table R2-4: Tributary C Wet and Dry Annual Runoff (mm)

Return Period (Years)	Dry Condition	Wet Condition
1000	280	727
200	311	683
100	327	662
50	345	641
20	371	608
10	396	579
5	425	546
2	484	484

Note: mm – millimetres

Table R2-5: Tributary C Monthly Runoff (mm)

Event		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Median		7	3	2	3	77	133	89	72	52	24	14	8
Wet	5-Year	8	4	2	3	87	150	100	81	59	27	15	10
	10-Year	9	4	3	3	92	159	106	86	62	28	16	10
	100-Year	10	4	3	4	106	182	121	98	71	33	19	12
Dry	5-Year	6	3	2	2	68	117	78	63	46	21	12	7
	10-Year	6	3	2	2	63	109	72	58	43	19	11	7
	100-Year	5	2	1	2	52	90	60	48	35	16	9	6

Note: mm – millimetres

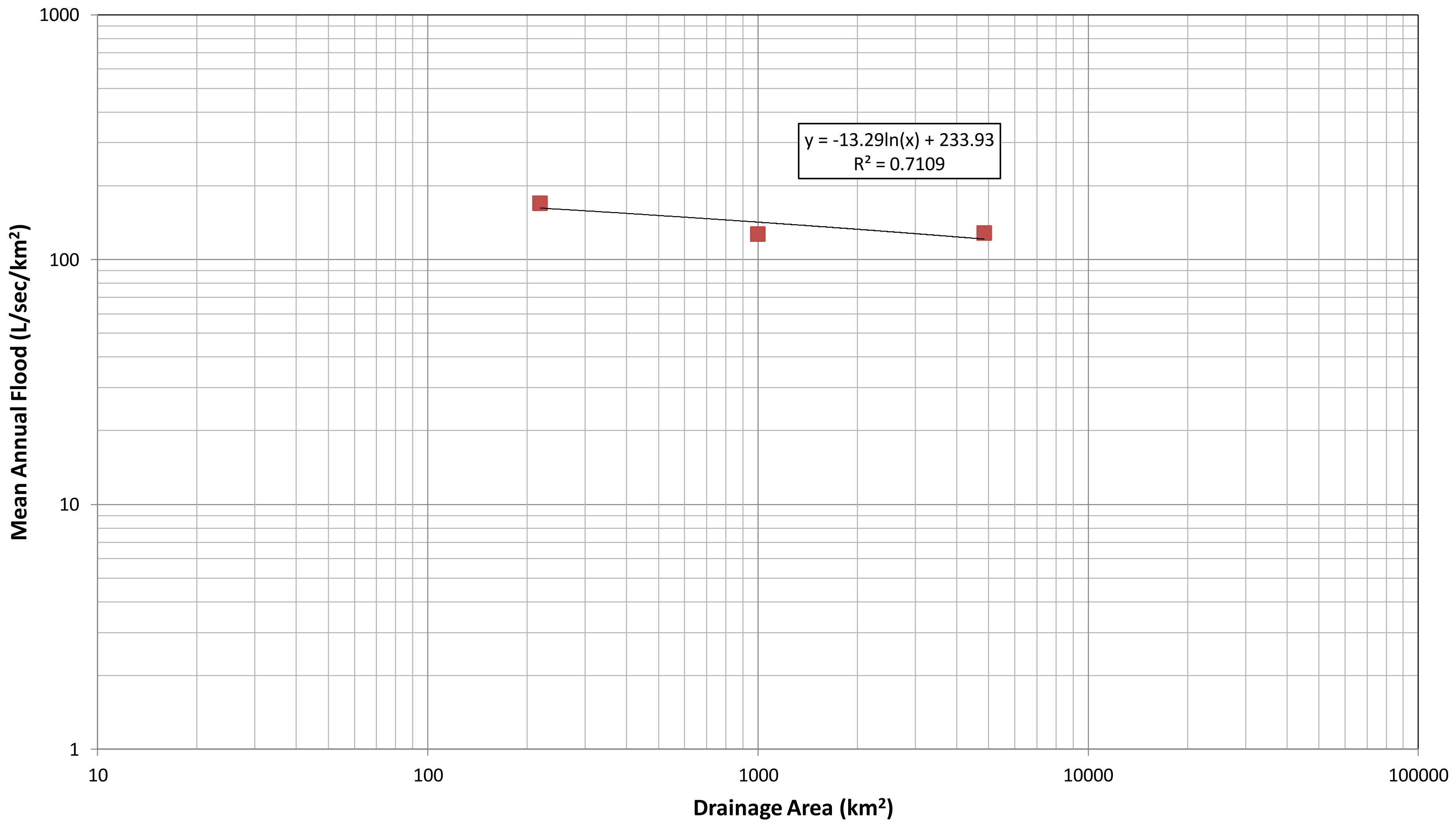
A flood frequency analysis was only completed for the three selected WSC stations as peak instantaneous data were not available for the Yukon Environment stations (29BA001 and 29BA002). However, all available data were used to extend the data range. For the years without peak instantaneous flow data, but with peak daily flow data, a factor was applied to the peak daily flow. This factor was the ratio between peak instantaneous flows and maximum daily flows for the three largest flows at the stations. Using the recommended Log-Pearson Type III Distribution for flood frequency analyses (U.S. Water Advisory 1982). Table R2-6 summarizes estimated peak instantaneous flows for the 2-year through 1,000-year return periods.

Table R2-6: Instantaneous Peak Flows for Selected Regional Hydrometric Stations (m^3/sec)

Return Period (Years)	Regional Stations		
	09BB001 (997 km²)	09DA001 (4840 km²)	10HA002 (Km²)
1,000	307	1520	79
200	252	1300	70
100	231	1200	66
50	210	1100	62
20	185	967	55
10	167	861	50
5	150	747	43
3	137	654	38
2	125	566	33

Notes: m^3/sec – cubic metres per second
km^2 – square kilometres

Results of the frequency analyses were used in the index flood method. The index flood method determines a relationship between the unit mean annual discharge, usually with a return period of 2.33 years, and drainage area. The mean annual flood for a specific catchment area can then be estimated using the curve equation (Figure R2-2) and the regional median ratio to the 2.33 return period flood (Table R2-7).



NOTES

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Index Flood Method Graph

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W23101211.004	SPB			0
OFFICE	DATE			
EBA-VANC	July, 2013			

Figure R2-2

Table R2-7: Index Flood Method Ratios and Tributary C Floods

Return Period (Years)	Regional Median Ratio to $Q_{2.33}$	Tributary C Floods (m^3/sec)
1,000	2.42	11.4
200	1.99	9.3
100	1.82	8.6
50	1.66	7.8
20	1.48	6.9
10	1.33	6.2
5	1.18	5.6
3	1.05	4.9
2	0.91	4.3

Notes: Flood values estimated for the Tributary C Hydrometric station (24.5 km^2)
m^3/sec – cubic metres per second

As summarized in Table R2-7, it was determined that the 100-year flood for Tributary C with a total catchment area of 24.5 km^2 would be approximately 8.6 m^3/sec.

Results from the frequency analysis were used to predict potential impacts to fish and fish habitat (Response R19) and evaluate the performance of the Ravine Dam Reservoir (Response R8).

2.2 Hess River South Tributary Site Specific Hydrology

R3: Provide representative measurements of annual stream flow/volume distribution to describe the temporal and spatial variability of the Hess River South Tributary flow regime at the point of water withdrawal, including annual peak and low flows. The measurements should be sufficient to develop proper stage-discharge curves for the watercourse. At a minimum, during periods of flow, measurements should be taken on a monthly basis over one year. Capture timing and flow information surrounding spring freshet, annual peak and winter low flow conditions.

Manual flows have been collected on Hess River South Tributary from March 2008 to November 2012. As of November 2012, a total of 45 manual flow measurements have been collected from Hess River South Tributary. In June 2008, a hydrometric station was installed to continuously measure stages (water elevations) in Hess River South Tributary where a stage-discharge relationship was established to evaluate flows. The total upstream catchment area of the Hess River South Tributary hydrometric station was determined to be 340 km^2.

The hydrometric station continuously monitors the Hess River South Tributary stages at 15 minute intervals. The stage is used to calculate the flow rate based on the stage-discharge relationship developed for the Hess River South Tributary hydrometric station. The stage-discharge relationship for Hess River South Tributary is presented in Figure R3-1 and the calculated flows are plotted in Figure R3-2. Hollow circles represent manual flow measurements which were taken during site visits. A maximum peak instantaneous flow of 29.45 m^3/sec was recorded June 8, 2012 and a minimum flow of 0.141 m^3/sec was recorded by manual measurement on March 28, 2008. Figure R3-2 summarizes all available data collected at Hess River South Tributary and the historical trends and seasonal patterns. Peak flows tend to occur in

June with freshet and continuously recede thereafter. Over the winter period, precipitation is stored as snow, causing flows to decrease as no surface runoff is released, and only base-flow contributes to stream-base-flow.

Table R3-1 summarizes mean monthly flows recorded for Hess River South Tributary and Table R3-2 summarizes mean monthly runoff (including base-flows) for the Hess River South Tributary catchment area (340 km^2). The data summarized in Tables R3-1 and R3-2 is based on both manual flow measurements and flows computed from hydrometric station stage data. Based on a total of five monitoring years (2008 to 2012), a mean total annual runoff of 506 mm was evaluated for Hess River South Tributary, where a peak flow occurs during freshet in June and winter low flows occur in March.

Table R3-1: Summary of Mean Monthly Flows (m^3/sec)

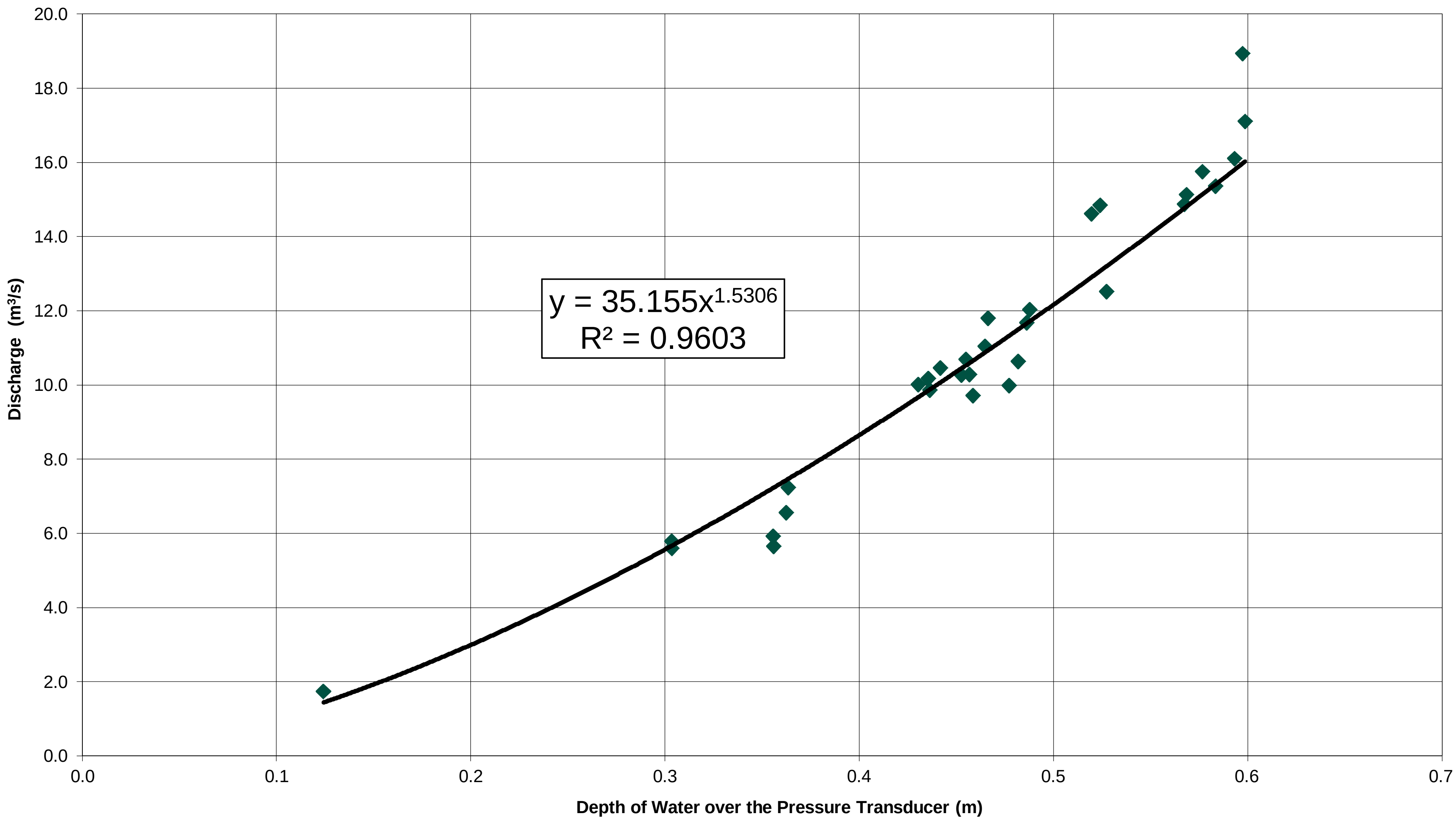
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008			0.14*	–	–	15.48	14.22	12.84	7.89	–		
2009		0.27*	–	0.26*	10.23*	11.31	8.86	11.28	11.09	–	0.54*	1.43*
2010			–	–	–	16.63	12.35	9.95	3.75	1.74*		1.43*
2011	0.54*		–	0.24*	13.65	14.76	11.39	9.80	5.51	3.02		
2012	0.45*		–	–	11.95	20.92	14.87	11.12	7.81	5.98	0.46*	
Average	0.50	0.27	0.14	0.25	11.94	15.82	12.34	11.00	7.21	3.58	0.50	1.43

Notes: Cells with an asterisk (*) indicate only a manual measurement was recorded
m^3/sec – cubic metres per second

Table R3-2: Summary of Mean Monthly Runoff and Percent Distribution

Month	Mean Monthly Flows (m^3/sec)	Mean Monthly Runoff (mm)	Monthly Distribution (%)
Jan	0.50	4	1
Feb	0.27	2	0
Mar	0.14	1	0
Apr	0.25	2	0
May	11.94	94	19
Jun	15.82	121	24
Jul	12.34	97	19
Aug	11.00	87	17
Sep	7.21	55	11
Oct	3.58	28	6
Nov	0.50	4	1
Dec	1.43	11	2
Mean Annual	5.41	506	100

Note: Mean flows, mean runoffs and monthly distributions presented are based on partial records from Hess River South Tributary.
m^3/sec – cubic metres per second
mm – millimetres
% - percent



NOTES

Creek stages are recorded every 15 minutes by the hydrometric station. Stages are recorded as metres above the elevation of the pressure transducer sensor.
Includes all data collected to November 2012

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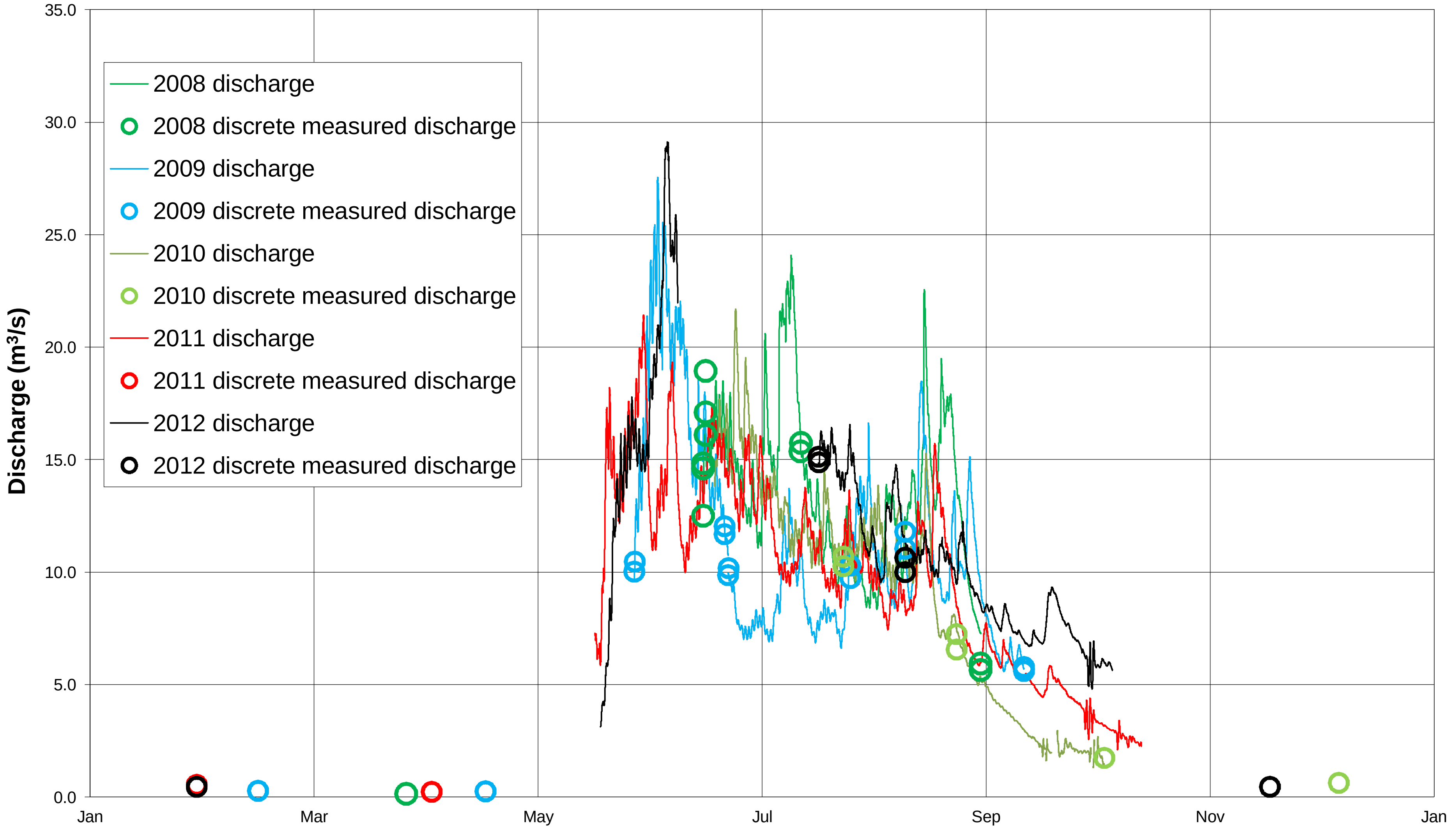
MACTUNG PROJECT
2012 HYDROLOGICAL STUDY

South Tributary of the Hess River
Stage - Discharge Relationship

PROJECT NO.	DWN	CKD	APVD	REV
W23101021.028	RED	JAS	JAS	0

OFFICE	DATE
EBA-VANC	January, 2013

Figure R3-1



NOTES

Discharge data are determined by applying the stage discharge relationship to the recorded stage data for the South Tributary of the Hess River.

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MACTUNG PROJECT
2012 HYDROLOGICAL STUDY

South Tributary of the Hess River Discharge Hydrographs 2008 to 2012

PROJECT NO.	DWN	CKD	APVD	REV
W23101021.028	RED	JAS	JAS	0

OFFICE	DATE
EBA-VANC	January, 2013

Figure R3-2

R4: Based on the flow information collected, characterize runoff conditions for the Hess River South Tributary catchment areas using runoff coefficients. Model and evaluate extreme flow conditions for both wet and dry events using these runoff coefficients and appropriate duration and return periods. (For additional information see "Proponents Guide: Water information Requirements for Quartz Mining Project Proposals" (YESAB 2011)).

As summarized in Table R3-2, in Response R3, an average total annual runoff of 506 mm for the period from 2008 to 2012 was calculated based on the data from the Hess River South Tributary hydrometric monitoring program. Based on the precipitation analysis (see Response R6), it is estimated that the total average annual precipitation for the corresponding period (2008-2012) was approximately 746 mm.

A runoff coefficient is defined as the total reported runoff divided by the corresponding precipitation. A catchment with a smaller runoff coefficient exhibits greater losses (i.e., evapotranspiration and infiltration) than a watershed with a much larger runoff coefficient. Based on the evaluated total runoff and precipitation it was found that Hess River South Tributary has an annual runoff coefficient of 0.68.

A regional analysis was conducted to provide confidence in baseline hydrological trends and to evaluate extreme flow conditions. Historical hydrometric data was obtained from the Water Survey of Canada (WSC) and Yukon Environment to supplement the hydrological regime of the Hess River South Tributary. A total of five regional stations within a 200 km radius from Hess River South Tributary were investigated. Figure R2-1 (presented in Response 2) illustrates the location of the five regional stations and Table R4-1 provides information on the stations, including the period of record and distance away from Hess River South Tributary.

Table R4-1: Local and Regional Hydrometric Stations Information

Station No.	Name	Latitude	Longitude	Distance from Site (km)	Area (km^2)	Average Basin Elev. (m asl)	Period of Record
Local	Tributary C	63° 17' 04"	130° 15' 23"	1 km W	24.5	1805	2006 - 2012
Local	Hess River South Tributary	63° 18' 45"	130° 19' 31"	5 km NW	340	1730	2008 - 2012
09DA001[1]	Hess River above Emerald Creek	63° 20' 10"	131° 30' 00"	58 km W	4840	1330	1977 - 1996
09BB001[1]	South Macmillan River at km 407 Canol Road	62° 55' 30"	130° 32' 30"	45 km S	997	1420	1975 - 1996
29BB001[2]	Boulder Creek at km 387 Canol Highway	62° 51' 50"	130° 49' 55"	56 km SW	84.1	1171	1983 - 1991

Table R4-1: Local and Regional Hydrometric Stations Information

Station No.	Name	Latitude	Longitude	Distance from Site (km)	Area (km^2)	Average Basin Elev. (m asl)	Period of Record
29BA002[2]	180 Mile Creek at Km 295.8 North Canol Highway	62° 18' 00"	131° 41' 00"	132 km SW	83.1	1100	1983 - 1993
10HA002[1]	Tsichu River at Canol Road	63° 18' 14"	129° 47' 24"	27 km E	219	1345	1975 - 1992

Notes: [1] Data from Water Survey of Canada
[2] Data from Hydrometric Manual 2005, Yukon Environment, Government of Yukon
km – kilometres
km^2 – square kilometres
m asl – metres above mean sea level

Of the selected hydrometric stations, none has a concurrent period of record similar to the Hess River South Tributary and two regional hydrometric stations have smaller catchments areas. Table R4-2 summarizes recorded average monthly runoffs for the selected regional stations and estimated monthly runoffs for Hess River South Tributary, based on the local hydrometric program at Site.

Table R4-2: Summary of Mean Monthly Runoffs (mm)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
09BB001	6	4	4	4	83	204	133	78	58	35	15	9	633
09DA001	6	4	4	5	73	155	91	65	48	28	12	8	500
29BA002					138	124	61	40	38				
29BB001					187	114	45	36	45				
10HA002	3	2	2	2	40	204	121	60	42	22	10	5	515
Regional	5	4	3	4	104	160	90	56	46	29	12	7	521
Hess Trib	4	2	1	2	94	121	97	87	55	28	4	11	506

Notes: Period of records are not concurrent
Blank cells indicate data were not available
mm – millimetres

As summarized in Table R4-2, the regional hydrometric stations have a similar seasonal pattern. The mean annual runoff of the regional stations differs by approximately 3% of the recorded runoff in Hess River South Tributary. Flows at the stations are seasonally distinct and associated with temperature conditions. The highest flows tend to occur in June with freshet and continuously decline thereafter until the next freshet occurs. Over the winter period, precipitation is stored as snow and this causes surface flows to decrease and base flows to mostly contribute to flow. The historical regional and local data presented in Table R4-2 indicate that winter base flows in the Hess Tributary range from between 1 and 11 mm per month.

A frequency analysis was conducted for the three selected WSC stations to evaluate the total annual wet and dry runoff. The two Yukon Environment stations (29BA001 and 29BA002) were omitted from the total annual wet and dry analysis as data were not available at these stations for the winter months. Wet and dry annual runoffs for the 2-year through 1,000-year return periods were calculated using the HYFRAN commercial software (version 1.1). Historical peak flow data were used to construct a frequency distribution (Table R2-3) where the Log-Normal distribution provided a good fit to the data.

Table R4-3: Annual Runoff Frequency Analysis for Selected Regional Stations (mm)

Return Period	Regional Stations					
	09BB001		09DA001		10HA002	
Mean Elev.	1420 m asl		1330 m asl		1345 m asl	
Condition	Wet	Dry	Wet	Dry	Wet	Dry
1,000	892	378	770	329	804	241
200	848	420	714	351	755	285
100	827	440	688	363	731	307
50	805	463	662	376	705	330
20	770	497	624	396	666	366
10	740	527	592	416	632	398
5	703	563	557	441	591	438
2	633	633	495	495	514	514

Notes: mm – millimetres
m asl – metres above mean sea level
Same as Table R2-3

As regional average runoff conditions were evaluated to have a 3% difference from observed runoff conditions at Hess River South Tributary, it was determined that the average of the frequency analysis could be applied to evaluate total annual wet and dry runoffs for Hess River South Tributary. Table R4-4 summarizes the total annual runoff for a range of return period at Hess River South Tributary and Table R4-5 summarizes monthly distributions for a range of return periods.

Table R4-4: Hess River South Tributary Wet and Dry Annual Runoff (mm)

Return Period	Dry Condition	Wet Condition
1,000	307	798
200	342	750
100	359	727
50	378	703
20	408	667
10	434	636
5	467	599
2	532	532

Note: mm – millimetres

Table R4-5: Hess River South Tributary Monthly Runoff (mm)

Event		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Median		4	2	1	2	99	127	102	91	58	30	4	12
Wet	5-Year	5	2	1	2	112	143	115	103	65	33	5	13
	10-Year	5	2	1	2	118	152	122	109	69	35	5	14
	100-Year	6	3	2	3	135	173	140	125	79	41	6	16
Dry	5-Year	4	2	1	2	87	111	90	80	51	26	4	10
	10-Year	3	2	1	2	81	104	83	74	47	24	3	10
	100-Year	3	1	1	1	67	86	69	62	39	20	3	8

Note: mm – millimetres

A flood frequency analysis was completed for the three selected WSC stations only as peak instantaneous data was not available for the Yukon Environment stations (29BA001 and 29BA002). To make use of all available flow data and to extend the data range, years without peak instantaneous flow data but with peak daily flow data were utilized by applying a factor to the peak daily flow. This factor was the ratio between peak instantaneous flows and maximum daily flows for the three largest floods at the stations. Using the recommended Log-Pearson Type III Distribution for flood frequency analyses (U.S. Water Advisory 1982), Table R4-6 summarizes estimated peak instantaneous flows for the 2-year through 1000-year return periods.

Table R4-6: Instantaneous Peak Flows for Selected Regional Hydrometric Stations (m^3/sec)

Return Period	Regional Stations		
	09BB001 ($997\ km^2$)	09DA001 ($4840\ km^2$)	10HA002 ($219\ km^2$)
1,000	307	1520	79
200	252	1300	70
100	231	1200	66
50	210	1100	62
20	185	967	55
10	167	861	50
5	150	747	43
3	137	654	38
2	125	566	33

Notes: m^3/sec – cubic metres per second
km^2 – square kilometres
Same as Table R2-6

Results of the frequency analyses were used in the index flood method. The index flood method determines a relationship between the unit mean annual discharge, usually with a return period of 2.33 years, and drainage area. The mean annual flood for a specific catchment area can then be estimated using the curve equation (Figure R2-2 in Response 2) and the regional median ratio to the 2.33 return period flood (Table R4-7).

Table R4-7: Index Flood Method Ratios and Hess River South Tributary Floods

Return Period (Years)	Regional Median Ratio to $Q_{2.33}$	Hess River South Tributary Floods (m^3/sec)
1,000	2.42	128.9
200	1.99	105.8
100	1.82	97.0
50	1.66	88.2
20	1.48	78.6
10	1.33	70.8
5	1.18	63.0
3	1.05	55.9
2	0.91	48.4

Notes:Flood values estimated for the Hess River South Tributary Hydrometric station (340 km^2)
m^3/sec – cubic metres per second

As summarized in Table R4-7, it was determined that the 100-year flood for Hess River South Tributary with a total catchment area of 340 km^2 would be approximately 97.0 m^3/sec.

Results from the frequency analysis were used to predict potential impacts to fish and fish habitat (Response R19) and evaluate the performance of the Ravine Dam Reservoir (Response R8).

2.3 Site-Specific Precipitation Information

R5: Provide on-site precipitation measurements to describe the temporal and spatial variability of precipitation scenarios at the Mactung Mine site. At a minimum, precipitation measurements should be taken on a daily basis over one year. Provide a description of critical flow periods (e.g., freshet, transition from rainfall to snowfall) and site hydraulic responses to precipitation scenarios during those periods.

An all-weather precipitation gauge, which measures rainfall and snow water equivalent, was installed at the Mactung meteorological station on August 12, 2013. When site-specific precipitation data are available, they will be used to validate the precipitation estimates, water balance and water quality predictions as the project progresses through the regulatory permitting phases. As acknowledged by YESAB in its letter to NATC dated March 6, 2013, the precipitation estimates in this submission are based on an updated regional analysis (see Response R6).

The updated regional analysis for precipitation includes a sensitivity analysis that takes into consideration the variability and ranges of precipitation volumes. This variability is also included in the water balance model (R8) to determine the range of possible results. The water balance model also takes into account the transition from rainfall to snowfall as well as the accumulation and melting of snow. The site hydraulic responses for a range of precipitation scenarios are described in detail in Response R8.

R6: Provide an update to the precipitation estimates derived from precipitation datasets from other climate stations referenced in your proposal and the on-site precipitation measurements requested in R5.

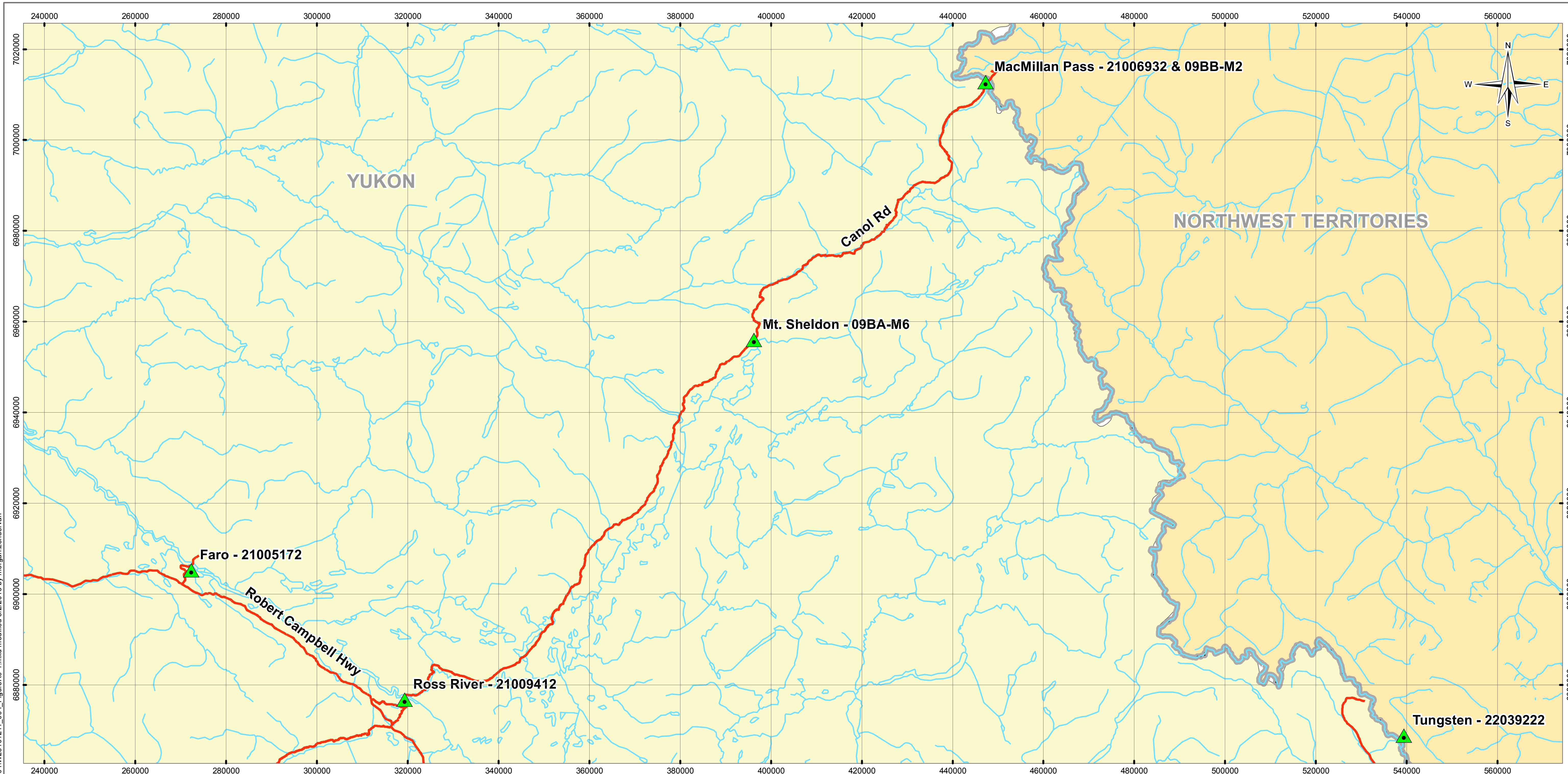
As explained in Response R5, the precipitation gauge at the Mactung project site was installed in August 2013, and therefore the regional analysis was updated to evaluate precipitation at the Mactung site. Five climate stations with relatively long periods of record were selected within a 200 km radius of the site. Figure R6-1 illustrates the location of the five regional stations and Table R6-1 summarizes properties of the selected climate stations.

Table R6-1: Regional Climate Stations Used for the Mactung Precipitation Analysis

Station Name	Station Number	Latitude (degrees)	Longitude (degrees)	Distance from Site (km)	Elevation (m msl)	Period of Record
Ross River	2100941[2]	61.98	-132.45	186 km SW	698	1994-2007
Tungsten	2203922[2]	61.95	-128.25	170 km SE	1,143	1967-1990
Faro	2100517[2]	62.21	-133.38	200 km SW	717	1978-2012
Macmillan Pass[1]	2100693[2] 09BB-M2[3]	63.24	-130.05	<10 km SE	1,414	1999-2012
Mt Sheldon	09BA-M6[3]	62.72	-131.03	75 km SW	920	1999-2008

Notes: [1] Data for Macmillan Pass was merged using the Canadian Meteorological station and the Yukon Environment station
[2] Data from Canadian Meteorological Network
[3] Data from Yukon Environment, Government of Yukon
m msl – metres above mean sea level
mm - millimetres

Table R6-2 summarizes the monthly precipitation, mean annual precipitation, the standard deviation of the total annual precipitation record per station, and the percent variability from the mean of the annual precipitation. Mean annual precipitation was plotted against station elevation as shown in Figure R6-2 to evaluate the total mean annual precipitation for the Mactung Site which lies at a higher elevation of 1,860 m msl. Based on the updated regional analysis, the mean annual precipitation for Mactung was determined to be 704 mm. As a conservative approach, the greatest percent variability regionally observed (20%) was applied to obtain a standard deviation of 141 mm. Therefore, the annual precipitation at the Mactung site is estimated to be 704 mm plus +/- 141 mm. Table R6-3 summarizes the monthly distribution of precipitation based on the precipitation distributions observed regionally.



LEGEND

- Climate Station
- Major Road
- Watercourse

NOTES
Base data source: Yukon Geomatics

STATUS
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Climate Station Locations

PROJECTION	DATUM	CLIENT
UTM Zone 9	NAD83	NORTH AMERICAN TUNGSTEN CORPORATION LTD

Scale: 1:850,000
10 5 0 10
Kilometres

FILE NO.
W23101211_004_FigureR6-1.mxd

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PROJECT NO.	DWN	CKD	APVD	REV
W23101211.004	MEZ	MAN	MAN	0

OFFICE	DATE
EBA-VANC	August 2, 2013

Figure R6-1

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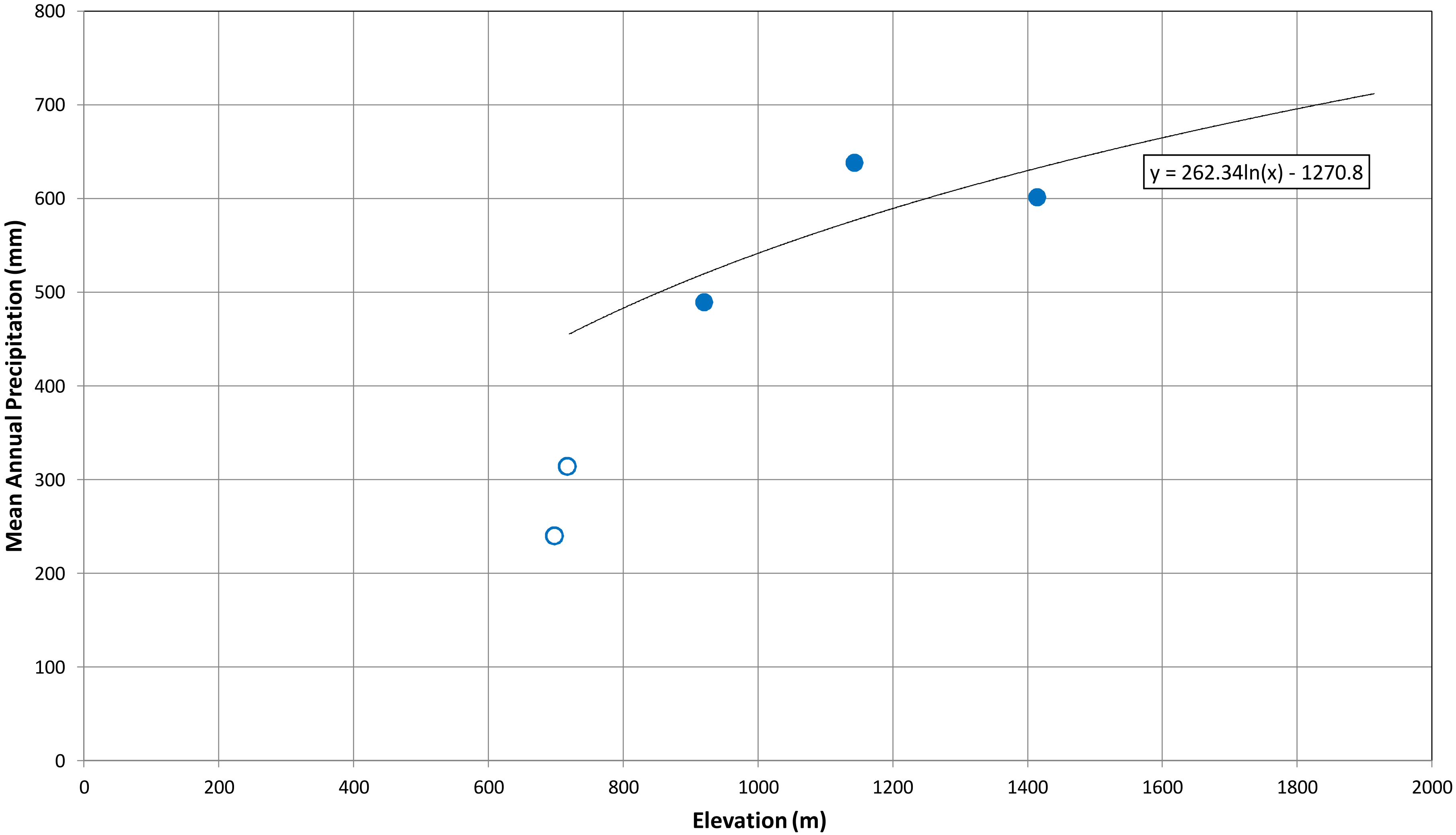

NOTES

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MACTUNG PROJECT

Mean Annual Precipitation Graph

PROJECT NO.	DWN	CKD	APVD	REV
W23101211.004	SPB			0
OFFICE	DATE			
EBA-VANC	July, 2013			

Figure R6-2

Table R6-2: Summary of Regional Precipitation Analysis (mm)

Month	Ross River	Tungstun	Faro	Macmillan Pass	Mt Sheldon
January	12	42	15	35	27
February	9	32	12	40	23
March	6	33	12	45	26
April	5	37	8	36	20
May	23	39	25	30	18
June	31	62	40	66	66
July	50	88	55	85	81
August	33	82	49	94	70
September	26	64	38	75	63
October	14	71	26	57	54
November	18	53	19	45	41
December	16	34	17	49	39
Mean Annual	243	638	315	657	528
Standard Deviation	25	102	60	105	79
% Variability	10%	16%	19%	20%	16%

Notes:
mm – millimetres
% - percent

Table R6-3: Mactung Mean Annual Precipitation and Monthly Distribution

Month	Precipitation (mm)	Distribution (%)
January	38.0	5%
February	42.4	6%
March	48.5	7%
April	38.9	6%
May	32.2	5%
June	71.0	10%
July	91.0	13%
August	100.4	14%
September	80.3	11%
October	61.4	9%
November	48.1	7%
December	52.1	7%
Mean Annual	704.2	100%

Notes: mm – millimetres
% - percent

A second approach was applied to evaluate the mean annual precipitation at the Mactung Site using ClimateWNA (ver 4.72). ClimateWNA is a program which generates high-resolution data in Western Canada for specific locations based on latitude and longitude. Table R6-4 summarizes the calculated mean annual precipitation using historical data from the five meteorological stations and the corresponding estimates obtained from ClimateWNA.

Table R6-4: Comparison of Mean Annual Precipitation

Stations Name	Mean Annual Precipitation (mm)		% Difference
	Historical[1]	ClimateWNA[2]	
Ross River	240	331	38%
Tungsten	638	668	5%
Faro	314	318	1%
Macmillan Pass	601	611	2%
Mt Sheldon	489	565	16%
Mactung Site	704	676	4%

Notes: [1] Historical data based on available range of data (see Table R6-1)
[2] ClimateWNA data range from 1981 to 2009
[3] Historical Mactung Mean Annual Precipitation of 704 mm based on trend illustrated in Figure R6-2
mm – millimetres
% - percent

The difference in the estimated precipitation at the Mactung site was determined to be 4%, which provides a reasonable level of confidence in the precipitation estimate using the regional precipitation analysis. As a conservative approach, the regional precipitation of 704 mm was used as the mean annual direct precipitation to evaluate runoff coefficients at site and as an input in the water balance.

To aid in determining the runoff coefficients summarized in Responses R2 and R4 for Tributary C and Hess River South Tributary respectively, two modified regional precipitation analysis were conducted to evaluate precipitation at Mactung site over a time period concurrent with available flow data for these two streams. As such, these two modified regional analyses only included regional precipitation data collected over the same time period as those for which Tributary C and the Hess Tributary flows were being continually monitored. Table R6-5 summarizes the average estimated precipitation at site from 2006 to 2012 (flow monitoring period for Tributary C) and from 2008 to 2012 (flow monitoring period for Hess River).

Two climate stations, Faro and Macmillan Pass had precipitation data available for these required time periods. Total annual precipitation was calculated for both climate stations over the two periods of interest. These annual precipitations were then compared to the historical annual precipitation observed at each climate station to develop a ratio which reflected how the climate over the periods of interest compared to all historical data. These ratios were then averaged to develop a ratio for the Mactung Site. Once ratios for the Mactung Site were developed, they were applied to the mean total historical precipitation calculated for Mactung (704 mm) to estimate annual precipitation which occurred on site between 2006 and 2012 (for Tributary C) and from 2008 to 2012 (for Hess Tributary).

Table R6-5: Mactung Mean Annual Precipitation (mm) from year 2006 to 2012

Climate Station	Mean Total Historical (1967 - 2012)	2006 – 2012[A]		2008 – 2012[B]	
		Mean	Ratio	Mean	Ratio
Faro	314	316	1.01	323	1.03
Macmillan Pass	601	649	1.08	661	1.10
Mactung Site	704	734	1.04*	746	1.06*

Notes: * Based on average ratio of Faro (1.03) and Macmillan Pass (1.10) climate stations
mm – millimetre
[A] Precipitation data used to evaluate Trib C runoff coefficient
[B] Precipitation data used to evaluate Hess Trib runoff coefficient

A frequency analysis was conducted for the five selected regional stations to evaluate total annual wet and dry precipitation for the Mactung site. Wet and dry annual precipitation for the 2-year through 200-year return periods was calculated using a normal distribution which was found to provide the best fit to the observed data. Table R6-6 summarizes the results from the frequency analysis for the five selected regional stations.

Table R6-6: Annual Precipitation Frequency Analysis for Selected Regional Stations (mm)

Return Period	Regional Stations									
	Ross River		Tungstun		Faro		Macmillan Pass		Sheldon	
Elevation	698 m		1143 m		717 m		1414 m		920 m	
Condition	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
200	530	2	901	375	468	163	836	439	797	269
100	504	27	876	400	453	178	817	458	772	295
50	476	55	848	428	437	194	796	479	744	323
20	434	97	806	470	413	218	764	511	702	365
10	397	134	769	507	391	240	736	539	665	402
5	352	179	724	552	365	266	702	573	619	447
2	266	266	638	638	315	315	638	638	533	533

Notes: mm – millimetres

Similar plots to Figure R6-1 were created for each return period to evaluate the wet and dry annual precipitation for the Mactung Site and results are summarized in Table R6-7.

Table R6-7: Mactung Wet and Dry Annual Precipitation (mm)

Return Period	Dry Condition	Wet Condition
200	617	1088
100	639	1066
50	665	1041
20	703	1003
10	736	970
5	776	929
2	853	853

Notes: mm – millimetres

A precipitation gauge was installed adjacent to the existing Mactung meteorological station near the camp on August 12, 1013. This gauge will provide year-round precipitation data which will be used after a minimum of one full year of data is collected to validate the precipitation estimates in this response.

The calculated mean annual precipitation, estimated annual variability and monthly distributions from the updated calculations presented herein were included in the updated water balance presented in Response R8.

2.4 Groundwater Estimates

R7: Describe the 'most probable scenario' of groundwater inflow rate that will be used in the site water balance. Provide a detailed discussion of the uncertainties of the 'most probable scenario' and how these uncertainties will be addressed in the site water balance. Conduct a sensitivity analysis based on those uncertainties.

Groundwater inflow rates to the proposed underground workings were previously estimated based on four different analytical models including two 'equivalent-well' approaches and two 2-dimensional models (NATC, YOR #2008-0304-082-2; Singh and Reed, 1988). Inflow rates were calculated for different input parameter values reflecting the range of observed field data or a range of literature values where field data were absent. The results are summarized in Table R7-1 (same as Table 5.2-3 in NATC, YOR #2008-0304-082-2). The estimated inflow rates vary over three orders of magnitude, primarily due to the uncertainty in bedrock hydraulic conductivity. Hydraulic conductivity in bedrock aquifers can typically vary over several orders of magnitude (e.g., Freeze and Cherry, 1979) on a local scale and hence, the estimated inflow rates vary over a similarly large range.

The 'most probable scenario' presented was based on input parameter values that were deemed to be most representative of the anticipated hydrogeological conditions in the area of the proposed underground workings. However, this deterministic approach, which used ranges of parameter values and included best case, worst case, and most probable scenarios, only yielded a range of estimated inflow rates without quantifying their associated uncertainties. To address YESAB's R7 information request, additional analysis was required to quantify the uncertainty in the input parameters into the simulation results (inflow rates). Therefore, a more rigorous stochastic approach to estimate groundwater inflow to the proposed underground workings, including quantification of the associated uncertainty, was carried out and is presented here.

Monte Carlo simulation is a well-established stochastic method for propagating (translating) uncertainties in model inputs into uncertainties in model outputs (results). It is a type of simulation that explicitly and quantitatively represents uncertainties. If the inputs describing a system are uncertain, the prediction of future performance (output) is necessarily uncertain. Monte Carlo simulation involves explicitly representing uncertainties by specifying inputs as *probability distributions*. Hence, the result of any analysis based on inputs represented by probability distributions is itself a probability distribution.

Table R7-1: Results of Analytical Models for Prediction of Mine Water Inflow Rates (from 2009 study)

Model	Model Assumptions	Equation	Scenarios	Results
1*	Equivalent well: Leaky aquifer, linear flow, transient state	$Q = \frac{4 \cdot \pi \cdot T \cdot s}{W(u)}$ $u = \frac{r^2 S}{4Tt}$	Parameter variation: K = 10-8 to 10-6 m/s s = 30 to 70 m S = 10-4 to 10-7 t = 1 and 6 years	Q_{MAX} = 516 m^3/d Q_{MIN} = 1 m^3/d Q_{MEAN} = 68 m^3/d
			Most probable scenario: K = 6×10-7 m/s s = 40 m S = 10-6 t = 3 years	Q_{MP} = 85 m^3/d
2	Equivalent well: Unconfined aquifer, linear flow, steady-state	$Q = \frac{\pi \cdot K \cdot s^2}{\ln\left(\frac{R}{r}\right)}$	Parameter variation: K = 10-8 to 10-6 m/s s = 30 to 70 m R = 300 to 1000 m	Q_{MAX} = 1919 m^3/d Q_{MIN} = 1 m^3/d Q_{MEAN} = 142 m^3/d
			Most probable scenario: K = 6×10-7 m/s s = 40 m R = 700	Q_{MP} = 169 m^3/d
3	Two-dimensional model: Unconfined aquifer, linear flow, steady state	$Q = \frac{K \cdot d \cdot s^2}{R}$	Parameter variation: K = 10-8 to 10-6 m/s s = 30 to 70 m R = 300 to 1000 m	Q_{MAX} = 423 m^3/d Q_{MIN} = 0.2 m^3/d Q_{MEAN} = 30 m^3/d
			Most probable scenario: K = 6×10-7 m/s s = 40 m R = 700	Q_{MP} = 36 m^3/d
4	Two-dimensional model: Confined aquifer, linear flow, steady state	$Q = \frac{2 \cdot K \cdot d \cdot s^2}{R}$	Parameter variation: K = 10-8 to 10-6 m/s s = 30 to 70 m R = 300 to 1000 m	Q_{MAX} = 846 m^3/d Q_{MIN} = 0.5 m^3/d Q_{MEAN} = 61 m^3/d
			Most probable scenario: K = 6×10-7 m/s s = 40 m R = 700	Q_{MP} = 71 m^3/d

Q	Discharge / inflow rate [m^3/s]	R	Equivalent radius of underground workings = radius at which drawdown is required [m]
K	Hydraulic Conductivity [m/s]	D	Equivalent length of underground workings = diameter of underground workings [m]
T	Transmissivity [m^2/s]	S	Storativity [-]
s	Drawdown [m]		
$W(u)$	Well function (exponential integral)		
R	Radius of influence [m]		

* This model was used in the original submission to estimate mine water inflow rates.

In Monte Carlo simulation, the entire system is simulated a large number (e.g., thousands) of times. Each simulation is equally likely and referred to as a *realization* of the system. For each realization, all of the uncertain input parameters are sampled (i.e., a single random value is selected from the specified distribution describing each parameter). The model is then run for each set of randomly selected input parameter values which results in a large number of separate and independent results, each representing a possible inflow rate. The results of the independent system realizations are assembled into probability distributions of possible outcomes. As a result, the outputs are not single values, but probability distributions.

The following paragraphs present a detailed discussion of the range of input parameter values and probability distributions used for the inflow estimates to the proposed underground workings at Mactung.

Hydraulic Conductivity K

As discussed in NATC, YOR #2008-0304-082-2, the hydraulic conductivity (or the directly proportional transmissivity) of the aquifer is the most highly variable parameter determining the estimated inflow rates. The hydraulic conductivity of a bedrock aquifer can vary over several orders of magnitude on a relatively small scale depending on the type of bedrock and the extent of fracturing of the rock or other secondary porosity (e.g., Freeze and Cherry, 1979).

Packer tests were conducted in a total of four wells drilled at Mt. Allan at Mactung to infer the hydraulic conductivity of the bedrock in the vicinity of the proposed underground workings. Figure R7-1 shows the results of the packer tests in boreholes MW-MT-08-01, MW-MT-08-02, MW-MT-08-08, and MW-MT-09-10. The results of the first three boreholes were also included in the previous analysis (NATC, YOR #2008 0304 082 2); additional packer tests were conducted in MW-MT-09-10 in August 2009 to further characterize the hydraulic conductivity in the area of the proposed underground workings. The lower detection limit of the packer test method applied was about 1×10^{-8} m/s.

Figure R7-1 also shows the results of a short-term constant rate pumping test conducted in monitoring well MW-MT-08-08. The hydraulic conductivity of 6×10^{-7} m/s inferred from the pumping test agrees well with the packer test results from a similar test interval in MW-MT-08-08 (9×10^{-7} m/s at a depth of about 1,700 m asl, see Figure R7-1).

The depth profile of inferred hydraulic conductivities suggests that the hydraulic conductivities increase below an elevation of about 1,800 m asl. This increase might be due to the presence of permafrost at higher elevations (e.g., see Figure 5-1 in NATC, YOR #2008-0304-057-2), resulting in lower bedrock hydraulic conductivity where fractures are filled with ice. Therefore, only hydraulic test results from below an elevation of 1,800 m asl were used for the inflow estimates. A total of 11 packer tests below 1,800 m asl with a geometric mean of 7×10^{-8} m/s were used for the inflow estimates.

The hydraulic conductivity K for bedrock usually follows a lognormal distribution (i.e., the logarithm of the hydraulic conductivities ($\log(K)$) is normally distributed) (e.g., Freeze and Cherry, 1979). For the purpose of the inflow estimates, we therefore assumed that $\log(K)$ in the area of the proposed underground workings is normally distributed. The $\log(K)$ normal distribution is characterized by a mean value ($\mu = -7.15$) and standard deviation ($\sigma = 0.73$) based on the results of the packer tests below 1,800 m asl.

Figure R7-2 shows the results of the packer tests and the cumulative distribution function Φ of hydraulic conductivity used for the inflow estimates. The cumulative distribution function Φ for the normal distribution is defined as:

$$\Phi(x) = \frac{1}{2}\left[1 + \mathrm{erf}\left(\frac{x-\mu}{\sqrt{2\sigma^2}}\right)\right] \qquad \text{(Eq. 1)}$$

with $\mu = -7.15$ and $\sigma^2 = 0.53$.

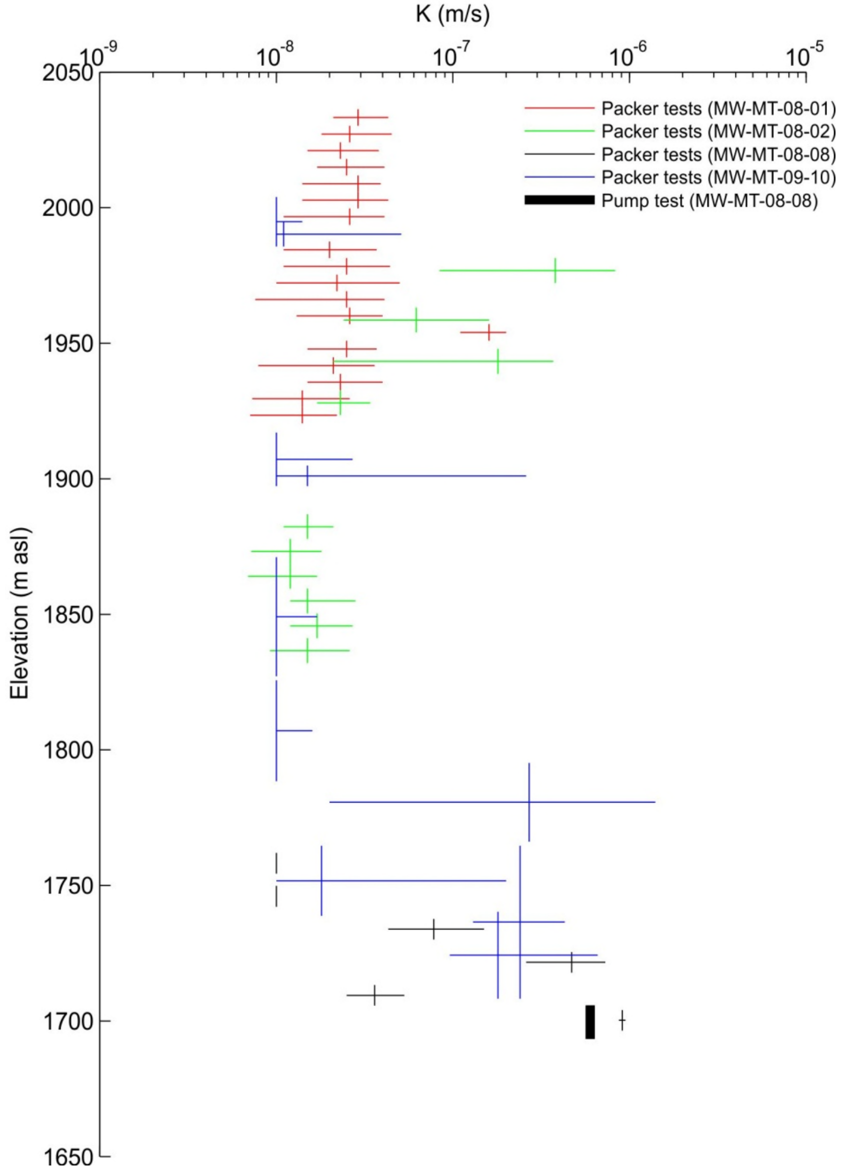


Figure R7-1: Hydraulic test results in the area of the proposed underground workings. Note that the detection limit of the packer testing method used is about 1×10 8 m/s. The horizontal lines indicate the range of hydraulic conductivities inferred for each individual test and the vertical lines indicate the geometric mean and elevation range of the test interval.

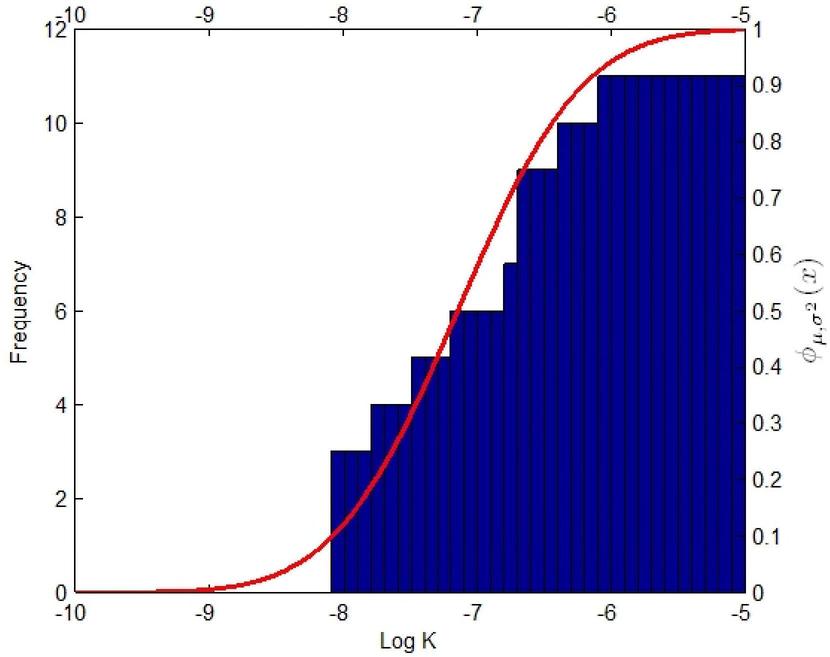


Figure R7-2: Cumulative distribution function *Φ(x)* of hydraulic conductivity used for the inflow estimates. The blue bars represent the hydraulic conductivities inferred from packer tests below 1,800 m asl. The red line shows the cumulative distribution function assuming a normal distribution of log*(K)* (Eq. 1) with $\mu = -7.15$ and $\sigma = 0.73$.

Drawdown s

The required maximum drawdown of the groundwater table was determined by the baseline piezometric elevation prior to mine development and the maximum depth of the proposed underground workings. The baseline piezometric elevation at Mt. Allan has been monitored at MW-MT-08-08 and MW-MT-08-01 (see Figure R7-3). For the purpose of the inflow estimates, EBA inferred that the baseline piezometric elevation is at about 1,735 m asl to 1,760 m asl in the area of the proposed underground workings prior to development.

The bottom of the proposed underground workings will be located at an elevation of about 1,710 m asl. Therefore, based on available data, a drawdown of the existing static piezometric water level by 25 to 50 m will become necessary to dewater the deepest, western part of the proposed underground workings. This assumption is conservative because it implies that the groundwater table will be drawn down to the bottom of the underground workings instantaneously and during the entire time of operation.

For the purpose of inflow estimates, the drawdown is assumed to be uniformly distributed. The cumulative distribution function is given by (Figure R7-4):

$$\Phi(x) = \begin{cases} 0 & \text{for } x < a \\ \frac{x-a}{b-a} & \text{for } x \epsilon [a,b) \\ 1 & \text{for } x \geq b \end{cases} \qquad \text{(Eq. 2)}$$

with $a = 25$ m and $b = 50$ m

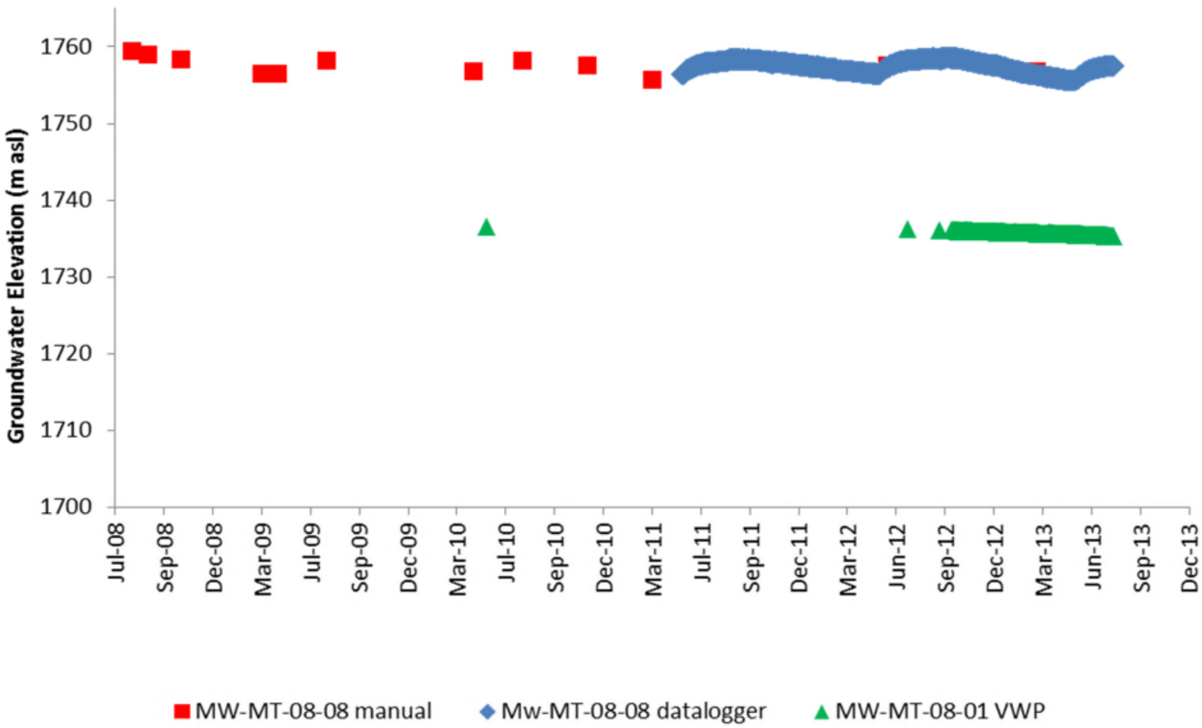


Figure R7-3: Hydrograph for Monitoring Wells MW-MT-08-01 and MW-MT-08-08.

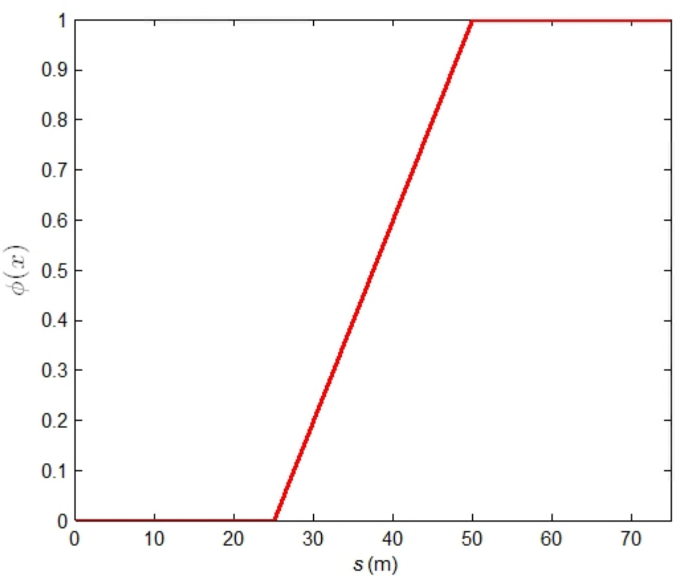


Figure R7-4: Cumulative Distribution Function *Φ(x)* of Drawdown *s* used for the Inflow Estimates.

Radius of Influence R

The radius of influence R describes the maximum distance at which surrounding piezometric levels will be influenced by the drawdown during dewatering of the underground workings. The radius of influence was based on the approximate diameter of the proposed underground workings (300 m, assigned as the lower limit), and the topography in the area of the underground workings (1,000 m, assigned as the upper limit).

Similarly to the drawdown s, a uniform distribution was assumed for the radius of influence R, with $a = 300$ m and $b = 1000$ m (see Eq. 2 and Figure R7-5).

Storativity S

A range of storativity values was assumed for the purpose of the inflow estimates based on literature values (e.g., Freeze and Cherry, 1979; Domenico and Schwartz, 1998). The storativity of confined bedrock aquifers typically ranges over several orders of magnitude. For the purpose of the inflow estimates it was assumed that the storativity may range from $a = 10^{-7}$ to $b = 10^{-4}$ following a uniform distribution of $\log(S)$ (see Eq. 2 and Figure R7-6).

Constant/Non-random Parameters

The equivalent radius ($\mathrm{r} = 150$ m) and equivalent length ($\mathrm{d} = 300$ m) of the underground workings are given by the geometry of the proposed underground workings and are therefore constant (with no uncertainty assigned for this analysis).

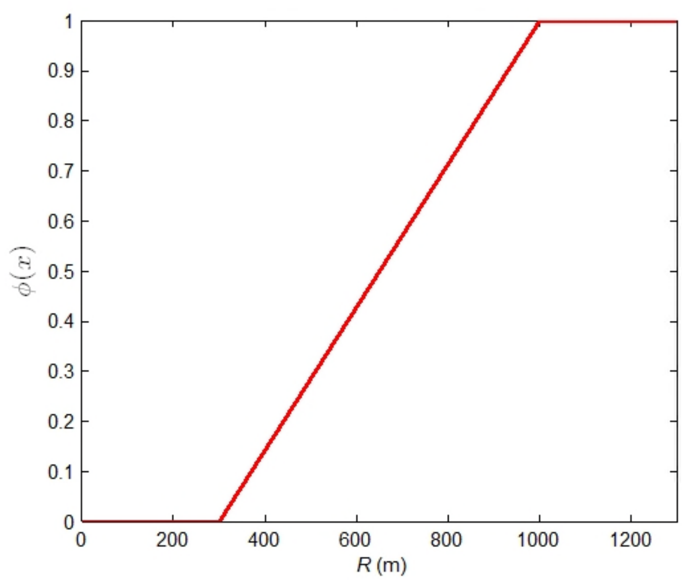


Figure R7-5: Cumulative Distribution Function Φ(x) of Radius of Influence R used for the Inflow Estimates.

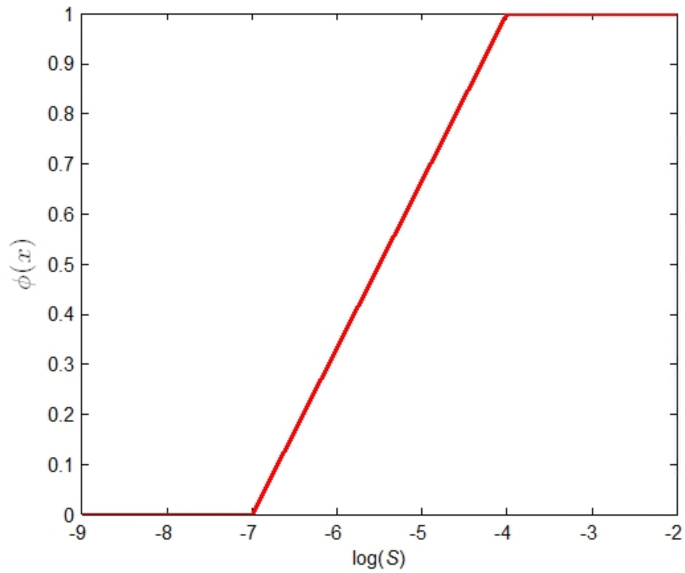


Figure R7-6: Cumulative Distribution Function Φ(x) of Log(S) used for the Inflow Estimates.

Monte Carlo Simulation

Using the input parameter probability distributions described above, Monte Carlo simulations were computed for the four different models (Model No. 1-4) used to estimate the groundwater inflow to the proposed underground workings. A total of 100,000 realizations were computed for each model in order to produce statistically meaningful results. The resulting probability distributions for the estimated inflow rates Q are summarized in Table R7-2.

Because the hydraulic conductivity values are lognormally distributed, the resulting inflow rates also follow a lognormal distribution (i.e., the logarithm of the inflow rates (log (Q)) is represented by a normal distribution). Table R7-2 also shows the geometric mean of the estimated inflow rate Q_{geo} and the 90% probability level inflow rate Q_{90}. That is, with a probability of 90% the actual inflow rate is smaller than the Q_{90} value. Table R7-2 also presents the minimum and maximum inflow rates ($Q_{\min}$ and $Q_{\max}$) for each simulation; however, the minimum and maximum values have negligible significance as their realization is extremely unlikely (probability <1%).

The estimated mean inflow rates range from 4 m^3/d to 19 m^3/d. The 90% probability level inflow rates range from 30 m^3/d to 144 m^3/d.

The range of inferred inflow rates using the stochastic approach presented here is similar to our previous estimates of about 1 m^3/day to 1000 m^3/day. However, the stochastic approach demonstrates that the low and high ends of this range have a very low associated statistical significance. The range of inferred inflow rates, e.g., for the purpose of the site water balance, can therefore be significantly reduced based on the results of the stochastic model.

Model #2 yields the highest inflow rates. Even though fractured bedrock at the mine site with a permafrost cap is not likely to behave in an unconfined manner, we recommend that the results of Model #2 be used as input for the water balance to provide a conservative estimate of groundwater inflow to the deepest portion of the proposed underground workings at Mactung. Based on the current mine plan, groundwater inflow is expected to occur starting around Year 6 of the proposed mining operations when the underground workings reach the groundwater table.

Table R7-2: Estimated Inflow Rates using Monte Carlo Simulations

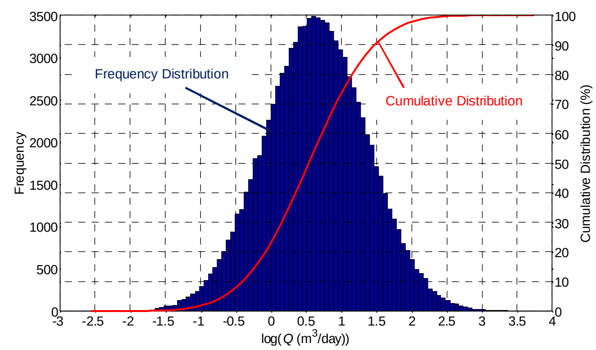
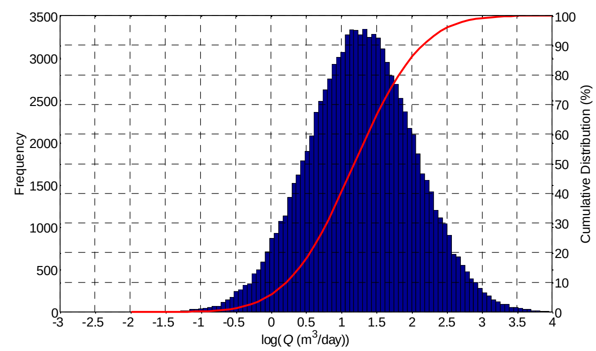
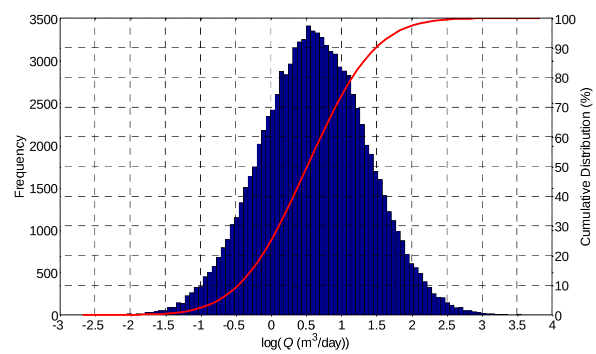
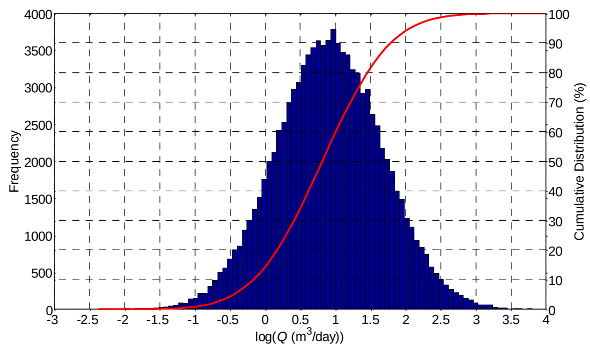
Model	Model Assumptions	Equation	Results	
1	Equivalent well: Leaky aquifer, linear flow, transient state	$Q = \frac{4 \cdot \pi \cdot T \cdot s}{W(u)}$ $u = \frac{r^2 S}{4Tt}$	$\mu_{\log(Q)} = 0.63$ $\sigma_{\log(Q)} = 0.73$ $Q_{\min}$ $= 0.0021\ \mathrm{m^3/d}$ $Q_{\max}$ $= 4{,}893\ \mathrm{m^3/d}$ $\boldsymbol{Q_{geo} = 4\ m^3/d}$ 90%-probability level:	
2	Equivalent well: Unconfined aquifer, linear flow, steady-state	$Q = \frac{\pi \cdot K \cdot s^2}{\ln\left(\frac{R}{r}\right)}$	$\mu_{\log(Q)} = 1.3$ $\sigma_{\log(Q)} = 0.76$ $Q_{\min}$ $= 0.0123\ \mathrm{m^3/d}$ $Q_{\max}$ $= 24{,}853\ \mathrm{m^3/d}$ $\boldsymbol{Q_{geo} = 19\ m^3/d}$ 90%-probability level: $\boldsymbol{Q_{90} = 144\ m^3/d}$	
3	Two-dimensional model: Unconfined aquifer, linear flow, steady state	$Q = \frac{K \cdot d \cdot s^2}{R}$	$\mu_{\log(Q)} = 0.61$ $\sigma_{\log(Q)} = 0.76$ $Q_{\min}$ $= 0.0020\ \mathrm{m^3/d}$ $Q_{\max}$ $= 4{,}876\ \mathrm{m^3/d}$ $\boldsymbol{Q_{geo} = 4\ m^3/d}$ 90%-probability level:	

Table R7-2: Estimated Inflow Rates using Monte Carlo Simulations

Model	Model Assumptions	Equation	Results	
4	Two-dimensional model: Confined aquifer, linear flow, steady state	$Q = \frac{2 \cdot K \cdot d \cdot s^2}{R}$	$\mu_{\log(Q)} = 0.91$ $\sigma_{\log(Q)} = 0.76$ $Q_{\min} = 0.0032\ \mathrm{m^3/d}$ $Q_{\max} = 31{,}826\ \mathrm{m^3/d}$ $\boldsymbol{Q_{geo} = 8\ \mathrm{m^3/d}}$ 90%-probability level: $\boldsymbol{Q_{90} = 61\ \mathrm{m^3/d}}$	

2.5 Site Water Balance

R8: Update the water balance model using the updated precipitation and hydrology information. As part of the water balance model report, provide a discussion of hydrological variability between wet years and dry years and consider more extreme conditions of flood and drought (i.e. volumes, duration and frequency). The water balance model report shall show how the reservoir will respond in times of high flow, short duration events, (e.g. a few hours or a few days) which cannot be accurately captured in a water balance model using monthly time steps. The model report should provide and interpret the results of sensitivity analysis on the water balance model. (For additional information see "Proponents Guide: Water information Requirements for Quartz Mining Project Proposals" (YESAB, 2011))

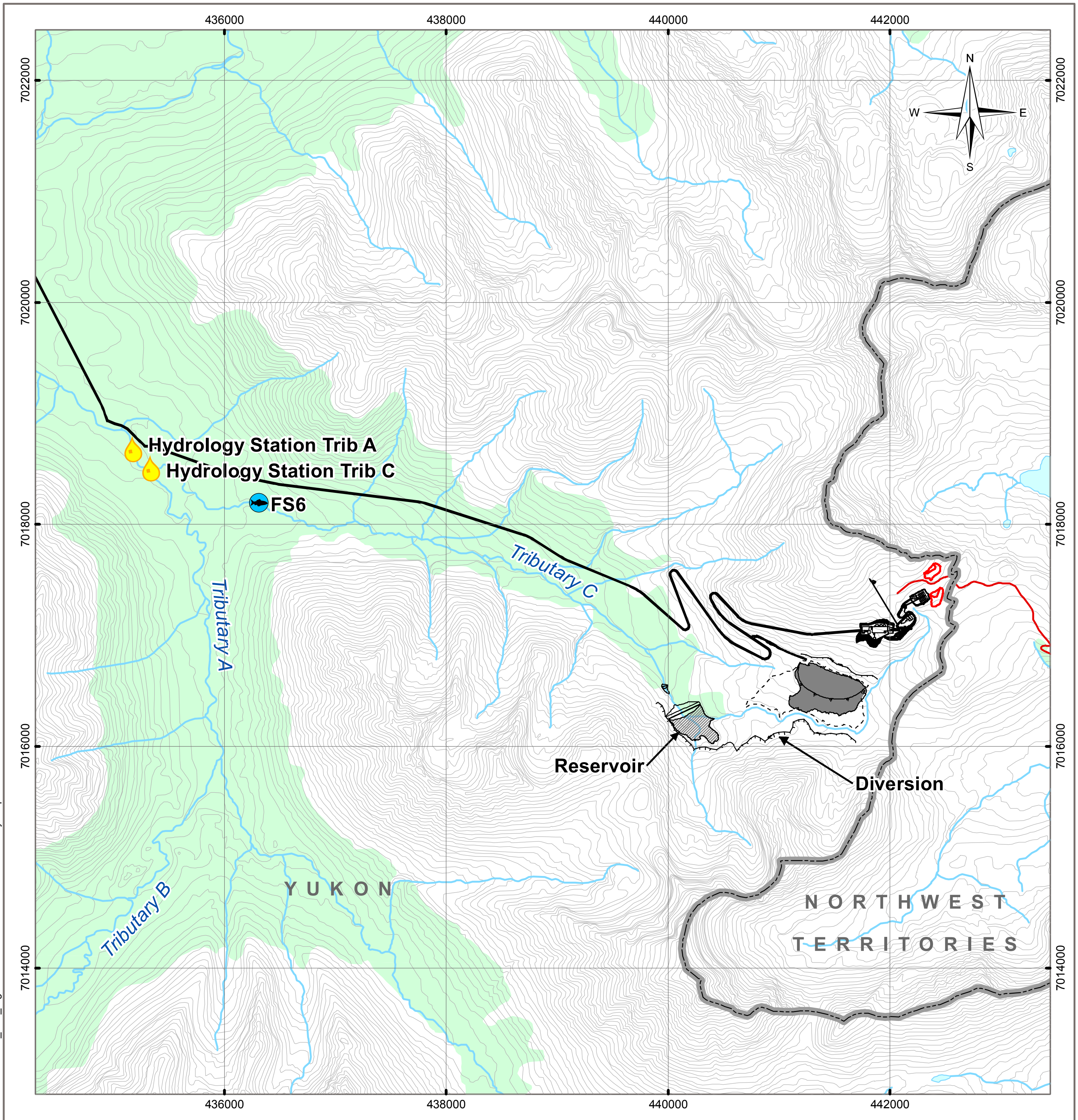
GoldSim™ software was used to model the site water balance and to evaluate the capacity of the Ravine Dam Reservoir (reservoir), the variability of precipitation and resulting runoff from the Mactung site. GoldSim is a software platform that has been used for many applications within the mining industry to dynamically model all types of complex systems. It has the ability to conduct Monte Carlo scenarios, where the model runs for multiple realizations where each realization is equally likely to occur and is saved as a possible solution. After the completion of a Monte Carlo simulation, the results of all the solutions are analysed and a probability distribution of the results is generated. The water balance model is based on regional precipitation and regional and local runoff analyses where inputs to the model are average temperature, total precipitation, runoff coefficient, monthly distributions and length of day (for evaporation estimates). The model accounts for snow accumulation, snowmelt, evaporation and runoff.

Quantities of water in this updated water balance differ from those presented in Response to Request for Supplementary Information for the Mactung Project Proposal - YESAB 2008-0304 July 2011. This document presents ranges of values to demonstrate the potential sensitivity resulting from variability of the input data.

Model Structure

The water balance using GoldSim™ was established for the Mactung water reservoir and Tributary C. The reservoir is located upstream of the Tributary C hydrometric station (Figure R8-1). Based on topography, the un-diverted upstream catchment area of the reservoir was estimated to be approximately 2.51 km^2.

Based on the current design of the reservoir, the total surface area at the spillway elevation (1514 m asl) maximum capacity was estimated to be approximately 88,143 m^2. Table R8-1 summarizes the stage-volume-area data for the reservoir in the water balance.



LEGEND

- Hydrology Station
- Fisheries Station
- Existing Road
- Proposed Road
- Temporary Waste Rock Dump
- NWT-YT Border
- Contours (20 m)
- Watercourse
- Waterbody
- Wetland
- Vegetation

NOTES
Base data source: 1:50,000 NTS

STATUS
ISSUED FOR USE

MACTUNG

Site Map

PROJECTION	DATUM	CLIENT
UTM Zone 9	NAD83	NORTH AMERICAN TUNGSTEN CORPORATION LTD

Scale: 1:50,000
1 0.5 0 1
Kilometres

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PROJECT NO.	DWN	CKD	APVD	REV
W23101211.004	SL	X	SP	0

OFFICE	DATE
EBA-VANC	August 29, 2013

Figure R8-1

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Table R8-1: Ravine Dam Stage-Storage-Area Curve

Stage (m asl)	Volume (m^3)	Surface Area (m^2)	Comment
1,500.5	11,200	7,000	
1,501.0	15,000	7,600	
1,501.5	20,000	10,000	
1,502.0	26,000	12,000	
1,502.5	33,000	14,000	
1,503.0	41,000	16,000	
1,503.5	50,200	18,400	
1,504.0	60,500	20,600	
1,504.5	72,000	23,000	
1,505.0	84,700	25,400	
1,505.5	98,900	28,400	
1,506.0	114,000	30,200	Outlet Control Invert
1,506.5	131,000	34,000	
1,507.0	150,000	38,000	
1,507.5	171,200	42,400	
1,508.0	194,800	47,200	
1,508.5	221,000	52,400	
1,509.0	248,700	55,400	
1,509.5	278,300	59,200	
1,510.0	309,100	61,600	
1,510.5	341,400	64,600	
1,511.0	374,800	66,800	
1,511.5	410,000	70,400	
1,512.0	446,100	72,200	
1,512.5	483,900	75,600	
1,513.0	540,000	81,379	Maximum Operating Level
1,513.5	580,000	84,761	
1,514.0	612,000	88,143	Emergency Spillway Invert
1,516.5	793,333*	98,423	Crest of Dam

Notes: * linear extrapolation to top of dam

m asl – m above mean sea level

m^3 – cubic metres

m^2 – metre square

Figure R8-2 illustrates the conceptual water balance for the project during operations.

As illustrated, inflows in the water balance of the reservoir consist of:

- Upstream runoff;
- Rainfall falling directly onto the reservoir;
- Snowmelt from the reservoir surface area;
- Mill discharge;
- Wastewater treatment discharge;
- Dry-stacked tailings (DSTF) discharge;
- Underground dewatering starting at Year 6; and
- Seepage return to the reservoir
- Outflows and losses consist of:
- Reclaim to the mill;
- Seepage outflow;
- Discharge to Tributary C; and
- Evaporation from the reservoir surface area.

Model Parameters

Figure R8-3 illustrates the GoldSim water balance structure. As shown, the water balance accounts for all inputs and outputs listed above. The model inputs are based on monthly values, however the model simulation runs on a daily timestep. This means that the monthly values are distributed equally over the number of days in a month. The model is set-up to run for an 11 year period (assumed mine life) for a total of 1,000 Monte Carlo simulations.

As presented in Response R6, a regional analysis was conducted to evaluate precipitation at the Mactung site. Based on the regional analysis, it was determined that the average annual precipitation estimate, based on historical records, is in the order of 704 mm with a standard deviation of 141 mm. Based on a frequency analysis, it was found that a normal distribution provided a good fit to the historical data. Therefore, to account for the variability of total annual precipitation at site, a normal distribution was applied in the GoldSim water balance. The monthly distribution applied to the annual precipitation in the model is summarized in Table R6-3 in Response R6.

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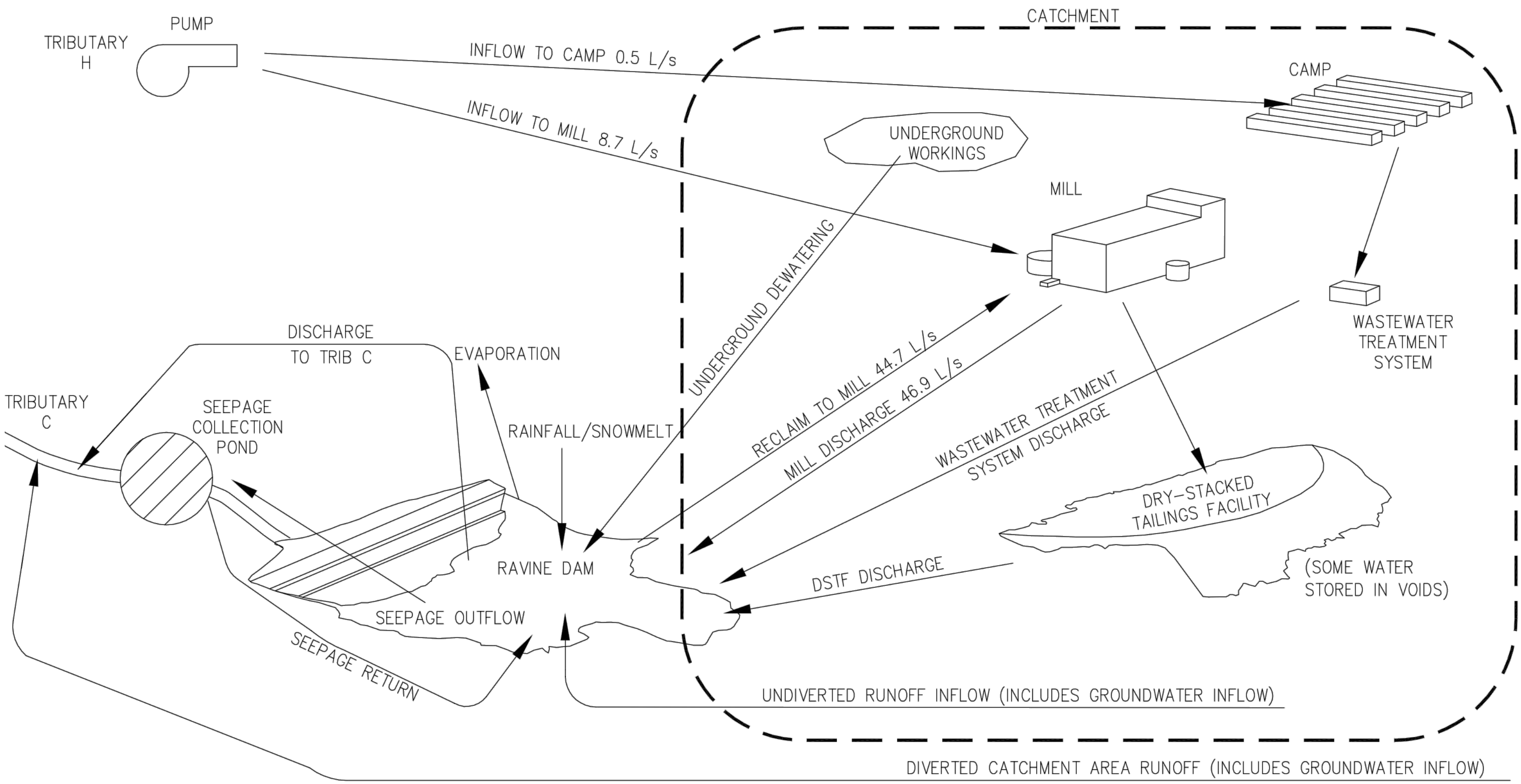

CLIENT

NORTH AMERICAN TUNGSTEN CORPORATION LTD

MACTUNG

CONCEPTUAL WATER BALANCE

eba A TETRA TECH COMPANY

PROJECT NO.	DWN	CKD	REV
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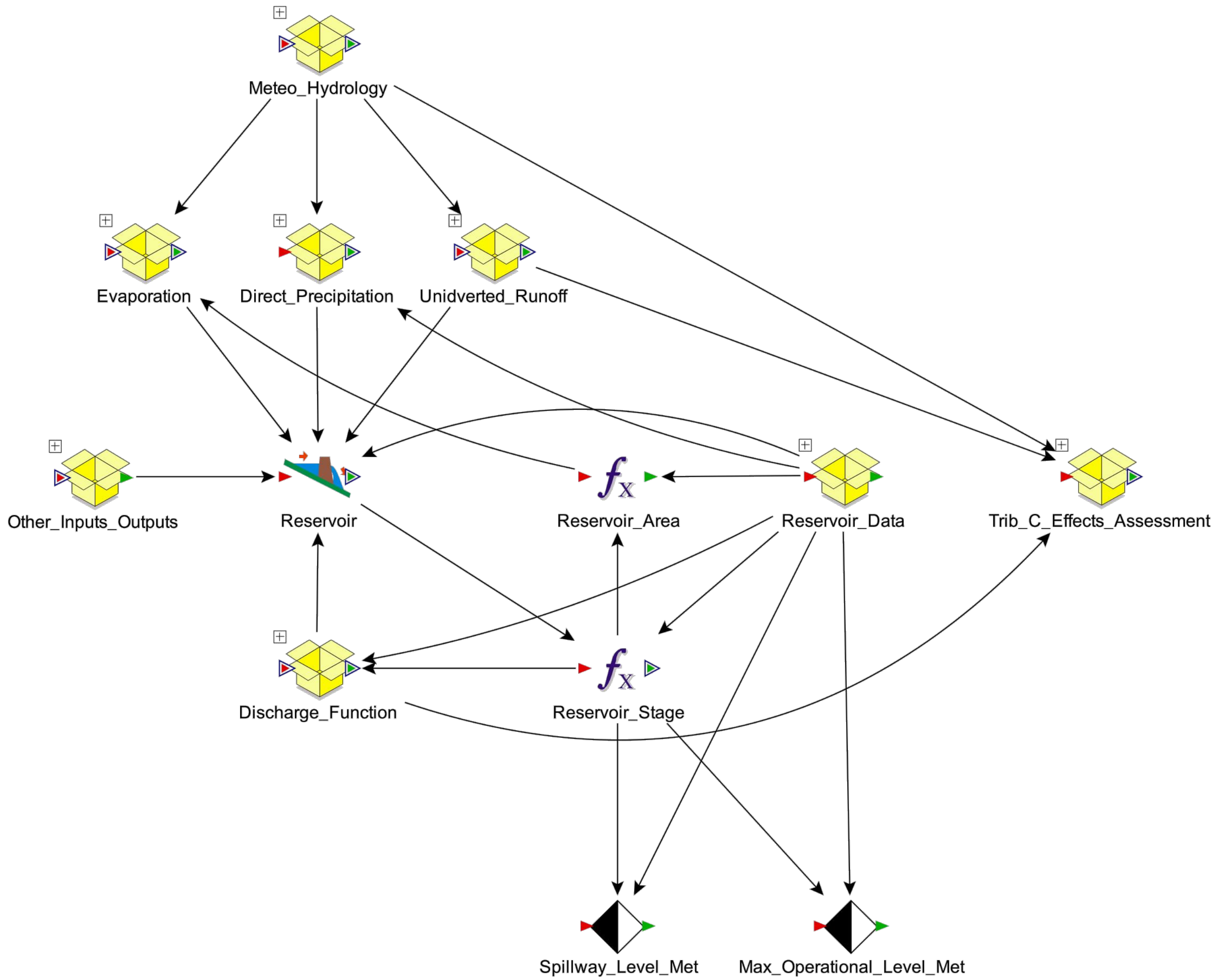
Figure R8-2



CLIENT: NORTH AMERICAN TUNGSTEN CORPORATION LTD	MACTUNG				
	GOLDSIM WATER BALANCE STRUCTURE				
eba A TETRA TECH COMPANY	PROJECT NO. [illegible]	DWN [illegible]B	CKD [illegible]MR	REV [illegible]	Figure R8-3
	OFFICE [illegible]	DATE [illegible]ugust [illegible]			

The water balance model accounts for the difference between rainfall and snow as well as the accumulation and melting of snow. Separation between snow and rainfall is determined by the following formulation (Hay and McCabe 2010):

$$P_{snow} = P \; for \; T_a \; \leq T_{snow}$$

$$= P\left(\frac{T_{rain} - T_a}{T_{rain} - T_{snow}}\right) \; for \; T_{snow} < T_a < T_{rain}$$

$$= 0 \; for \; T_a \geq T_{rain}$$

Where:

P_{snow} = daily precipitation of snow in mm

P = total daily precipitation in mm

T_a = mean daily air temperature in degrees Celsius

T_{rain} = threshold above which all precipitation is rain

T_{snow} = threshold below which all precipitation is snow.

When air temperature is between T_{rain} and T_{snow}, the proportion of precipitation that is snow or rain changes linearly. In the model that accounts for snow accumulation and melt, snow that occurs on a daily timestep is added to the snowpack and is subject to melt, if conditions are such that melting can occur. For some cases, snow, rain and snowmelt can occur in the same timestep. The amount of snow that is melted is computed as (McCabe and Markstrong 2007):

$$SM = snostor \times meltmax \times \left(\frac{T - T_{snow}}{T_{rain} - T_{snow}}\right)$$

Where:

SM = snowmelt in millimetres of snow water equivalent

snostor = cumulative snow storage (snowpack)

meltmax = maximum melting rate.

The input values for T-Snow, T-Rain and meltmax used in the water balance are based on literature values applied in the Yukon (Hay and McCabe 2010). To quantify the level of confidence of the final model results, a sensitivity analysis was conducted on the input parameters mentioned above and on other parameters (i.e., standard deviation of the runoff coefficient). It is suggested that a calibration of these parameters be conducted at a later time when site precipitation data is obtained. Site specific data may be used to determine the percentage of precipitation which falls as snow. It is anticipated that after a full year of precipitation data is obtained at site that a calibration of the water balance will be conducted.

Average monthly air temperatures included in the model are based on recorded temperatures from the weather station installed at the Mactung site from 2005 to present. Table R8-2 summarizes recorded monthly averages and observed standard deviations. Based on the available record, it was found that monthly temperatures best fit a normal distribution.

Table R8-2: Recorded Mean Temperature Record and Inputs (°C)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2005	-	-	-	-	-	-	5.1	5.7	-0.3	-6.4	-12.0	-10.4
2006	-17.1	-10.9	-10.4	-7.3	-0.8	6.7	8.3	4.6	2.5		-22.0	-12.1
2007	-14.3	-20.3	-18.5	-6.8	-0.6	6.5	8.5	6.6	-1.1	-8.3	-12.0	-16.9
2008	-17.4	-17.6	-13.3	-8.5	0.4	4.4	5.4	3.8	-0.4	-7.7	-11.9	-19.4
2009	-18.0	-16.5	-17.6	-7.5	-0.3	6.0	8.9	5.7	1.2	-7.0	-13.1	-13.7
2010	-14.1	-9.9	-12.5	-4.9	1.1	5.2	8.0	6.7	-0.1	-7.1	-13.1	-17.4
2011	-16.2	-17.2	-16.8	-9.0	0.7	5.4	7.3	4.4	0.2	-7.0	-17.7	-13.8
2012	-19.6	-12.1	-15.2	-5.4	-1.3	6.0	7.4	6.2	0.6	-4.5	-	-
Mean	-16.7	-15.6	-15.7	-7.1	-0.1	5.7	7.7	5.5	0.1	-7.3	-13.3	-14.8
STDEV	2.0	3.9	2.4	1.5	0.9	0.8	1.1	1.1	0.8	0.7	2.2	3.2

Notes: °C - Degree Celsius
STDEV – standard deviation

The total evaporation from the reservoir surface area was estimated using a simple estimate based on Hamon's equation (see below), day length (based on latitude and time of year) and temperature (McCabe and Markstrong 2007).

$$PET = 13.97 \times d \times D^2 \times W_t$$

Where:

PET = daily evaporation in millimetres

D = hours of daylight in units of 12 hrs

W_t = saturated water vapour density in grams per cubic metre, calculated by:

$$W_t = \frac{4.95 \times e^{0.062 \times T}}{100}$$

Where:

T = mean daily temperature in degrees Celsius.

The runoff volumes estimated in the GoldSim water balance model are based on total annual precipitation, estimated runoff coefficient and a monthly distribution. As summarized in Response R2, the average runoff coefficient from 2006 to 2012 was determined to be approximately 0.63 for Tributary C. A sensitivity analysis was conducted to determine how the variability of the runoff coefficient affects the final results.

GoldSim has the ability to carry out sensitivity analyses on a number of parameters by running the model multiple times, systematically sampling each variable over a specified range while holding all of the other variables constant. Results of the sensitivity analysis are summarized in Tornado charts which graphically illustrate the values of the results for different independent parameters. Table R8-3 summarizes the four parameters of the sensitivity analysis and the investigated range of values. The lower and upper bounds refer to the lower and upper limit of the selected data range.

The central values of T-rain, T-snow and meltmax are based on literature values (Hay and McCabe 2010) and the lower and upper bounds were included to model both extremes. The central value of the standard deviation of the runoff coefficient is based on the available observed runoff for Tributary C during the months of May to September. As shown in Table R8-4, it was found that the average runoff during the months of May to September is 0.73 m^3/sec with a corresponding standard deviation of 0.11 m^3/sec which is equivalent to a 15% deviation from the mean. Therefore a 15% deviation from a mean runoff coefficient of 0.63 would equate to a standard deviation of 0.09. To model the possibility of the runoff coefficient being greater than the estimated 0.63 for Tributary C, a standard deviation of 0.16 was applied (equivalent to 25% greater) assess the impact on the reservoir due to the increase in site runoff.

Table R8-3: Sensitivity Analysis Parameters

Parameter	Description	Lower Bound	Central Value	Upper Bound
T-rain	Temperature threshold above which all precipitation in a month is rain	1	3	10
T-snow	Temperature threshold below which all precipitation in a month is snow	-1	0	1
meltmax	Maximum melting rate	50%	90%	100%
Runoff Coefficient STDEV	Standard deviation applied to runoff coefficient to evaluate variability	0	0.03	0.14

Note: Lower and Upper Bounds refer to the lower and upper limit of the selected data range

Table R8-4: Summary of Mean Monthly Flows (m^3/sec)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	May–Sep
2006							0.97	0.82	0.62				
2007							0.95	0.54	0.36				
2008					0.11*	1.52	1.03	0.81	0.73				0.84
2009				0.03*	0.97*	0.89	0.67	0.85	0.68	0.24*	0.08*	0.10*	0.81
2010					1.71*	1.00	0.50	0.35	0.19	0.13	0.09*	0.05*	0.75
2011	0.08*			0.03*	0.42	1.22	0.58	0.52	0.35	0.21	0.12	0.08	0.62
2012	0.05	0.03	0.02	0.01	0.15	1.36	0.72	0.47	0.36	0.25	0.20	0.06	0.61
Average	0.06	0.03	0.02	0.02	0.67	1.20	0.77	0.62	0.47	0.21	0.12	0.07	0.73

Notes: Cells with an asterisk (*) indicate only a manual measurement was recorded

m^3/sec – cubic metres per second

By comparing the resulting change in total annual inputs to the reservoir, the relative influence of each parameter (sensitivity) in Figure R8-4 and Figure R8-5. The results of the sensitivity analysis indicate that the T-snow, T-rain and meltmax parameters do not significantly affect the total inflow into the reservoir; however, the unknown variability of the runoff coefficient does significantly affect the magnitude of annual inflow into the reservoir. It should be emphasized that a runoff coefficient of 0.63 was evaluated using observed data for Tributary C from 2006 to 2012. However, as a conservative measure, a Monte Carlo simulation was applied to the runoff coefficient with a standard deviation of 0.16 to the mean runoff coefficient of 0.63 to evaluate the possibility of a larger runoff coefficient at site.

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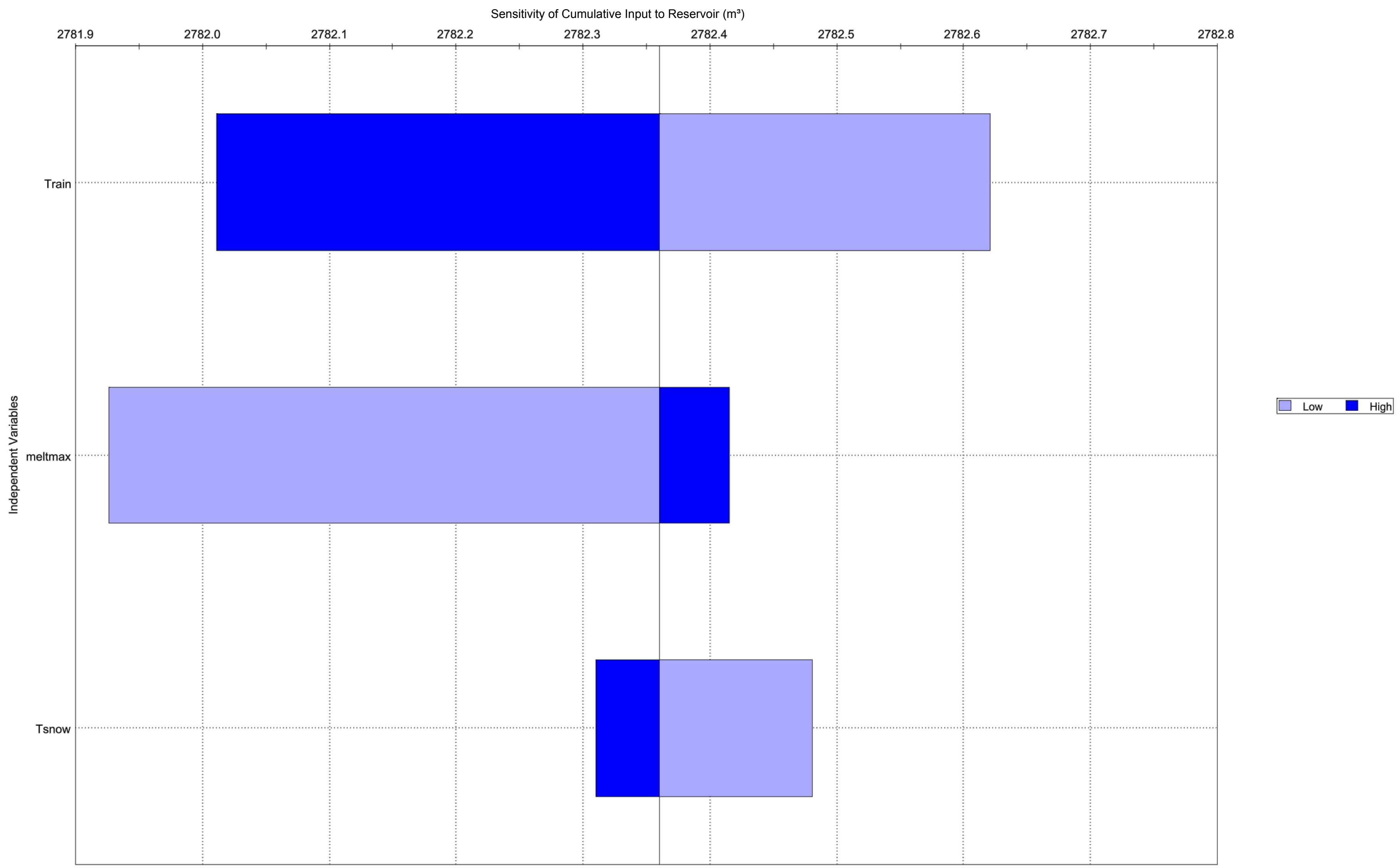

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SENSITIVITY ANALYSIS TRAIN, MELTMAX, TSNOW

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Figure R8-4

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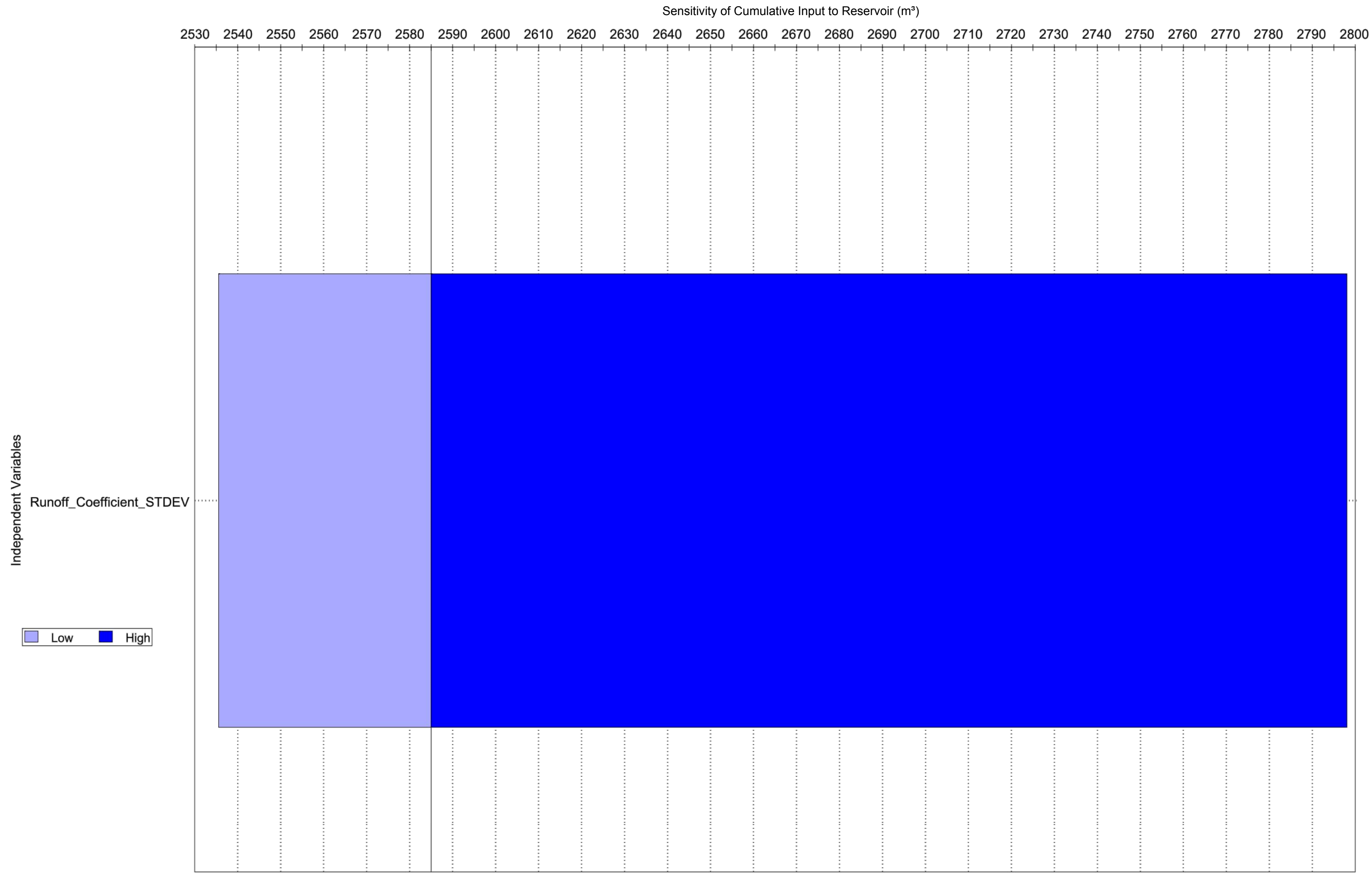

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SENSITIVITY ANALYSIS, RUN-OFF COEFFICIENT

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Table R8-5 summarizes all parameters and inputs included in the water balance.

Table R8-5: Water Balance Parameter and Input Summary

Parameter/Input	Description	Values
▪ Precipitation	▪ Mean annual precipitation applied a normal distribution with a standard deviation and monthly distribution	▪ Mean Annual Precipitation = 704 mm ▪ Standard Deviation = 141 mm ▪ Monthly Distribution see Table R6-3
▪ T_{-rain}	▪ Temperature threshold above which all precipitation is rain	▪ 3 °C
▪ T_{-snow}	▪ Temperature threshold below which all precipitation is snow	▪ 0 °C
▪ meltmax	▪ Maximum melt rate	▪ 0.9
▪ Temperature	▪ Mean monthly temperatures based on historical data at Mactung site	▪ See Table R8-2
▪ Evaporation	▪ Reservoir surface evaporation	▪ Based on Hamon equation, daylight and temperature
▪ Runoff Coefficient	▪ Fraction of precipitation that is observed as runoff for Tributary C	▪ Mean Coefficient = 0.63 ▪ Standard Deviation = 0.16
▪ Runoff	▪ Undiverted runoff and diverted runoff based on precipitation, runoff coefficient and monthly distribution	▪ Monthly Distribution see Table R1-2
▪ Mill Discharge	▪ Discharge from the mill process plant to the reservoir	▪ 46.9 L/sec
▪ Wastewater Treatment Discharge	▪ Discharge from the wastewater treatment Plant	▪ 0.5 L/sec
▪ Dry-stacked tailings Discharge	▪ Discharge from the dry-stack	▪ 0.3 L/sec from May to October
▪ Underground dewatering	▪ Discharge from underground dewatering	▪ Based on Response R7 ▪ Lognormal Mean = 1.3 m^3/day ▪ Standard Deviation = 0.76 m^3/day ▪ Starting at Year 6 of Water Balance
▪ Seepage outflow and return	▪ Seepage outflow from reservoir and seepage return to reservoir	▪ Seepage outflow and inflow balanced (not included in water balance)
▪ Reclaim	▪ Reclaim to the Mill	▪ 44.7 L/sec
▪ Discharges	▪ Release to Tributary C	▪ Outlet Control Elevation = 1506.2 m ▪ Overflow Spillway Elevation = 1514 m

Discharge from the reservoir to downstream Tributary C are controlled with an outlet and an overflow spillway. The overflow spillway was positioned at an elevation of 1,514.0 m asl and the outlet at an elevation of 1,506.2 m asl (corresponding volume of 120,000 m^3) to ensure an adequate volume of water is available during winter operation. Downstream flow conditions were evaluated for three locations along Tributary C. As illustrated in Figure R8-1, the three locations are at the Tributary C hydrometric station (24.5 km^2) at the fisheries sampling point FS6 (21.2 km^2) and immediately downstream of the proposed reservoir (2.51 km^2 undiverted and 2.45 km^2 diverted).

As shown in Figure R8-6, it was found that an outlet control with a diameter of 150 mm would be required to maintain near baseline conditions in Tributary C at the monitoring station positioned approximately 1 km downstream of the proposed reservoir. Table R8-6 summarizes expected average baseline flows and the possible range of flows during operations in Tributary C at the three monitoring locations.

Table R8-6: Tributary C Flows at Hydrometric Station during Baseline and Operations (L/sec)

%	Event	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
At Tributary C Monitoring Station (24.5 km^2)													
5th	Baseline	32.1	17.3	12.3	12.3	404.6	700.7	451.5	370.1	273.9	100.9	44.3	41.8
	Operation	28.7	15.5	11.1	11.1	442.3	702.7	469.1	377.8	278.4	105.3	39.7	37.5
	% Diff.	-10%	-10%	-10%	-10%	9%	0%	4%	2%	2%	4%	-10%	-10%
50th	Baseline	52.7	28.4	20.3	20.3	664.8	1151.3	741.8	608.1	450.0	166.2	72.9	68.9
	Operation	47.2	25.4	18.2	18.2	697.1	1139.6	769.1	625.3	461.0	173.8	65.4	61.7
	% Diff.	-10%	-10%	-10%	-10%	5%	-1%	4%	3%	2%	5%	-10%	-10%
95th	Baseline	75.2	40.5	28.9	28.9	949.2	1643.6	1059.1	868.1	642.4	236.8	104.0	98.2
	Operation	67.4	36.3	25.9	25.9	972.5	1612.7	1094.2	897.6	664.2	251.0	93.2	88.0
	% Diff.	-10%	-10%	-10%	-10%	2%	-2%	3%	3%	3%	6%	-10%	-10%
At Fishery Station FS6 (21.2 km^2)													
5th	Baseline	28.1	15.1	10.8	10.8	354.4	613.8	395.5	324.2	239.9	88.4	38.8	36.6
	Operation	24.8	13.3	9.5	9.5	392.1	615.9	413.1	331.9	244.5	92.8	34.2	32.3
	% Diff.	-12%	-12%	-12%	-12%	11%	0%	4%	2%	2%	5%	-12%	-12%
50th	Baseline	46.2	24.9	17.8	17.8	582.4	1008.6	649.9	532.7	394.2	145.6	63.9	60.4
	Operation	40.7	21.9	15.7	15.7	614.7	996.8	677.2	549.9	405.2	153.2	56.3	53.2
	% Diff.	-12%	-12%	-12%	-12%	6%	-1%	4%	3%	3%	5%	-12%	-12%
95th	Baseline	65.9	35.5	25.4	25.4	831.5	1439.9	927.8	760.5	562.8	207.5	91.1	86.0
	Operation	58.1	31.3	22.3	22.3	854.9	1408.9	962.9	790.0	584.6	221.6	80.3	75.8
	% Diff.	-12%	-12%	-12%	-12%	3%	-2%	4%	4%	4%	7%	-12%	-12%
Immediately Downstream of Reservoir (5.0 km^2)													
5th	Baseline	6.6	3.6	2.5	2.5	83.6	144.8	93.3	76.5	56.6	20.8	9.2	8.6
	Operation	3.3	1.8	1.3	1.3	120.8	146.8	110.9	84.2	61.1	25.1	4.6	4.3
	% Diff.	-50%	-50%	-50%	-50%	45%	1%	19%	10%	8%	21%	-50%	-50%
50th	Baseline	10.9	5.9	4.2	4.2	137.4	237.9	153.3	125.6	93.0	34.3	15.1	14.2
	Operation	5.4	2.9	2.1	2.1	169.6	226.1	180.6	142.8	104.0	42.0	7.5	7.1
	% Diff.	-50%	-50%	-50%	-50%	23%	-5%	18%	14%	12%	22%	-50%	-50%
95th	Baseline	15.5	8.4	6.0	6.0	196.1	339.6	218.8	179.4	132.7	48.9	21.5	20.3
	Operation	7.7	4.2	3.0	3.0	219.9	308.7	253.9	208.9	154.6	63.1	10.7	10.1
	% Diff.	-50%	-50%	-50%	-50%	12%	-9%	16%	16%	16%	29%	-50%	-50%

Notes: % - percentile, where 50th percentile is the median

L/sec – litres per second

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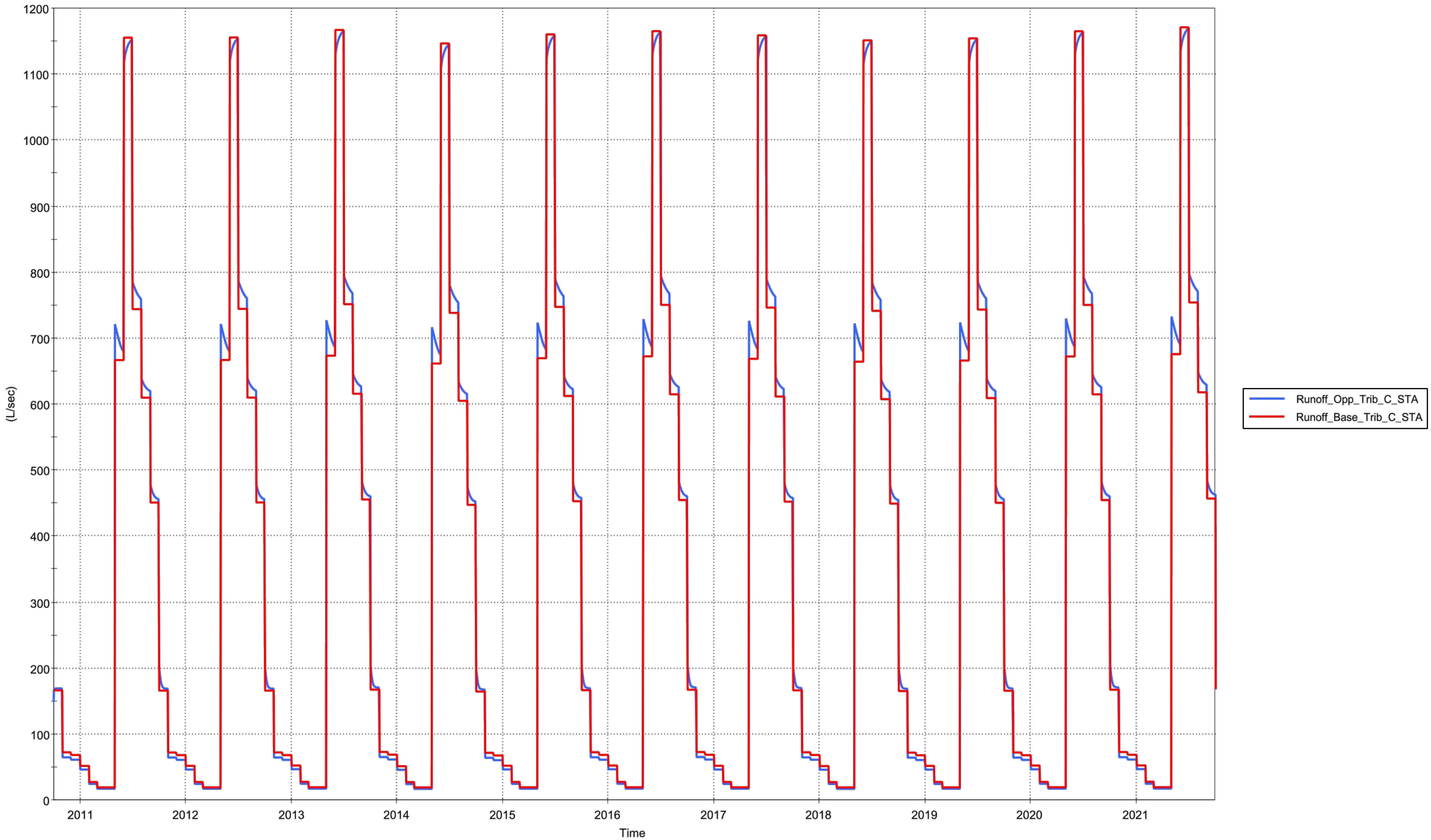

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TRIBUTARY C RUNOFF COMPARISON

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Figure R8-6

As illustrated in Figure R8-7, discharges are only released during the warmer months of the year (May to October) and discharges to downstream Tributary C peak in May and July. The first peak is a response due to the high water level in the reservoir accumulated during the winter season. The second peak is a response to the increase in water level during freshet. As shown, the peak 95th percentile of the controlled discharges to downstream Tributary C was evaluated to be 158 L/sec.

As summarized in Table R8-6, downstream flows during operations have a much greater impact on baseline flows near the reservoir than at the downstream hydrometric station. Since, discharges from the reservoir are only released from May to October; percent differences are greatest during the winter months where it was found that flows would be reduced by approximately 50% and 10% downstream of the reservoir and at the hydrometric stations respectively.

Figure R8-8 illustrates the Monte Carlo results of the reservoir volume for a total duration of 11 years. As illustrated, the reservoir volume does not reach the bottom of the spillway at an elevation of 1514 m (612,000 m^3) and the discharges are controlled solely by the outlet control. Based on the Monte Carlo simulation it was found that 95 % of the time, the maximum reservoir level would be below 1512.30 m providing 1.7 m of freeboard below the spillway.

Table R8-7 illustrates the average 5th, 50th and 95th percentile of inflows and outflow parameters with assigned variability.

Table R8-7: Summary of Monte Carlo Water Balance Results (L/sec)

Parameter	%	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Undiverted Runoff	5th	3.33	1.79	1.28	1.28	41.97	72.67	46.83	38.38	28.40	10.46	4.59	4.34
	50th	5.47	2.94	2.10	2.10	68.95	119.41	76.94	63.07	46.67	17.23	7.57	7.15
	95th	7.80	4.20	3.00	3.00	98.44	170.48	109.85	90.04	66.63	24.57	10.78	10.19
Rainfall + Snowmelt	5th	0.00	0.00	0.00	0.00	0.00	8.89	5.21	3.68	0.00	0.00	0.00	0.00
	50th	0.00	0.00	0.00	0.00	0.34	11.66	7.01	5.19	0.23	0.00	0.00	0.00
	95th	0.00	0.00	0.00	0.00	7.20	14.43	8.80	6.67	2.50	0.00	0.00	0.00
Evaporation	5th	0.00	0.00	0.00	0.00	0.01	1.22	1.17	0.66	0.00	0.00	0.00	0.00
	50th	0.00	0.00	0.00	0.00	0.33	1.54	1.55	0.84	0.17	0.00	0.00	0.00
	95th	0.00	0.00	0.00	0.00	1.01	1.90	2.01	1.09	0.49	0.00	0.00	0.00
Underground Dewatering	5th	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	50th	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.09	0.09	0.09
	95th	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	0.95	0.95	0.95
Discharges to Tributary C	5th	0.00	0.00	0.00	0.00	78.33	74.83	64.52	46.22	32.94	14.77	0.00	0.00
	50th	0.00	0.00	0.00	0.00	101.24	107.78	104.41	80.36	57.70	24.99	0.00	0.00
	95th	0.00	0.00	0.00	0.00	123.15	139.79	145.17	119.84	88.68	38.94	0.00	0.00

Note: Monte Carlo results based on a 1,000 simulations

The GoldSim illustrates the reservoir response during times of high flow and low flows (Figure R8-8). In order to evaluate flood routing events of short duration such as the Inflow Design Flood (IDF), a HEC-HMS model developed by the U.S. Army Corps of Engineers was used to evaluate the response of the reservoir.

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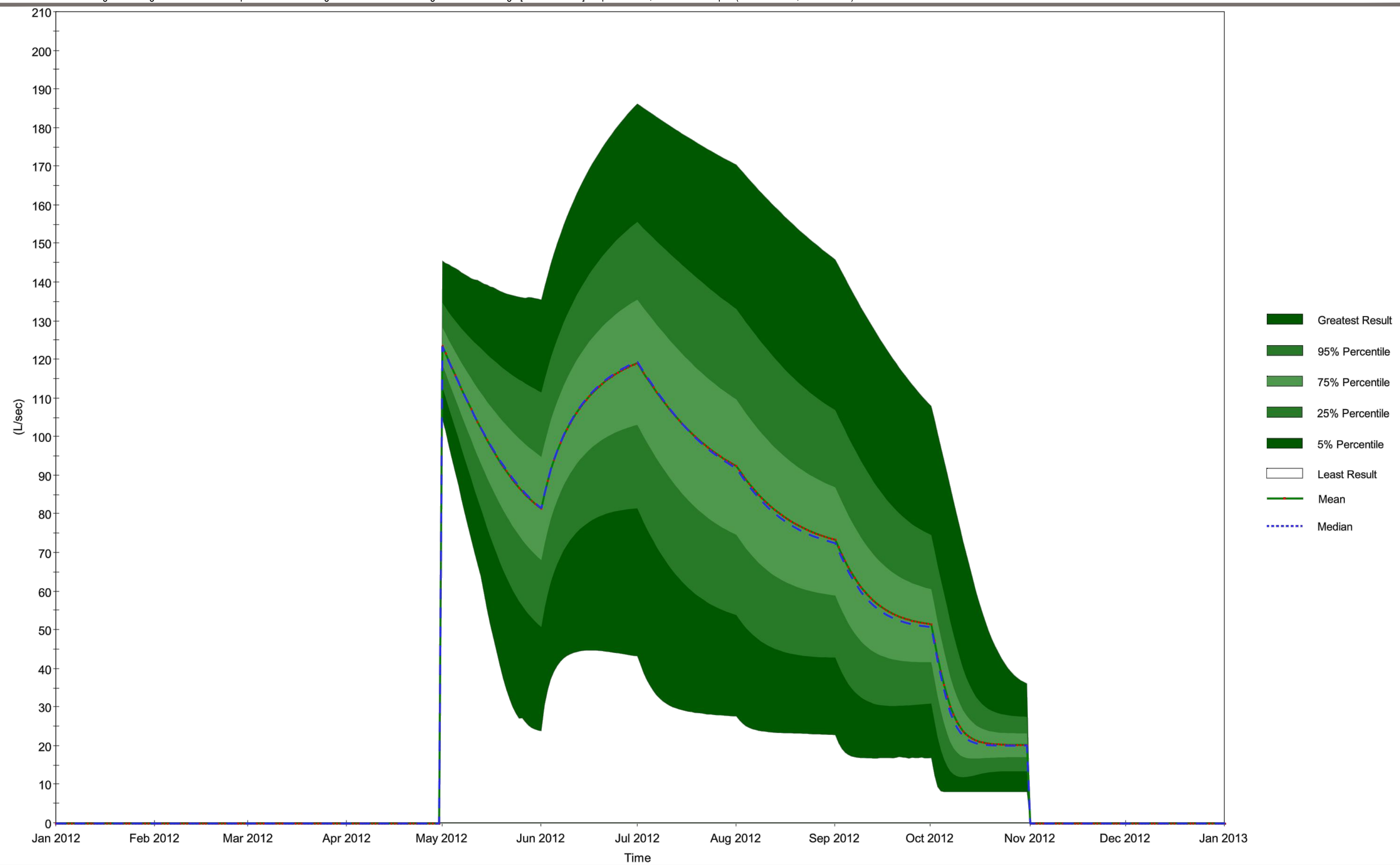

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Figure R8-7

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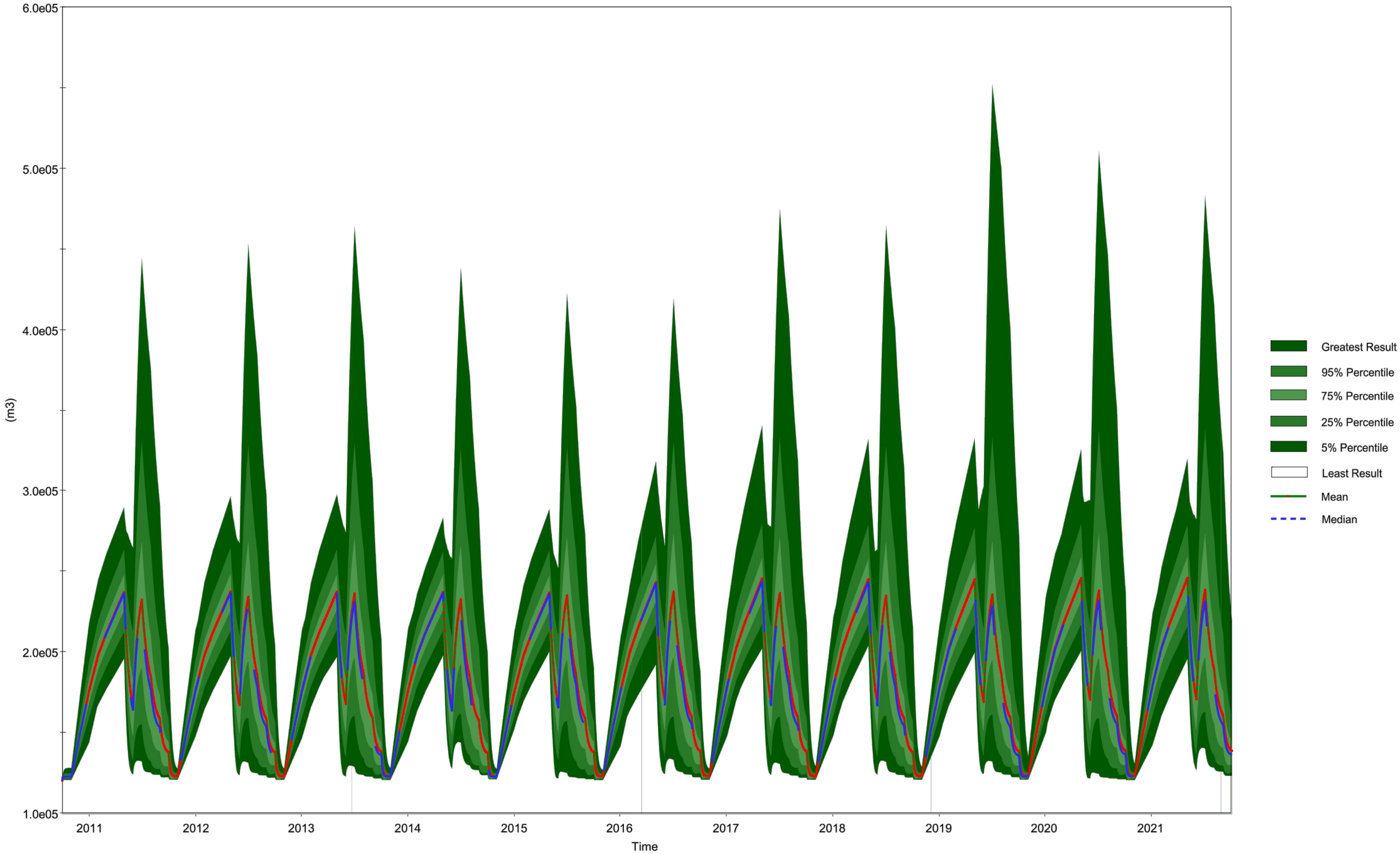

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Figure R8-8

As per the Canadian Dam Association (CDA), the IDF is the most severe inflow flood (peak, volume, shape, duration, timing) for which a dam and its associated facilities are designed. To ensure that the dam will not overtop during a major storm event, the emergency spillway structure should be capable of passing the IDF and show that there is an adequate amount of freeboard below the dam crest. The CDA requires that the magnitude of the IDF be based on the dam's consequence category. For a significant consequence dam, it is recommended that the IDF be between the 100 year and 1,000 year return period. For the purpose of this analysis, the 1000 year return period event was adopted for the design of the emergency spillway structure of the reservoir. It was found that a 1 m wide spillway would be sufficient to route the 1,000 year IDF.

A flood routing model was developed using HEC-HMS to simulate water levels in the reservoir during the IDF. Based on the regional frequency analysis using the index flood method (see Response R2), Table R8-8 summarizes calculated instantaneous peak flows, the estimated corresponding average daily flow and an estimated 24 hour inflow volume for the un-diverted catchment (2.51 km^2) upstream of the reservoir.

Based on the regional analysis for the selected stations with peak instantaneous data (09BB001, 09DA001 and 10HA002), it was found that the average ratio between the observed peak instantaneous flows to average daily flow on the same day was approximately 1.20. This factor was applied to the calculated peak flows upstream of the reservoir to evaluate the average daily data during an extreme event and the total expected volume over a period of 24 hours (Table R8-8).

Table R8-8: Index Flood Method Ratios and Undiverted Floods

Return Period (Years)	Instantaneous Peak Flow (m^3/sec)	Avg. Max Daily Flow (m^3/sec)	24-hr Volume (m^3)
1,000	1.35	1.13	97,450
200	1.11	0.93	79,992
100	1.01	0.85	73,326
50	0.92	0.77	66,660
20	0.82	0.69	59,381
10	0.74	0.62	53,551
5	0.66	0.55	47,614
3	0.58	0.49	42,243
2	0.51	0.42	36,559

Notes: m^3/sec – metres cube per second
m^3– metres cube

For the purpose of the flood routing analysis, the water level in the reservoir was assumed to be at the maximum operating capacity. It should also be emphasized that based on the GoldSim model, the maximum 95th percentile water level was estimated to be at 1,512.30 m. Table R8-9 summarizes the response of the reservoir for a range of return periods.

Table R8-9: HEC-HMS Results of Flood Routing

Return Period (Years)[A]	Inflow (m^3/sec)	Total Inflow Volume (m^3)	Peak Water Level (m asl)	Peak Storage (m^3)	Spillway Release (m^3) within a 24-hour period
1,000	1.13	97,450	1514.3	634,700	2,900
200	0.93	79,992	1514.1	620,100	200
100	0.85	73,326	1514.02	613,400	6
50	0.77	66,660	1513.9	606,500	0
20	0.69	59,381	1513.8	599,600	0
10	0.62	53,551	1513.7	593,600	0
5	0.55	47,614	1513.6	587,500	0
3	0.49	42,243	1513.5	582,300	0
2	0.42	36,559	1513.5	576,300	0

Notes: m^3/sec – metres cube per second

m^3– metres cube

[A]Return periods applied when the reservoir is already at 95% operating capacity

Results from the flood routing indicate that the 100 year flood will be contained in the reservoir below the spillway. The 200 and 1,000 year flood will be routed through the spillway and discharged downstream into Tributary C. During the 1,000 year flood with a 1 m wide spillway the peak water level would reach an elevation of 1,514.3 allowing 2.2 m of freeboard below the dam crest. Further studies of the dam consequence category, determination of the IDF, spillway sizing and effect of wave heights be re-visited at the detailed design stage when more information on the runoff conditions at site are obtained.

R9: Provide an electronic version of the water balance to the Executive Committee. This will allow the reviewers to better understand the assumptions, inputs and mass balances which were used.

Provided with this document is a CD with the GoldSim Water Balance for the Mactung Mine Project. To open the file, install the GoldSim Player (a free program) provided by GoldSim (http://www.goldsim.com/forms/playerdownload.aspx). The GoldSim player is special version of GoldSim that allows a user to view, navigate and run GoldSim models without requiring a GoldSim Licence.

Please note that the input values for the water balance have been locked and cannot be modified.

2.6 Ravine Dam Capacity

R10: If the updated water balance model predicts a required operational range greater than 420 000 m^3, provide a re-design of the reservoir with an appropriate capacity.

As stated in the October 2011 submission to YESAB (YOR 2008-0304-176-1) and restated in response R8 above, the design operating capacity of the reservoir is 540,000 m^3 and the volume of water that the reservoir can hold before the dam emergency spillway comes into effect is 612,000 m^3. The reference to 420,000 m^3 capacity does not originate from any reservoir designs provided to YESAB. NATC's response to both R8 (water balance update) and this response are based on a reservoir maximum operating capacity of 540,000 m^3.

As demonstrated in the response to R8 that provides the detailed and updated water balance model, the reservoir, as originally designed, is sufficiently sized for the mine operation inputs and outputs. The model indicates that only 6 m^3 of water would be discharged through the emergency spillway over a twenty-four hour period during a one in a 100 year storm event. This discharge would happen at a time when the reservoir is already at 95% or greater operating capacity. Please note that for 95% of the year, the maximum reservoir water volume would be well below the 95% operating capacity.

Based on the revised water balance (R8), the reservoir design has not been revised and remains the same as that submitted in the original 2008 Project Proposal.

2.7 Water Quality Predictions

R11: Provide an updated water quality prediction model with an interpretation based on loadings (e.g. mg-constituents of potential concern per mass of material per time or mg/kg/wk) instead of the direct measure of constituent concentrations from each of the testing procedures. The water quality prediction model shall combine the water balance with predictions of contaminant loading and concentrations from mine sources (e.g. DSTF, underground, temporary waste rock pile). The water quality prediction model should predict both concentrations and loadings for relevant water quality parameters in local receiving waters.

The current mine plan, including the limited exposure of waste materials at surface and the placement of the tailings, either within the mined-out underground stopes or within the DSTF, represents acceptable and appropriate mitigation to prevent acid generating conditions. NATC is committed to undertaking further modeling and/or bench scale testing, as necessary, prior to mine development to refine the data and predictions. The modeling and testing will help determine the effectiveness of selected treatment technologies to control metals concentrations in the reservoir and subsequently discharge water to the downstream receiving environment.

The PHREEQCI water quality model submitted in October 2011 to YESAB (YOR# 2008-0304-095-2) has been updated as per the information request R11 in YESAB's Request for Supplementary Information issued January 4, 2013, and the approach subsequently outlined in a memo from NATC to YESAB dated February 7, 2013.

The input source terms for the model have been derived using a loadings approach for all waste rock and tailings samples and include supplementary surface and groundwater quality data that have been collected since the previous water quality model was completed in 2011. Mixing proportions are based upon the updated GoldSim modeling completed and explained in the water balance response (R8).

The planned construction of the dry-stacked tailings facility (DSTF) includes 600 mm lift heights that are well compacted which will significantly limit infiltration of precipitation, as well as limit the length of time that any one lift is fully exposed to air and precipitation. Based on the proposed milling rate, the density and potential areas of the DSTF, the 600 mm lifts to the DSTF have been calculated to occur approximately every 17 to 35 weeks during mining operations.

Without moisture, weathering of the tailings cannot produce the acidic leachate that was observed after 86 weeks in the humidity cell tests. The water quality predicted to seep from or run-off the DSTF is therefore modeled on the pre-acidic water quality data from the humidity cell testwork. In addition, shake flask data are used in this model as a substitute for humidity cell data (which are not yet available) as a conservative approach for predicting long-term leaching behaviour of waste rock leachate. The use of shake flask extraction data (a static analytical method) is generally used to represent short-term behavior. The shake flask method typically yields high concentrations of various parameters in the initial flushing of the materials. When the waste rock humidity cell tests (a kinetic analytical method) reach steady state conditions, the model can be updated to reflect these loading and concentration results for the waste rock leachate.

MODEL INPUTS AND ASSUMPTIONS

Two humidity test cells (HTC) are ongoing for the tailings material and include tailings samples generated from metallurgical testing on composite ore materials, submitted for humidity cell testing in June 2009; Cell No. T1, 50051-001 Drill Core Composite Mill Tailings (2008 Composite Tailings Sample) and Cell No. T2, 50051-001 Tailings 2005 Drill Core Composite (2005 Composite Tailings Sample).

The sensitivity analysis included in the model and was based on average, wet, and dry annual precipitation derived from the revised water balance in response R8. The range of precipitation volumes, and hence run-off or leachate, provides average, low, and high leachate or run-off concentrations respectively.

As of June 2011, the tailings humidity test cells had been in operation for a total of 105 weeks. During that time, the cell containing tailings generated from 2008 core material became acid generating after approximately 86 weeks. The cell containing tailings generated from 2005 core material has not yet become acid generating after 105 weeks of operation. The results of this testwork have been used in this water quality model. At the time of writing this response, humidity test cells for the waste rock materials are currently in week 19 of operation and have not yet sufficiently advanced to be used in the updated model. As such, the loadings approach for the waste rock solutions is based on the shake flask leachate. The results of the shake flask testing (typically a one day test) have been scaled for a time factor of 365 days to calculate annual leachate concentrations and loadings. Comparatively, humidity cell testwork results are generated weekly and are scaled to annual concentrations or loadings based on 52 weeks. Again, this scaling treatment produces extremely conservative loadings values. Once the waste rock HTC reaches a minimum of 40 weeks of operation, the model loading calculations can be updated to replace the use of shake flask leachate.

The revised model includes the assumptions defined below:

- The 95th, 50th, and 5th percentiles of the GoldSim water balance, dated August 15, 2013, were used to represent wet, average, and dry conditions, respectively.
- Carbonate/bicarbonate and/or chloride concentrations were not reported in all laboratory analyses. Therefore, carbonate was artificially added to all source solutions in the model at a concentration of 100 mg/L. The model was then allowed to adjust the carbonate concentration to attain a charge balance with the other solution constituents.
- Mixing was performed within PHREEQCI modeling software and common secondary mineral phases were allowed to precipitate if the solution became saturated.

- The material composition of the waste rock and the DSTF is expected to remain constant over time.
- The waste rock pile temporarily placed at surface is assumed to be a uniform mixture of materials from Unit 1 and 3C in representative proportions to the planned excavated tonnages[1,2]. The current geochemical model assumes that a total of 560,676 tonnes of development rock will be generated; 63,508 tonnes from Unit 1 (11.3% of total) and 497,168 tonnes from Unit 3C (88.7% of total). Therefore, the leachate/runoff solutions are assumed to be a mixture of 11.3% Unit 1 leachate and 88.7% Unit 3C leachate. The tailings composition is assumed to be constant throughout the operational life of the mine.
- Waste rock humidity test cells have not yet reached steady state conditions. Shake flask tests were used to derive the quality of the waste rock run-off. The median values of the shake flask test results were used to represent each waste rock unit, and scaled similarly to the HTC results from the tailings tests, with the exception that the test was taken as a one day time-step, as opposed to the weekly time-step in the HTC data. This is due to the consideration that the shake flask test is a one day leachate test whereas humidity cell leachate is generated over the course of a week.
- The average of the last 5 weeks of the 2005 composite tailings HTC results (Cell No. T2, 5051-001) was used to represent expected conditions within the DSTF. The HTC results were converted to loadings by multiplying the leachate concentration by the exposed volume and density of the tailings, with unit conversions for time.
- For the purposes of the PHREEQCI model, DSTF run-off loadings were converted to concentrations based on the annual volume of precipitation onto the DSTF.
- For the purposes of the PHREEQCI model, DSTF seepage loadings were converted to concentrations based on the annual seepage volume from the DSTF.
- The process water was represented by the 2005 and 2008 supernatant generated by bench scale studies (Supplementary Geochemical Information for Waste and Mineralized Rocks, Mactung Deposit, July 2009).
- Precipitation falling directly onto the ravine reservoir was modeled by allowing atmospheric concentrations of oxygen and carbon dioxide to equilibrate with pure water at a pH of 5.6.
- The median total metal concentrations from monitoring well data from MW-MT-08-08D were used to represent groundwater conditions as that monitoring well is located within the planned underground workings.
- Effluent from the sanitary wastewater treatment plant servicing the camp was approximated by data originating from another arctic site (client confidential) using Seprotech sewage treatment technology.

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[1] EBA Engineering Consultants Ltd. (EBA). 2009a. Response to YESAB's Adequacy Review Report for the Propo Mactung Mine, Macmillan Pass, Yukon (YESAB Project Number 2008-0304)

[2] EBA Engineering Consultants Ltd. (EBA). 2009b. Supplementary Geochemical Information for Waste Rock and Mineralized Rocks. Mactung Deposit, Yukon Territory (YESAB Project Number 2008-0304)

- The median total metal concentrations from monitoring station WQ-C0 were used to represent surface water/runoff conditions as that monitoring location is located downstream of the planned underground development and within the same catchment area.
- Water quality in the reservoir was simulated by monthly mixing in the proportions dictated by the GoldSim water balance (R8). A sensitivity analysis was completed for wet, dry and average year conditions. Monthly simulations representing wet, dry, and average conditions were performed. The drainage quality expected from the DSTF was approximated based on the tailings HTC results, prior to the onset of acid generation, and estimated from ABA of waste rock samples.
- Mixed solutions were then allowed to equilibrate with atmospheric gases and generate precipitate phases within the model simulation. All reactions were allowed to progress to completion (i.e., no kinetic limitations) as this will provide a more conservative approach to the final output.
- The model was constructed to permit the formation of common precipitates as per Price (2009). Any precipitate phases were assumed to settle out of solution for the purposes of calculating total aqueous concentrations. These precipitates are listed below:
  - Amorphous aluminum, chromium, and iron hydroxides;
  - Alunite;
  - Anglesite;
  - Aragonite;
  - Barite;
  - Basaluminite;
  - Calcite;
  - Celestite;
  - Dolomite;
  - Goethite;
  - Gypsum;
  - Jarosite;
  - Malachite;
  - Melanterite; and
  - Siderite

All model source terms have been provided in Table R11-1: Mactung Water Quality Source Terms, 2005 Supernatant Solution and Table R11-2: Mactung Water Quality Source Terms, 2008 Supernatant Solution. The text version of the PHREEQCI model input files are available on a compact disc included with this response document (Appendix B).

MODEL RESULTS

The results of the modeling scenarios have been summarized in the attached Table R11-3: Mactung Reservoir Water Quality Model Results, 2005 Supernatant Concentrations, and Table R11-4: Mactung Reservoir Water Quality Model Results, 2008 Supernatant Concentrations. These tables represent the predicted chemical composition of the water exiting the waste rock and the DSTF, which would contribute to the reservoir water quality. The data are presented for each of the 36 model runs that were performed using both the 2005 (Table R11-3) and 2008 (R11-4) tailings supernatant solutions (for mill discharge effluent).

The Metal Mining Effluent Regulations (MMER) and Canadian Council of the Ministers of the Environment (CCME) guideline water quality concentrations are also presented in the tables for comparison. The parameter concentrations in ***bold italic*** indicate a concentration greater than the CCME guideline concentrations. Additional tables have been provided that present the monthly and annual metal loadings, as well as the potential precipitate phases which may form with mixing, as follows:

- Table R11-5: Mactung Reservoir Loadings, 2005 Supernatant Concentrations;
- Table R11-6: Mactung Reservoir Loadings, 2008 Supernatant Concentrations;
- Table R11-7: Mactung Reservoir Precipitate Phases, 2005 Supernatant Concentrations; and
- Table R11-8: Mactung Reservoir Precipitate Phases, 2008 Supernatant Concentrations.

RESERVOIR WATER QUALITY SIMULATIONS

The DSTF will be constructed to limit oxygen and water exposure of the tailings which will mitigate pyrite oxidation. The pH in the ravine reservoir is expected to range from 7.8 to 8.8, depending on the amount of annual precipitation and the water quality of the mill discharge effluent. The reservoir water quality, based on the 2005 supernatant and summarized in Table R11-3, is predicted to have concentrations greater than the CCME guideline concentrations for chloride, fluoride, arsenic, cadmium, copper and selenium. Aluminum was greater than the CCME guideline concentration in the early months of the year, while nitrate was greater than the CCME guideline concentration in the summer months. Regardless of the amount of rainfall/snowmelt, all analytes are below the MMER concentrations. The solution is expected to be saturated with basaluminite, calcite, and goethite, and to a lesser degree with barite, resulting in the potential formation of minor precipitate phases.

The reservoir water quality, based on the 2008 supernatant, and summarized in Table R11-4 is also predicted to have concentrations greater than the CCME guideline concentrations for chloride, fluoride, cadmium, chromium, copper, and selenium and, on one occasion, arsenic. Nitrate concentrations are greater than the CCME guideline concentrations in the summer months, regardless of the amount of rainfall/snowmelt. All analytes are below the MMER concentrations. The solution is expected to be saturated with basaluminite and goethite, and to a lesser degree with barite and calcite, resulting in the potential formation of minor precipitate phases.

It should be noted that natural background concentrations of multiple metals in Tributary C are greater than the relevant CCME guideline concentrations. At monitoring point C0, for example, aluminum and cadmium have exceeded the relevant CCME guideline concentrations in all 17 sampling events between May 2009 and September 2012. Copper, selenium and phosphorous have also regularly exceeded the relevant CCME guideline concentrations, while nickel and zinc had a single result each that was greater than the CCME guideline concentration. Tributaries in the area regularly exhibit concentrations greater than the CCME guideline concentrations for nitrate, aluminum, cadmium, copper, and selenium. Historical surface water quality monitoring data have been plotted and presented in Figure R11-1: Background Aluminum Concentrations in Surface Waters, Figure R11-2: Background Arsenic Concentrations in Surface Waters, Figure R11-3: Background Cadmium Concentrations in Surface Waters, Figure R11-4: Background Copper Concentrations in Surface Waters, and Figure R11-5: Background Selenium Concentrations in Surface Waters.

Table R11-1: Mactung Water Quality Source Terms, 2005 Supernatant Solution

Group	Description	pH	Percent Error in Charge Balance	TDS	Alkalinity	Chloride	Fluoride	Phosphate	Sulphate	Aluminum	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Lithium
				(mg/L)	(mg/L as CaCO3)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
MMER				-	-	-	-	-	-	-	-	0.5	-	-	-	-	-	-	-	0.3	-	-	-
CCME		**6.5**				120	0.12			0.1		0.005			1.5	0.000017		0.001		0.004	0.3	0.007	
WRSF source	Unit 1 Waste Rock Runoff	7.90	1.83E-13	6	5.48	0.07	0.00	0.00	0.25	0.03	0.00	0.000	0.00	0.00	0.00	0.000000	0.86	0.000	0.00	0.000	0.00	0.000	0.00
WRSF source	Unit 3C Waste Rock Runoff	7.90	-3.85E-07	5	4.81	0.01	0.00	0.01	0.25	0.04	0.00	0.000	0.00	0.00	0.00	0.000000	0.75	0.000	0.00	0.000	0.00	0.000	0.00
Tailings source	Tailings Runoff	7.53	-1.10E-14	4126	12.13	***1299.28***	0.00	0.08	2812.25	***0.78***	0.02	***0.016***	0.14	0.00	0.65	***0.002370***	1859.23	***0.003***	0.02	***0.061***	0.03	0.000	0.11
Seepage Source	Tailings Seepage	7.53	9.66E-15	55652	164.68	***17526.83***	0.00	1.08	37935.05	***10.47***	0.25	***0.214***	1.93	0.00	***8.78***	***0.031968***	25080.46	***0.035***	0.28	***0.818***	***0.35***	0.007	1.51
Process Source	Process Water/Supernatant	9.95	-2.92E-14	565	526.54	22.51	***0.44***	1.50	13.01	***0.26***	0.00	***0.011***	0.00	0.00	0.02	***0.000020***	5.71	0.001	0.00	***0.008***	***0.34***	0.004	0.00
Precipitation Source	Precipitation	5.60	1.00E-10	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.00	0.00	0.00	0.000000	0.00	0.000	0.00	0.000	0.00	0.000	0.00
SW Source	Tributary C0 Background	7.42	-1.47E-14	165	91.82	0.18	0.00	0.02	72.61	***0.18***	0.00	0.000	0.02	0.00	0.00	***0.000360***	35.96	0.000	0.00	0.002	0.01	0.000	0.01
GW Source	GW MW-MT-08-08D	7.48	-5.96E-14	123	43.59	0.23	0.00	0.02	79.21	0.03	0.00	0.001	0.01	0.00	0.00	***0.000020***	36.36	0.001	0.00	0.001	0.10	0.001	0.00
WWTP Source	Waste Water Treatment Plant Effluent	6.60	2.94E+01	0	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.00	0.00	0.00	0.000000	0.00	0.000	0.00	0.000	0.00	0.000	0.00
WRSF	Waste Rock Storage Facility Runoff	6.86	-3.34E-07	5	4.57	0.02	0.00	0.01	0.22	0.00	0.00	0.000	0.00	0.00	0.00	0.000000	0.76	0.000	0.00	0.000	0.00	0.000	0.00
Trib C0	Tributary C0, calculated	7.37	-1.75E-11	505	17.19	***133.98***	0.00	0.02	353.82	0.00	0.00	0.002	0.01	0.00	0.07	***0.000563***	223.39	0.000	0.00	***0.008***	0.00	0.000	0.02

Exceeds CCME
Exceeds MMER

Table R11-1: Mactung Water Quality Source Terms, 2005 Supernatant Solution (Cont'd)

Group	Description	pH	Percent Error in Charge Balance	Magnesium	Manganese	Molybdenum	Mercury	Nickel	Potassium	Selenium	Sodium	Silver	Strontium	Thallium	Tin	Titanium	Tungsten	Uranium	Vanadium	Yttrium	Zinc	Cyanide	Nitrate	Ammonia
				(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
MMER				-	-	-	-	0.5	-	-	-	-	-	-	-	-	-	-	-	-	0.5	1	-	-
CCME		**6.5**				0.073	0.000026	0.15		0.001		0.0001		0.0008				0.015			0.03	0.005	13	
WRSF source	Unit 1 Waste Rock Runoff	7.90	1.83E-13	0.02	0.00	0.000	0.000000	0.00	0.32	0.000	0.13	0.0000	0.00	0.0000	0.00	0.00	0.00	0.000	0.00	0.00	0.00	0.00	0.00	0.00
WRSF source	Unit 3C Waste Rock Runoff	7.90	-3.85E-07	0.03	0.00	0.000	***0.000415***	0.00	0.21	0.000	0.11	0.0000	0.00	0.0000	0.00	0.00	0.00	0.000	0.00	0.00	0.00	0.00	0.00	0.00
Tailings source	Tailings Runoff	7.53	-1.10E-14	11.19	6.56	0.064	***0.000130***	0.01	37.49	***0.019***	6.25	0.0001	2.13	***0.0008***	0.00	0.01	0.00	0.012	0.00	0.00	***0.08***	0.00	0.00	0.00
Seepage Source	Tailings Seepage	7.53	9.66E-15	151.00	88.52	***0.861***	***0.001756***	***0.16***	505.77	***0.253***	84.30	***0.0009***	28.70	***0.0109***	0.03	0.09	0.00	***0.165***	0.04	0.00	***1.12***	0.00	0.00	0.00
Process Source	Process Water/Supernatant	9.95	-2.92E-14	0.29	0.01	0.010	0.000010	0.00	1.89	***0.001***	134.06	0.0000	0.01	0.0000	0.00	0.00	0.00	0.001	0.01	0.00	0.00	0.00	0.97	0.01
Precipitation Source	Precipitation	5.60	1.00E-10	0.00	0.00	0.000	0.000000	0.00	0.00	0.000	0.00	0.0000	0.00	0.0000	0.00	0.00	0.00	0.000	0.00	0.00	0.00	0.00	0.00	0.00
SW Source	Tributary C0 Background	7.42	-1.47E-14	2.69	0.10	0.001	0.000005	0.01	0.70	0.000	0.52	0.0000	0.09	0.0000	0.00	0.00	0.00	0.000	0.00	0.00	0.02	0.00	0.35	6.07
GW Source	GW MW-MT-08-08D	7.48	-5.96E-14	0.67	0.01	0.007	0.000005	0.00	0.20	0.000	4.80	0.0000	0.05	0.0000	0.00	0.00	0.01	0.000	0.00	0.00	0.00	0.00	0.04	0.05
WWTP Source	Waste Water Treatment Plant Effluent	6.60	2.94E+01	0.00	0.00	0.000	0.000000	0.00	0.00	0.000	93.02	0.0000	0.00	0.0000	0.00	0.00	0.00	0.000	0.00	0.00	0.00	0.00	***243.06***	60.71
WRSF	Waste Rock Storage Facility Runoff	6.86	-3.34E-07	0.03	0.00	0.000	***0.000368***	0.00	0.22	0.000	0.11	0.0000	0.00	0.0000	0.00	0.00	0.00	0.000	0.00	0.00	0.00	0.00	0.00	0.00
Trib C0	Tributary C0, calculated	7.37	-1.75E-11	3.54	0.76	0.007	0.000022	0.01	4.48	***0.002***	1.11	0.0000	0.30	0.0001	0.00	0.00	0.00	0.001	0.00	0.00	0.02	0.00	***19.96***	0.00

Exceeds CCME
Exceeds MMER

Table R11-2: Mactung Water Quality Source Terms, 2008 Supernatant Solution

Group	Description	pH	Percent Error in Charge Balance	TDS	Alkalinity	Chloride	Fluoride	Phosphate	Sulphate	Aluminum	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Lithium
				(mg/L)	(mg/L as CaCO3)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
MMER				-	-	-	-	-	-	-	-	0.5	-	-	-	-	-	-	-	0.3	-	-	-
CCME		**6.5**				120	0.12			0.1		0.005			1.5	0.000017		0.001		0.004	0.3	0.007	
WRSF source	Unit 1 Waste Rock Runoff	7.90	1.83E-13	6	5.48	0.07	0.00	0.00	0.25	0.03	0.00	0.000	0.00	0.00	0.00	0.000000	0.86	0.000	0.00	0.000	0.00	0.000	0.00
WRSF source	Unit 3C Waste Rock Runoff	7.90	-3.85E-07	5	4.81	0.01	0.00	0.01	0.25	0.04	0.00	0.000	0.00	0.00	0.00	0.000000	0.75	0.000	0.00	0.000	0.00	0.000	0.00
Tailings source	Tailings Runoff	7.53	-1.10E-14	4126	12.13	***1299.28***	0.00	0.08	2812.25	***0.78***	0.02	***0.016***	0.14	0.00	0.65	***0.002370***	1859.23	***0.003***	0.02	***0.061***	0.03	0.000	0.11
Seepage Source	Tailings Seepage	7.53	9.66E-15	55652	164.68	***17526.83***	0.00	1.08	37935.05	***10.47***	0.25	***0.214***	1.93	0.00	***8.78***	***0.031968***	25080.46	***0.035***	0.28	***0.818***	***0.35***	0.007	1.51
Process Source	Process Water/Supernatant	9.18	-1.01E-13	214	179.47	24.90	***0.32***	0.55	8.38	0.06	0.00	0.005	0.00	0.00	0.03	***0.000060***	11.30	***0.052***	0.00	***0.013***	0.08	0.000	0.00
Precipitation Source	Precipitation	5.60	1.00E-10	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.00	0.00	0.00	0.000000	0.00	0.000	0.00	0.000	0.00	0.000	0.00
SW Source	Tributary C0 Background	7.42	-1.47E-14	165	91.82	0.18	0.00	0.02	72.61	***0.18***	0.00	0.000	0.02	0.00	0.00	***0.000360***	35.96	0.000	0.00	0.002	0.01	0.000	0.01
GW Source	GW MW-MT-08-08D	7.48	-5.96E-14	123	43.59	0.23	0.00	0.02	79.21	0.03	0.00	0.001	0.01	0.00	0.00	***0.000020***	36.36	0.001	0.00	0.001	0.10	0.001	0.00
WWTP Source	Waste Water Treatment Plant Effluent	6.60	2.94E+01	0	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.00	0.00	0.00	0.000000	0.00	0.000	0.00	0.000	0.00	0.000	0.00
WRSF	Waste Rock Storage Facility Runoff	6.86	-3.34E-07	5	4.57	0.02	0.00	0.01	0.22	0.00	0.00	0.000	0.00	0.00	0.00	0.000000	0.76	0.000	0.00	0.000	0.00	0.000	0.00
Trib C0	Tributary C0, calculated	7.37	-1.75E-11	505	17.19	***133.98***	0.00	0.02	353.82	0.00	0.00	0.002	0.01	0.00	0.07	***0.000563***	223.39	0.000	0.00	***0.008***	0.00	0.000	0.02

Exceeds CCME
Exceeds MMER

Table R11-2: Mactung Water Quality Source Terms, 2008 Supernatant Solution (Cont'd)

Group	Description	pH	Percent Error in Charge Balance	Magnesium	Manganese	Molybdenum	Mercury	Nickel	Potassium	Selenium	Sodium	Silver	Strontium	Thallium	Tin	Titanium	Tungsten	Uranium	Vanadium	Yttrium	Zinc	Cyanide	Nitrate	Ammonia
				(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
MMER				-	-	-	-	0.5	-	-	-	-	-	-	-	-	-	-	-	-	0.5	1	-	-
CCME		**6.5**				0.073	0.000026	0.15		0.001		0.0001		0.0008				0.015			0.03	0.005	13	
WRSF source	Unit 1 Waste Rock Runoff	7.90	1.83E-13	0.02	0.00	0.000	0.000000	0.00	0.32	0.000	0.13	0.0000	0.00	0.0000	0.00	0.00	0.00	0.000	0.00	0.00	0.00	0.00	0.00	0.00
WRSF source	Unit 3C Waste Rock Runoff	7.90	-3.85E-07	0.03	0.00	0.000	***0.000415***	0.00	0.21	0.000	0.11	0.0000	0.00	0.0000	0.00	0.00	0.00	0.000	0.00	0.00	0.00	0.00	0.00	0.00
Tailings source	Tailings Runoff	7.53	-1.10E-14	11.19	6.56	0.064	***0.000130***	0.01	37.49	***0.019***	6.25	0.0001	2.13	***0.0008***	0.00	0.01	0.00	0.012	0.00	0.00	***0.08***	0.00	0.00	0.00
Seepage Source	Tailings Seepage	7.53	9.66E-15	151.00	88.52	***0.861***	***0.001756***	***0.16***	505.77	***0.253***	84.30	***0.0009***	28.70	***0.0109***	0.03	0.09	0.00	***0.165***	0.04	0.00	***1.12***	0.00	0.00	0.00
Process Source	Process Water/Supernatant	9.18	-1.01E-13	0.93	0.02	0.010	0.000010	0.00	5.48	***0.003***	44.11	0.0000	0.03	0.0000	0.00	0.00	0.00	0.001	0.00	0.00	0.00	0.00	1.02	0.06
Precipitation Source	Precipitation	5.60	1.00E-10	0.00	0.00	0.000	0.000000	0.00	0.00	0.000	0.00	0.0000	0.00	0.0000	0.00	0.00	0.00	0.000	0.00	0.00	0.00	0.00	0.00	0.00
SW Source	Tributary C0 Background	7.42	-1.47E-14	2.69	0.10	0.001	0.000005	0.01	0.70	0.000	0.52	0.0000	0.09	0.0000	0.00	0.00	0.00	0.000	0.00	0.00	0.02	0.00	0.35	6.07
GW Source	GW MW-MT-08-08D	7.48	-5.96E-14	0.67	0.01	0.007	0.000005	0.00	0.20	0.000	4.80	0.0000	0.05	0.0000	0.00	0.00	0.01	0.000	0.00	0.00	0.00	0.00	0.04	0.05
WWTP Source	Waste Water Treatment Plant Effluent	6.60	2.94E+01	0.00	0.00	0.000	0.000000	0.00	0.00	0.000	93.02	0.0000	0.00	0.0000	0.00	0.00	0.00	0.000	0.00	0.00	0.00	0.00	***243.06***	60.71
WRSF	Waste Rock Storage Facility Runoff	6.86	-3.34E-07	0.03	0.00	0.000	***0.000368***	0.00	0.22	0.000	0.11	0.0000	0.00	0.0000	0.00	0.00	0.00	0.000	0.00	0.00	0.00	0.00	0.00	0.00
Trib C0	Tributary C0, calculated	7.37	-1.75E-11	3.54	0.76	0.007	0.000022	0.01	4.48	***0.002***	1.11	0.0000	0.30	0.0001	0.00	0.00	0.00	0.001	0.00	0.00	0.02	0.00	***19.96***	0.00

Exceeds CCME
Exceeds MMER

Table R11-3: Mactung Reservoir Water Quality Model Results, 2005 Supernatant Concentrations

Group	Description	pH	Percent Error in Charge Balance	TDS	Alkalinity	Chloride	Fluoride	Phosphate	Sulphate	Aluminum	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Lithium
				(mg/L)	(mg/L as CaCO3)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
MMER				-	-	-	-	-	-	-	-	0.5	-	-	-	-	-	-	-	0.3	-	-	-
CCME		**6.5**				120	0.12			0.1		0.005			1.5	0.000017		0.001		0.004	0.3	0.007	
Reservoir, Dry	January Water Quality	8.7	0.30	614	403.26	29.60	***0.41***	1.39	35.12	***0.10***	0.00	***0.010***	0.00	0.00	0.02	***0.000055***	4.83	0.001	0.00	***0.008***	0.00	0.004	0.00
Reservoir, Dry	February Water Quality	8.8	0.30	646	445.60	26.33	***0.42***	1.43	25.18	***0.13***	0.00	***0.011***	0.00	0.00	0.02	***0.000040***	4.00	0.001	0.00	***0.008***	0.00	0.004	0.00
Reservoir, Dry	March Water Quality	8.8	0.30	658	460.51	25.21	***0.42***	1.45	21.74	***0.14***	0.00	***0.011***	0.00	0.00	0.02	***0.000034***	3.77	0.001	0.00	***0.008***	0.00	0.004	0.00
Reservoir, Dry	April Water Quality	8.8	0.30	658	460.51	25.21	***0.42***	1.45	21.74	***0.14***	0.00	***0.011***	0.00	0.00	0.02	***0.000034***	3.77	0.001	0.00	***0.008***	0.00	0.004	0.00
Reservoir, Dry	May Water Quality	8.0	0.10	614	82.99	***132.31***	***0.23***	0.80	297.43	0.01	0.00	***0.007***	0.01	0.00	0.07	***0.000380***	151.23	0.001	0.00	***0.011***	0.00	0.002	0.01
Reservoir, Dry	June Water Quality	8.0	0.07	575	79.53	***124.20***	***0.16***	0.56	291.64	0.01	0.00	***0.006***	0.01	0.00	0.07	***0.000398***	162.39	0.001	0.00	***0.009***	0.00	0.001	0.01
Reservoir, Dry	July Water Quality	8.0	0.09	590	82.71	***126.67***	***0.21***	0.72	287.21	0.01	0.00	***0.007***	0.01	0.00	0.07	***0.000371***	150.02	0.001	0.00	***0.010***	0.00	0.002	0.01
Reservoir, Dry	August Water Quality	8.1	0.10	596	84.55	***127.30***	***0.23***	0.80	284.03	0.01	0.00	***0.007***	0.01	0.00	0.07	***0.000358***	143.31	0.001	0.00	***0.011***	0.00	0.002	0.01
Reservoir, Dry	September Water Quality	8.1	0.12	619	86.82	***132.22***	***0.27***	0.94	287.83	0.01	0.00	***0.008***	0.01	0.00	0.07	***0.000347***	137.10	0.001	0.00	***0.011***	0.00	0.002	0.01
Reservoir, Dry	October Water Quality	8.1	0.15	636	96.06	***133.38***	***0.35***	1.22	271.15	0.01	0.00	***0.010***	0.01	0.00	0.07	***0.000284***	110.46	0.001	0.00	***0.012***	0.00	0.003	0.01
Reservoir, Dry	November Water Quality	8.7	0.30	589	371.36	32.13	***0.40***	1.36	42.85	0.09	0.00	***0.010***	0.00	0.00	0.02	***0.000068***	5.65	0.001	0.00	***0.008***	0.00	0.003	0.00
Reservoir, Dry	December Water Quality	8.7	0.30	594	377.58	31.63	***0.40***	1.36	41.32	0.09	0.00	***0.010***	0.00	0.00	0.02	***0.000065***	5.48	0.001	0.00	***0.008***	0.00	0.003	0.00
Reservoir, Average	January Water Quality	8.7	0.29	573	350.01	33.76	***0.39***	1.33	48.05	0.08	0.00	***0.010***	0.00	0.00	0.02	***0.000076***	6.34	0.001	0.00	***0.008***	0.00	0.003	0.00
Reservoir, Average	February Water Quality	8.8	0.30	620	412.70	28.74	***0.41***	1.40	32.76	***0.11***	0.00	***0.010***	0.00	0.00	0.02	***0.000051***	4.62	0.001	0.00	***0.008***	0.00	0.004	0.00
Reservoir, Average	March Water Quality	8.8	0.30	638	435.68	26.96	***0.42***	1.42	27.35	***0.12***	0.00	***0.010***	0.00	0.00	0.02	***0.000043***	4.17	0.001	0.00	***0.008***	0.00	0.004	0.00
Reservoir, Average	April Water Quality	8.8	0.30	638	435.68	26.96	***0.42***	1.42	27.35	***0.12***	0.00	***0.010***	0.00	0.00	0.02	***0.000043***	4.17	0.001	0.00	***0.008***	0.00	0.004	0.00
Reservoir, Average	May Water Quality	8.0	0.07	611	78.43	***133.59***	***0.18***	0.62	312.39	0.01	0.00	***0.006***	0.01	0.00	0.07	***0.000423***	171.51	0.001	0.00	***0.010***	0.00	0.002	0.01
Reservoir, Average	June Water Quality	8.0	0.05	574	76.08	***125.37***	0.12	0.41	304.57	0.01	0.00	0.004	0.01	0.00	0.07	***0.000436***	179.45	0.001	0.00	***0.009***	0.00	0.001	0.01
Reservoir, Average	July Water Quality	8.0	0.07	585	78.61	***127.02***	***0.16***	0.55	299.46	0.01	0.00	***0.005***	0.01	0.00	0.07	***0.000410***	167.80	0.001	0.00	***0.010***	0.00	0.001	0.01
Reservoir, Average	August Water Quality	8.0	0.08	590	80.01	***127.79***	***0.18***	0.62	296.80	0.01	0.00	***0.006***	0.01	0.00	0.07	***0.000398***	161.77	0.001	0.00	***0.010***	0.00	0.002	0.01
Reservoir, Average	September Water Quality	8.0	0.09	615	81.70	***133.35***	***0.22***	0.76	302.33	0.01	0.00	***0.007***	0.01	0.00	0.07	***0.000390***	156.80	0.001	0.00	***0.011***	0.00	0.002	0.01
Reservoir, Average	October Water Quality	8.1	0.14	627	91.77	***132.38***	***0.32***	1.09	277.57	0.01	0.00	***0.009***	0.01	0.00	0.07	***0.000311***	121.63	0.001	0.00	***0.012***	0.00	0.003	0.01
Reservoir, Average	November Water Quality	8.6	0.29	540	305.51	37.58	***0.38***	1.28	59.68	0.06	0.00	***0.010***	0.00	0.00	0.03	***0.000094***	8.26	0.001	0.00	***0.008***	0.00	0.003	0.00
Reservoir, Average	December Water Quality	8.6	0.29	546	313.84	36.85	***0.38***	1.29	57.42	0.06	0.00	***0.010***	0.00	0.00	0.03	***0.000091***	7.84	0.001	0.00	***0.008***	0.00	0.003	0.00
Reservoir, Wet	January Water Quality	8.6	0.29	528	294.95	37.29	***0.37***	1.25	61.29	0.06	0.00	***0.009***	0.00	0.00	0.03	***0.000095***	8.82	0.001	0.00	***0.008***	0.00	0.003	0.00
Reservoir, Wet	February Water Quality	8.7	0.30	584	371.42	30.69	***0.39***	1.34	41.35	0.09	0.00	***0.010***	0.00	0.00	0.02	***0.000063***	5.63	0.001	0.00	***0.008***	0.00	0.003	0.00
Reservoir, Wet	March Water Quality	8.7	0.30	607	401.46	28.29	***0.40***	1.37	34.06	***0.10***	0.00	***0.010***	0.00	0.00	0.02	***0.000051***	4.85	0.001	0.00	***0.008***	0.00	0.003	0.00
Reservoir, Wet	April Water Quality	8.7	0.30	607	401.46	28.29	***0.40***	1.37	34.06	***0.10***	0.00	***0.010***	0.00	0.00	0.02	***0.000051***	4.85	0.001	0.00	***0.008***	0.00	0.003	0.00
Reservoir, Wet	May Water Quality	8.0	0.06	579	77.20	***125.74***	***0.13***	0.47	302.49	0.01	0.00	0.005	0.01	0.00	0.07	***0.000426***	174.16	0.001	0.00	***0.009***	0.00	0.001	0.01
Reservoir, Wet	June Water Quality	8.0	0.04	571	74.35	***125.20***	0.09	0.32	310.70	0.01	0.00	0.004	0.01	0.00	0.07	***0.000457***	188.72	0.001	0.00	***0.009***	0.00	0.001	0.01
Reservoir, Wet	July Water Quality	8.0	0.05	578	76.43	***126.11***	***0.12***	0.44	305.28	0.01	0.00	0.005	0.01	0.00	0.07	***0.000434***	178.10	0.001	0.00	***0.009***	0.00	0.001	0.01
Reservoir, Wet	August Water Quality	8.0	0.06	579	77.84	***125.46***	***0.14***	0.50	300.05	0.01	0.00	***0.005***	0.01	0.00	0.07	***0.000420***	170.95	0.001	0.00	***0.009***	0.00	0.001	0.01
Reservoir, Wet	September Water Quality	8.0	0.07	594	79.51	***128.64***	***0.18***	0.61	300.92	0.01	0.00	***0.006***	0.01	0.00	0.07	***0.000407***	164.57	0.001	0.00	***0.010***	0.00	0.002	0.01
Reservoir, Wet	October Water Quality	8.1	0.12	618	88.23	***131.24***	***0.28***	0.97	283.44	0.01	0.00	***0.009***	0.01	0.00	0.07	***0.000333***	132.10	0.001	0.00	***0.011***	0.00	0.003	0.01
Reservoir, Wet	November Water Quality	8.5	0.27	495	246.87	42.29	***0.35***	1.20	75.97	0.04	0.00	***0.009***	0.00	0.00	0.03	***0.000119***	12.60	0.001	0.00	***0.008***	0.00	0.003	0.00
Reservoir, Wet	December Water Quality	8.6	0.27	501	255.78	41.35	***0.35***	1.21	73.13	0.04	0.00	***0.009***	0.00	0.00	0.03	***0.000114***	11.73	0.001	0.00	***0.008***	0.00	0.003	0.00

Exceeds CCME
Exceeds MMER

Table R11-3: Mactung Reservoir Water Quality Model Results, 2005 Supernatant Concentrations

Group	Description	pH	Percent Error in Charge Balance	Magnesium (mg/L)	Manganese (mg/L)	Molybdenum (mg/L)	Mercury (mg/L)	Nickel (mg/L)	Potassium (mg/L)	Selenium (mg/L)	Sodium (mg/L)	Silver (mg/L)	Strontium (mg/L)	Thallium (mg/L)	Tin (mg/L)	Titanium (mg/L)	Tungsten (mg/L)	Uranium (mg/L)	Vanadium (mg/L)	Yttrium (mg/L)	Zinc (mg/L)	Cyanide (mg/L)	Nitrate (mg/L)	Ammonia (mg/L)
MMER				-	-	-	-	0.5	-	-	-	-	-	-	-	-	-	-	-	-	0.5	1	-	-
CCME		6.5				0.073	0.000026	0.15		0.001		0.0001		0.0008				0.015			0.03	0.005	13	
Reservoir, Dry	January Water Quality	8.7	0.30	0.50	0.06	0.010	0.000011	0.00	2.04	***0.001***	124.92	0.0000	0.03	0.0000	0.00	0.00	0.00	0.001	0.01	0.00	0.01	0.000	6.99	0.00
Reservoir, Dry	February Water Quality	8.8	0.30	0.41	0.04	0.010	0.000010	0.00	1.97	***0.001***	128.79	0.0000	0.02	0.0000	0.00	0.00	0.00	0.001	0.01	0.00	0.00	0.000	6.58	0.00
Reservoir, Dry	March Water Quality	8.8	0.30	0.37	0.03	0.010	0.000010	0.00	1.94	***0.001***	130.13	0.0000	0.02	0.0000	0.00	0.00	0.00	0.001	0.01	0.00	0.00	0.000	6.44	0.00
Reservoir, Dry	April Water Quality	8.8	0.30	0.37	0.03	0.010	0.000010	0.00	1.94	***0.001***	130.13	0.0000	0.02	0.0000	0.00	0.00	0.00	0.001	0.01	0.00	0.00	0.000	6.44	0.00
Reservoir, Dry	May Water Quality	8.0	0.10	2.31	0.66	0.012	0.000021	0.01	4.76	***0.002***	71.44	0.0000	0.24	0.0001	0.00	0.00	0.00	0.002	0.00	0.00	0.02	0.000	12.56	0.00
Reservoir, Dry	June Water Quality	8.0	0.07	2.45	0.64	0.010	0.000020	0.01	4.38	***0.002***	49.82	0.0000	0.24	0.0001	0.00	0.00	0.00	0.001	0.00	0.00	0.02	0.000	***13.43***	0.00
Reservoir, Dry	July Water Quality	8.0	0.09	2.26	0.63	0.011	0.000020	0.01	4.53	***0.002***	64.27	0.0000	0.24	0.0001	0.00	0.00	0.00	0.002	0.00	0.00	0.02	0.000	12.27	0.00
Reservoir, Dry	August Water Quality	8.1	0.10	2.17	0.63	0.011	0.000020	0.01	4.59	***0.002***	71.31	0.0000	0.23	0.0001	0.00	0.00	0.00	0.002	0.00	0.00	0.02	0.000	11.72	0.00
Reservoir, Dry	September Water Quality	8.1	0.12	2.09	0.64	0.012	0.000021	0.01	4.81	***0.002***	83.96	0.0000	0.23	0.0001	0.00	0.00	0.00	0.002	0.01	0.00	0.02	0.000	11.24	0.00
Reservoir, Dry	October Water Quality	8.1	0.15	1.66	0.61	0.014	0.000021	0.00	4.96	***0.003***	109.52	0.0000	0.21	0.0001	0.00	0.00	0.00	0.002	0.01	0.00	0.01	0.000	8.53	0.00
Reservoir, Dry	November Water Quality	8.7	0.30	0.57	0.08	0.010	0.000011	0.00	2.10	***0.001***	121.91	0.0000	0.04	0.0000	0.00	0.00	0.00	0.001	0.01	0.00	0.01	0.000	7.28	0.00
Reservoir, Dry	December Water Quality	8.7	0.30	0.56	0.08	0.010	0.000011	0.00	2.09	***0.001***	122.51	0.0000	0.04	0.0000	0.00	0.00	0.00	0.001	0.01	0.00	0.01	0.000	7.24	0.00
Reservoir, Average	January Water Quality	8.7	0.29	0.62	0.09	0.010	0.000011	0.00	2.14	***0.001***	119.71	0.0000	0.04	0.0000	0.00	0.00	0.00	0.001	0.01	0.00	0.01	0.000	7.47	0.00
Reservoir, Average	February Water Quality	8.8	0.30	0.48	0.06	0.010	0.000011	0.00	2.02	***0.001***	125.64	0.0000	0.03	0.0000	0.00	0.00	0.00	0.001	0.01	0.00	0.01	0.000	6.85	0.00
Reservoir, Average	March Water Quality	8.8	0.30	0.43	0.05	0.010	0.000010	0.00	1.98	***0.001***	127.74	0.0000	0.03	0.0000	0.00	0.00	0.00	0.001	0.01	0.00	0.00	0.000	6.65	0.00
Reservoir, Average	April Water Quality	8.8	0.30	0.43	0.05	0.010	0.000010	0.00	1.98	***0.001***	127.74	0.0000	0.03	0.0000	0.00	0.00	0.00	0.001	0.01	0.00	0.00	0.000	6.65	0.00
Reservoir, Average	May Water Quality	8.0	0.07	2.59	0.69	0.011	0.000021	0.01	4.72	***0.002***	54.96	0.0000	0.26	0.0001	0.00	0.00	0.00	0.002	0.00	0.00	0.02	0.000	***14.23***	0.00
Reservoir, Average	June Water Quality	8.0	0.05	2.70	0.67	0.009	0.000020	0.01	4.36	***0.002***	36.29	0.0000	0.25	0.0001	0.00	0.00	0.00	0.001	0.00	0.00	0.02	0.000	***14.94***	0.00
Reservoir, Average	July Water Quality	8.0	0.07	2.52	0.66	0.010	0.000020	0.01	4.47	***0.002***	48.91	0.0000	0.25	0.0001	0.00	0.00	0.00	0.002	0.00	0.00	0.02	0.000	***13.86***	0.00
Reservoir, Average	August Water Quality	8.0	0.08	2.44	0.65	0.010	0.000020	0.01	4.53	***0.002***	55.40	0.0000	0.25	0.0001	0.00	0.00	0.00	0.002	0.00	0.00	0.02	0.000	***13.33***	0.00
Reservoir, Average	September Water Quality	8.0	0.09	2.37	0.67	0.011	0.000021	0.01	4.77	***0.002***	67.70	0.0000	0.25	0.0001	0.00	0.00	0.00	0.002	0.00	0.00	0.02	0.000	12.88	0.00
Reservoir, Average	October Water Quality	8.1	0.14	1.84	0.62	0.013	0.000021	0.00	4.88	***0.003***	98.10	0.0000	0.22	0.0001	0.00	0.00	0.00	0.002	0.01	0.00	0.01	0.000	9.72	0.00
Reservoir, Average	November Water Quality	8.6	0.29	0.73	0.12	0.010	0.000012	0.00	2.23	***0.001***	115.21	0.0000	0.05	0.0000	0.00	0.00	0.00	0.001	0.01	0.00	0.01	0.000	7.97	0.00
Reservoir, Average	December Water Quality	8.6	0.29	0.71	0.11	0.010	0.000011	0.00	2.21	***0.001***	116.09	0.0000	0.05	0.0000	0.00	0.00	0.00	0.001	0.01	0.00	0.01	0.000	7.89	0.00
Reservoir, Wet	January Water Quality	8.6	0.29	0.75	0.12	0.009	0.000011	0.00	2.20	***0.001***	112.66	0.0000	0.05	0.0000	0.00	0.00	0.00	0.001	0.01	0.00	0.01	0.000	7.88	0.00
Reservoir, Wet	February Water Quality	8.7	0.30	0.55	0.07	0.010	0.000011	0.00	2.04	***0.001***	120.27	0.0000	0.04	0.0000	0.00	0.00	0.00	0.001	0.01	0.00	0.01	0.000	7.05	0.00
Reservoir, Wet	March Water Quality	8.7	0.30	0.48	0.06	0.010	0.000010	0.00	1.99	***0.001***	123.07	0.0000	0.03	0.0000	0.00	0.00	0.00	0.001	0.01	0.00	0.01	0.000	6.74	0.00
Reservoir, Wet	April Water Quality	8.7	0.30	0.48	0.06	0.010	0.000010	0.00	1.99	***0.001***	123.07	0.0000	0.03	0.0000	0.00	0.00	0.00	0.001	0.01	0.00	0.01	0.000	6.74	0.00
Reservoir, Wet	May Water Quality	8.0	0.06	2.64	0.66	0.009	0.000020	0.01	4.40	***0.002***	41.90	0.0000	0.25	0.0001	0.00	0.00	0.00	0.001	0.00	0.00	0.02	0.000	***14.58***	0.00
Reservoir, Wet	June Water Quality	8.0	0.04	2.84	0.68	0.009	0.000020	0.01	4.31	***0.002***	28.03	0.0000	0.26	0.0001	0.00	0.00	0.00	0.001	0.00	0.00	0.02	0.000	***15.78***	0.00
Reservoir, Wet	July Water Quality	8.0	0.05	2.68	0.67	0.009	0.000020	0.01	4.39	***0.002***	38.72	0.0000	0.25	0.0001	0.00	0.00	0.00	0.001	0.00	0.00	0.02	0.000	***14.79***	0.00
Reservoir, Wet	August Water Quality	8.0	0.06	2.59	0.66	0.010	0.000020	0.01	4.40	***0.002***	44.41	0.0000	0.25	0.0001	0.00	0.00	0.00	0.001	0.00	0.00	0.02	0.000	***14.32***	0.00
Reservoir, Wet	September Water Quality	8.0	0.07	2.50	0.66	0.010	0.000021	0.01	4.56	***0.002***	54.57	0.0000	0.25	0.0001	0.00	0.00	0.00	0.002	0.00	0.00	0.02	0.000	***13.70***	0.00
Reservoir, Wet	October Water Quality	8.1	0.12	2.00	0.63	0.012	0.000021	0.01	4.79	***0.002***	87.28	0.0000	0.23	0.0001	0.00	0.00	0.00	0.002	0.01	0.00	0.02	0.000	10.61	0.00
Reservoir, Wet	November Water Quality	8.5	0.27	0.89	0.15	0.009	0.000012	0.00	2.32	***0.001***	107.38	0.0000	0.07	0.0000	0.00	0.00	0.00	0.001	0.01	0.00	0.01	0.000	8.52	0.00
Reservoir, Wet	December Water Quality	8.6	0.27	0.86	0.14	0.009	0.000012	0.00	2.30	***0.001***	108.47	0.0000	0.06	0.0000	0.00	0.00	0.00	0.001	0.01	0.00	0.01	0.000	8.37	0.00

Exceeds CCME
Exceeds MMER

Table R11-4: Mactung Reservoir Water Quality Model Results, 2008 Supernatant Concentrations

Group	Description	pH	Percent Error in Charge Balance	TDS	Alkalinity	Chloride	Fluoride	Phosphate	Sulphate	Aluminum	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Lithium
				(mg/L)	(mg/L as CaCO3)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
MMER				-	-	-	-	-	-	-	-	0.5	-	-	-	-	-	-	-	0.3	-	-	-
CCME		**6.5**				120	0.12			0.1		0.005			1.5	0.000017		0.001		0.004	0.3	0.007	
Reservoir, Dry	January Water Quality	8.7	0.30	470	403.26	29.60	***0.41***	1.39	35.12	***0.10***	0.00	***0.010***	0.00	0.00	0.02	***0.000055***	4.83	0.001	0.00	***0.008***	0.00	0.004	0.00
Reservoir, Dry	February Water Quality	8.8	0.30	499	445.60	26.33	***0.42***	1.43	25.18	***0.13***	0.00	***0.011***	0.00	0.00	0.02	***0.000040***	4.00	0.001	0.00	***0.008***	0.00	0.004	0.00
Reservoir, Dry	March Water Quality	8.8	0.30	510	460.51	25.21	***0.42***	1.45	21.74	***0.14***	0.00	***0.011***	0.00	0.00	0.02	***0.000034***	3.77	0.001	0.00	***0.008***	0.00	0.004	0.00
Reservoir, Dry	April Water Quality	8.8	0.30	510	460.51	25.21	***0.42***	1.45	21.74	***0.14***	0.00	***0.011***	0.00	0.00	0.02	***0.000034***	3.77	0.001	0.00	***0.008***	0.00	0.004	0.00
Reservoir, Dry	May Water Quality	8.0	0.10	514	82.99	***132.31***	***0.23***	0.80	297.43	0.01	0.00	***0.007***	0.01	0.00	0.07	***0.000380***	151.23	0.001	0.00	***0.011***	0.00	0.002	0.01
Reservoir, Dry	June Water Quality	8.0	0.07	496	79.53	***124.20***	***0.16***	0.56	291.64	0.01	0.00	***0.006***	0.01	0.00	0.07	***0.000398***	162.39	0.001	0.00	***0.009***	0.00	0.001	0.01
Reservoir, Dry	July Water Quality	8.0	0.09	498	82.71	***126.67***	***0.21***	0.72	287.21	0.01	0.00	***0.007***	0.01	0.00	0.07	***0.000371***	150.02	0.001	0.00	***0.010***	0.00	0.002	0.01
Reservoir, Dry	August Water Quality	8.1	0.10	497	84.55	***127.30***	***0.23***	0.80	284.03	0.01	0.00	***0.007***	0.01	0.00	0.07	***0.000358***	143.31	0.001	0.00	***0.011***	0.00	0.002	0.01
Reservoir, Dry	September Water Quality	8.1	0.12	508	86.82	***132.22***	***0.27***	0.94	287.83	0.01	0.00	***0.008***	0.01	0.00	0.07	***0.000347***	137.10	0.001	0.00	***0.011***	0.00	0.002	0.01
Reservoir, Dry	October Water Quality	8.1	0.15	502	96.06	***133.38***	***0.35***	1.22	271.15	0.01	0.00	***0.010***	0.01	0.00	0.07	***0.000284***	110.46	0.001	0.00	***0.012***	0.00	0.003	0.01
Reservoir, Dry	November Water Quality	8.7	0.30	448	371.36	32.13	***0.40***	1.36	42.85	0.09	0.00	***0.010***	0.00	0.00	0.02	***0.000068***	5.65	0.001	0.00	***0.008***	0.00	0.003	0.00
Reservoir, Dry	December Water Quality	8.7	0.30	452	377.58	31.63	***0.40***	1.36	41.32	0.09	0.00	***0.010***	0.00	0.00	0.02	***0.000065***	5.48	0.001	0.00	***0.008***	0.00	0.003	0.00
Reservoir, Average	January Water Quality	8.7	0.29	434	350.01	33.76	***0.39***	1.33	48.05	0.08	0.00	***0.010***	0.00	0.00	0.02	***0.000076***	6.34	0.001	0.00	***0.008***	0.00	0.003	0.00
Reservoir, Average	February Water Quality	8.8	0.30	476	412.70	28.74	***0.41***	1.40	32.76	***0.11***	0.00	***0.010***	0.00	0.00	0.02	***0.000051***	4.62	0.001	0.00	***0.008***	0.00	0.004	0.00
Reservoir, Average	March Water Quality	8.8	0.30	492	435.68	26.96	***0.42***	1.42	27.35	***0.12***	0.00	***0.010***	0.00	0.00	0.02	***0.000043***	4.17	0.001	0.00	***0.008***	0.00	0.004	0.00
Reservoir, Average	April Water Quality	8.8	0.30	492	435.68	26.96	***0.42***	1.42	27.35	***0.12***	0.00	***0.010***	0.00	0.00	0.02	***0.000043***	4.17	0.001	0.00	***0.008***	0.00	0.004	0.00
Reservoir, Average	May Water Quality	8.0	0.07	525	78.43	***133.59***	***0.18***	0.62	312.39	0.01	0.00	***0.006***	0.01	0.00	0.07	***0.000423***	171.51	0.001	0.00	***0.010***	0.00	0.002	0.01
Reservoir, Average	June Water Quality	8.0	0.05	507	76.08	***125.37***	0.12	0.41	304.57	0.01	0.00	0.004	0.01	0.00	0.07	***0.000436***	179.45	0.001	0.00	***0.009***	0.00	0.001	0.01
Reservoir, Average	July Water Quality	8.0	0.07	506	78.61	***127.02***	***0.16***	0.55	299.46	0.01	0.00	***0.005***	0.01	0.00	0.07	***0.000410***	167.80	0.001	0.00	***0.010***	0.00	0.001	0.01
Reservoir, Average	August Water Quality	8.0	0.08	506	80.01	***127.79***	***0.18***	0.62	296.80	0.01	0.00	***0.006***	0.01	0.00	0.07	***0.000398***	161.77	0.001	0.00	***0.010***	0.00	0.002	0.01
Reservoir, Average	September Water Quality	8.0	0.09	518	81.70	***133.35***	***0.22***	0.76	302.33	0.01	0.00	***0.007***	0.01	0.00	0.07	***0.000390***	156.80	0.001	0.00	***0.011***	0.00	0.002	0.01
Reservoir, Average	October Water Quality	8.1	0.14	503	91.77	***132.38***	***0.32***	1.09	277.57	0.01	0.00	***0.009***	0.01	0.00	0.07	***0.000311***	121.63	0.001	0.00	***0.012***	0.00	0.003	0.01
Reservoir, Average	November Water Quality	8.6	0.29	405	305.51	37.58	***0.38***	1.28	59.68	0.06	0.00	***0.010***	0.00	0.00	0.03	***0.000094***	8.26	0.001	0.00	***0.008***	0.00	0.003	0.00
Reservoir, Average	December Water Quality	8.6	0.29	410	313.84	36.85	***0.38***	1.29	57.42	0.06	0.00	***0.010***	0.00	0.00	0.03	***0.000091***	7.84	0.001	0.00	***0.008***	0.00	0.003	0.00
Reservoir, Wet	January Water Quality	8.6	0.29	395	294.95	37.29	***0.37***	1.25	61.29	0.06	0.00	***0.009***	0.00	0.00	0.03	***0.000095***	8.82	0.001	0.00	***0.008***	0.00	0.003	0.00
Reservoir, Wet	February Water Quality	8.7	0.30	445	371.42	30.69	***0.39***	1.34	41.35	0.09	0.00	***0.010***	0.00	0.00	0.02	***0.000063***	5.63	0.001	0.00	***0.008***	0.00	0.003	0.00
Reservoir, Wet	March Water Quality	8.7	0.30	466	401.46	28.29	***0.40***	1.37	34.06	***0.10***	0.00	***0.010***	0.00	0.00	0.02	***0.000051***	4.85	0.001	0.00	***0.008***	0.00	0.003	0.00
Reservoir, Wet	April Water Quality	8.7	0.30	466	401.46	28.29	***0.40***	1.37	34.06	***0.10***	0.00	***0.010***	0.00	0.00	0.02	***0.000051***	4.85	0.001	0.00	***0.008***	0.00	0.003	0.00
Reservoir, Wet	May Water Quality	8.0	0.06	506	77.20	***125.74***	***0.13***	0.47	302.49	0.01	0.00	0.005	0.01	0.00	0.07	***0.000426***	174.16	0.001	0.00	***0.009***	0.00	0.001	0.01
Reservoir, Wet	June Water Quality	8.0	0.04	511	74.35	***125.20***	0.09	0.32	310.70	0.01	0.00	0.004	0.01	0.00	0.07	***0.000457***	188.72	0.001	0.00	***0.009***	0.00	0.001	0.01
Reservoir, Wet	July Water Quality	8.0	0.05	509	76.43	***126.11***	***0.12***	0.44	305.28	0.01	0.00	0.005	0.01	0.00	0.07	***0.000434***	178.10	0.001	0.00	***0.009***	0.00	0.001	0.01
Reservoir, Wet	August Water Quality	8.0	0.06	504	77.84	***125.46***	***0.14***	0.50	300.05	0.01	0.00	***0.005***	0.01	0.00	0.07	***0.000420***	170.95	0.001	0.00	***0.009***	0.00	0.001	0.01
Reservoir, Wet	September Water Quality	8.0	0.07	510	79.51	***128.64***	***0.18***	0.61	300.92	0.01	0.00	***0.006***	0.01	0.00	0.07	***0.000407***	164.57	0.001	0.00	***0.010***	0.00	0.002	0.01
Reservoir, Wet	October Water Quality	8.1	0.12	504	88.23	***131.24***	***0.28***	0.97	283.44	0.01	0.00	***0.009***	0.01	0.00	0.07	***0.000333***	132.10	0.001	0.00	***0.011***	0.00	0.003	0.01
Reservoir, Wet	November Water Quality	8.5	0.27	367	246.87	42.29	***0.35***	1.20	75.97	0.04	0.00	***0.009***	0.00	0.00	0.03	***0.000119***	12.60	0.001	0.00	***0.008***	0.00	0.003	0.00
Reservoir, Wet	December Water Quality	8.6	0.27	372	255.78	41.35	***0.35***	1.21	73.13	0.04	0.00	***0.009***	0.00	0.00	0.03	***0.000114***	11.73	0.001	0.00	***0.008***	0.00	0.003	0.00

Exceeds CCME
Exceeds MMER

Table R11-4: Mactung Reservoir Water Quality Model Results, 2008 Supernatant Concentrations (Cont'd)

Group	Description	pH	Percent Error in Charge Balance	Magnesium	Manganese	Molybdenum	Mercury	Nickel	Potassium	Selenium	Sodium	Silver	Strontium	Thallium	Tin	Titanium	Tungsten	Uranium	Vanadium	Yttrium	Zinc	Cyanide	Nitrate	Ammonia
				(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
MMER				-	-	-	-	0.5	-	-	-	-	-	-	-	-	-	-	-	-	0.5	1	-	-
CCME		**6.5**				0.073	0.000026	0.15		0.001		0.0001		0.0008				0.015			0.03	0.005	13	
Reservoir, Dry	January Water Quality	8.7	0.30	0.50	0.06	0.010	0.000011	0.00	2.04	***0.001***	124.92	0.0000	0.03	0.0000	0.00	0.00	0.00	0.001	0.01	0.00	0.01	0.000	6.99	0.00
Reservoir, Dry	February Water Quality	8.8	0.30	0.41	0.04	0.010	0.000010	0.00	1.97	***0.001***	128.79	0.0000	0.02	0.0000	0.00	0.00	0.00	0.001	0.01	0.00	0.00	0.000	6.58	0.00
Reservoir, Dry	March Water Quality	8.8	0.30	0.37	0.03	0.010	0.000010	0.00	1.94	***0.001***	130.13	0.0000	0.02	0.0000	0.00	0.00	0.00	0.001	0.01	0.00	0.00	0.000	6.44	0.00
Reservoir, Dry	April Water Quality	8.8	0.30	0.37	0.03	0.010	0.000010	0.00	1.94	***0.001***	130.13	0.0000	0.02	0.0000	0.00	0.00	0.00	0.001	0.01	0.00	0.00	0.000	6.44	0.00
Reservoir, Dry	May Water Quality	8.0	0.10	2.31	0.66	0.012	0.000021	0.01	4.76	***0.002***	71.44	0.0000	0.24	0.0001	0.00	0.00	0.00	0.002	0.00	0.00	0.02	0.000	12.56	0.00
Reservoir, Dry	June Water Quality	8.0	0.07	2.45	0.64	0.010	0.000020	0.01	4.38	***0.002***	49.82	0.0000	0.24	0.0001	0.00	0.00	0.00	0.001	0.00	0.00	0.02	0.000	***13.43***	0.00
Reservoir, Dry	July Water Quality	8.0	0.09	2.26	0.63	0.011	0.000020	0.01	4.53	***0.002***	64.27	0.0000	0.24	0.0001	0.00	0.00	0.00	0.002	0.00	0.00	0.02	0.000	12.27	0.00
Reservoir, Dry	August Water Quality	8.1	0.10	2.17	0.63	0.011	0.000020	0.01	4.59	***0.002***	71.31	0.0000	0.23	0.0001	0.00	0.00	0.00	0.002	0.00	0.00	0.02	0.000	11.72	0.00
Reservoir, Dry	September Water Quality	8.1	0.12	2.09	0.64	0.012	0.000021	0.01	4.81	***0.002***	83.96	0.0000	0.23	0.0001	0.00	0.00	0.00	0.002	0.01	0.00	0.02	0.000	11.24	0.00
Reservoir, Dry	October Water Quality	8.1	0.15	1.66	0.61	0.014	0.000021	0.00	4.96	***0.003***	109.52	0.0000	0.21	0.0001	0.00	0.00	0.00	0.002	0.01	0.00	0.01	0.000	8.53	0.00
Reservoir, Dry	November Water Quality	8.7	0.30	0.57	0.08	0.010	0.000011	0.00	2.10	***0.001***	121.91	0.0000	0.04	0.0000	0.00	0.00	0.00	0.001	0.01	0.00	0.01	0.000	7.28	0.00
Reservoir, Dry	December Water Quality	8.7	0.30	0.56	0.08	0.010	0.000011	0.00	2.09	***0.001***	122.51	0.0000	0.04	0.0000	0.00	0.00	0.00	0.001	0.01	0.00	0.01	0.000	7.24	0.00
Reservoir, Average	January Water Quality	8.7	0.29	0.62	0.09	0.010	0.000011	0.00	2.14	***0.001***	119.71	0.0000	0.04	0.0000	0.00	0.00	0.00	0.001	0.01	0.00	0.01	0.000	7.47	0.00
Reservoir, Average	February Water Quality	8.8	0.30	0.48	0.06	0.010	0.000011	0.00	2.02	***0.001***	125.64	0.0000	0.03	0.0000	0.00	0.00	0.00	0.001	0.01	0.00	0.01	0.000	6.85	0.00
Reservoir, Average	March Water Quality	8.8	0.30	0.43	0.05	0.010	0.000010	0.00	1.98	***0.001***	127.74	0.0000	0.03	0.0000	0.00	0.00	0.00	0.001	0.01	0.00	0.00	0.000	6.65	0.00
Reservoir, Average	April Water Quality	8.8	0.30	0.43	0.05	0.010	0.000010	0.00	1.98	***0.001***	127.74	0.0000	0.03	0.0000	0.00	0.00	0.00	0.001	0.01	0.00	0.00	0.000	6.65	0.00
Reservoir, Average	May Water Quality	8.0	0.07	2.59	0.69	0.011	0.000021	0.01	4.72	***0.002***	54.96	0.0000	0.26	0.0001	0.00	0.00	0.00	0.002	0.00	0.00	0.02	0.000	***14.23***	0.00
Reservoir, Average	June Water Quality	8.0	0.05	2.70	0.67	0.009	0.000020	0.01	4.36	***0.002***	36.29	0.0000	0.25	0.0001	0.00	0.00	0.00	0.001	0.00	0.00	0.02	0.000	***14.94***	0.00
Reservoir, Average	July Water Quality	8.0	0.07	2.52	0.66	0.010	0.000020	0.01	4.47	***0.002***	48.91	0.0000	0.25	0.0001	0.00	0.00	0.00	0.002	0.00	0.00	0.02	0.000	***13.86***	0.00
Reservoir, Average	August Water Quality	8.0	0.08	2.44	0.65	0.010	0.000020	0.01	4.53	***0.002***	55.40	0.0000	0.25	0.0001	0.00	0.00	0.00	0.002	0.00	0.00	0.02	0.000	***13.33***	0.00
Reservoir, Average	September Water Quality	8.0	0.09	2.37	0.67	0.011	0.000021	0.01	4.77	***0.002***	67.70	0.0000	0.25	0.0001	0.00	0.00	0.00	0.002	0.00	0.00	0.02	0.000	12.88	0.00
Reservoir, Average	October Water Quality	8.1	0.14	1.84	0.62	0.013	0.000021	0.00	4.88	***0.003***	98.10	0.0000	0.22	0.0001	0.00	0.00	0.00	0.002	0.01	0.00	0.01	0.000	9.72	0.00
Reservoir, Average	November Water Quality	8.6	0.29	0.73	0.12	0.010	0.000012	0.00	2.23	***0.001***	115.21	0.0000	0.05	0.0000	0.00	0.00	0.00	0.001	0.01	0.00	0.01	0.000	7.97	0.00
Reservoir, Average	December Water Quality	8.6	0.29	0.71	0.11	0.010	0.000011	0.00	2.21	***0.001***	116.09	0.0000	0.05	0.0000	0.00	0.00	0.00	0.001	0.01	0.00	0.01	0.000	7.89	0.00
Reservoir, Wet	January Water Quality	8.6	0.29	0.75	0.12	0.009	0.000011	0.00	2.20	***0.001***	112.66	0.0000	0.05	0.0000	0.00	0.00	0.00	0.001	0.01	0.00	0.01	0.000	7.88	0.00
Reservoir, Wet	February Water Quality	8.7	0.30	0.55	0.07	0.010	0.000011	0.00	2.04	***0.001***	120.27	0.0000	0.04	0.0000	0.00	0.00	0.00	0.001	0.01	0.00	0.01	0.000	7.05	0.00
Reservoir, Wet	March Water Quality	8.7	0.30	0.48	0.06	0.010	0.000010	0.00	1.99	***0.001***	123.07	0.0000	0.03	0.0000	0.00	0.00	0.00	0.001	0.01	0.00	0.01	0.000	6.74	0.00
Reservoir, Wet	April Water Quality	8.7	0.30	0.48	0.06	0.010	0.000010	0.00	1.99	***0.001***	123.07	0.0000	0.03	0.0000	0.00	0.00	0.00	0.001	0.01	0.00	0.01	0.000	6.74	0.00
Reservoir, Wet	May Water Quality	8.0	0.06	2.64	0.66	0.009	0.000020	0.01	4.40	***0.002***	41.90	0.0000	0.25	0.0001	0.00	0.00	0.00	0.001	0.00	0.00	0.02	0.000	***14.58***	0.00
Reservoir, Wet	June Water Quality	8.0	0.04	2.84	0.68	0.009	0.000020	0.01	4.31	***0.002***	28.03	0.0000	0.26	0.0001	0.00	0.00	0.00	0.001	0.00	0.00	0.02	0.000	***15.78***	0.00
Reservoir, Wet	July Water Quality	8.0	0.05	2.68	0.67	0.009	0.000020	0.01	4.39	***0.002***	38.72	0.0000	0.25	0.0001	0.00	0.00	0.00	0.001	0.00	0.00	0.02	0.000	***14.79***	0.00
Reservoir, Wet	August Water Quality	8.0	0.06	2.59	0.66	0.010	0.000020	0.01	4.40	***0.002***	44.41	0.0000	0.25	0.0001	0.00	0.00	0.00	0.001	0.00	0.00	0.02	0.000	***14.32***	0.00
Reservoir, Wet	September Water Quality	8.0	0.07	2.50	0.66	0.010	0.000021	0.01	4.56	***0.002***	54.57	0.0000	0.25	0.0001	0.00	0.00	0.00	0.002	0.00	0.00	0.02	0.000	***13.70***	0.00
Reservoir, Wet	October Water Quality	8.1	0.12	2.00	0.63	0.012	0.000021	0.01	4.79	***0.002***	87.28	0.0000	0.23	0.0001	0.00	0.00	0.00	0.002	0.01	0.00	0.02	0.000	10.61	0.00
Reservoir, Wet	November Water Quality	8.5	0.27	0.89	0.15	0.009	0.000012	0.00	2.32	***0.001***	107.38	0.0000	0.07	0.0000	0.00	0.00	0.00	0.001	0.01	0.00	0.01	0.000	8.52	0.00
Reservoir, Wet	December Water Quality	8.6	0.27	0.86	0.14	0.009	0.000012	0.00	2.30	***0.001***	108.47	0.0000	0.06	0.0000	0.00	0.00	0.00	0.001	0.01	0.00	0.01	0.000	8.37	0.00

Exceeds CCME
Exceeds MMER

Table R11-5: Mactung Reservoir Loadings, 2005 Supernatant Concentrations

Group	Description	pH	Liters Inflow per Month	TDS	Alkalinity	Chloride	Fluoride	Phosphate	Sulphate	Aluminum	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Lithium
				(kg/mo)	(kg/mo as CaCO3)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)
Reservoir, Dry	January Water Quality	8.7	135883274	135966082	54796	4022	55	189	4772	14.0	0.3	1.4	0.5	3.1	0.0	656	0.1	0.0	1.1	0.0	0.5	0.3	68
Reservoir, Dry	February Water Quality	8.8	119018562	119094860	53035	3134	50	171	2997	15.4	0.3	1.3	0.4	2.6	0.0	477	0.1	0.0	1.0	0.0	0.4	0.2	48
Reservoir, Dry	March Water Quality	8.8	130400265	130485328	60051	3287	55	189	2835	18.3	0.3	1.4	0.5	2.8	0.0	491	0.1	0.0	1.1	0.0	0.5	0.2	49
Reservoir, Dry	April Water Quality	8.8	126193805	126276125	58114	3181	54	183	2744	17.7	0.3	1.3	0.4	2.7	0.0	475	0.1	0.0	1.0	0.0	0.5	0.2	47
Reservoir, Dry	May Water Quality	8.0	240201479	240383351	19934	31782	55	192	71443	1.4	0.7	1.8	2.0	17.3	0.1	36327	0.2	0.7	2.6	0.0	0.5	3.3	554
Reservoir, Dry	June Water Quality	8.0	338242987	338489777	26902	42008	54	189	98645	1.9	0.9	1.9	2.9	22.5	0.1	54928	0.2	1.0	3.2	0.0	0.5	4.6	827
Reservoir, Dry	July Water Quality	8.0	270274523	270472345	22355	34235	56	195	77625	1.6	0.8	1.8	2.3	18.5	0.1	40545	0.2	0.8	2.8	0.0	0.5	3.6	610
Reservoir, Dry	August Water Quality	8.1	242193604	242370664	20477	30832	56	193	68790	1.5	0.7	1.8	2.0	16.8	0.1	34709	0.2	0.7	2.6	0.0	0.5	3.2	525
Reservoir, Dry	September Water Quality	8.1	197291157	197438805	17128	26087	54	185	56787	1.3	0.6	1.6	1.6	14.3	0.1	27049	0.1	0.5	2.2	0.0	0.5	2.6	412
Reservoir, Dry	October Water Quality	8.1	155801430	155916465	14967	20780	55	190	42245	1.2	0.6	1.6	1.3	11.6	0.0	17209	0.1	0.4	1.9	0.0	0.5	1.9	258
Reservoir, Dry	November Water Quality	8.7	134781208	134860187	50052	4331	54	183	5776	11.7	0.3	1.4	0.5	3.3	0.0	762	0.1	0.1	1.1	0.0	0.5	0.4	77
Reservoir, Dry	December Water Quality	8.7	138590367	138672207	52329	4384	55	189	5726	12.5	0.3	1.4	0.5	3.3	0.0	759	0.1	0.1	1.1	0.0	0.5	0.4	78
Reservoir, Dry Conditions, Total Annual Loading			**2228872659**	**2230426197**	**450139**	**208062**	**653**	**2249**	**440386**	**98.7**	**6.3**	**18.6**	**15.0**	**118.7**	**0.6**	**214387**	**1.5**	**4.3**	**21.8**	**0.0**	**5.7**	**20.9**	**3552**
Reservoir, Average	January Water Quality	8.7	141871980	141952872	49657	4790	55	189	6817	11.0	0.3	1.4	0.5	3.5	0.0	899	0.1	0.1	1.2	0.0	0.5	0.4	88
Reservoir, Average	February Water Quality	8.8	122040408	122115583	50366	3507	50	171	3998	13.2	0.3	1.3	0.4	2.8	0.0	564	0.1	0.0	1.0	0.0	0.4	0.3	58
Reservoir, Average	March Water Quality	8.8	132862857	132946977	57886	3582	55	189	3634	16.3	0.3	1.4	0.5	2.9	0.0	555	0.1	0.0	1.1	0.0	0.5	0.3	57
Reservoir, Average	April Water Quality	8.8	128576958	128658365	56018	3466	54	183	3517	15.8	0.3	1.3	0.5	2.8	0.0	537	0.1	0.0	1.1	0.0	0.5	0.3	55
Reservoir, Average	May Water Quality	8.0	314522904	314766460	24668	42018	55	194	98253	1.7	0.9	1.9	2.6	22.6	0.1	53945	0.2	1.0	3.2	0.0	0.5	4.6	816
Reservoir, Average	June Water Quality	8.0	467637945	467986521	35580	58629	54	192	142427	2.5	1.1	2.1	3.9	31.1	0.2	83920	0.3	1.5	4.2	0.0	0.5	6.7	1261
Reservoir, Average	July Water Quality	8.0	357048486	357314293	28066	45354	56	196	106921	2.0	0.9	2.0	3.0	24.3	0.1	59914	0.2	1.1	3.4	0.0	0.5	5.0	900
Reservoir, Average	August Water Quality	8.0	313112506	313345448	25052	40013	56	195	92931	1.8	0.9	1.9	2.6	21.5	0.1	50654	0.2	1.0	3.1	0.0	0.5	4.3	763
Reservoir, Average	September Water Quality	8.0	245893565	246081428	20090	32789	54	187	74341	1.4	0.7	1.7	2.0	17.8	0.1	38556	0.2	0.7	2.6	0.0	0.5	3.4	583
Reservoir, Average	October Water Quality	8.1	174150087	174279022	15981	23054	55	191	48340	1.2	0.6	1.6	1.5	12.7	0.1	21183	0.1	0.4	2.1	0.0	0.5	2.2	321
Reservoir, Average	November Water Quality	8.6	142694601	142771544	43595	5363	54	183	8516	8.6	0.3	1.4	0.6	3.8	0.0	1179	0.1	0.1	1.2	0.0	0.5	0.5	105
Reservoir, Average	December Water Quality	8.6	146325253	146404985	45923	5392	55	189	8403	9.3	0.4	1.4	0.6	3.8	0.0	1147	0.1	0.1	1.2	0.0	0.5	0.5	104
Reservoir, Average Conditions, Total Annual Loading			**2686737549**	**2688623496**	**452881**	**267956**	**653**	**2259**	**598097**	**84.9**	**7.2**	**19.4**	**18.7**	**149.6**	**0.8**	**313051**	**1.7**	**6.2**	**25.4**	**0.0**	**5.8**	**28.4**	**5111**
Reservoir, Wet	January Water Quality	8.6	150914593	150994251	44512	5628	55	189	9249	8.6	0.4	1.4	0.6	4.0	0.0	1331	0.1	0.1	1.2	0.0	0.5	0.5	112
Reservoir, Wet	February Water Quality	8.7	127602791	127676940	47394	3917	50	171	5276	11.2	0.3	1.3	0.5	3.0	0.0	718	0.1	0.1	1.0	0.0	0.4	0.3	71
Reservoir, Wet	March Water Quality	8.7	138052389	138135640	55423	3905	55	189	4702	14.2	0.3	1.4	0.5	3.1	0.0	670	0.1	0.0	1.1	0.0	0.5	0.3	67
Reservoir, Wet	April Water Quality	8.7	133599086	133679652	53635	3779	54	183	4551	13.8	0.3	1.4	0.5	3.0	0.0	648	0.1	0.0	1.1	0.0	0.5	0.3	65
Reservoir, Wet	May Water Quality	8.0	416471371	416781566	32152	52369	56	197	125980	2.3	1.1	2.0	3.5	27.9	0.2	72532	0.2	1.3	3.8	0.0	0.5	5.9	1098
Reservoir, Wet	June Water Quality	8.0	610801684	611260677	45416	76474	54	195	189774	3.1	1.4	2.3	5.1	40.4	0.3	115271	0.3	2.1	5.3	0.0	0.5	8.9	1735
Reservoir, Wet	July Water Quality	8.0	454003538	454343211	34700	57256	56	199	138598	2.4	1.1	2.1	3.8	30.4	0.2	80858	0.3	1.5	4.1	0.0	0.5	6.5	1217
Reservoir, Wet	August Water Quality	8.0	392767786	393059124	30572	49277	56	196	117851	2.2	1.0	2.0	3.3	26.3	0.2	67143	0.2	1.3	3.7	0.0	0.5	5.5	1018
Reservoir, Wet	September Water Quality	8.0	307056720	307287274	24413	39499	54	188	92399	1.7	0.9	1.8	2.6	21.2	0.1	50532	0.2	1.0	3.0	0.0	0.5	4.3	767
Reservoir, Wet	October Water Quality	8.1	196116662	196262187	17304	25739	55	191	55588	1.3	0.7	1.7	1.6	14.1	0.1	25906	0.1	0.5	2.2	0.0	0.5	2.5	392
Reservoir, Wet	November Water Quality	8.5	153281035	153357491	37840	6482	54	183	11645	6.4	0.4	1.4	0.7	4.4	0.0	1932	0.1	0.1	1.2	0.0	0.5	0.7	136
Reservoir, Wet	December Water Quality	8.6	156785624	156864636	40103	6483	55	189	11466	6.9	0.4	1.4	0.7	4.4	0.0	1840	0.1	0.1	1.3	0.0	0.5	0.7	135
Reservoir, Wet Conditions, Total Annual Loading			**3237453278**	**3239702650**	**463463**	**330807**	**653**	**2271**	**767079**	**74.2**	**8.2**	**20.3**	**23.3**	**182.2**	**1.1**	**419381**	**1.9**	**8.2**	**29.2**	**0.0**	**5.8**	**36.4**	**6813**

Table R11-5: Mactung Reservoir Loadings, 2005 Supernatant Concentrations

Group	Description	pH	Liters Inflow per Month	Magnesium	Manganese	Molybdenum	Mercury	Nickel	Potassium	Selenium	Sodium	Silver	Strontium	Thallium	Tin	Titanium	Tungsten	Uranium	Vanadium	Yttrium	Zinc	Cyanide	Nitrate	Ammonia
				(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	kg/mo
Reservoir, Dry	January Water Quality	8.7	135883274	9	1.3	0.0	0.2	277	0.2	16974	4	0.0	0.1	0.5	0.0	0.1	1.0	0.0	0.7	0.0	950	0.0	0.0	0.0
Reservoir, Dry	February Water Quality	8.8	119018562	5	1.2	0.0	0.1	234	0.1	15328	3	0.0	0.0	0.4	0.0	0.1	0.9	0.0	0.6	0.0	784	0.0	0.0	0.0
Reservoir, Dry	March Water Quality	8.8	130400265	4	1.3	0.0	0.1	253	0.1	16969	3	0.0	0.1	0.5	0.0	0.1	1.0	0.0	0.6	0.0	840	0.0	0.0	0.0
Reservoir, Dry	April Water Quality	8.8	126193805	4	1.2	0.0	0.1	245	0.1	16421	3	0.0	0.0	0.5	0.0	0.1	1.0	0.0	0.6	0.0	813	0.0	0.0	0.0
Reservoir, Dry	May Water Quality	8.0	240201479	158	2.8	0.0	1.7	1143	0.6	17159	59	0.0	0.1	0.7	0.3	0.4	1.1	0.0	4.2	0.0	3016	0.0	0.0	0.0
Reservoir, Dry	June Water Quality	8.0	338242987	217	3.3	0.0	2.8	1482	0.8	16850	82	0.0	0.1	0.8	0.5	0.5	1.1	0.0	6.0	0.0	4543	0.0	0.0	0.1
Reservoir, Dry	July Water Quality	8.0	270274523	171	2.9	0.0	1.9	1224	0.6	17371	64	0.0	0.1	0.8	0.3	0.4	1.1	0.0	4.5	0.0	3317	0.0	0.0	0.0
Reservoir, Dry	August Water Quality	8.1	242193604	152	2.7	0.0	1.6	1111	0.6	17270	56	0.0	0.1	0.7	0.3	0.4	1.1	0.0	4.0	0.0	2839	0.0	0.0	0.0
Reservoir, Dry	September Water Quality	8.1	197291157	126	2.4	0.0	1.2	949	0.5	16565	46	0.0	0.1	0.7	0.2	0.3	1.0	0.0	3.2	0.0	2217	0.0	0.0	0.0
Reservoir, Dry	October Water Quality	8.1	155801430	95	2.2	0.0	0.6	773	0.4	17063	33	0.0	0.1	0.6	0.1	0.3	1.0	0.0	2.1	0.0	1329	0.0	0.0	0.0
Reservoir, Dry	November Water Quality	8.7	134781208	11	1.3	0.0	0.2	283	0.2	16431	5	0.0	0.1	0.5	0.0	0.1	1.0	0.0	0.8	0.0	981	0.0	0.0	0.0
Reservoir, Dry	December Water Quality	8.7	138590367	11	1.3	0.0	0.2	290	0.2	16978	5	0.0	0.1	0.5	0.0	0.1	1.0	0.0	0.8	0.0	1004	0.0	0.0	0.0
Reservoir, Dry Conditions, Total Annual Loading			**2228872659**	**963**	**23.9**	**0.0**	**11.0**	**8264**	**4.3**	**201382**	**363**	**0.1**	**0.9**	**7.3**	**1.8**	**2.9**	**12.1**	**0.0**	**28.0**	**0.0**	**22633**	**0.0**	**0.0**	**0.3**
Reservoir, Average	January Water Quality	8.7	141871980	13	1.4	0.0	0.3	303	0.2	16983	6	0.0	0.1	0.5	0.0	0.1	1.0	0.0	0.9	0.0	1059	0.0	0.0	0.0
Reservoir, Average	February Water Quality	8.8	122040408	7	1.2	0.0	0.2	246	0.1	15333	4	0.0	0.0	0.5	0.0	0.1	0.9	0.0	0.6	0.0	837	0.0	0.0	0.0
Reservoir, Average	March Water Quality	8.8	132862857	6	1.3	0.0	0.2	263	0.2	16972	3	0.0	0.1	0.5	0.0	0.1	1.0	0.0	0.6	0.0	883	0.0	0.0	0.0
Reservoir, Average	April Water Quality	8.8	128576958	6	1.3	0.0	0.2	254	0.1	16424	3	0.0	0.1	0.5	0.0	0.1	1.0	0.0	0.6	0.0	855	0.0	0.0	0.0
Reservoir, Average	May Water Quality	8.0	314522904	216	3.3	0.0	2.7	1483	0.8	17288	81	0.0	0.1	0.9	0.5	0.5	1.1	0.0	6.0	0.0	4475	0.0	0.0	0.1
Reservoir, Average	June Water Quality	8.0	467637945	311	4.2	0.0	4.5	2037	1.0	16973	119	0.0	0.2	1.0	0.8	0.7	1.1	0.0	9.1	0.0	6988	0.0	0.0	0.1
Reservoir, Average	July Water Quality	8.0	357048486	235	3.5	0.0	3.1	1595	0.8	17464	89	0.0	0.1	0.9	0.6	0.5	1.1	0.0	6.6	0.0	4949	0.0	0.0	0.1
Reservoir, Average	August Water Quality	8.0	313112506	204	3.2	0.0	2.5	1417	0.7	17345	77	0.0	0.1	0.8	0.5	0.5	1.1	0.0	5.6	0.0	4175	0.0	0.0	0.1
Reservoir, Average	September Water Quality	8.0	245893565	164	2.8	0.0	1.9	1172	0.6	16647	61	0.0	0.1	0.7	0.3	0.4	1.0	0.0	4.4	0.0	3168	0.0	0.0	0.0
Reservoir, Average	October Water Quality	8.1	174150087	108	2.3	0.0	0.8	850	0.4	17084	39	0.0	0.1	0.6	0.1	0.3	1.0	0.0	2.5	0.0	1692	0.0	0.0	0.0
Reservoir, Average	November Water Quality	8.6	142694601	17	1.4	0.0	0.4	318	0.2	16440	8	0.0	0.1	0.5	0.1	0.1	1.0	0.0	1.0	0.0	1137	0.0	0.0	0.0
Reservoir, Average	December Water Quality	8.6	146325253	16	1.4	0.0	0.3	323	0.2	16986	8	0.0	0.1	0.5	0.1	0.1	1.0	0.0	1.0	0.0	1155	0.0	0.0	0.0
Reservoir, Average Conditions, Total Annual Loading			**2686737549**	**1304**	**27.3**	**0.0**	**17.0**	**10263**	**5.3**	**201939**	**498**	**0.2**	**1.0**	**8.0**	**3.0**	**3.6**	**12.3**	**0.0**	**38.8**	**0.0**	**31373**	**0.0**	**0.1**	**0.4**
Reservoir, Wet	January Water Quality	8.6	150914593	18	1.4	0.0	0.4	332	0.2	17002	8	0.0	0.1	0.5	0.1	0.1	1.0	0.0	1.0	0.0	1189	0.0	0.0	0.0
Reservoir, Wet	February Water Quality	8.7	127602791	9	1.2	0.0	0.2	261	0.1	15347	5	0.0	0.0	0.5	0.0	0.1	0.9	0.0	0.7	0.0	900	0.0	0.0	0.0
Reservoir, Wet	March Water Quality	8.7	138052389	8	1.3	0.0	0.2	274	0.2	16989	4	0.0	0.1	0.5	0.0	0.1	1.0	0.0	0.7	0.0	931	0.0	0.0	0.0
Reservoir, Wet	April Water Quality	8.7	133599086	8	1.3	0.0	0.2	265	0.2	16441	4	0.0	0.1	0.5	0.0	0.1	1.0	0.0	0.7	0.0	901	0.0	0.0	0.0
Reservoir, Wet	May Water Quality	8.0	416471371	275	3.9	0.0	3.8	1833	0.9	17451	105	0.0	0.1	1.0	0.7	0.6	1.1	0.0	7.9	0.0	6071	0.0	0.0	0.1
Reservoir, Wet	June Water Quality	8.0	610801684	413	5.2	0.0	6.3	2635	1.3	17122	160	0.0	0.2	1.2	1.2	0.9	1.2	0.0	12.3	0.0	9637	0.0	0.0	0.1
Reservoir, Wet	July Water Quality	8.0	454003538	303	4.2	0.0	4.3	1995	1.0	17581	116	0.0	0.2	1.0	0.8	0.7	1.1	0.0	8.8	0.0	6713	0.0	0.0	0.1
Reservoir, Wet	August Water Quality	8.0	392767786	258	3.8	0.0	3.5	1730	0.9	17441	98	0.0	0.1	0.9	0.7	0.6	1.1	0.0	7.4	0.0	5625	0.0	0.0	0.1
Reservoir, Wet	September Water Quality	8.0	307056720	203	3.2	0.0	2.6	1399	0.7	16757	76	0.0	0.1	0.8	0.5	0.5	1.1	0.0	5.6	0.0	4208	0.0	0.0	0.1
Reservoir, Wet	October Water Quality	8.1	196116662	123	2.5	0.0	1.1	940	0.5	17118	45	0.0	0.1	0.7	0.2	0.3	1.0	0.0	3.0	0.0	2081	0.0	0.0	0.0
Reservoir, Wet	November Water Quality	8.5	153281035	23	1.4	0.0	0.5	356	0.2	16460	10	0.0	0.1	0.5	0.1	0.1	1.0	0.0	1.2	0.0	1307	0.0	0.0	0.0
Reservoir, Wet	December Water Quality	8.6	156785624	23	1.5	0.0	0.5	360	0.2	17006	10	0.0	0.1	0.5	0.1	0.1	1.0	0.0	1.2	0.0	1312	0.0	0.0	0.0
Reservoir, Wet Conditions, Total Annual Loading			**3237453278**	**1663**	**30.9**	**0.1**	**23.5**	**12380**	**6.4**	**202714**	**642**	**0.2**	**1.1**	**8.7**	**4.5**	**4.3**	**12.5**	**0.0**	**50.6**	**0.0**	**40873**	**0.0**	**0.1**	**0.6**

Table R11-6: Mactung Reservoir Loadings, 2008 Supernatant Concentrations

Group	Description	pH	Liters Inflow per Month	TDS	Alkalinity	Chloride	Fluoride	Phosphate	Sulphate	Aluminum	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Lithium
				(kg/mo)	(kg/mo as CaCO3)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)
Reservoir, Dry	January Water Quality	8.4	135883274	33796	21588	4322	40	70	4204	3.7	0.3	0.6	0.6	4.4	0.0	3411	6.5	0.1	1.7	0.0	0.0	0.6	148
Reservoir, Dry	February Water Quality	8.4	119018562	27813	19444	3406	36	63	2482	3.7	0.3	0.5	0.5	3.7	0.0	2251	5.9	0.1	1.5	0.0	0.0	0.4	121
Reservoir, Dry	March Water Quality	8.4	130400265	29797	21508	3588	40	69	2264	4.3	0.3	0.6	0.5	4.0	0.0	2186	6.5	0.1	1.7	0.0	0.0	0.5	129
Reservoir, Dry	April Water Quality	8.4	126193805	28836	20814	3472	39	67	2191	4.2	0.3	0.6	0.5	3.9	0.0	2116	6.3	0.1	1.6	0.0	0.0	0.4	125
Reservoir, Dry	May Water Quality	8.0	240201479	166800	17769	32083	40	73	70883	1.2	0.7	1.0	2.1	18.5	0.1	45288	6.6	0.7	3.2	0.0	0.1	3.5	634
Reservoir, Dry	June Water Quality	8.0	338242987	229257	24229	42302	39	73	98099	1.7	0.9	1.1	2.9	23.8	0.1	63569	6.5	1.1	3.8	0.0	0.1	4.8	906
Reservoir, Dry	July Water Quality	8.0	270274523	182166	20128	34539	41	74	77060	1.4	0.8	1.0	2.4	19.8	0.1	49600	6.7	0.8	3.3	0.0	0.1	3.8	691
Reservoir, Dry	August Water Quality	8.0	242193604	161985	18165	31135	41	73	68227	1.3	0.7	0.9	2.1	18.0	0.1	43707	6.7	0.7	3.1	0.0	0.1	3.4	606
Reservoir, Dry	September Water Quality	8.0	197291157	133763	14834	26378	39	70	56247	1.1	0.6	0.9	1.7	15.5	0.1	35679	6.4	0.6	2.8	0.0	0.0	2.8	490
Reservoir, Dry	October Water Quality	8.0	155801430	101358	12094	21081	40	71	41687	0.9	0.6	0.8	1.4	12.8	0.0	26025	6.6	0.4	2.5	0.0	0.0	2.1	338
Reservoir, Dry	November Water Quality	8.3	134781208	34493	20440	4622	39	67	5227	3.2	0.3	0.6	0.6	4.5	0.0	3931	6.3	0.1	1.7	0.0	0.0	0.6	155
Reservoir, Dry	December Water Quality	8.3	138590367	35317	21254	4684	40	70	5159	3.4	0.3	0.6	0.6	4.6	0.0	3939	6.5	0.1	1.7	0.0	0.0	0.6	158
Reservoir, Dry Conditions, Total Annual Loading			**2228872659**	**1165380**	**232268**	**211613**	**475**	**838**	**433730**	**30.2**	**6.3**	**9.1**	**15.9**	**133.5**	**0.6**	**281702**	**77.6**	**4.6**	**28.6**	**0.0**	**0.5**	**23.4**	**4501**
Reservoir, Average	January Water Quality	8.3	141871980	36870	20732	5090	40	70	6251	3.1	0.3	0.6	0.6	4.8	0.0	4507	6.5	0.1	1.8	0.0	0.0	0.6	169
Reservoir, Average	February Water Quality	8.4	122040408	29888	19502	3779	36	63	3485	3.4	0.3	0.5	0.5	3.9	0.0	2881	5.9	0.1	1.5	0.0	0.0	0.5	131
Reservoir, Average	March Water Quality	8.4	132862857	31445	21552	3883	40	69	3064	4.0	0.3	0.6	0.6	4.2	0.0	2688	6.5	0.1	1.7	0.0	0.0	0.5	137
Reservoir, Average	April Water Quality	8.4	128576958	30431	20856	3757	39	67	2965	3.9	0.3	0.6	0.5	4.0	0.0	2601	6.3	0.1	1.6	0.0	0.0	0.5	133
Reservoir, Average	May Water Quality	8.0	314522904	226784	22742	42320	40	74	97694	1.6	0.9	1.1	2.7	23.8	0.1	62977	6.7	1.0	3.8	0.0	0.1	4.8	896
Reservoir, Average	June Water Quality	7.9	467637945	319847	26311	58922	39	75	141879	1.6	1.1	1.3	4.0	32.3	0.2	91226	6.5	1.6	4.8	0.0	0.1	6.9	1340
Reservoir, Average	July Water Quality	8.0	357048486	247289	25278	45659	41	76	106355	1.7	0.9	1.1	3.1	25.6	0.2	68856	6.7	1.1	4.0	0.0	0.1	5.2	981
Reservoir, Average	August Water Quality	8.0	313112506	216371	22989	40316	40	74	92368	1.6	0.9	1.1	2.7	22.8	0.1	59701	6.7	1.0	3.7	0.0	0.1	4.5	844
Reservoir, Average	September Water Quality	8.0	245893565	173003	18064	33081	39	71	73800	1.3	0.7	0.9	2.1	19.0	0.1	47256	6.4	0.8	3.2	0.0	0.1	3.6	661
Reservoir, Average	October Water Quality	8.0	174150087	115056	13340	23354	40	71	47781	1.0	0.6	0.8	1.5	14.0	0.1	30045	6.6	0.5	2.7	0.0	0.0	2.4	401
Reservoir, Average	November Water Quality	8.3	142694601	38667	19331	5654	39	68	7970	2.7	0.3	0.6	0.7	5.0	0.0	5412	6.3	0.1	1.7	0.0	0.0	0.7	183
Reservoir, Average	December Water Quality	8.3	146325253	39307	20099	5692	40	70	7838	2.8	0.4	0.6	0.7	5.1	0.0	5371	6.5	0.1	1.8	0.0	0.0	0.7	185
Reservoir, Average Conditions, Total Annual Loading			**2686737549**	**1504959**	**250795**	**271508**	**475**	**848**	**591450**	**28.7**	**7.2**	**9.9**	**19.6**	**164.4**	**0.9**	**383521**	**77.8**	**6.5**	**32.2**	**0.0**	**0.6**	**30.9**	**6060**
Reservoir, Wet	January Water Quality	8.3	150914593	41017	20226	5929	40	70	8685	2.8	0.4	0.6	0.7	5.2	0.0	5862	6.5	0.1	1.8	0.0	0.0	0.8	193
Reservoir, Wet	February Water Quality	8.3	127602791	32380	19541	4188	36	63	4764	3.2	0.3	0.5	0.6	4.1	0.0	3632	5.9	0.1	1.6	0.0	0.0	0.5	143
Reservoir, Wet	March Water Quality	8.4	138052389	33646	21711	4206	40	70	4134	3.7	0.3	0.6	0.6	4.3	0.0	3326	6.5	0.1	1.7	0.0	0.0	0.5	147
Reservoir, Wet	April Water Quality	8.4	133599086	32561	21011	4070	39	67	4001	3.6	0.3	0.6	0.6	4.2	0.0	3219	6.3	0.1	1.6	0.0	0.0	0.5	143
Reservoir, Wet	May Water Quality	7.9	416471371	286531	26289	52672	40	77	125416	1.7	1.1	1.2	3.5	29.2	0.2	80810	6.7	1.4	4.4	0.0	0.1	6.1	1179
Reservoir, Wet	June Water Quality	7.8	610801684	417809	28733	76768	39	78	189228	1.6	1.4	1.5	5.1	41.6	0.3	121080	6.6	2.1	5.8	0.0	0.1	9.1	1813
Reservoir, Wet	July Water Quality	7.9	454003538	312855	26981	57560	41	78	138031	1.7	1.1	1.3	3.8	31.7	0.2	88813	6.8	1.5	4.7	0.0	0.1	6.7	1299
Reservoir, Wet	August Water Quality	7.9	392767786	269722	25919	49579	41	76	117289	1.7	1.0	1.2	3.4	27.6	0.2	75672	6.7	1.3	4.2	0.0	0.1	5.7	1099
Reservoir, Wet	September Water Quality	8.0	307056720	214367	22458	39791	39	72	91856	1.6	0.9	1.0	2.6	22.5	0.1	59268	6.5	1.0	3.6	0.0	0.1	4.5	846
Reservoir, Wet	October Water Quality	8.0	196116662	131334	14848	26040	40	72	55029	1.1	0.7	0.9	1.7	15.4	0.1	34807	6.6	0.5	2.8	0.0	0.1	2.7	473
Reservoir, Wet	November Water Quality	8.2	153281035	44381	18939	6773	39	68	11101	2.3	0.4	0.6	0.7	5.6	0.0	7235	6.3	0.2	1.8	0.0	0.0	0.9	214
Reservoir, Wet	December Water Quality	8.2	156785624	44828	19664	6784	40	70	10903	2.5	0.4	0.6	0.8	5.7	0.0	7139	6.5	0.2	1.9	0.0	0.0	0.9	215
Reservoir, Wet Conditions, Total Annual Loading			**3237453278**	**1861431**	**266320**	**334360**	**475**	**860**	**760436**	**27.5**	**8.2**	**10.8**	**24.2**	**197.1**	**1.1**	**490864**	**78.1**	**8.5**	**36.0**	**0.0**	**0.7**	**38.9**	**7763**

Table R11-6: Mactung Reservoir Loadings, 2008 Supernatant Concentrations

Group	Description	pH	Liters Inflow per Month	Magnesium	Manganese	Molybdenum	Mercury	Nickel	Potassium	Selenium	Sodium	Silver	Strontium	Thallium	Tin	Titanium	Tungsten	Uranium	Vanadium	Yttrium	Zinc	Cyanide	Nitrate	Ammonia
				(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	(kg/mo)	kg/mo
Reservoir, Dry	January Water Quality	8.4	135883274	9	1.3	0.0	0.2	728	0.4	5676	7	0.0	0.3	0.1	0.0	0.1	0.3	0.0	0.3	0.0	978	0.0	0.0	0.0
Reservoir, Dry	February Water Quality	8.4	119018562	6	1.1	0.0	0.2	641	0.4	5122	5	0.0	0.3	0.1	0.0	0.1	0.3	0.0	0.2	0.0	809	0.0	0.0	0.0
Reservoir, Dry	March Water Quality	8.4	130400265	5	1.2	0.0	0.2	704	0.4	5669	5	0.0	0.3	0.1	0.0	0.1	0.3	0.0	0.2	0.0	868	0.0	0.0	0.0
Reservoir, Dry	April Water Quality	8.4	126193805	5	1.2	0.0	0.2	681	0.4	5486	5	0.0	0.3	0.1	0.0	0.1	0.3	0.0	0.2	0.0	840	0.0	0.0	0.0
Reservoir, Dry	May Water Quality	8.0	240201479	159	2.7	0.0	1.8	1594	0.9	5858	61	0.0	0.3	0.3	0.3	0.4	0.4	0.0	3.8	0.0	3044	0.0	0.0	0.0
Reservoir, Dry	June Water Quality	8.0	338242987	218	3.3	0.0	2.8	1923	1.0	5811	84	0.0	0.3	0.4	0.5	0.5	0.4	0.0	5.7	0.0	4570	0.0	0.0	0.1
Reservoir, Dry	July Water Quality	8.0	270274523	172	2.9	0.0	2.0	1680	0.9	5942	66	0.0	0.3	0.3	0.3	0.4	0.4	0.0	4.2	0.0	3345	0.0	0.0	0.0
Reservoir, Dry	August Water Quality	8.0	242193604	153	2.7	0.0	1.7	1565	0.8	5889	59	0.0	0.3	0.3	0.3	0.3	0.4	0.0	3.6	0.0	2867	0.0	0.0	0.0
Reservoir, Dry	September Water Quality	8.0	197291157	127	2.4	0.0	1.2	1386	0.8	5630	48	0.0	0.3	0.3	0.2	0.3	0.4	0.0	2.8	0.0	2244	0.0	0.0	0.0
Reservoir, Dry	October Water Quality	8.0	155801430	96	2.1	0.0	0.6	1224	0.7	5764	36	0.0	0.3	0.2	0.1	0.2	0.4	0.0	1.7	0.0	1357	0.0	0.0	0.0
Reservoir, Dry	November Water Quality	8.3	134781208	12	1.3	0.0	0.3	720	0.4	5496	8	0.0	0.3	0.1	0.0	0.1	0.3	0.0	0.4	0.0	1008	0.0	0.0	0.0
Reservoir, Dry	December Water Quality	8.3	138590367	12	1.3	0.0	0.3	741	0.4	5679	8	0.0	0.3	0.1	0.0	0.1	0.3	0.0	0.4	0.0	1032	0.0	0.0	0.0
Reservoir, Dry Conditions, Total Annual Loading			**2228872659**	**973**	**23.4**	**0.0**	**11.3**	**13586**	**7.6**	**68021**	**391**	**0.2**	**3.6**	**2.4**	**1.8**	**2.5**	**4.1**	**0.0**	**23.5**	**0.0**	**22961**	**0.0**	**0.0**	**0.3**
Reservoir, Average	January Water Quality	8.3	141871980	14	1.3	0.0	0.3	754	0.4	5683	9	0.0	0.3	0.1	0.0	0.1	0.3	0.0	0.5	0.0	1087	0.0	0.0	0.0
Reservoir, Average	February Water Quality	8.4	122040408	8	1.1	0.0	0.2	654	0.4	5127	6	0.0	0.3	0.1	0.0	0.1	0.3	0.0	0.3	0.0	862	0.0	0.0	0.0
Reservoir, Average	March Water Quality	8.4	132862857	7	1.2	0.0	0.2	714	0.4	5673	6	0.0	0.3	0.1	0.0	0.1	0.3	0.0	0.3	0.0	911	0.0	0.0	0.0
Reservoir, Average	April Water Quality	8.4	128576958	7	1.2	0.0	0.2	691	0.4	5490	6	0.0	0.3	0.1	0.0	0.1	0.3	0.0	0.3	0.0	882	0.0	0.0	0.0
Reservoir, Average	May Water Quality	8.0	314522904	217	3.3	0.0	2.8	1936	1.0	5957	84	0.0	0.3	0.4	0.5	0.5	0.4	0.0	5.6	0.0	4503	0.0	0.0	0.1
Reservoir, Average	June Water Quality	7.9	467637945	312	4.2	0.0	4.5	2477	1.3	5945	121	0.0	0.4	0.6	0.8	0.6	0.4	0.0	8.7	0.0	7015	0.0	0.0	0.1
Reservoir, Average	July Water Quality	8.0	357048486	236	3.5	0.0	3.1	2052	1.1	6035	91	0.0	0.4	0.5	0.6	0.5	0.4	0.0	6.2	0.0	4977	0.0	0.0	0.1
Reservoir, Average	August Water Quality	8.0	313112506	205	3.2	0.0	2.6	1871	1.0	5965	79	0.0	0.3	0.4	0.5	0.4	0.4	0.0	5.2	0.0	4203	0.0	0.0	0.1
Reservoir, Average	September Water Quality	8.0	245893565	165	2.7	0.0	1.9	1609	0.9	5694	63	0.0	0.3	0.3	0.3	0.4	0.4	0.0	4.0	0.0	3195	0.0	0.0	0.0
Reservoir, Average	October Water Quality	8.0	174150087	109	2.2	0.0	0.9	1301	0.7	5785	41	0.0	0.3	0.2	0.1	0.3	0.4	0.0	2.2	0.0	1720	0.0	0.0	0.0
Reservoir, Average	November Water Quality	8.3	142694601	18	1.3	0.0	0.4	754	0.4	5505	10	0.0	0.3	0.1	0.1	0.1	0.3	0.0	0.6	0.0	1164	0.0	0.0	0.0
Reservoir, Average	December Water Quality	8.3	146325253	17	1.3	0.0	0.4	774	0.5	5688	10	0.0	0.3	0.1	0.1	0.1	0.3	0.0	0.6	0.0	1183	0.0	0.0	0.0
Reservoir, Average Conditions, Total Annual Loading			**2686737549**	**1314**	**26.7**	**0.0**	**17.3**	**15586**	**8.6**	**68546**	**526**	**0.2**	**3.7**	**3.1**	**3.0**	**3.1**	**4.3**	**0.0**	**34.3**	**0.0**	**31701**	**0.0**	**0.1**	**0.4**
Reservoir, Wet	January Water Quality	8.3	150914593	19	1.4	0.0	0.4	783	0.5	5703	11	0.0	0.3	0.1	0.1	0.1	0.3	0.0	0.7	0.0	1217	0.0	0.0	0.0
Reservoir, Wet	February Water Quality	8.3	127602791	10	1.2	0.0	0.2	668	0.4	5141	7	0.0	0.3	0.1	0.0	0.1	0.3	0.0	0.4	0.0	925	0.0	0.0	0.0
Reservoir, Wet	March Water Quality	8.4	138052389	9	1.3	0.0	0.2	725	0.4	5689	7	0.0	0.3	0.1	0.0	0.1	0.3	0.0	0.3	0.0	958	0.0	0.0	0.0
Reservoir, Wet	April Water Quality	8.4	133599086	9	1.2	0.0	0.2	702	0.4	5506	7	0.0	0.3	0.1	0.0	0.1	0.3	0.0	0.3	0.0	928	0.0	0.0	0.0
Reservoir, Wet	May Water Quality	7.9	416471371	276	3.9	0.0	3.9	2287	1.2	6077	107	0.0	0.4	0.6	0.7	0.6	0.4	0.0	7.6	0.0	6098	0.0	0.0	0.1
Reservoir, Wet	June Water Quality	7.8	610801684	414	5.2	0.0	6.3	3075	1.6	6100	162	0.1	0.4	0.8	1.2	0.8	0.5	0.0	12.0	0.0	9665	0.0	0.0	0.1
Reservoir, Wet	July Water Quality	7.9	454003538	304	4.1	0.0	4.3	2451	1.3	6145	118	0.0	0.4	0.6	0.8	0.6	0.5	0.0	8.4	0.0	6741	0.0	0.0	0.1
Reservoir, Wet	August Water Quality	7.9	392767786	259	3.7	0.0	3.5	2184	1.2	6058	101	0.0	0.4	0.5	0.7	0.5	0.4	0.0	7.0	0.0	5653	0.0	0.0	0.1
Reservoir, Wet	September Water Quality	8.0	307056720	203	3.1	0.0	2.6	1837	1.0	5776	79	0.0	0.3	0.4	0.5	0.4	0.4	0.0	5.3	0.0	4235	0.0	0.0	0.1
Reservoir, Wet	October Water Quality	8.0	196116662	124	2.4	0.0	1.1	1391	0.8	5818	47	0.0	0.3	0.3	0.2	0.3	0.4	0.0	2.7	0.0	2109	0.0	0.0	0.0
Reservoir, Wet	November Water Quality	8.2	153281035	24	1.4	0.0	0.5	792	0.5	5526	13	0.0	0.3	0.1	0.1	0.1	0.3	0.0	0.8	0.0	1333	0.0	0.0	0.0
Reservoir, Wet	December Water Quality	8.2	156785624	24	1.4	0.0	0.5	811	0.5	5707	13	0.0	0.3	0.1	0.1	0.1	0.3	0.0	0.8	0.0	1339	0.0	0.0	0.0
Reservoir, Wet Conditions, Total Annual Loading			**3237453278**	**1673**	**30.3**	**0.1**	**23.8**	**17706**	**9.6**	**69246**	**670**	**0.2**	**3.8**	**3.8**	**4.5**	**3.8**	**4.5**	**0.0**	**46.2**	**0.0**	**41202**	**0.0**	**0.1**	**0.6**

Table R11-7: Mactung Reservoir Precipitate Phases, 2005 Supernatant Concentrations

Group	Description	Precipitate Phases																		
		Al(OH)3(a)	Cr(OH)3(am)	Fe(OH)3(a)	Alunite	Anglesite	Aragonite	Barite	Basaluminite	Calcite	Celestite	Dolomite	Goethite	Gypsum	JarositeH	Jarosite-K	Jarosite-Na	Malachite	Melanterite	Siderite
WRSF source	Unit 1 Waste Rock Runoff			X					X				X							
WRSF source	Unit 3C Waste Rock Runoff			X					X				X							
Tailings source	Tailings Runoff	X		X	X			X	X				X	X						
Seepage Source	Tailings Seepage			X			X			X		X	X							
Process Source	Process Water/Supernatant	X		X	X			X	X				X							
Precipitation Source	Precipitation			X				X	X				X							
SW Source	Tributary C0 Background			X					X				X							
GW Source	GW MW-MT-08-08D	X		X	X			X	X		X		X	X		X	X			
WWTP Source	Waste Water Treatment Plant Effluent			X	X	X		X	X		X		X	X	X	X	X			
WRSF	Waste Rock Storage Facility Runoff								X				X							
Trib C0	Tributary C0, calculated							X	X				X							
Reservoir, Dry	January Water Quality								X	X			X							
Reservoir, Dry	February Water Quality								X	X			X							
Reservoir, Dry	March Water Quality								X	X			X							
Reservoir, Dry	April Water Quality								X	X			X							
Reservoir, Dry	May Water Quality							X	X	X			X							
Reservoir, Dry	June Water Quality							X	X	X			X							
Reservoir, Dry	July Water Quality							X	X	X			X							
Reservoir, Dry	August Water Quality							X	X	X			X							
Reservoir, Dry	September Water Quality							X	X	X			X							
Reservoir, Dry	October Water Quality							X	X	X			X							
Reservoir, Dry	November Water Quality								X	X			X							
Reservoir, Dry	December Water Quality								X	X			X							
Reservoir, Average	January Water Quality								X	X			X							
Reservoir, Average	February Water Quality								X	X			X							
Reservoir, Average	March Water Quality								X	X			X							
Reservoir, Average	April Water Quality								X	X			X							
Reservoir, Average	May Water Quality							X	X	X			X							
Reservoir, Average	June Water Quality							X	X	X			X							
Reservoir, Average	July Water Quality							X	X	X			X							
Reservoir, Average	August Water Quality							X	X	X			X							
Reservoir, Average	September Water Quality							X	X	X			X							
Reservoir, Average	October Water Quality							X	X	X			X							
Reservoir, Average	November Water Quality								X	X			X							
Reservoir, Average	December Water Quality								X	X			X							
Reservoir, Wet	January Water Quality								X	X			X							
Reservoir, Wet	February Water Quality								X	X			X							
Reservoir, Wet	March Water Quality								X	X			X							
Reservoir, Wet	April Water Quality								X	X			X							
Reservoir, Wet	May Water Quality							X	X	X			X							
Reservoir, Wet	June Water Quality							X	X	X			X							
Reservoir, Wet	July Water Quality							X	X	X			X							
Reservoir, Wet	August Water Quality							X	X	X			X							
Reservoir, Wet	September Water Quality							X	X	X			X							
Reservoir, Wet	October Water Quality							X	X	X			X							
Reservoir, Wet	November Water Quality								X	X			X							
Reservoir, Wet	December Water Quality								X	X			X							

Table R11-8: Mactung Reservoir Precipitate Phases, 2008 Supernatant Concentrations

Group	Description	Precipitate Phases									
		Al(OH)3(a)	Cr(OH)3(am)	Fe(OH)3(a)	Alunite	Anglesite	Aragonite	Barite	Basaluminite	Calcite	Celestite
WRSF source	Unit 1 Waste Rock Runoff			X					X		
WRSF source	Unit 3C Waste Rock Runoff			X					X		
Tailings source	Tailings Runoff	X		X	X			X	X		
Seepage Source	Tailings Seepage			X			X			X	
Process Source	Process Water/Supernatant	X		X	X			X	X		
Precipitation Source	Precipitation			X				X	X		
SW Source	Tributary C0 Background			X					X		
GW Source	GW MW-MT-08-08D	X		X	X			X	X		X
WWTP Source	Waste Water Treatment Plant Effluent			X	X	X		X	X		X
WRSF	Waste Rock Storage Facility Runoff								X		
Trib C0	Trib C0 Neutral							X	X		
Reservoir, Dry	January Water Quality								X		
Reservoir, Dry	February Water Quality								X		
Reservoir, Dry	March Water Quality								X		
Reservoir, Dry	April Water Quality								X		
Reservoir, Dry	May Water Quality							X	X	X	
Reservoir, Dry	June Water Quality							X	X		
Reservoir, Dry	July Water Quality							X	X	X	
Reservoir, Dry	August Water Quality							X	X	X	
Reservoir, Dry	September Water Quality							X	X	X	
Reservoir, Dry	October Water Quality							X	X	X	
Reservoir, Dry	November Water Quality								X	X	
Reservoir, Dry	December Water Quality								X	X	
Reservoir, Average	January Water Quality								X	X	
Reservoir, Average	February Water Quality								X		
Reservoir, Average	March Water Quality								X		
Reservoir, Average	April Water Quality								X		
Reservoir, Average	May Water Quality							X	X	X	
Reservoir, Average	June Water Quality							X	X		
Reservoir, Average	July Water Quality							X	X		
Reservoir, Average	August Water Quality							X	X	X	
Reservoir, Average	September Water Quality							X	X	X	
Reservoir, Average	October Water Quality							X	X	X	
Reservoir, Average	November Water Quality								X	X	
Reservoir, Average	December Water Quality								X	X	
Reservoir, Wet	January Water Quality								X	X	
Reservoir, Wet	February Water Quality								X	X	
Reservoir, Wet	March Water Quality								X		
Reservoir, Wet	April Water Quality								X		
Reservoir, Wet	May Water Quality							X	X		
Reservoir, Wet	June Water Quality							X	X		
Reservoir, Wet	July Water Quality							X	X		
Reservoir, Wet	August Water Quality							X	X		
Reservoir, Wet	September Water Quality							X	X	X	
Reservoir, Wet	October Water Quality							X	X	X	
Reservoir, Wet	November Water Quality								X	X	
Reservoir, Wet	December Water Quality								X	X	

Table R11-8: Mactung Reservoir Precipitate Phases, 2008 Supernatant Concentrations

Group	Description	Precipitate Phases								
		Dolomite	Goethite	Gypsum	JarositeH	Jarosite-K	Jarosite-Na	Malachite	Melanterite	Siderite
WRSF source	Unit 1 Waste Rock Runoff		X							
WRSF source	Unit 3C Waste Rock Runoff		X							
Tailings source	Tailings Runoff		X	X						
Seepage Source	Tailings Seepage		X							
Process Source	Process Water/Supernatant		X							
Precipitation Source	Precipitation		X							
SW Source	Tributary C0 Background		X							
GW Source	GW MW-MT-08-08D		X	X		X	X			
WWTP Source	Waste Water Treatment Plant Effluent		X	X	X	X	X			
WRSF	Waste Rock Storage Facility Runoff		X							
Trib C0	Trib C0 Neutral		X							
Reservoir, Dry	January Water Quality		X							
Reservoir, Dry	February Water Quality		X							
Reservoir, Dry	March Water Quality		X							
Reservoir, Dry	April Water Quality		X							
Reservoir, Dry	May Water Quality		X							
Reservoir, Dry	June Water Quality		X							
Reservoir, Dry	July Water Quality		X							
Reservoir, Dry	August Water Quality		X							
Reservoir, Dry	September Water Quality		X							
Reservoir, Dry	October Water Quality		X							
Reservoir, Dry	November Water Quality		X							
Reservoir, Dry	December Water Quality		X							
Reservoir, Average	January Water Quality		X							
Reservoir, Average	February Water Quality		X							
Reservoir, Average	March Water Quality		X							
Reservoir, Average	April Water Quality		X							
Reservoir, Average	May Water Quality		X							
Reservoir, Average	June Water Quality		X							
Reservoir, Average	July Water Quality		X							
Reservoir, Average	August Water Quality		X							
Reservoir, Average	September Water Quality		X							
Reservoir, Average	October Water Quality		X							
Reservoir, Average	November Water Quality		X							
Reservoir, Average	December Water Quality		X							
Reservoir, Wet	January Water Quality		X							
Reservoir, Wet	February Water Quality		X							
Reservoir, Wet	March Water Quality		X							
Reservoir, Wet	April Water Quality		X							
Reservoir, Wet	May Water Quality		X							
Reservoir, Wet	June Water Quality		X							
Reservoir, Wet	July Water Quality		X							
Reservoir, Wet	August Water Quality		X							
Reservoir, Wet	September Water Quality		X							
Reservoir, Wet	October Water Quality		X							
Reservoir, Wet	November Water Quality		X							
Reservoir, Wet	December Water Quality		X							

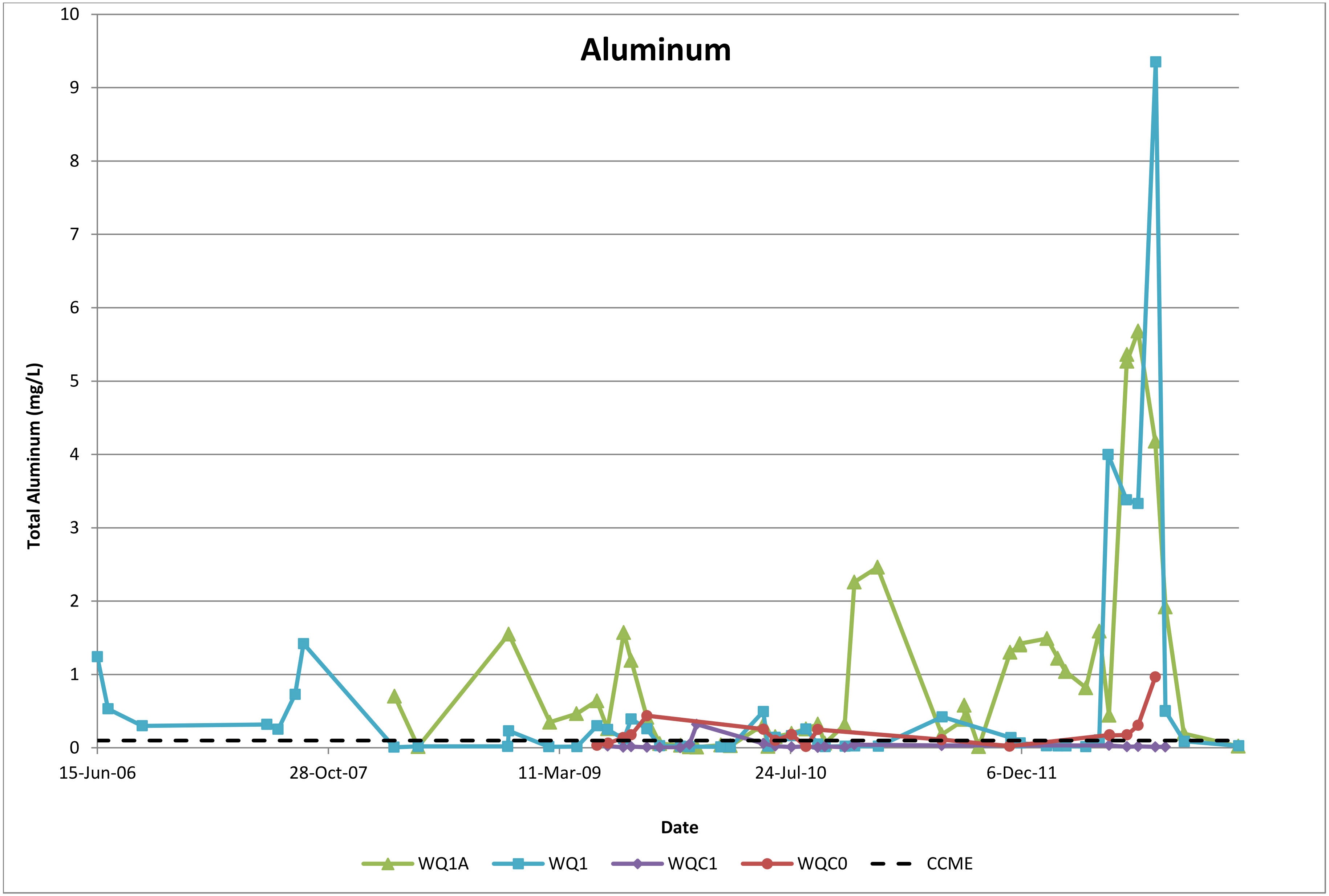


Figure R11-1: Background Aluminum Concentrations in Surface Waters

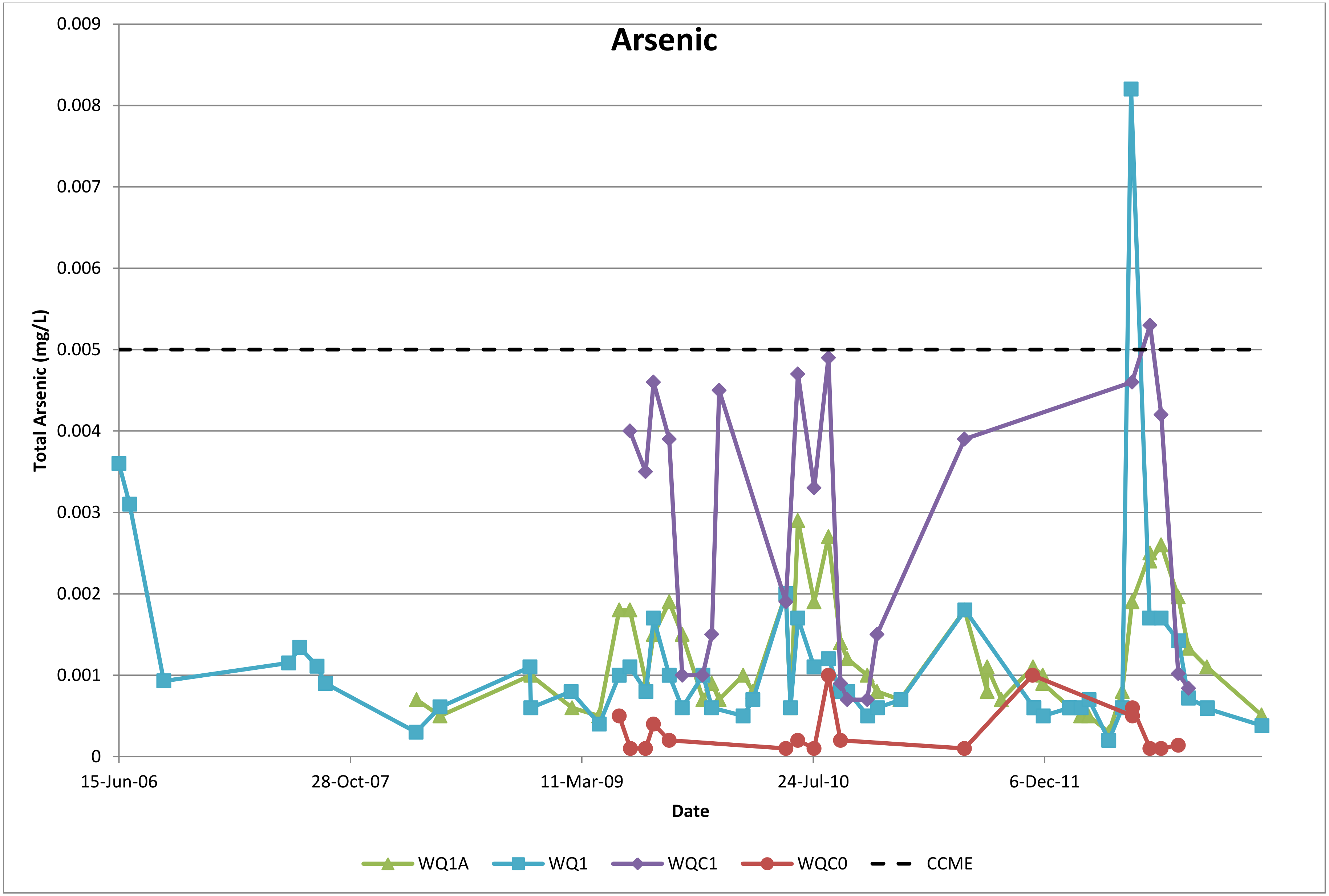


Figure R11-2: Background Arsenic Concentrations in Surface Waters

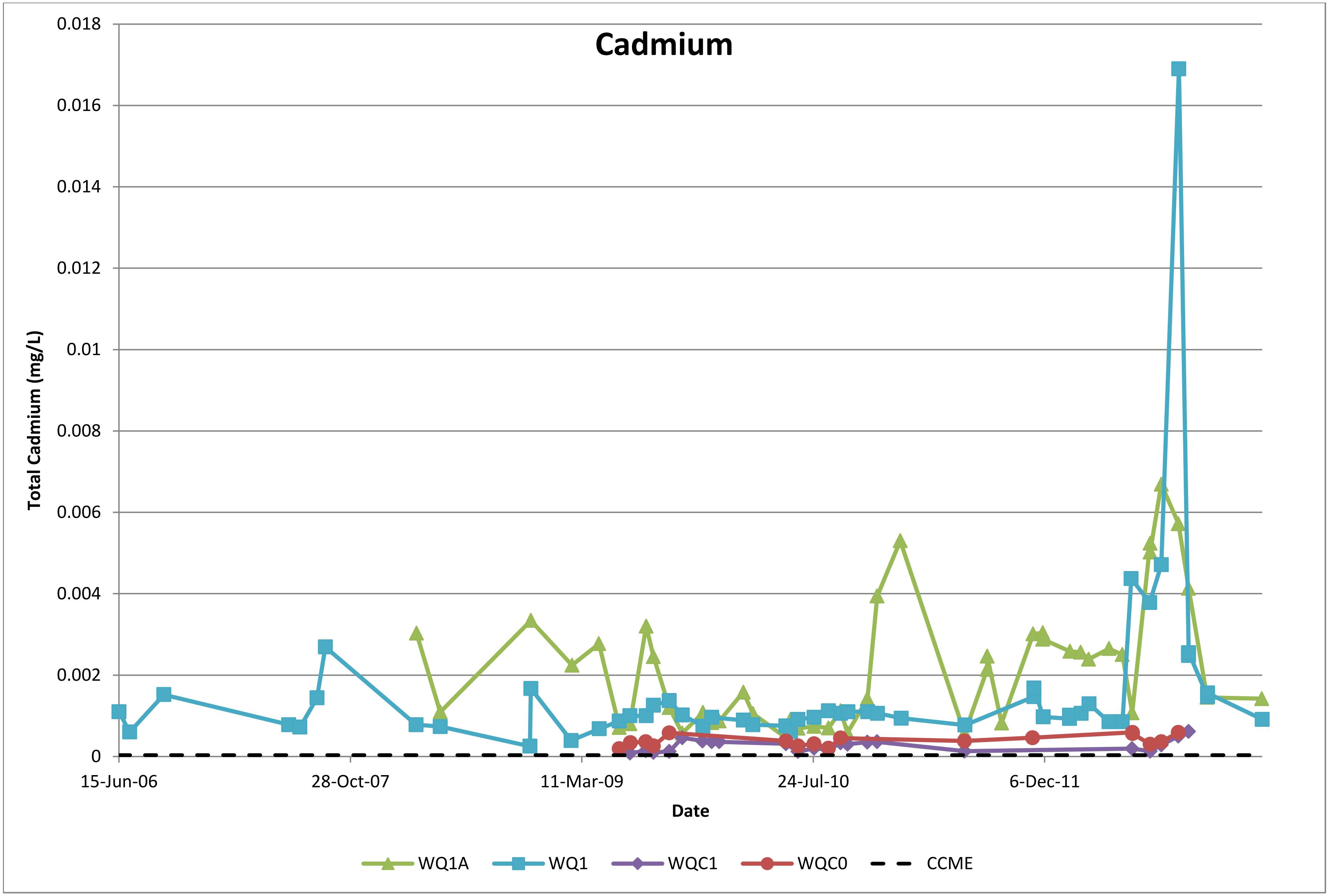


Figure R11-3: Background Cadmium Concentrations in Surface Waters

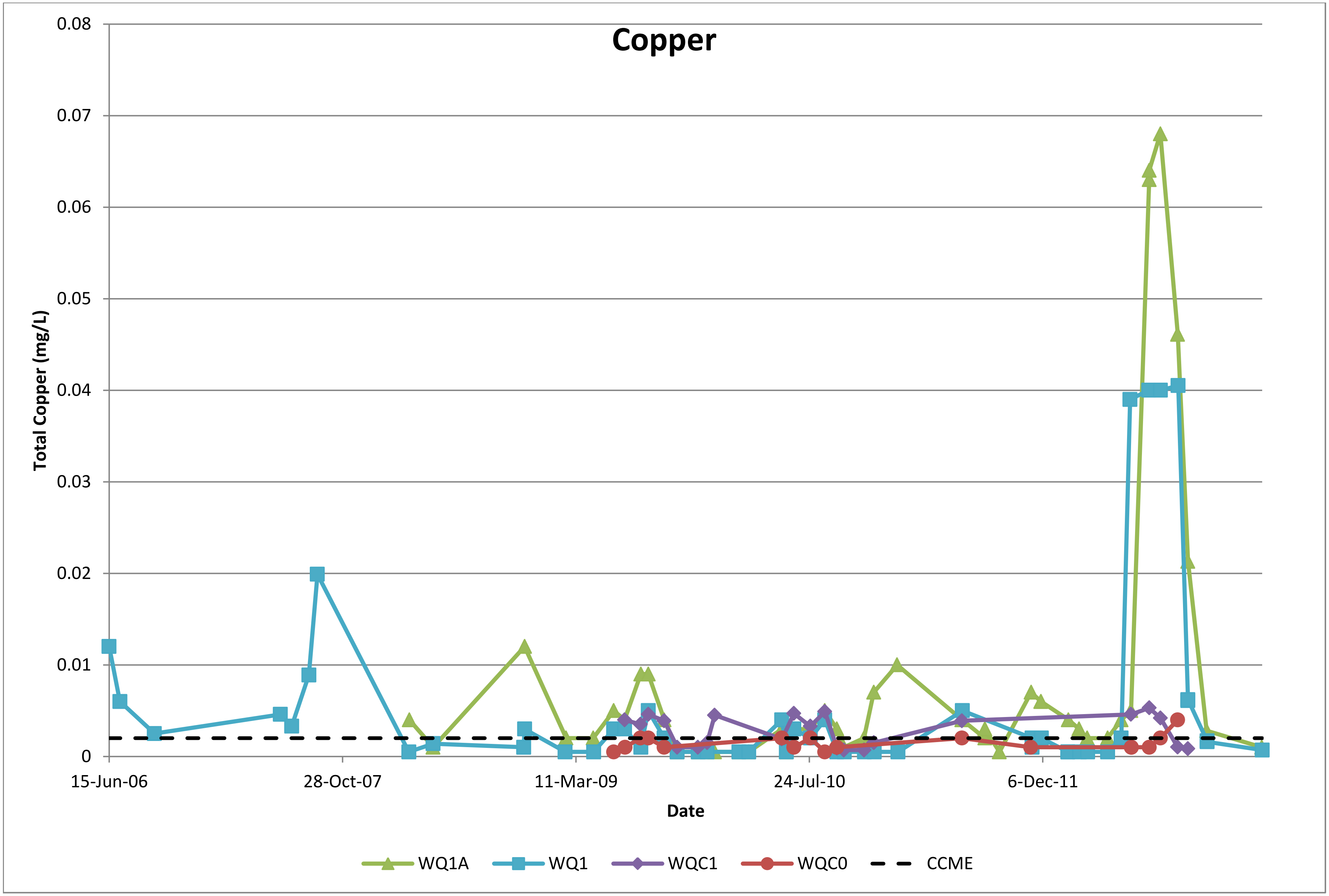


Figure R11-4: Background Copper Concentrations in Surface Waters

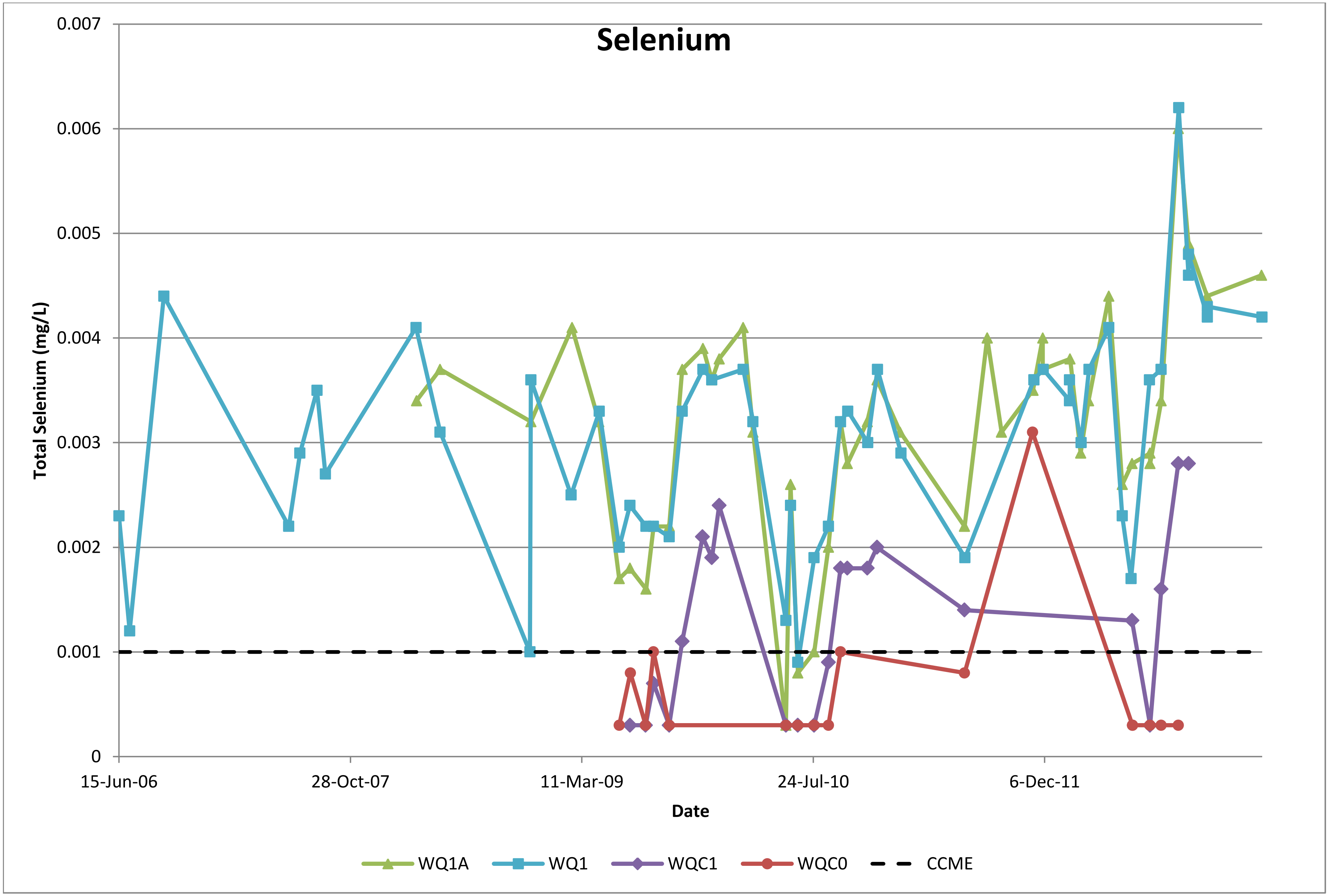


Figure R11-5: Background Selenium Concentrations in Surface Waters

2.8 Water Treatment and Discharge

R12: Provide water treatment targets (MMER or others related to protection of the downstream environment) for the constituents of potential concern based on the updated water balance and water quality predictions. Describe the compliance point location for all constituents of potential concern.

Both the Mactung water balance (R8) and the water quality prediction model (R11) have been updated and revised for the proposed Mactung project. These updates allow for further comparisons to be made between baseline water quality and the modelled and predicted water quality in the reservoir prior to discharge to the downstream environment. A location downstream of the discharge point has also been suggested to provide a comparison between concentrations of any contaminants of potential concern (COPCs) and the Canadian Council of Ministers of the Environment (CCME) guideline values for the protection of freshwater aquatic life.

As discussed in the response to R11 in this document, the revised water quality prediction model results indicate that for the water discharged from the reservoir to the downstream environment, no parameters are anticipated to exceed the MMER concentrations based on the proposed operations and the application of planned mitigation measures. As stated in previous submissions to YESAB, NATC is committed to meeting the MMER concentrations for all regulated parameters at the point of discharge to the downstream environment (the Ravine Dam).

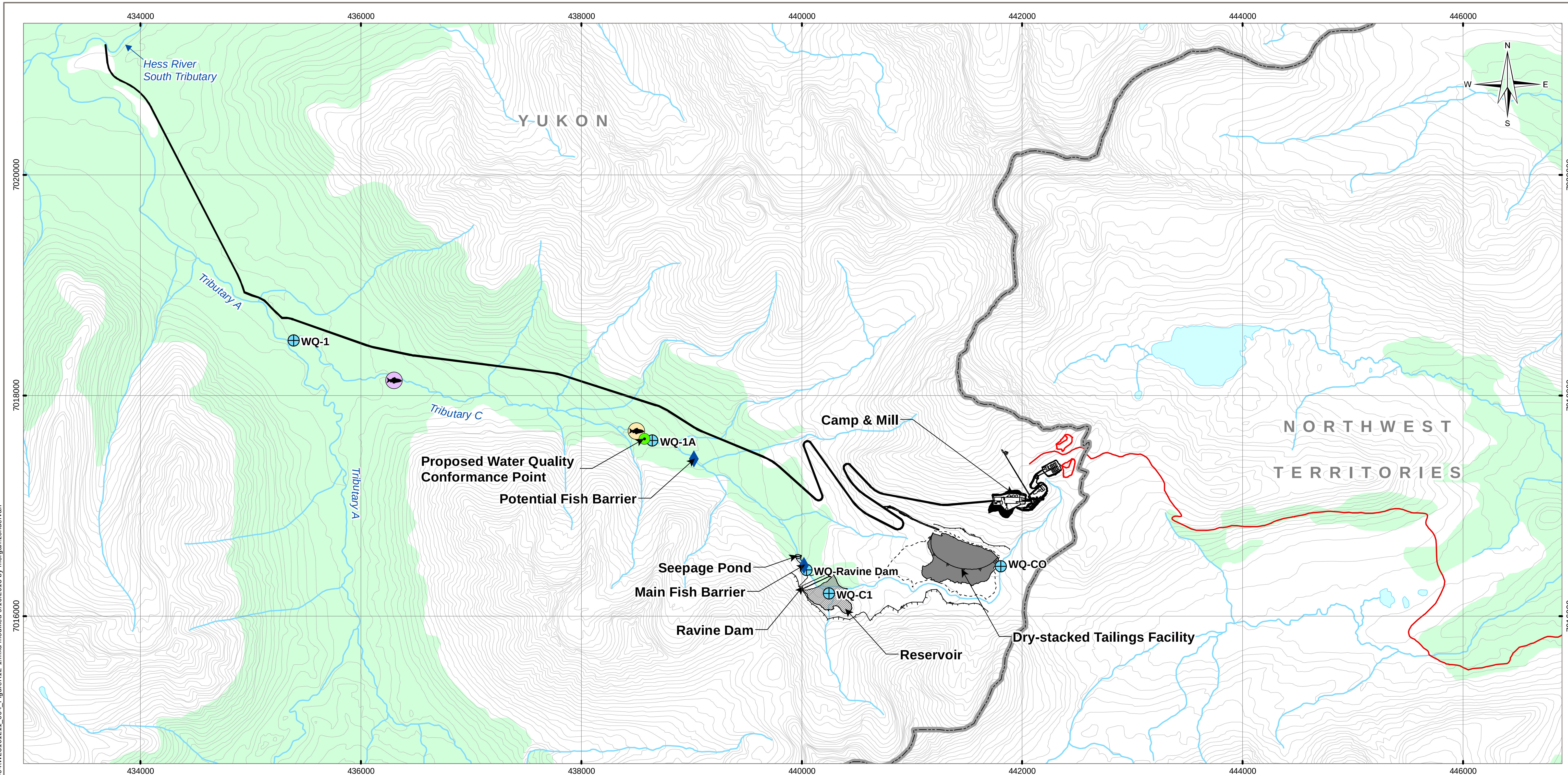
As discussed in response to R11 in this document, the revised water quality prediction model results indicate that for the water discharged from the reservoir to the downstream environment, no parameters are anticipated to exceed the MMER concentrations based on the proposed operations and the application of planned mitigation measures. As stated in previous submissions to YESAB, NATC is committed to meeting the MMER concentrations for all regulated parameters at the point of discharge to the downstream environment (the Ravine Dam). NATC has committed to installing a water treatment plant (WTP) at Mactung that will be available to treat water with COPCs should the need arise. The WTP is discussed further in response R13. The remainder of this response concentrates on proposing a water quality conformance point on Tributary C, downstream of the Ravine Dam.

Baseline Water Quality

Table R12-1 presents the total number of sampling events that have occurred at selected water quality sampling locations for Mactung (Figure R12-1).

Table R12-1: Number of Water Quality Sampling Events at Selected Locations, Mactung

Station Identification	Number of sampling events	Sampling Events Date Range
WQ1A	46	March 2008 to March 2013
WQ1	52	June 2006 to March 2013
WQC1	21	June 2009 to October 2012
WQC0	17	May 2009 to September 2012
WQRavine Dam	30	April 2009 to October 2012



LEGEND

- WQ_Sept2011 selection
- Downstream Water Quality Conformance Point
- Potential Fish Habitat
- Highest Recorded Fish Location (2007)
- Fish Barrier
- Water Quality Station
- Existing Road
- Proposed Road
- Temporary Waste Rock Dump
- NWT-YT Border
- Contours (20 m)
- Watercourse
- Waterbody
- Vegetation

NOTES
Base data source: 1:50,000 NTS

STATUS
ISSUED FOR USE

MACTUNG

Water Quality Stations and Proposed Conformance Point

PROJECTION	DATUM	CLIENT
UTM Zone 9	NAD83	NORTH AMERICAN TUNGSTEN CORPORATION LTD

Scale: 1:35,000
500 250 0 500
Metres

FILE NO.
W23101211_004_FigureR12-1.mxd

PROJECT NO.	DWN	CKD	APVD	REV
W23101211.004	MEZ	X	GR	0

OFFICE	DATE
EBA-VANC	September 10, 2013

eba
A TETRA TECH COMPANY

Figure R12-1

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Figures R12-2 to R12-10 illustrate the natural baseline variability of the water quality at locations WQ1A, WQ1, WQC1 and WQC0 and WQRavine Dam (Figure 12-1). Only those parameters that have naturally occurring concentrations above CCME guideline values are included in the Figures. All other analyzed parameters have concentrations that are below the CCME guideline concentrations and the regulated MMER concentrations, or have no applicable guideline or regulatory concentrations.

As illustrated in Figures R12-2 to R12-10, natural baseline concentrations of aluminum, copper, cadmium, selenium and zinc are regularly greater than the CCME guideline concentrations. The natural background concentrations for arsenic, iron, uranium and silver have been higher than the CCME guideline concentrations during at least one sampling event at most of the sampling stations. This natural variability in concentrations has been taken into account when proposing site specific water quality objectives (SSWQO) at a suggested conformance point on Tributary C, downstream of the reservoir.

Proposed Conformance Point in Tributary C

NATC recognizes that the location of the proposed water quality conformance point downstream of the Ravine Dam will need to be discussed with regulators as the project progresses through the regulatory process. NATC is suggesting that the downstream conformance point be used as a management tool to obtain data to compare to the SSWQOs and to use these data to help make informed management decisions about water quality objectives in the reservoir.

The location of the proposed conformance point is indicated in Figure R12-1 and is based on the following criteria:

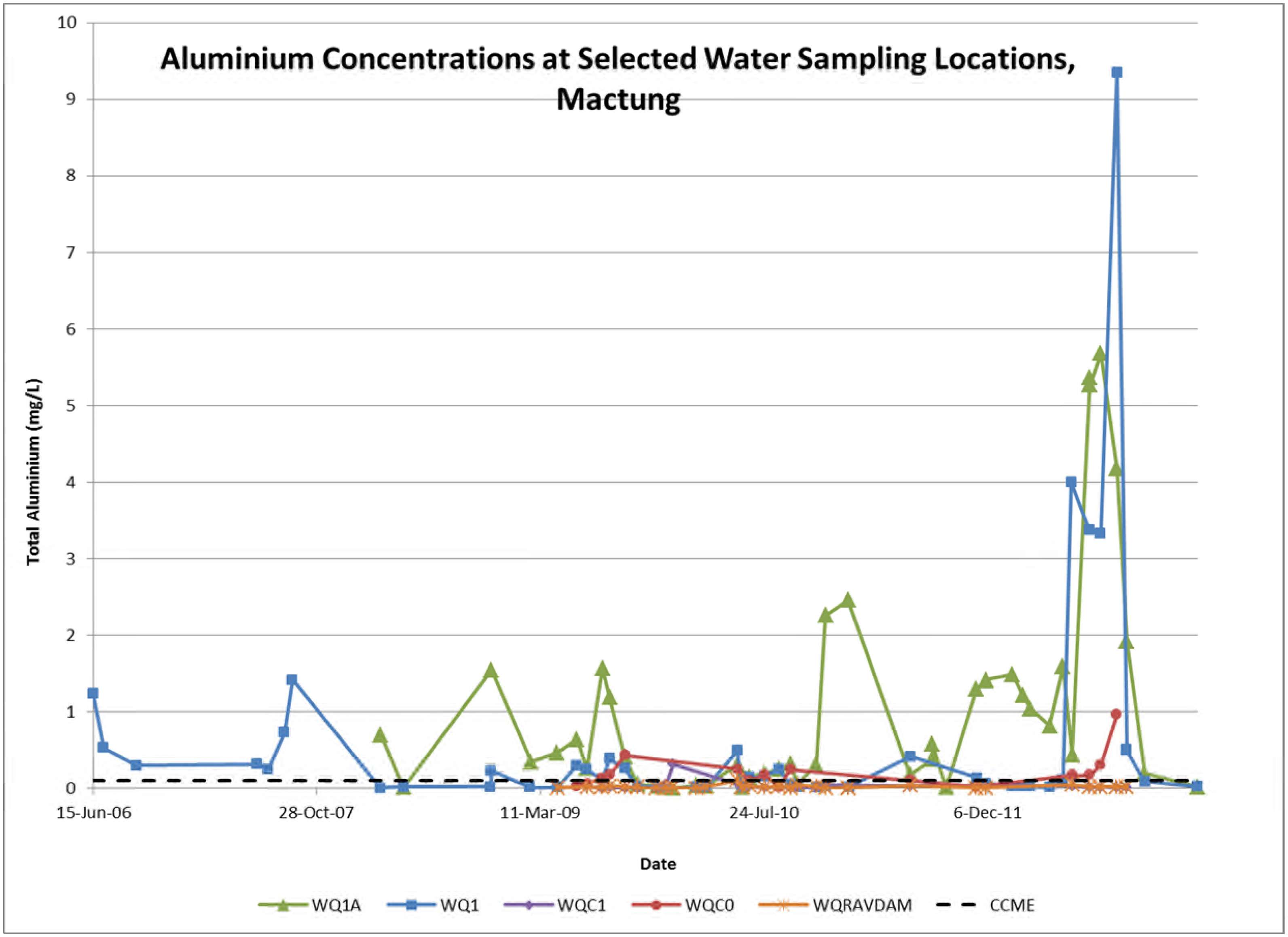
- The highest elevation and location where fish presence was recorded on Tributary C during recent fish studies completed in 2007 and 2008 (below the suggested conformance point);
- The highest elevation and location on Tributary C where suitable fish habitat was identified (below the suggested conformance point); and
- A location downstream of the discharge point that allows for some natural mixing and dilution to occur.

NATC suggests that all water quality parameters at the downstream conformance point will meet the CCME guideline concentrations except for those parameters that have been shown to naturally occur above CCME guideline concentrations (aluminum, copper, cadmium, selenium, arsenic, iron, uranium, silver, and zinc). For those parameters that are naturally above the CCME guideline concentrations, NATC suggests that the target concentrations at the conformance point will equate to the 95th percentile concentrations of the natural baseline concentrations, based on the water quality data collected at WQ-1A. Table R12-2 summarizes the suggested conformance point concentrations.

Table R12-2: Contaminants of Potential Concern (COPC) and Target Downstream Conformance Point Concentrations

Contaminants of Potential Concern (COPC)[A]	MMER Concentrations (mg/L)	CCME Guideline Concentrations (mg/L)[B]	Lowest Detected Natural Baseline Concentrations at WQ-1A (mg/L)[D]	Highest Detected Natural Baseline Concentrations at WQ-1A (mg/L)[D]	Target Concentration at Downstream Water Quality Conformance Point (mg/L)[C]
Aluminum	-	0.1	0.01	**5.68**	**4.998**
Cadmium	-	0.000033	**0.00046**	**0.00669**	**0.005285**
Copper	0.3	0.00238	0.0005	**0.068**	**0.058775**
Iron	-	0.3	0.005	**3.38**	**2.9325**
Selenium	-	0.001	0.0003	**0.006**	**0.00455**
Silver	-	0.0001	0.000005	**0.00013**	**0.000075**
Uranium	-	0.015	0.0014	**0.0193**	0.010925
Zinc	0.5	0.03	**0.031**	**0.624**	**0.3748**

Notes: [A] COPCs based on analytes with concentrations naturally higher than CCME guideline concentrations at water quality stations on Tributary C. All other constituents to be within the CCME guideline concentrations
[B] Cadmium and Copper guidelines determined using the average Total Hardness at WQ-1A
[C] Concentrations based on the 95th percentile of water quality data collected at station WQ-1A
[D] Values in bold and underlined indicate concentrations that are greater than CCME guideline concentrations for the protection of freshwater aquatic life



LEGEND

NOTES

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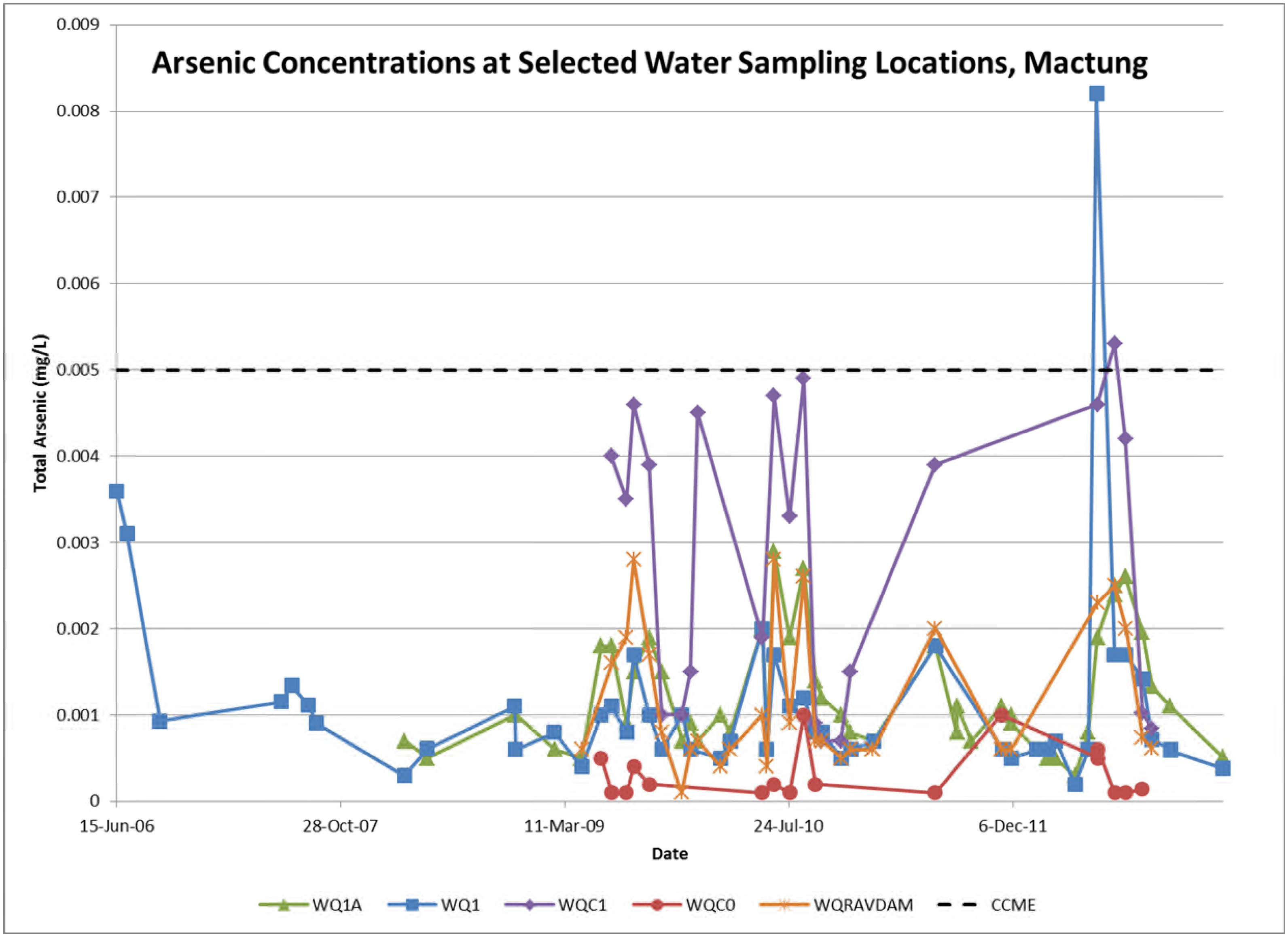
Aluminum Concentrations, Selected Water Quality Stations

PROJECT NO.	DWN	CKD	APVD	REV
W23101211-01.004	JB	GMR	RH	-

OFFICE	DATE
EBA-WHSE	September 10, 2013

Figure R12-2



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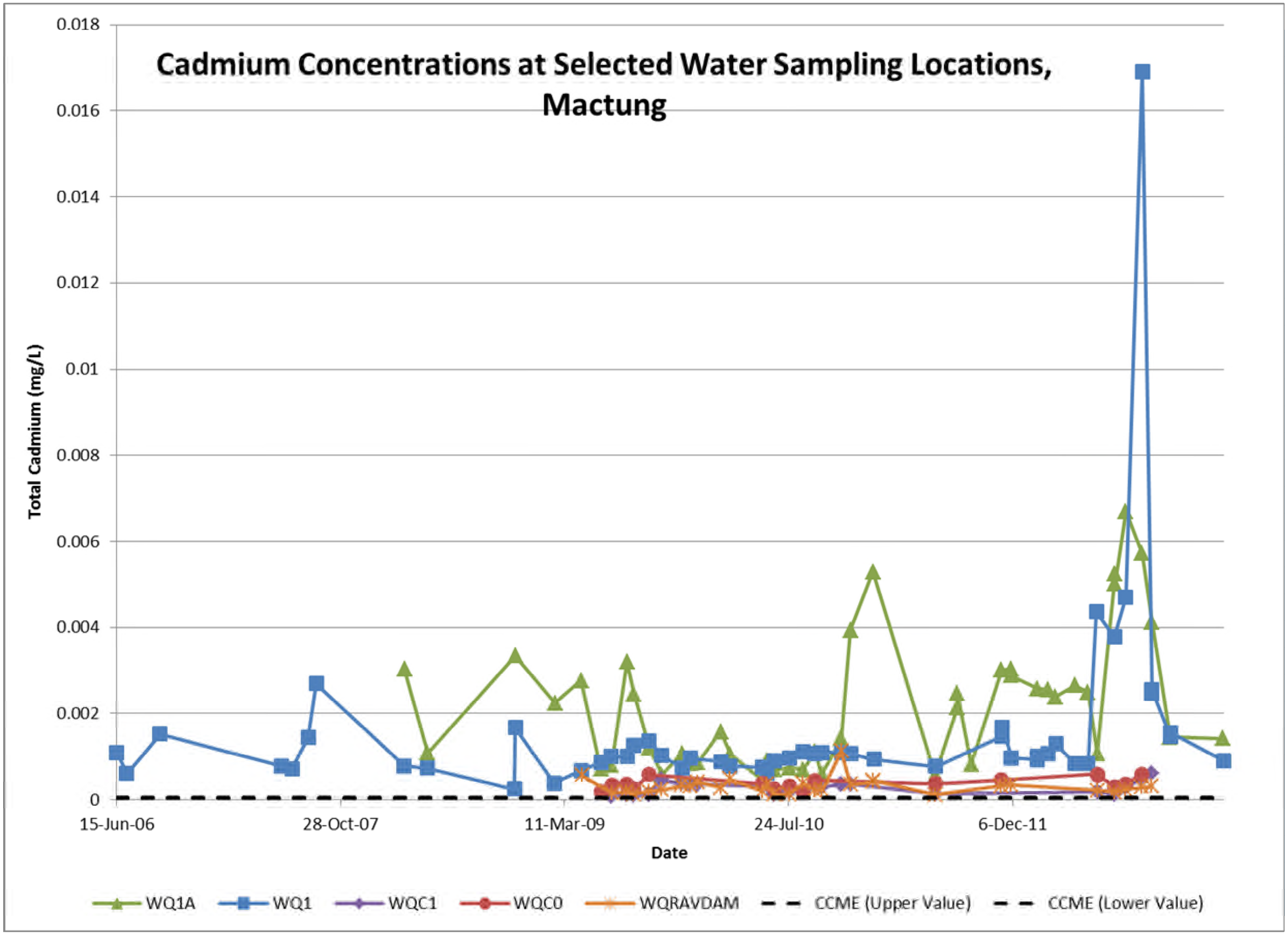
Arsenic Concentrations, Selected Water Quality Stations

PROJECT NO.	DWN	CKD	APVD	REV	
W23101211.004	JB	GMR	RH	-	Figure R12-3
OFFICE	DATE				
EBA-WHSE	September 10, 2013				



LEGEND

NOTES
CCME concentrations based on highest and lowest hardness concentrations of all the stations

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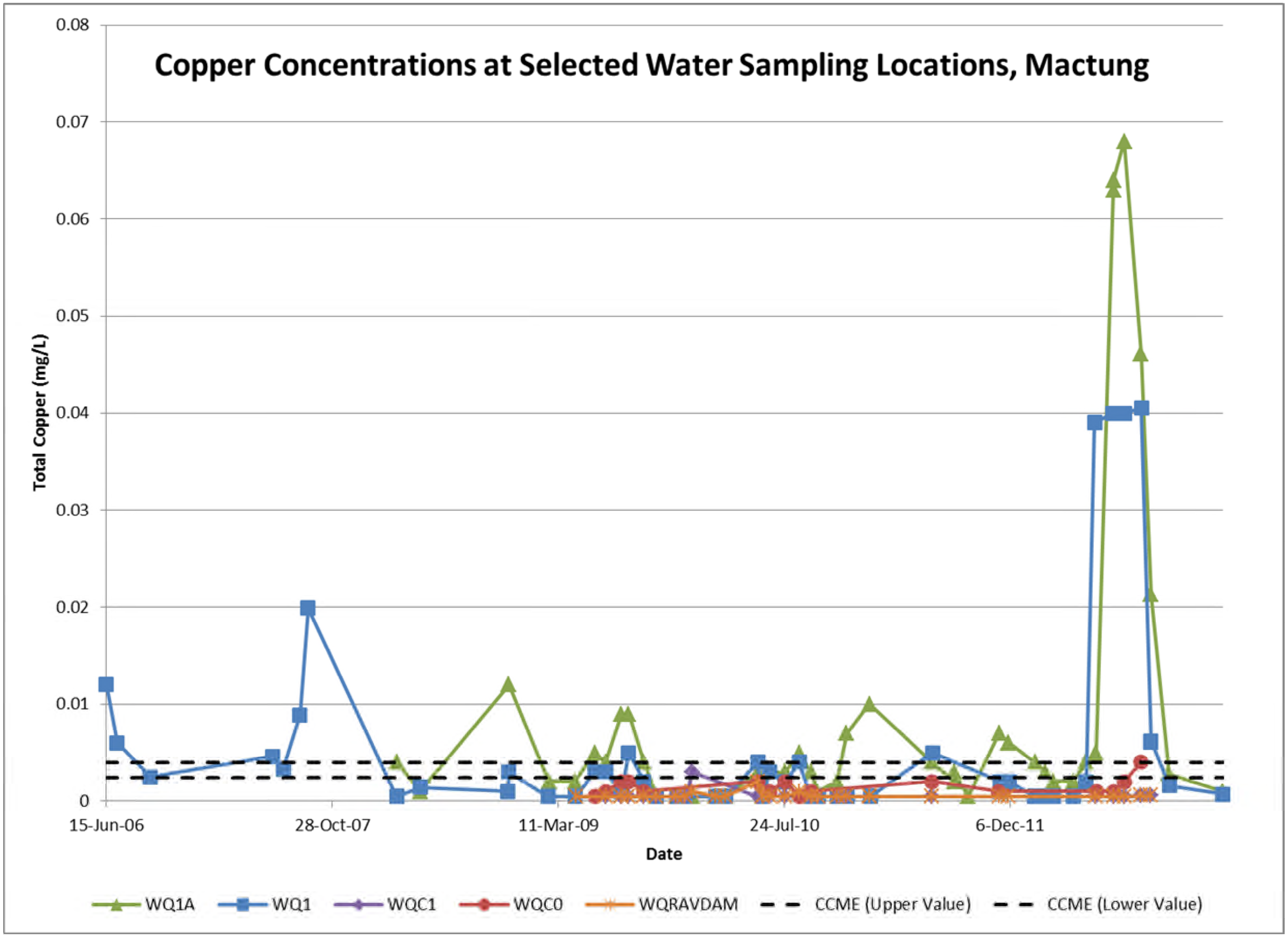
Cadmium Concentrations, Selected Water Quality Station

PROJECT NO.	DWN	CKD	APVD	REV
W23101211.004	JB	GMR	RH	-

OFFICE	DATE
EBA-WHSE	September 10, 2013

Figure R12-4



LEGEND

NOTES
CCME concentrations based on highest and lowest hardness concentrations of all the stations

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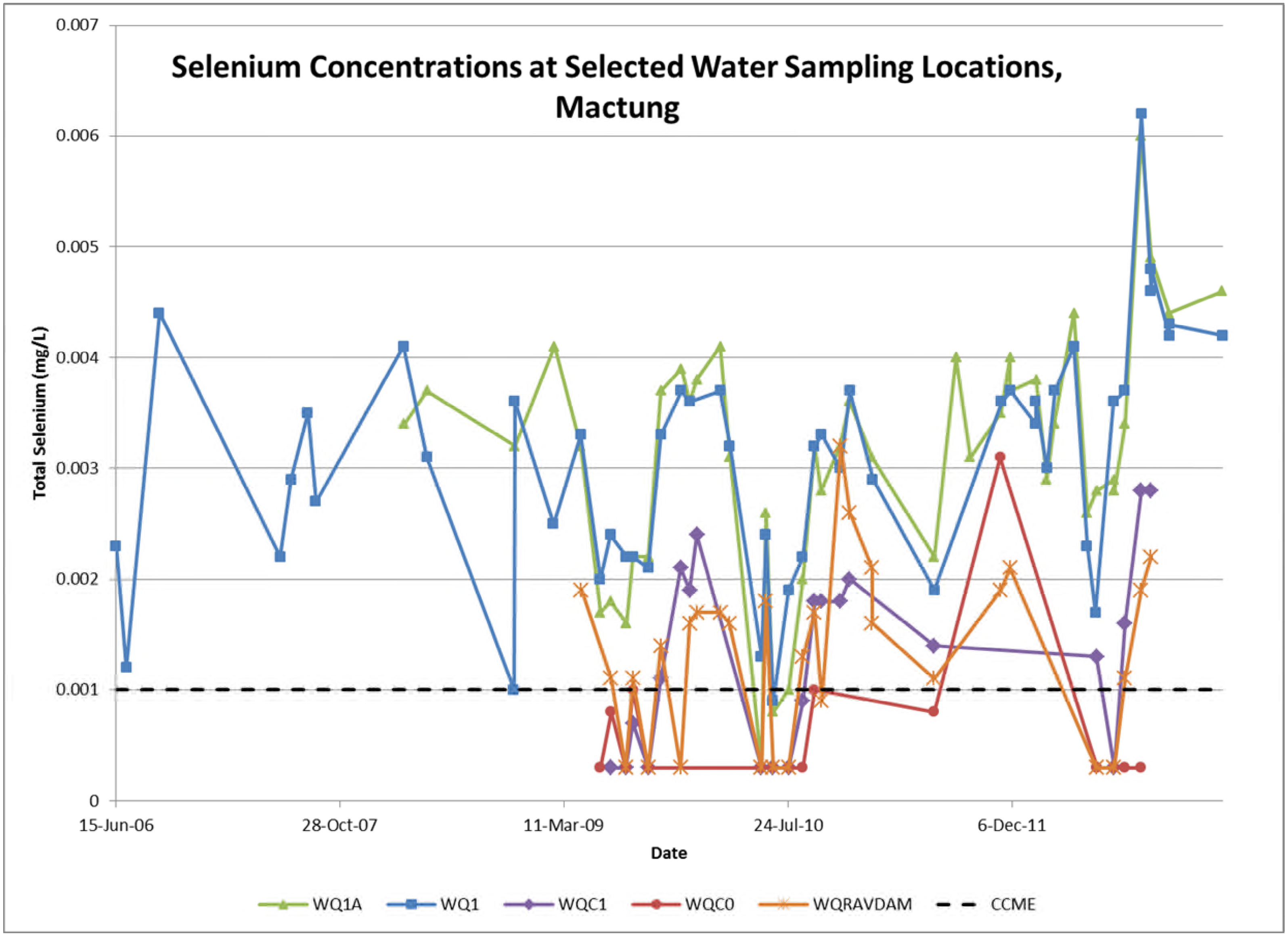
Copper Concentrations, Selected Water Quality Stations

PROJECT NO.	DWN	CKD	APVD	REV
W23101211.004	JB	GMR	RH	-

OFFICE	DATE
EBA-WHSE	September 10, 2013

Figure R12-5



LEGEND

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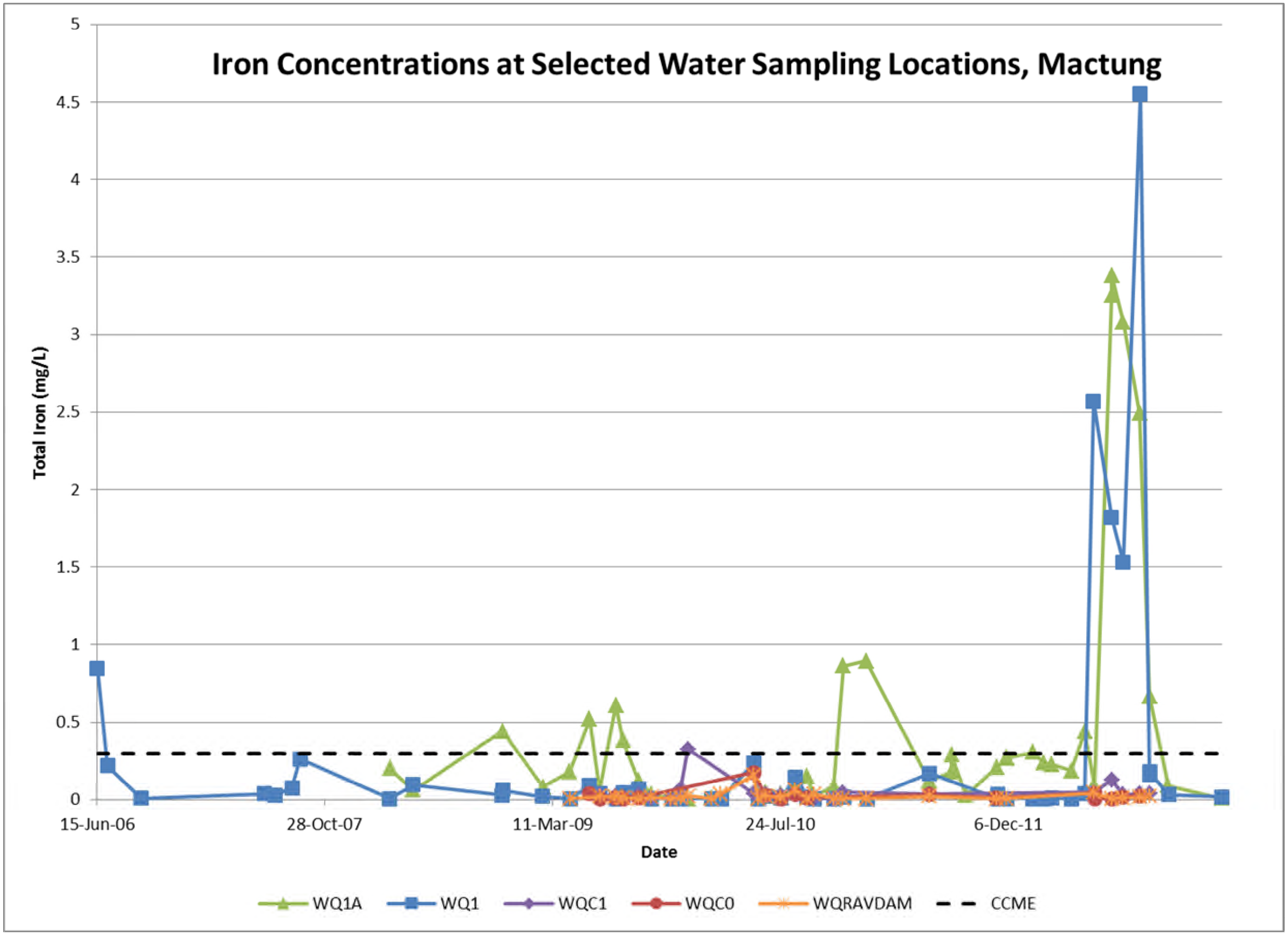
Selenium Concentrations, Selected Water Quality Stations

PROJECT NO.	DWN	CKD	APVD	REV
W23101211.004	JB	GMR	RH	-

OFFICE	DATE
EBA-WHSE	September 10, 2013

Figure R12-6



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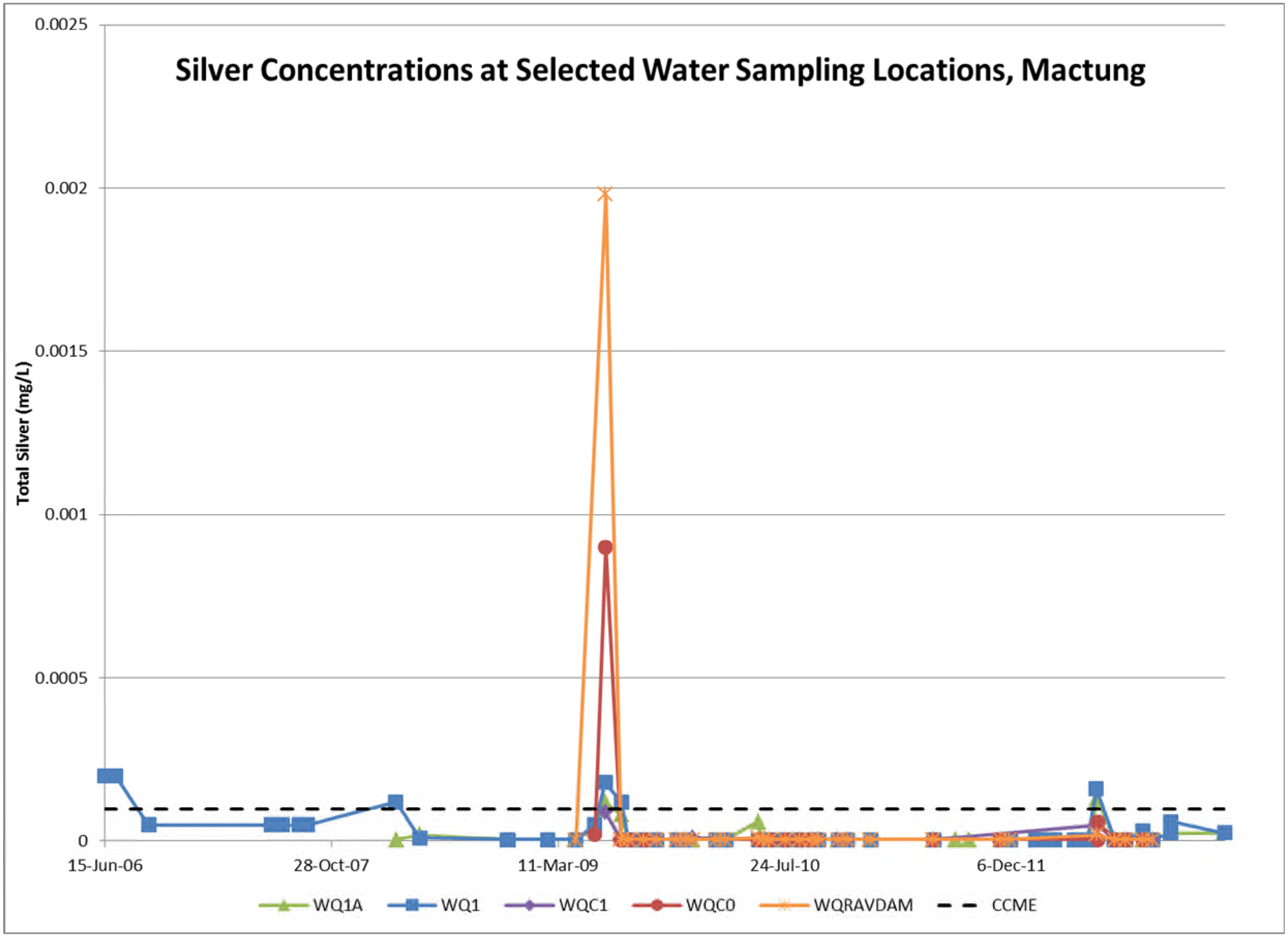
Iron Concentrations, Selected Water Quality Stations

PROJECT NO.	DWN	CKD	APVD	REV
W23101211.004	JB	GMR	RH	-

OFFICE	DATE
EBA-WHSE	September 10, 2013

Figure R12-7



LEGEND

NOTES

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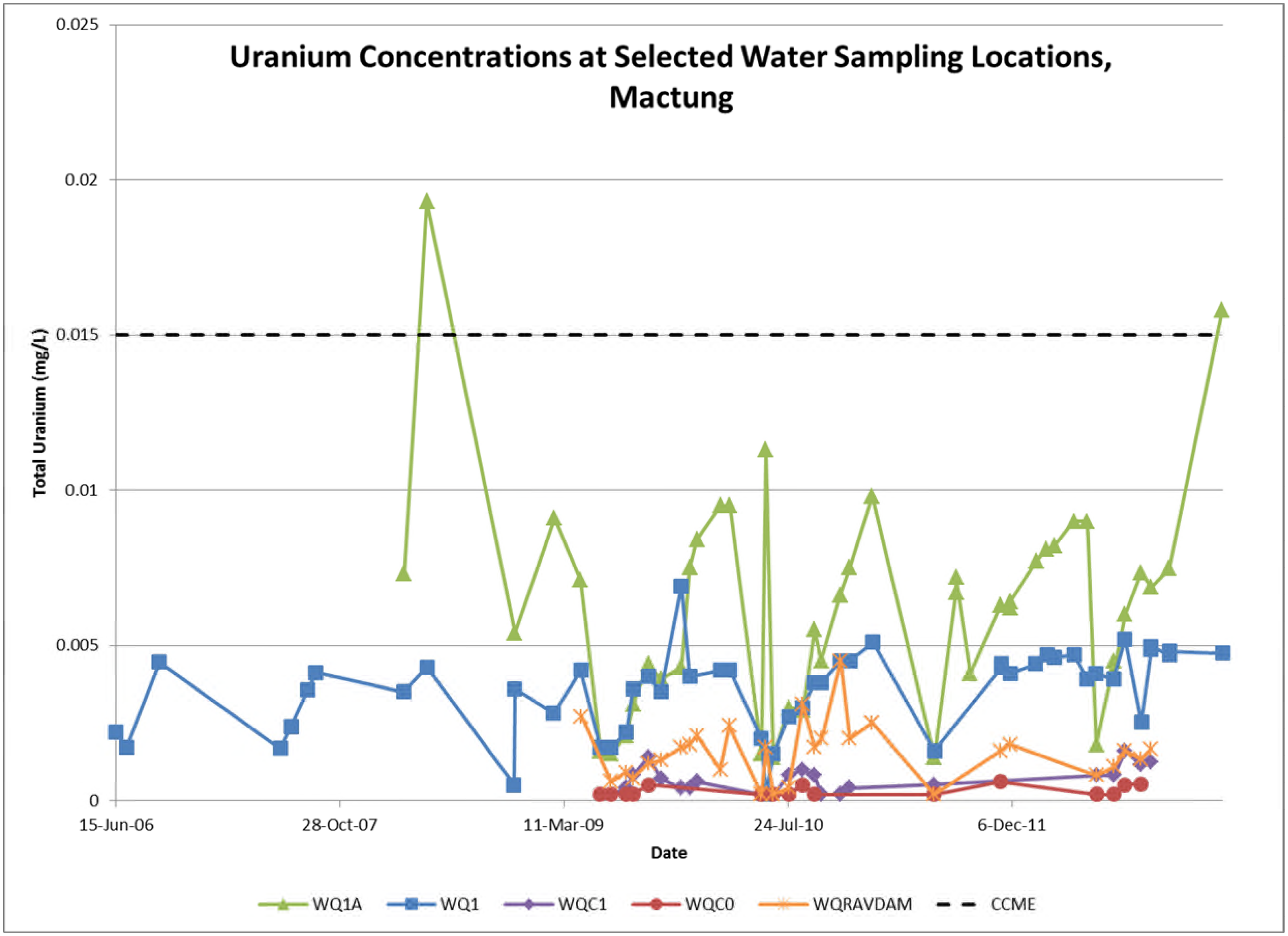
Silver Concentrations, Selected Water Quality Stations

PROJECT NO.	DWN	CKD	APVD	REV
W23101211.004	JB	GMR	RH	-

OFFICE	DATE
EBA-WHSE	September 10, 2013

Figure R12-8



LEGEND

NOTES

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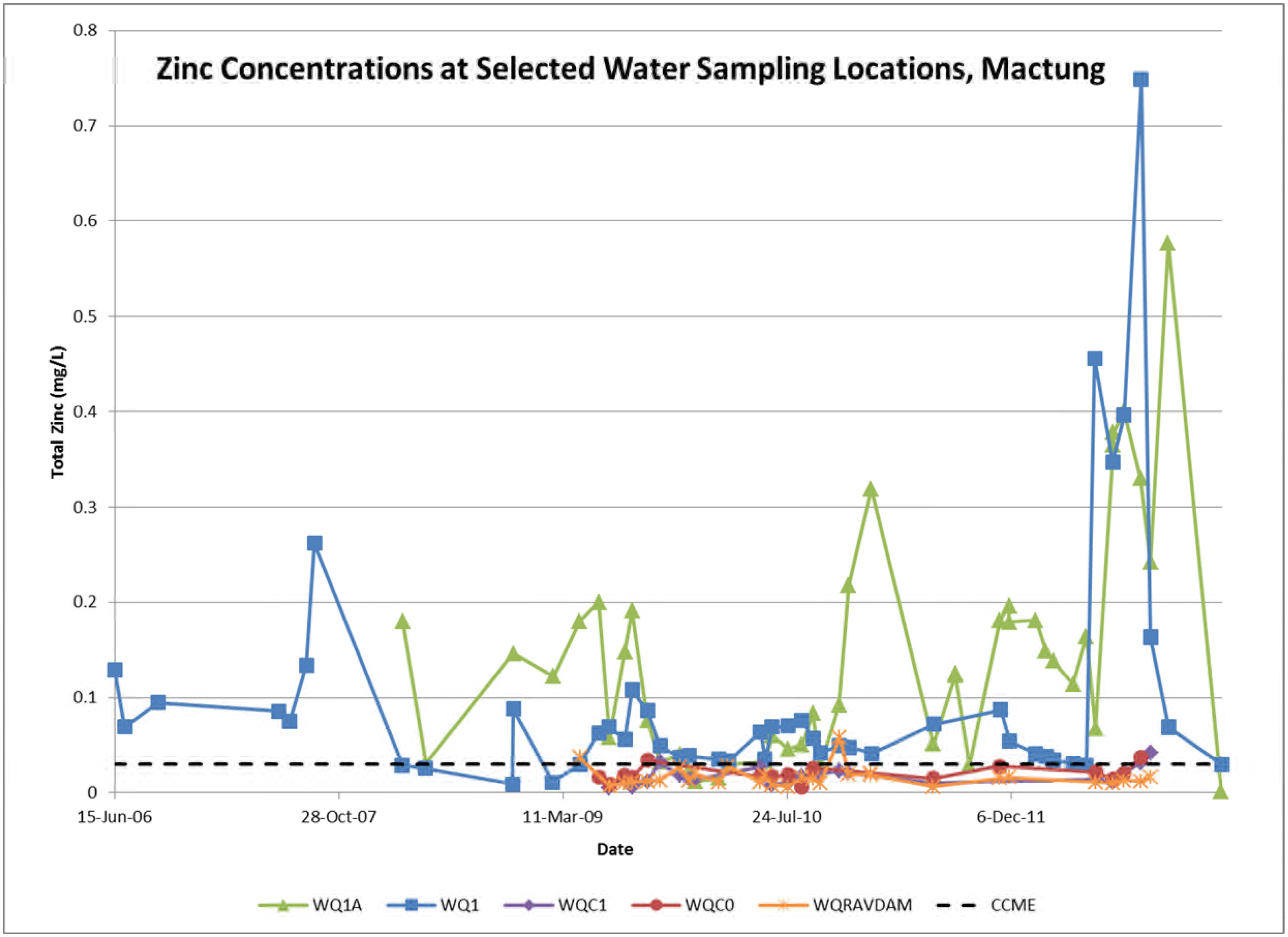
Uranium Concentrations, Selected Water Quality Stations

PROJECT NO.	DWN	CKD	APVD	REV	
W23101211.004	JB	GMR	RH	-	Figure R12-9
OFFICE	DATE				
EBA-WHSE	September 10, 2013				



LEGEND

NOTES

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Zinc Concentrations, Selected Water Quality Stations

PROJECT NO.	DWN	CKD	APVD	REV
W23101211.004	JB	GMR	RH	-

OFFICE	DATE
EBA-WHSE	September 10, 2013

Figure R12-10

STATUS
ISSUED FOR USE

R13: Provide a further description of a conceptual water treatment plant that would be capable of successfully treating water taking the following matters into consideration:

a) Flow rates as described in the updated site water balance.

b) Range of possible constituents of potential concern that were identified in the updated water quality prediction model (cadmium, chromium, copper, lead, selenium, and zinc) that may require treatment.

As discussed in Response R11 and in Response R12, all baseline data and the water quality prediction model indicate that none of the water quality constituents in the reservoir are anticipated to exceed the Metal Mining Effluent Regulations (MMER) concentrations. The planned operations include built-in mitigations such as the regular compacted lifts associated with the dry-stacked tailings facility (DSTF) and progressive reclamation of the DSTF. The water quality prediction model indicates that none of the constituents of the reservoir water will exceed MMER concentrations. The predicted concentrations of the MMER-regulated arsenic, copper, nickel, zinc and cyanide are at least one order of magnitude below the MMER standard (Table R11-3, Table R11-4).

Nonetheless, NATC has committed to installing a water treatment plant at Mactung that will be available to help NATC meet all water quality objectives, should the need arise. Potential metals that may require treatment to meet downstream water quality objectives would be aluminum, arsenic, copper, selenium and cadmium. As there will be regular water quality sampling at the reservoir during mine operations, all constituents will be monitored on a regular basis. In the event that concentrations of any constituents become a concern, then water treatment measures would be initiated. The activation of the water treatment plant may be one mitigation measure used.

In a previous memo submitted to YESAB (YOR#2008-0304-231-1) that discussed the proposed water treatment plant (WTP), the lowest and highest predicted discharge flow rates from the ravine dam were presented. The flow rates were a low of 47 L/s to a maximum of 215 L/s. The revised flow rates, based on the updated water balance estimates (R8), range from approximately 25 L/s to a peak flow of 158 L/s (95^{th} percentile). The revised high flow rate is lower than the flow rate of 215 L/s originally provided to prospective suppliers of the WTP.

Nickel was not discussed in previous submissions to YESAB as a contaminant of potential concern (COPC). However, as can be seen in the attached WTP promotional material and data from Veolia (Appendix F), a supplier of water treatment units, up to 98% nickel removal from water in a mining environment has been achieved using the existing technology. Based on all previous water quality work completed to date for the proposed Mactung mine, and to be conservative with its approach to COPCs, NATC will pay close attention to the anticipated concentrations of all reservoir water constituents during future updates to the water quality prediction model, for the detailed design of the WTP and during mining operations. No changes to the previously proposed water treatment plant conceptual design or water quality management plan are proposed by NATC at this time.

2.9 Underground Disposal of Tailings

R14: Develop and provide an adaptive management plan for tailings and waste rock disposal. As part of the adaptive management plan,

a) Provide a conceptual approach and timeline to monitor and assess the effectiveness of underground co-disposal of waste rock and tailings in mitigating potential effects of ARD/ML. This could include laboratory and in-situ testing programs. Describe how the information obtained would be used to inform waste rock and tailings management decisions.

b) Provide an alternative conceptual plan for the long-term management of waste rock and tailings that does not include co-disposal in stopes above the natural water table. Include estimates of potential acid generating and metal leaching materials that exceed the capacity of underground co-disposal below the natural water table. Describe how disposal options will effectively manage ARD/ML issues and affect the current plan for surface storage of waste rock and the DSTF.

c) Provide a framework for waste rock management and site water management components of an adaptive management plan based on the waste rock and tailings management plan developed in response to R14b. The framework should specifically include a geochemical monitoring program to guide waste rock management decisions during operations, and a water quality monitoring program with established triggers to guide the implementation of mitigation measures such as collecting and treating contaminated mine water and seepage from waste rock storage piles and/or amending tailings and waste rock.

NATC has prepared an Adaptive Management Plan (Appendix C) as part of the Mactung Project Proposal in response to the information request above. The plan includes:

- A conceptual approach and timeline to monitor and assess the effectiveness of underground co-disposal of waste rock and tailings in mitigating potential effects of ARD/ML;
- An alternative conceptual plan for the long-term management of waste rock and tailings that does not include co-disposal in stopes above the natural water table; and
- A framework for waste rock management and site water management based on the alternative conceptual waste rock and tailings management plan.

2.10 Temporary Closure Plan

R15: Provide a plan for the temporary closure or suspended operations of the mine site. Include within the temporary mine closure plan measures to monitor and mitigate the potential ARD/ML conditions of the DSTF and WRSTA during temporary closure.

A Temporary Closure Plan (Appendix D) has been prepared as part of the Mactung Project Proposal in response to the information request above. The plan defines temporary closure and provides information on the measures to monitor and mitigate potential ARD/ML conditions in the event of suspended mining operations or a temporary closure. The plan concentrates on the management of the DSTF and the temporary surface Waste Rock Storage Facility. In addition, the plan outlines management of the general and ancillary site infrastructure.

3.0 GEOCHEMICAL ROCK CHARACTERIZATION

3.1 Waste Rock Geochemical Characterization

R16: Provide additional geochemical characterization of geologic units that make up the waste rock including kinetic testing. The geochemical characterization should be consistent with the MEND Report 1.20.1 "Prediction Manual Drainage Chemistry from Sulphidic Geologic Materials" (Price, 2009).

YESAB recognized and acknowledged in their letter dated March 6, 2013 that the complete results of the humidity test cells currently being run for the Mactung waste rock will be not be available to the Executive Committee prior to the completion of the assessment. However, NATC has provided some background information below on the samples currently included in the HTC program and how NATC will use these data when adequate data become available.

Humidity Cell (HC) test work has been initiated for six samples representative of the anticipated waste rock at Mactung. Twelve samples were collected by Mr. Dave Tenney of NATC in October 2012, and submitted for laboratory analysis in February 2013. The samples were submitted for pre-humidity cell static test work, consistent with that recommended by Price (2009), including acid-base accounting (ABA), ICP whole rock elemental analysis, and shake flask extraction (SFE) metal leaching analysis. ABA provides an initial indication if material has the potential to generate acid. ICP whole rock metals serves to identify which rock types have solid phase elemental concentrations that are of potential drainage chemistry concerns. Shake flask analysis is the recommended method to determine the mass of soluble constituents, at higher water to solid ratios.

The selection of six HC samples was based on a review of the sample lithological descriptions, static test results and spatial distribution within the proposed underground workings. Samples were selected to be representative of the two waste rock units (Unit 1 and Unit 3C as previously described in the YESAB submission (YOR #_2008-0304-177-2), Appendix B: Mactung Geochemical Characterization and Predictive Water Quality Modeling Report (EBA 2011), and to capture variability in sulphur and carbon content, geochemical composition, and acid generation potential.

In accordance with Price (2009), a well-flushed Humidity cell is the recommended kinetic test for prediction of reaction rates under aerobic weathering conditions. This information, along with the static information, is used in the predictive geochemistry.

Two HC's were started for Unit 1 waste rock and 4 HC's for Unit 3C waste rock on May 3, 2013. The six HC's are from the following samples:

- Sample #16360 - Unit 1 waste rock sampled from 368.2 m to 369.0 m in borehole MS223. This sample is located on the eastern extent of the proposed underground workings. This sample has a Sulphide sulphur content of 0.45 S%, and a sNPR value of 1.18 (classified as Uncertain ARD potential). The hand sample was described as having minor iron alteration on surface of the core, fine grained, grey brown colour containing epidote clays.

- Sample #16364 – Unit 1 waste rock sampled from 200.4 m to 201.1 m in borehole MS236. This sample is located on the western extent of the proposed underground workings. This sample has a Sulphide sulphur content of 1.66 S%, and a sNPR value of 0.21 (classified as Potentially Acid Generating, PAG). The hand sample was described as shiny clay rich with waxy texture, minor orange iron alterations with quartz banding and no visible sulphides.
- Sample #16353 – Unit 3 waste rock sampled from 53.5 m to 54.3 m in borehole MS187. This sample has a sulphide sulphur of 2.04 S% and a sNPR of 0.3. SFE tests indicated leachable uranium and selenium concentrations above the average. The hand sample was described as having few visible sulphides, no carbonates and high green clay content.
- Sample #16358 – Unit 3 waste rock sampled from 250.0 m to 250.8 m in borehole MS214. This sample has a sulphide sulphur content of 1.52 S% and sNPR of 0.74 (classified as PAG). SFE analysis gives indication of elevated leachable aluminium and iron concentrations. The hand sample was described as very clean, no surface oxidation, brownish grey, quartz veins, no visible sulphides or carbonates.
- Sample #16357 – Unit 3 waste rock sampled from 122.3 m to 123.1 m in borehole MS209. This sample has a sulphide sulphur content of 1.66 S% and sNPR of 1.02. It had a greater sulphide sulphur content than other samples, with a similar sNPR value. SFE and ICP metals show slightly higher aluminium, selenium and arsenic than other samples. The hand sample was described as very clean with no surface oxidation, fine grained quartz rich and mica poor with o visible sulphides or carbonates.
- Sample #16362 – Unit 3 waste rock sampled from 317.9 m to 318.7 m in borehole MS227. This sample has a sulphide sulphur content of 0.47 S%, and sNPR of 1.73 and was selected to represent the low end of sulphide sulphur content, and Uncertain classification. Static test work indicates that this sample has a slightly elevated arsenic concentration and it is located within the proposed underground workings. The hand sample was described as clean, fine grained with no visible sulphides or carbonates, minor quartz veining, light grey-brown with some clay.

As of September 20, 2013 the humidity test cells were in their 19th week of testing and are expected to be in operation for a minimum of 40 weeks, and potentially for several years prior to reaching a stable state. As data becomes available with regards to reaction rates and leachable metals, these data will be used to reduce uncertainty and improve confidence in the water quality modeling and leachate chemistry prediction. Specifically, data from these humidity cells will be used to replace the SFE and Tailings HC data which were used as surrogate data in the initial models (EBA 2011).

In addition to the updated geochemistry inputs, the mine design will also be refined as engineering studies progress, thus providing more accurate values for waste rock volumes, storage, mine plan and scheduling. Ultimately, this will provide long term testing and more refined predictive chemistry work, and feed into the water management strategy and closure planning for the site as detail design progresses on the project. These data and results will be made available to the Water Board and other regulatory agencies during the project permitting phase when they become available.

Following humidity cell test work, and based upon the detailed mine design, there is potential that field-based cells may be required to further refine predictive site geochemistry at later stages in the project. Field based cells will refine the humidity cell data by considering actual site conditions including weathering, particle size, site specific and long-term temperatures and humidity as well as evaluation of more long-term accumulation of secondary weathering products. If they are required, field cells would then be correlated with lab results to further reduce uncertainty in predictive geochemistry. We would anticipate evaluating the need for field cells at later stages in the project and the results would be reported to the appropriate regulatory agencies at that time.

3.2 Borrow Material and Quarry Rock Geochemical Characterization

R17: Provide additional geochemical characterization of geologic units that make up the borrow material and quarry rock to be used for construction purposes. The geochemical characterization should be consistent with the MEND Report 1.20.1 "Prediction Manual Drainage Chemistry from Sulphidic Geologic Materials" (Price, 2009).

NATC recognizes that additional geochemical characterization for quarry and borrow materials will likely be required before mine construction can proceed. At the detailed design stage of the project, the requirements for borrow materials and rock fill to be used during construction of the project will be determined. The final quantities of borrow and quarry materials will depend on the final mine design which will only be completed once it is determined that mining will be going ahead.

Geochemical characterization of borrow material and potential rock quarry materials will be carried out in accordance with MEND Report 1.20.1. Initially, geologic inspection of the rock, along with geotechnical testing to determine the suitability of the quarry or borrow material for the intended construction, will be evaluated. At this time, preliminary characterization of rock materials will be completed, including static acid base accounting test work and shake flask extraction metals leaching test work. The purpose of the geochemical characterization test-work will be similar to the geotechnical evaluation, in that, NATC will determine if the material is suitable for use as construction materials. It is possible that materials that undergo preliminary test work will be deemed unsuitable based on either geotechnical or geochemical results and will be rejected as quarry or borrow materials.

Each individual potential quarry or borrow source will be mapped geologically and assessed for variability. Samples will be collected in accordance with MEND 1.20.1, Table 8.2 (Price 2009), which bases the number of samples for assessment purpose on overall tonnage. Each quarry or borrow site will be treated separately and evaluated independently. Table 17-1 (from Price 2009) is included below for reference:

Table 17-1: Suggested Initial Sampling Frequency Based on Tonnage when Sampling without Prior Information (adapted from BCAMDTF 1989).

Tonnage of Unit (metric tonnes)	Minimum Number of Samples
< 10,000	3
< 100,000	8
< 1,000,000	26
< 10,000,000	80

Source: Price (2009)

Samples of fresh (unweathered) materials from each proposed quarry or borrow site will be collected to represent the geologic and spatial variability within each individual site. Laboratory analysis will be completed by an accredited laboratory, such as ALS that is familiar with the MEND guidelines and testing procedures.

If, based on preliminary assessment, the quarry and borrow materials are found to be suitable geotechnically, and then the static test work will be reviewed to evaluate the material for acid generation. Acid base accounting test work, including carbonate and sobek neutralizing potential values, and total sulphur and sulphate analysis will be assessed. Initial classification of borrow sources and quarry rock will be made based on the net potential ratio (NPR) of neutralization potential (NP) to acid generation potential (AP) in accordance with the criteria described in section 14.2.1 of MEND Report 1.20.1 where:

- A sample is potentially acid generating (PAG) if the NPR is less than 1;
- A sample is non-PAG if the NPR is greater than 2; and
- A sample is "uncertain" if NPR is greater than 1 or less than 2.

SOBEK NPR will be calculated using SOBEK NP values and Carbonate NPR will be calculated based on Carbonate NP values. SOBEK and Carbonate NPR values will be compared to evaluate whether or not a significant amount of NP comes from the slower reacting silicate minerals, or from the faster reacting carbonate minerals. In the event that SOBEK NPR and Carbonate NPR values differ significantly (i.e., the sample classification is affected by which methodology is used) additional work such as petrographic studies may be required prior to proceeding with sourcing borrow or quarry materials from the potential quarry location.

Assuming materials pass both geotechnical requirements and are also evaluated to be non-acid generating, shake flask extraction metal leaching test work will be used to evaluate the potential for neutral metal leaching potential from the potential borrow and quarry sites. Metal leachate results will be compared to the site-appropriate standards for water quality and site information such as location, environmental receptors, dilution, and ecological risk will be evaluated.

In the event that a particular borrow or quarry site does not meet the geotechnical or geochemical standards (i.e., PAG or ML materials), alternative quarry sites that meet the requirements will be used. In the event that there are no suitable borrow or quarry sites available for construction, or if all quarry sites are established to be PAG or ML, additional kinetic test work would be carried out to establish mitigation measures.

4.0 EFFECTS TO FISH AND FISH HABITAT

R18: Provide the results of studies that identify riparian zones and fish habitat along Tributary C and Hess River South Tributary that may be affected by the impacts of a reduced flow due to the Project.

The results of studies identifying fish habitat and vegetation within the riparian zones along Tributary C and Hess River South Tributary were presented in Section 4.1.11, Aquatic Ecosystems and Fisheries Resources, of the 2008 YESAB Mactung Project Proposal. The 2006, 2007, and 2008 fisheries and aquatic resources baseline study reports were previously provided to YESAB in the following Project Proposal appendices:

- Appendix I1: 2006 Environmental Baseline Studies, Fisheries and Aquatic Resources Report;
- Appendix I2: 2007 Environmental Baseline Studies, Fisheries and Aquatic Resources Report; and
- Appendix I3: 2008 Environmental Baseline Studies, Fisheries and Aquatic Resources Report.

A summary of the fish habitat and riparian zone information for Tributary C and Hess River South Tributary from Appendices I1 to I3 is provided in Table R18-1 and Table R18-2, respectively and Figure R18-1 illustrates the fish assessment locations.

According to the results of the 2006, 2007, and 2008 fish and aquatics baseline studies, Tributary C was considered to provide good overall fish habitat, including habitat for Dolly Varden (*Salvelinus malma*), which were captured during the 2007 fish sampling efforts. Tributary C is primarily fed from the main valley, with headwaters that begin inside the Mactung Project footprint area. The fish and fish habitat assessments found areas of suitable fish habitat, which potentially satisfy all major habitat needs for Dolly Varden, including spawning, nursery, migration, and over-wintering habitats. Fish habitat observations included deep pools, riffle habitats, and extensive undercut banks with woody debris structures. Benthic resources were also found to be diverse and abundant at site FS6.

However, during the fish assessments, seasonal and permanent barriers to fish passage were identified within Tributary C (Figure R18-1). Although habitat features at FS10 appeared to be suitable for fish, this area is assumed to have limited fish use due to steep gradients and potential barriers downstream. The upper reaches of Tributary C, located within the Project footprint area, are considered non-fish bearing due to the impassable waterfall barrier (upstream of FS10).

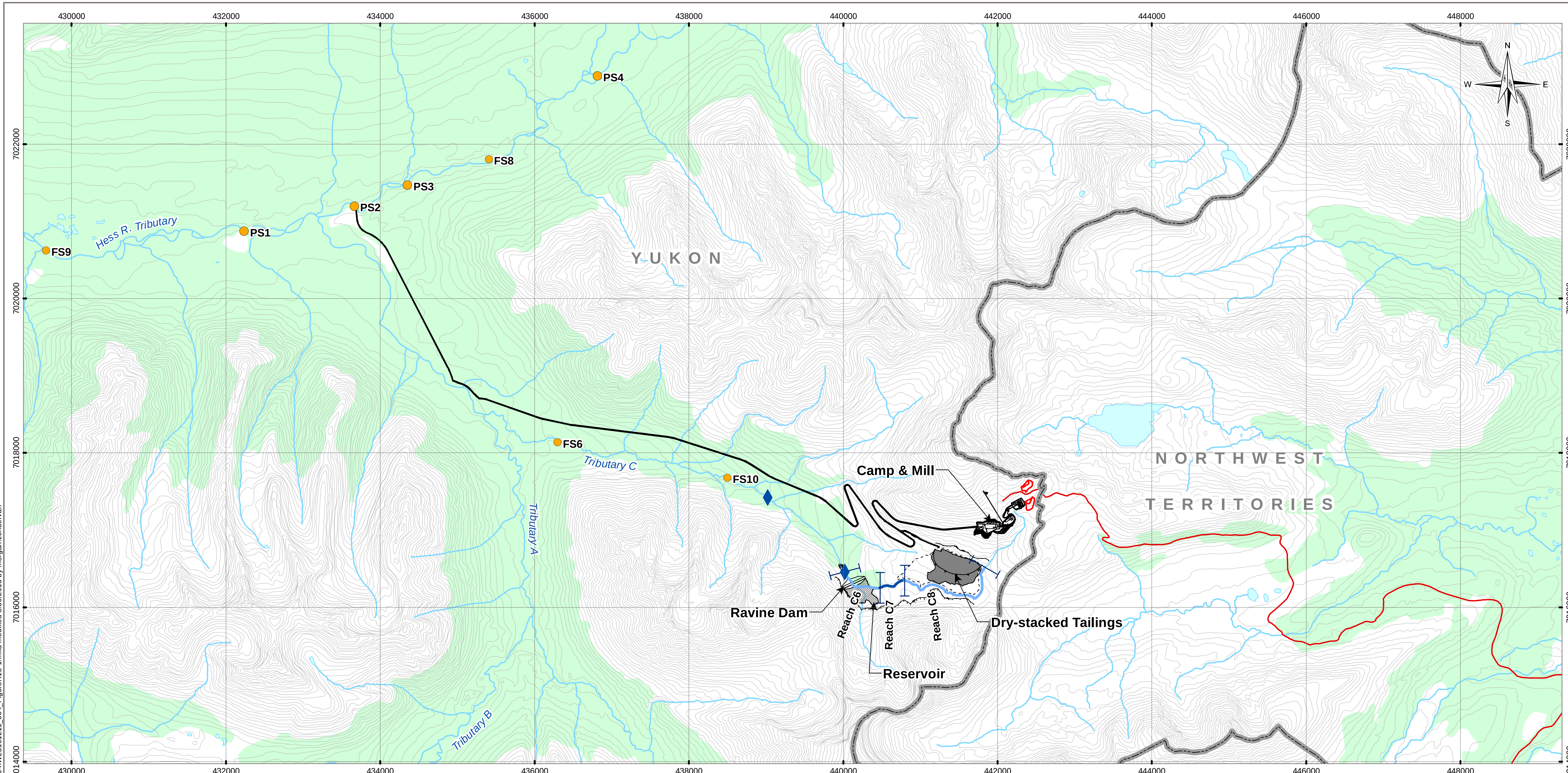
Following a further review of the existing data, it is apparent, as stated in previous reports, that Tributary C provides feeding, nursery, and migration habitat for Dolly Varden. However, existing evidence suggests that Tributary C does not provide suitable spawning and overwintering habitat for these fish. Given the winter conditions and high elevations of the study area and the high probability of Tributary C freezing to bottom in most sections of the watercourse, fish and egg survival (from spawning) during winter months is considered unlikely. In the previous reports, it was noted that Tributary C contained deep pools, which would be suitable for overwintering; however, according to the depth measurements, no deep pools (i.e., greater than one metre depth) (Johnston and Slaney 1996) were recorded. The fish observed during summer surveys are presumed to move up into Tributary C from the Hess River South Tributary to feed. These fish would then move back to higher order streams to overwinter and spawn.

In areas where fish were found, riparian vegetation consisted of mature spruce forest and willows (*Salix* spp.) with understory vegetation dominated by moss and species such bearberry (*Arctostaphylos uva-ursi*). Sedge (*Carex* spp.) and subalpine fir (*Abies lasiocarpa*) with moss understory wasere also observed in the lower reaches of Tributary C. The non-fish bearing reaches of Tributary C were located at or above the treeline limit. Riparian vegetation at the treeline comprised shrubs with herbaceous cover. In areas where Tributary C extended into the alpine zone, little to no vegetation was present (Table R18-1). No changes to the riparian composition or function are expected since the changes in flow are not expected to significantly impact the wetted channel of Tributary C.

According to the results of the 2006 and 2007 fisheries and aquatics baseline studies, the Hess River South Tributary, both upstream and downstream of the proposed pumping infrastructure location, were found to provide suitable habitats for fish migration, over-wintering, and rearing. In general, the Hess River South Tributary was found to provide a good distribution of habitat types, including side channels, undercut banks, back eddies, riffle sections, deep pools, and off-channel pools.

However, in 2008, EBA conducted fall and early winter fish assessments of the Hess River South Tributary to better understand the degree to which Dolly Varden and other species were using the Hess River South Tributary for spawning and overwintering. Observations noted that by early fall, many off-channel habitats had dried or been reduced in size and overall fish presence and habitat use appeared to be seasonal. While the earlier baseline studies suggested that fish may use the Hess River South Tributary for spawning and overwintering, the lack of fish presence during the 2008 fall and early winter sampling suggests the Hess River South Tributary within the Project area does not provide significant spawning or overwintering habitats for sport fish species such as Dolly Varden and Arctic grayling (*Thymallus arcticus*).

Riparian vegetation along the Hess River South Tributary consisted of mature spruce forest, willows, and scrub birch (*Betula glandulosa*) with moss and sedge understory. Subalpine fir was also observed in higher areas of the watershed (Table R18-2). No changes to the riparian composition or function are expected since the changes in flow are not expected to significantly impact the wetted channel of the Hess River South Tributary.



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LEGEND

- Sampling Location
- Barrier
- Reach Break
- Existing Road
- Proposed Road
- Temporary Waste Rock Dump
- NWT-YT Border
- Contours (20 m)
- Watercourse
- Waterbody
- Vegetation

NOTES
Base data source: 1:50,000 NTS

STATUS
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Fish Assessment Locations

PROJECTION	DATUM	CLIENT
UTM Zone 9	NAD83	NORTH AMERICAN TUNGSTEN CORPORATION LTD

Scale: 1:50,000
1 0.5 0 1
Kilometre

FILE NO.
W23101211_004_FigureR18-1.mxd

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PROJECT NO.	DWN	CKD	APVD	REV
W23101211.004	MEZ	X	JL	0

OFFICE	DATE
EBA-VANC	August 30, 2013

Figure R18-1

Table R18-1: Fish Habitat Descriptions for Tributary C

Reference Document	Site	Riparian Zones	Fish Habitat Descriptions
Appendix I1 2006 Environmental Baseline Studies Fisheries and Aquatic Resources Report	FS6	▪ Predominantly willow and sedge with sub alpine fir (*Abies lasiocarpa*) ▪ In higher areas, sedge and forb (*Mertensia paniculata*, *Senecio triangularis*) or sphagnum moss understory.	▪ Wetted width of 7.0 m, channel width of 11.4 m ▪ Channel substrates predominantly boulders with some cobbles and gravels ▪ Stream morphology consisted of 20% pool, 30% run and 50% riffle ▪ Water depths approx. 20 cm in the riffles, 40 cm in the pools ▪ Cover was approx. 10% and consisted of deep pools, boulders, undercut banks, and overstream vegetation ▪ Rapids, a steep gradient, and small falls observed downstream could be an obstruction to fish passage.
Appendix I2 2007 Environmental Baseline Studies Fisheries and Aquatic Resources Report	FS6	▪ Riparian vegetation varied between mature spruce forest with willow shrub and tall willow shrub ▪ Understory vegetation was dominated by bearberry, mosses, lichens, Labrador tea, and blueberry.	▪ Wetted width of 4.8 m, channel width of 6.3 m ▪ Mean channel depth was 25 cm with a maximum channel depth of 31 cm ▪ Stream morphology consisted of fast flows with approx. 30% riffles, 25% cascade, 25% pool, and 20% run habitats ▪ Channel substrate consisted of boulders to small gravels with cobbles frequent ▪ Cover was approx. 45% and consisted of surface turbulence, overstream vegetation, undercut banks, and deep water ▪ The meandering channel provided potentially suitable spawning, migration, nursery, and feeding habitats.
	FS10	▪ Riparian vegetation was dominated by tall willow shrub and understory consisting of *Equisetum* and *Epilobium*.	▪ Wetted width of 1.8 m, channel width of 2.1 m ▪ Mean channel depth was 35 cm with a maximum channel depth of 52 cm ▪ Channel gradient was steep with stream morphology consisting of approx. 60% cascades, 25% riffle, 10% pool, and 5% runs ▪ Stream substrate dominated by boulders and larger cobble (70% aggregate) with smaller components of cobbles and gravel ▪ Cover was approx. 40% consisting of surface turbulence, overstream vegetation, deep pools, and small woody debris ▪ The frequently confined channel potentially provided suitable migration and feeding habitats, but several potential (small) barriers to fish passage were apparent in a reconnaissance between FS6 and FS10.
Appendix I3 2008 Environmental Baseline Studies Fisheries and Aquatic Resources Report	Reach C6*	▪ Riparian vegetation consisted of tall shrub and herbaceous cover and was located near the upper tree line limit.	▪ Stream characterized by step-pools with large boulders and steep gradient. Flatter portions of the stream contained riffles dominated by cobbles. Reach is above the treeline and cover is minimal (small or medium sized shrubs).
	Reach C6 Sub-tributary*	▪ Sub-tributary extended into the alpine zone and consisted of little to no vegetation.	▪ Stream substrates consisted of fines and supported no vegetation.
	Reach C7*	▪ Reach was characterized by a canyon with no vegetative cover.	▪ Bedrock controlled the canyon with large cascades and high energy flow. Considered a barrier to fish passage. No vegetative cover.
	Reach C8*	▪ Reach located in the alpine plateau therefore minimal riparian vegetation.	▪ Stream generally low slope across the alpine plateau. Deep channel is dominated by fines and gravel and confined by deep vegetated banks. Minimal overhead cover, although overhanging banks are frequent. Many small tributary feeders form a network of streams. Stream consists of riffle run morphology.

Notes: *Full fish habitat assessments were not conducted for Tributary C in 2008. Observations of riparian vegetation and fish habitat were recorded during fish sampling.

Table R18-2: Fish Habitat Descriptions for Hess River South Tributary

Reference Document	Site	Riparian Zones	Fish Habitat Descriptions
Appendix I1 2006 Environmental Baseline Studies Fisheries and Aquatic Resources Report	FS8	▪ Riparian vegetation was predominantly willow and sedge with sub alpine fir in higher areas and a sedge and forb or sphagnum moss understory.	▪ Estimated wetted width of 14 m and a channel width of 15 m ▪ Water depths could not be determined due to deep and fast flowing water ▪ Channel substrates consisted of small and large cobbles, boulders and gravels ▪ Channel morphology consisted of 60% rapids and 40% runs ▪ Cover was approx. 10% and consisted of boulders and overstream vegetation.
	FS9	▪ Riparian vegetation was predominantly willow and sedge with sub alpine fir in higher areas and a sedge and forb or sphagnum moss understory.	▪ Reach was braided over a large area with a wetted width of 9.4 m and a channel width of 19.8 m ▪ Water depths were 35 cm in the riffles and 70 cm in the runs ▪ Channel substrates consisted of small and large cobbles, boulders and gravels ▪ Channel morphology consisted of 50% riffle, 30% pool, and 20% run ▪ Cover was approx. 40% and consisted of deep pools and undercut banks ▪ Numerous side channels were observed.
Appendix I2 2007 Environmental Baseline Studies Fisheries and Aquatic Resources Report	FS8	▪ Riparian vegetation consisted of willows, birch shrub, and mature spruce with moss and sedge understory.	▪ Wetted channel was 19 m with mean and maximum water depths of 51 cm and 62 cm, respectively ▪ Channel morphology consisted of 70% rapids, 15% riffles, and 15% pools ▪ Channel substrates consisted primarily of cobbles with gravels, boulders and fines ▪ Cover was approx. 40% and consisted of surface turbulence with some overstream vegetation, undercut banks, and deep water.
	FS9	▪ Riparian vegetation consisted of willows, birch shrub, and mature spruce with moss and sedge understory.	▪ Estimated wetted width and channel width were 15.5 m and 17 m, respectively ▪ Water depths could not be determined due to deep, fast flows ▪ Channel morphology consisted of 50% runs, 25% riffle, 15% pool, and 10% cascades ▪ Cover was approx. 7% and consisted of surface turbulence, overstream vegetation, undercut banks, and small woody debris.
Appendix I3 2008 Environmental Baseline Studies Fisheries and Aquatic Resources Report	PS1, PS2, PS3 (FS8), and PS4	▪ Full fish habitat assessments were not conducted, only observations of fish habitat during fish sampling.	▪ Fish assessments conducted in July identified the presence of deep pools, off-channel pools and off-channel areas with calm currents, side channels, undercut banks, back eddies, and riffle sections ▪ Additional habitat at PS2 consisted of overhanging vegetation, boulders, and slow current ▪ A large pool was observed near PS1, PS2, and just downstream of PS4 ▪ By early October many side channels and shallow habitats were dewatered and/ or frozen.

R19: Develop a prediction of potential impacts to fish and fish habitat due to the reduction of flow in Tributary C resulting from the construction of the ravine dam and seepage dams and mine operations. Develop a prediction of potential impacts to fish and fish habitat due to the water withdrawal from the Hess River South Tributary. These predictions will include an analysis of the amount and type of fish habitat likely to be affected in both Tributary C and the Hess River South Tributary. Identify mitigation measures, including potential fish habitat compensation measures that will minimize the effects to fish and fish habitat.

Tributary C

Potential impacts to fish and fish habitat due to the reduction of flow in Tributary C resulting from the construction of the ravine dam, seepage dams, and mine operations are expected to be minimal. Information Request Response R8 of this submission indicated that the catchment area of Tributary C immediately upstream of the reservoir is 5.0 km^2. Water from approximately half of this catchment area will be diverted (catchment area of 2.45 km^2) downstream to maintain flow in the lower sections below the reservoir, while the other half will be un-diverted (catchment area of 2.51 km^2) and used to fill the reservoir during construction and for use during mine operations. Reduction of flows in Tributary C will therefore only be attributed to this un-diverted area in the headwaters of Tributary C. Approximately 10% of the Tributary C watershed will be diverted, resulting in a limited reduction of flows overall downstream.

During construction of the ravine dam and during mine operations, Tributary C will have an average reduction in flow of 50% immediately downstream of the reservoir (Table R8-6). As indicated in the baseline studies, the headwaters and upper reaches of Tributary C (above FS10) are considered non-fish bearing, therefore effects to fish and fish habitat as a result of reduced flows in these sections are not expected. Due to natural attenuation of water from side tributaries and runoff flowing into Tributary C downstream from the reservoir, the flows in the fish bearing reaches of Tributary C will be supplemented naturally. Average flows at FS6 (fish bearing reach of Tributary C) during summer and fall months will primarily be higher than baseline flows (within 6%) as a result of discharging water from the reservoir. Average flows at FS6 during winter months when no water will be discharged from the reservoir will be within 12% of baseline flows (Table R8-6). These flows are considered to be within the natural variability of the stream. As indicated in the review of the existing 2008 baseline studies, Dolly Varden and Arctic grayling are not likely to be spawning or overwintering in Tributary C during the winter months when flows will be at their lowest levels.

Effects Characterization

Approximately 50% of the catchment area in the upper reaches of Tributary C will be affected by the construction of the ravine dam and associated mine infrastructure. A permanent diversion channel is planned that will maintain downstream flow. Construction of the mine infrastructure will result in a 50% reduction in flow in Tributary C immediately downstream of the ravine dam. While temporary fluctuations to flow are predicted during these works, flows downstream in the fish bearing reaches of Tributary C are expected to remain within the range of natural variability (Table R8-6).

No effects in the upper reaches of Tributary C, immediately downstream of the ravine dam are anticipated from reduced flow as the upper reaches are considered non-fish bearing. No effects in the downstream fish bearing reaches of Tributary C are anticipated from reductions in flow resulting from the construction of the reservoir or mine operations, as flow is estimated to be reduced by approximately 12% during winter months, but modestly increased during summer months (Table R8-6). These flow changes are considered to be within the natural variability of the stream.

Mitigation Measures

While the anticipated effects of construction activities and mine operations on local watercourse flows are minimal, a permanent diversion channel will be constructed to maintain downstream flow and to minimize fluctuations in flow in the lower reaches of Tributary C.

Significance Determination

Following the implementation of mitigation measures, residual effects of construction of the ravine dam and mine operations on fish and fish habitat as a result of reduced flows are anticipated to be low in magnitude. Risks to downstream fish and fish habitat are not expected.

Hess River South Tributary

Water withdrawal from the Hess River South Tributary for operation of the mill and camp is expected to be 9.2 L/sec (0.0092 m^3/sec). The lowest recorded flows in the Hess River South Tributary occurred in March 2008 with a volume of 0.14 m^3/sec (Table R3-1). If compared to the lowest winter flows of 0.14 m^3/sec, water withdrawal for mine operations is expected to reduce flow in the Hess River South Tributary by approximately 6.6%, which is considered to be within the natural variability of the river. Peak average flows for the Hess River South Tributary in June was 15.82 m^3/sec (Table R3-1). Water withdrawal during freshet is <0.01%, which is considered an insignificant reduction in flows. As a result, no impacts to fish and fish habitat due to the limited water withdrawal from the Hess River South Tributary for mine operations are expected to occur.

Effects Characterization

Stream flows are not expected to change significantly in the Hess River South Tributary as a result of the proposed water withdrawal of 9.2 L/sec for construction and mine operations. As a result, no effects to fish and fish habitat are anticipated from the reduction in flow resulting from water withdrawal from the Hess River South Tributary.

Mitigation Measures

No mitigation measures are required.

Significance Determination

No residual effects are expected to occur to fish and fish habitat as a result of the limited water withdrawal from the Hess River South Tributary. As a result, no risks to downstream fish and fish habitat are expected to occur.

5.0 ACCESS ROAD TO THE MACTUNG MINE

R20, R21, R22, R23:

As Per YESAB, March 6, 2013: "A response to R20, R21, R22 and R23 is no longer required as a result of the proposed road being withdrawn from the Project Proposal". (See YOR #2008-0304-294-1).

6.0 HERITAGE RESOURCES AND TRADITIONAL LAND USE

R24: Provide the results of a study that identifies heritage resources and traditional land uses which may be affected by the proposed access road. NATC shall make best efforts to involve Ross River Dena Council, Liard First Nation and First Nation of Nacho Nyak Dun in the design and conduct of the study. Include in the results, mitigative measures to minimize the effects of the Project to heritage resources and traditional land uses.

See NATC cover letter.

7.0 WILDLIFE

R25: Address the following concerns identified during the review period regarding the effects of the proposed access road, pipeline and mine site on caribou, grizzly bear, sheep and moose:

a) Lack of seasonal data regarding habitat, populations, and distribution for sheep, moose, grizzly bear and caribou.

b) Effects to key habitats for grizzly bear (e.g., denning areas).

c) Effects on the frequency of use and access to mineral licks for all identified species.

The wildlife baseline data reports that were included in Appendix G of the Project Proposal and submitted to YESAB in 2008, and which formed the basis of the wildlife effects assessment component of the Project Proposal, are listed below:

1. EBA 2005. Environmental Baseline Studies 2005. Preliminary Wildlife Survey, Mactung Project, Yukon.
2. EBA 2006. Mactung Project. 2006 Environmental Baseline Studies Wildlife Report.
3. EBA 2007. Mactung Project. 2007 Environmental Baseline Studies Wildlife Report.
4. EBA 2008. Summary of Late Winter Ungulate Survey, March 26, 2008.
5. EBA 2008. Mactung Project. 2008 Environmental Baseline Studies Wildlife Report.

Since the above studies and reports were completed, there has been an important change to the original project scope. The proposed access road to the mine site in the Yukon was withdrawn from the Project Proposal by NATC in a letter to YESAB, dated February 26, 2013. As a consequence, NATC believes that some of the potential effects of the project on wildlife and wildlife habitat in the Yukon have been greatly reduced as NATC's preferred access to the project site is now the existing access road that starts from the North Canol Road in the NWT and extends back into the Yukon. NATC recognizes that the change to the project scope does not completely remove all the potential effects to wildlife and additional information is provided below.

Survey Methods and Seasonal Data

The survey methods used to document wildlife, particularly ungulates (i.e., sheep, caribou, moose, and goats) are detailed in each of the wildlife reports listed above. The survey methods selected for the 2005, 2006 and 2007 surveys were based on previous surveys completed at site that included flying fixed-width transects (Kershaw and Kershaw 1983), thereby allowing for a comparison of recent and historic data.

The 2008 survey methods were also based on the fixed-width transects but the east-west alignment was altered to maximize sight lines and take account of the topographical features. The 2008 surveys were focused on the proposed new access road (now withdrawn from the Project Proposal) but still provide useful regional data for use in the project effects assessment, as the study area overlaps with study areas from previous years. The survey methods used in each of the studies were described in the Wildlife Research Permit applications that were submitted to the Yukon Government prior to the surveys taking place. The Wildlife Research Permits were subsequently approved and issued by the Yukon Government.

Historical data and reports regarding woodland caribou in the project area indicate there is a movement of caribou in the fall and winter from the local study area to lower elevations to the east of the project site. These data are supported by NATC's own studies that reported higher numbers of caribou at lower elevations outside the local study area in September (EBA 2006; 2007), and in October, 2008 (EBA 2008). Consequently, winter surveys for caribou were not completed. The summer wildlife surveys in 2006, 2007 and 2008 indicate that woodland caribou are present throughout the local and regional study areas. The 2008 study indicates a concentration of summer caribou populations along the proposed access road that has now been withdrawn from the Project Proposal. All of this information from the reports and the assumptions were taken into account as part of the project effects assessment.

Most of the moose counts for each of the study years were at lower elevations within the local study area or outside the local study area. Moose were assumed to be using these areas throughout the different seasons and this was taken into consideration in the effects assessment in the Project Proposal.

There have only been a total of two observations of Dall's sheep during the 2005 to 2008 surveys completed in the Mactung project area. The 2008 wildlife survey allowed for a more targeted survey to be conducted due to the changes in elevation by helicopter around mountainous terrain and one of the two Dall's sheep was recorded at that time. Several signs of sheep (tracks, droppings) were recorded during the surveys.

Although sheep habitat exists in the Mactung project area, the harshness of the winter climatic conditions are believed to influence the number of sheep using the area around the Mactung project. NATC believes that additional targeted surveys for Dall's sheep at any time of the year is not warranted, given the very low numbers, and lack of groups of sheep detected during the four years of surveys completed for this project to date. NATC is committed to minimizing the effects of the project on wildlife and, as such, has previously provided a number of mitigation measures to YESAB. Many of these measures would equally apply to Dall's sheep as they would other wildlife.

NATC recognizes that the proposed Mactung project may have potential effects on wildlife. However, with the elimination of the proposed Yukon access road from the overall project scope, and once the magnitude, duration, and reversibility of the project are taken into consideration, the effects of the project on wildlife are considered by NATC to be low. Any additional wildlife studies or monitoring that may be deemed useful by NATC as the project progresses through the regulatory processes can first be discussed and planned with Yukon Government biologists.

Grizzly Bears

To determine the effects of the proposed Mactung project on key habitat for grizzly bears within the Wildlife Regional Study Area for the Mactung mine site, a cumulative effects assessment (CEA) model and denning spatial analysis has been completed. This assessment is included in full as Appendix E. The CEA model includes three main components: habitat effectiveness, security areas and linkage zones. In addition, suitable habitat for grizzly bear denning was also mapped.

With the exception of potential effects to the availability of secure areas in a few bear management areas (BMUs), the results of these CEA models suggest that the development and operation of the Mactung Project will result in minimal cumulative effects on grizzly bears and their habitat.

Road Access and the Mineral Lick

As documented in the 2006 and 2008 Mactung wildlife reports, the mineral lick located close to the Hess River South Tributary (Figure R26-1) is heavily used by ungulates – primarily moose, with some evidence of sheep and caribou also using the area. The frequency and seasonal use of this mineral lick is not known.

In August 2013 NATC initiated a program to document the use of the mineral lick by installing a digital camera in the area of the mineral lick that takes images when motion is detected within 40 feet of the camera. NATC intends to use the images obtained by the camera to gain an understanding of the frequency and seasonality of use of the mineral lick. The information can then be used in the following two ways:

- To help schedule the most appropriate time for the construction of project infrastructure in the area, and
- Possibly allow for scheduling of equipment checks and maintenance at the pump house during mining operations to help minimize potential disturbance to wildlife in the vicinity of the mineral lick.

It should be noted that the main project activity in proximity to the mineral lick will be the proposed service road to the pump house. This service road will be located a minimum of 600 m from the mineral lick and, during operations, will have very low and infrequent traffic volumes consisting mainly of light vehicles to allow personnel to complete daily inspections and maintenance of the pumps at the Hess River

South Tributary. As previously stated in Addendum I of the Project Proposal (YOR #2008-0304-086-2, page 206), placing the service road farther than 600 m from the mineral lick would position the road farther up hill, thereby increasing the potential for any noise and visual effects on the wildlife using the mineral lick.

8.0 ALTERNATIVE WATER SOURCE

R26: Describe whether the Tsichu River or a tributary of the Tsichu River has been considered as an alternative source of water and indicate whether it is feasible to utilize this source of water for the intended purposes.

As the conceptual mine plan was being developed by NATC in 2007, potential sources of water for the project were considered. The potential sources of water included Dale Creek, which crosses the existing access road to the Mactung site, in the Northwest Territories (NWT), the Tsichu River (downstream of Dale Creek), and the Hess River Tributary, approximately 9.5 km west of the proposed mine site, Yukon Territory (Figure R26-1). The criteria used to decide which of the water sources best suited the project were:

- The distance and location of the water source relative to the mine site;
- The method and engineering required to transport the water;
- The volume of water required at the mine site;
- The seasonal volumes of the water available at the potential source; and
- The location of the receiving environment for discharge water.

Dale Creek (NWT), an upstream tributary of the Tsichu River, was not considered suitable as a water source for the following reasons:

- It does not provide high enough volumes of water year-round to supply the proposed mine. The hydrology studies conducted on Dale Creek in 2006 and 2007 indicate that the water volumes are about 8 to 10 times lower than in the Hess Tributary.
- Dale Creek and its associated watershed are within the NWT jurisdiction while the mine and associated mine discharge would be within a watershed in the Yukon Territory. This creates an added level of complexity with respect to permits and also moves water between watersheds.

The Tsichu River (NWT), downstream of Dale Creek, was not considered to be a suitable option for the following reasons:

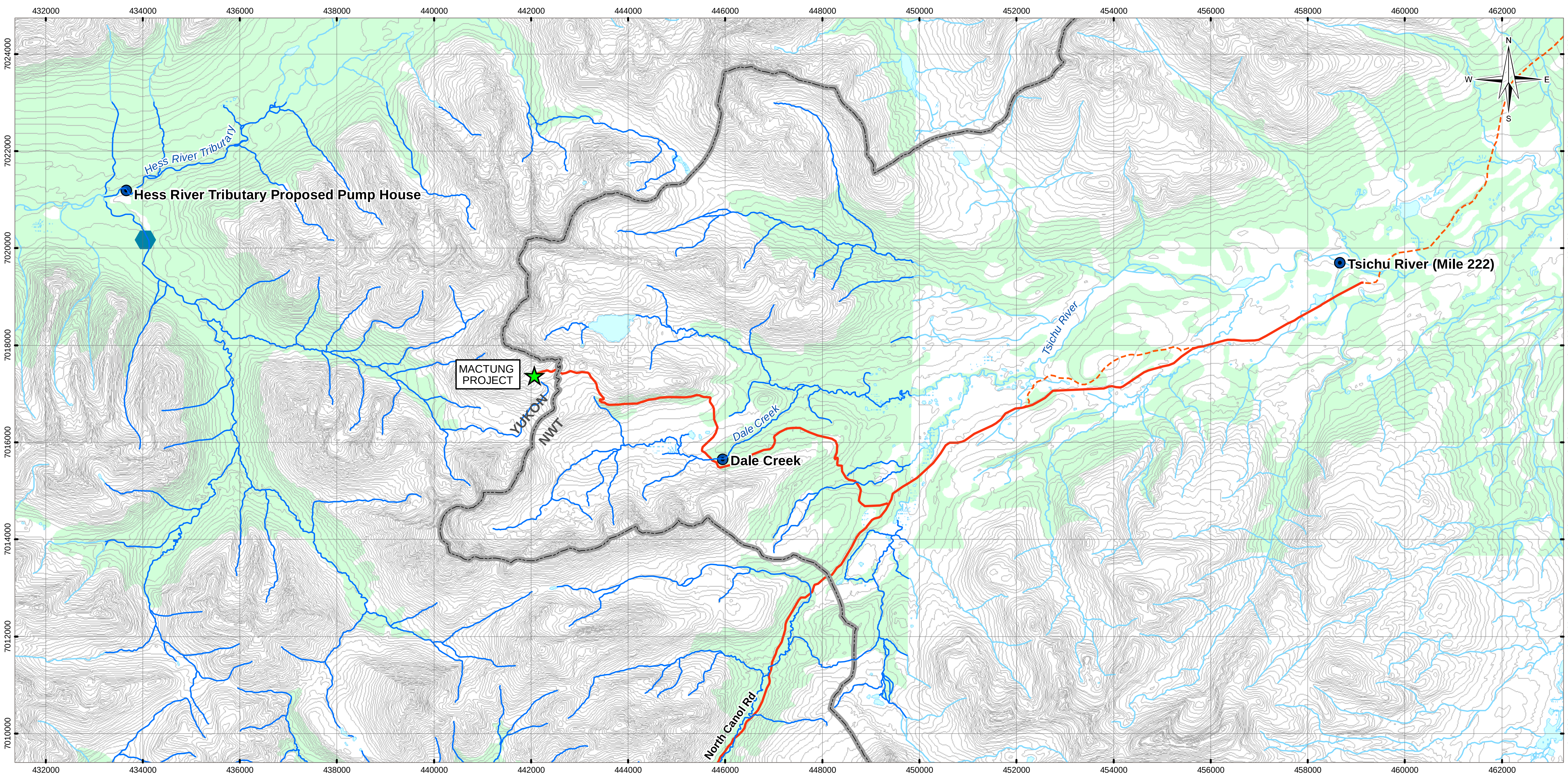
- A review of available hydrological data (1976 to 1992) for the Tsichu River completed in 2007 indicated that there may be periods of 2 to 3 weeks when there would not be sufficient water to supply the mine (EBA 2007).
- It is much farther from the proposed mine site than the other potential water sources. For example, the most likely location for water withdrawal would be close to Mile 222 on the North Canol Road which is

approximately 17.5 km east of the proposed mine site. The proposed Hess Tributary pump house location, by comparison, is approximately 9.5 km west of the proposed mine site.

- The Tsichu River and its associated watershed are within the NWT jurisdiction while the mine and associated mine discharge would be within a watershed in the Yukon Territory. This creates an added level of complexity with respect to permits and also moves water between watersheds.

The Hess River Tributary was considered to be the best option for the source of mine water for the following reasons:

- It has adequate year-round flow to supply the mine with water;
- It is within a reasonable distance from the proposed mine location (about 9.5 km);
- The discharged water from the mine is ultimately being returned to the same watershed and jurisdiction (via Tributary C); and
- The engineering required to design and install the pipeline is relatively simple.



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LEGEND

- Mactung Project
- Water Supply Options
- Known Mineral Lick Area
- Road
- Trail
- Contours (20 m)
- NWT-YT Border
- Watercourse
- Waterbody
- Wetland
- Vegetation

NOTES

Base data source:
Existing Roads copied from CanVec, digitized from Aerial photographs and Google Earth Imagery

STATUS
ISSUED FOR USE

MACTUNG PROJECT

Water Supply Options

PROJECTION	DATUM	CLIENT
UTM Zone 9	NAD83	NORTH AMERICAN TUNGSTEN CORPORATION LTD

Scale: 1:80,000

1 0.5 0 1

Kilometre

FILE NO.
W23101211_004_FigureR26-1.mxd

EBA A TETRA TECH COMPANY

PROJECT NO.	DWN	CKD	APVD	REV
W23101211.004	MEZ	GR	GR	0

OFFICE	DATE
EBA-VANC	August 16, 2013

Figure R26-1

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APPENDIX A & B (CD)

GOLDSIM PROGRAM (R9)

WATER QUALITY PREDICTION MODEL INPUT FILES (R11)

APPENDIX C

ADAPTIVE MANAGEMENT PLAN (R14)

APPENDIX D

TEMPORARY CLOSURE PLAN (R15)

APPENDIX E

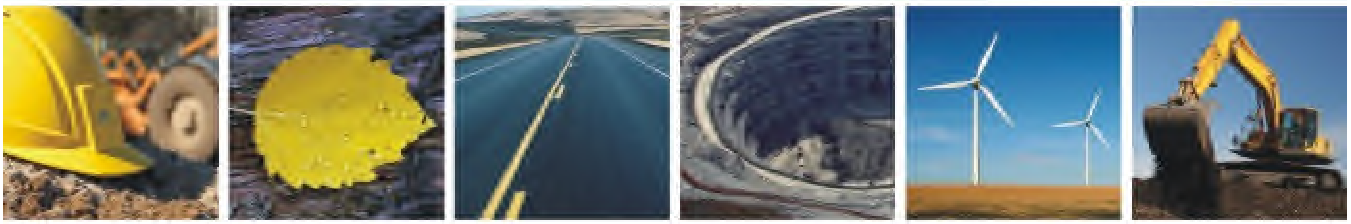
GRIZZLY BEAR CUMULATIVE EFFECTS MODEL REPORT (R25)

APPENDIX F

WATER TREATMENT PLANT INFORMATION (R13)

NORTH AMERICAN TUNGSTEN CORPORATION

ADAPTIVE MANAGEMENT PLAN FOR THE CO-DISPOSAL OF WASTE ROCK AND TAILINGS UNDERGROUND, ABOVE THE WATER TABLE



REPORT

SEPTEMBER 2013
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ACRONYMS & ABBREVIATIONS

ABA	Acid Base Accounting
AMP	Adaptive Management Plan
ARD/ML	Acid Rock Drainage and Metal Leaching
DSTF	Dry Stack Tailings Facility
EBA	EBA Engineering Consultants Ltd.
MEM	BC Ministry of Energy and Mines
MMER	Metal Mining Effluent Regulations (Department of Fisheries and Oceans 2002).
NATC	North American Tungsten Corporation
SFE	Shake Flask Extraction
YESAB	Yukon Environmental and Social-economic Assessment Board

LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of North American Tungsten Corporation and their agents. EBA Engineering Consultants Ltd. does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than North American Tungsten Corporation, or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this report is subject to the terms and conditions stated in EBA's Services Agreement. EBA's General Conditions are provided in Appendix A of this report.

1.0 INTRODUCTION

EBA Engineering Consultants Ltd. operating as EBA, A Tetra Tech Company (EBA) has prepared an Adaptive Management Plan (AMP) pertaining to the future disposal of tailings and waste rock material at North American Tungsten Corporation's (NATC) proposed Mactung Mine.

The intention of the AMP is to implement an approach to the handling of waste rock and tailings such that actual data are used as a basis for the selection of the appropriate techniques applied to tailings and waste rock management and the associated potential environmental impacts.

1.1 Underground Backfill Concept for Mactung

The mine plan (Annual Amended Technical report on Mactung Property, April 2009; Mactung Mine Project Proposal, 2008) includes co-disposal of waste rock and tailings material underground in mined-out stopes. The implementation of this strategy will serve to reduce the total volume of waste rock and tailings to be stored on surface and will also reduce the amount of exposure to oxygen and water which in turn will mitigate the potential generation of ARD/ML.

NATC has proposed that tailings and waste rock are placed in underground excavations behind bulkheads constructed to minimise oxygen ingress into the stopes. Figure 1 shows a conceptual layout of an underground backfilled stope.

The BC Ministry of Energy and Mines (MEM), Guidelines for Metal Leaching and Acid Rock Drainage at Mine sites in British Columbia (1998), Drebenstedt et al (2009) and MEND report 9.1b (2005) discuss strategies for backfill placement in underground excavations and the management of potential acidic leachate. These reports discuss the use of bulkheads to contain the underground backfill and the exclusion of oxygen as key to the mitigation of ARD/ML in underground disposal methods.

NATC plans to undertake underground mining through two methods; longhole open stoping and cut and fill mining. Both these methods can include backfilling of the underground excavations. NATC is confident that backfilling is a suitable option for waste rock and tailings disposal which is supported by available technology to mitigate and monitor potential environmental effects. NATC will continue to investigate feasible options as the project develops and moves through the detailed design phase.

1.2 Tailings and Waste Rock Disposal Alternatives

The options for tailings and waste rock disposal at the Mactung mine include the following:

1. A surface dry-stacked tailings facility which will include disposal of waste rock, within the tailings.
2. Underground co-disposal of waste rock and tailings in mined out stopes above the water table behind bulkheads.
3. Underground co-disposal of waste rock and tailings in mined out stopes below the water table behind bulkheads.

The current mine plan includes a combination of all three of the options above. The AMP addresses option 2, with the alternative to option 2 being options 1 and 3.

Figure 2 shows a plan view of the proposed surface and underground layouts of the Mactung Mine operation. Figure 3 shows the upper and lower ore bodies; the portion of the ore body that lies below the water table is illustrated in purple and green. More accurate positions and volumes for underground workings will become available once detailed design has been completed, and revisions to the geological structures and lithologies will be updated on a regular basis during operations. The level of detail of the AMP will also increase as the mine plan develops with respect to stope size and locations, geochemistry and water flows.

2.0 IN-SITU TESTING PROGRAMS - WASTE ROCK AND TAILINGS

Once the Mactung Mine is operational, monitoring and assessment for underground co-disposal of waste rock and tailings above the water table will commence. A key goal of the monitoring program will be to quantify the volume and water quality of leachate that may drain from the backfilled stope.

To assess ARD/ML effects for co-disposal of tailings and waste rock above the water table, NATC proposes to conduct in-situ testing of underground backfilling to quantify potential ARD/ML effects and compare them to a baseline condition of an empty (no backfill) open stope. In addition, water draining from surface storage facilities will also be compared to the backfilled stope (test stope) data. This will provide an objective comparison of leachate produced in an empty stope versus a backfilled stope, as well as comparatives to surface drainage quality from the same materials.

Undertaking the test stope will not interfere with mining as the surface DSTF can be adequately sized to contain the waste rock and tailings for the first nine years of the mine life. In the event that disposal of tailings and waste rock underground and above the water table is found to be unsuitable for mitigation of ARD/ML, then the DSTF can be expanded to sufficient capacity to contain waste rock and tailings which is in excess of the capacity of the stopes below the water table underground.

To validate the assumptions regarding acid generation within tailings and waste rock in underground stopes, the AMP will be implemented using an observational approach and laboratory data. Mitigation measures to address acidic leachate, if required, will be designed based upon the results of the test stope.

The selection of the test stope will follow detailed underground mine design. Prior to placement of backfill underground, groundwater assessment and sampling based on underground observations will enable estimation of the volume of groundwater percolating into the stope and draining out of the stope.

2.1 Test Stope Design Considerations

Prior to the backfilling of the test stope, a drainage collection system will be installed at the base of the mined out stope. Bulkheads will be installed at the upper and lower entrances to the stope. If required, grouting and or shotcrete will be used to seal the lower bulkhead. The bulkheads will be instrumented as follows:

- Upper bulkhead will contain an oxygen monitoring device which will measure oxygen levels inside the backfilled stope;
- Upper bulkhead will include a temperature probe in the tailings and waste rock, if possible, to monitor temperature changes over time; and

- Lower bulkhead will include stope drainage from which a volume can be measured and samples for water quality analysis can be collected.

The details of instrumentation placement are dependent upon test stope dimensions and groundwater conditions and will be determined at the detailed design stage.

Commercially available oxygen meters and digital temperature meters with extended probes can be purchased such that monitoring of oxygen can be achieved through the bulkhead, from a safe accessible position. For measuring the volume of the water leaching through the lower bulkhead, flow meters can be used with either data loggers or manual data collection to record flow volumes over time. The technique used to measure the volume will be subject to the volume of water which leaches out of the stope. It is estimated that where no groundwater inflow occurs, the leachate will be minimal to none once initial draining of the tailings and waste rock is complete. In such a case the volume of water collected in the sump can be monitored over a pre-determined duration.

2.2 Test Stope Assessment and Monitoring - Overview

The assessment of underground disposal will include three programs:

1. Underground baseline determination and selection of test stopes (during first year).
2. In-situ testing in the selected backfilled test stope and background testing of mine water quality from stope not backfilled (years one to three of mine life).
3. Ongoing monitoring from underground stopes, both backfilled and empty, throughout the life of mine.

During the mine operation the results of the leachate analysis and groundwater effects will be used as input for the water quality predication model that will inform the effectiveness of the underground disposal as envisaged in the feasibility study and subsequent mine design.

If the underground disposal of tailings and waste rock subsequently generates an acceptable quality of discharge, NATC will commence with ongoing backfilling of stopes above the water table, until stopes are available below the water table (later in the mine life). Monitoring of the backfilled stopes will continue through the bulkheads, mine water collection points and groundwater monitoring wells on surface. These data will continue to be integrated into the mine water model, which will consider the mine water volumes and quality during operation, temporary closures and post closure.

NATC has not yet identified a specific stope to backfill for evaluation of underground disposal. The test stope will be identified early in the mining process, ideally within the first year of underground mining operations, to ensure that there is sufficient time to monitor and evaluate the underground disposal. The test stope will be located above the natural water table and above other mine infrastructure such that the drainage from the stope can be monitored separately from non-naturally occurring underground water flows.

2.2.1 Underground Backfill Test Stope Water Baseline Conditions

Prior to starting the underground backfill test stope, NATC will conduct baseline monitoring of the underground water quality and quantity. This will include assessment of the groundwater conditions for the mine in general and for the stope used for the in-situ testing. During initial development of the mine and through to closure, baseline monitoring will include the following:

- Extraction of drill core samples of the unmined rockmass prior to excavation through exploratory diamond drilling;
- Extraction of chip samples from the rock face during excavation to monitor oxidation;
- Monitoring of any water in fissures or the water table-intersected underground; and
- Sampling of rock mass in contact with underground water flows intersected to determine the influence of the water table on oxidation of the rock mass prior to underground excavation.

During test stope monitoring the drainage collection system will intercept and divert any drainage from the backfill into a sump for collection. The water in the sump will be pumped to surface for treatment and discharge via the reservoir, as necessary. Settled material will be collected and placed in the DSTF.

2.2.2 Underground Stope Monitoring Program

To evaluate the feasibility of underground co-disposal of waste rock and tailings, NATC will set-up a program to monitor:

- A backfilled test stope above the water table;
- A control stope without backfill above the water table; and
- Surface disposal of tailings and waste rock (DSTF).

Monitoring of the above locations will be undertaken by sampling the leachate from behind the bulkhead. The leachate will be captured by the placement of perforated pipes, covered in burlap or geo fabric prior to backfilling. In addition to leachate monitoring, temperature and oxygen probes will be installed to monitor changes over time. The monitoring will be continued for a duration exceeding the length of time determined by kinetic tests when acidic leaching starts to occur. This will be done to clarify whether ARD/ML is prevented or just delayed by the underground backfilling.

The test stope will be monitored for three years or as dictated by results of the kinetic tests. The results will be assessed and used for decision making regarding the full-scale application of underground disposal of tailings and waste rock above the water table. The leachate will be sampled from of the stope as shown in Figure 1.

Once the test stope has been mined out and preparations are being made for underground disposal of waste rock and tailings, monitoring of the leachate and groundwater from the stope will commence. A similar monitoring program will be implemented for a stope that has not been backfilled and has not been sealed using bulkheads, for comparative analysis. This will be called the control stope.

2.3 Characterization of Tailings and Waste Rock Prior to Backfilling

The monitoring will commence upon completion of mining and prior to placement of backfill, so that potential changes in the quantity and chemistry of the leachate can be assessed. The proposed monitoring and sampling that will be undertaken will include tailings and waste rock geochemical characterization (prior to placement) and quantity and quality of leachate and groundwater.

2.3.1 Monitoring of Tailings and Waste Rock Geochemistry Prior to Placement

The geochemistry of the tailings and waste rock will be evaluated, by taking samples of the tailings and waste rock that will be placed underground prior to placement. Tailings sampling will be undertaken from the start of production, and will include collecting samples of materials sent to the DSTF. A daily composite sample will be taken in accordance with MEND Report 1.20.1 chapter 8. In addition, samples will be taken from the DSTF during the summer by trenching or auguring to evaluate the oxidation of the tailings within the facility.

Waste rock samples collected will be submitted for the standard suite of static test work for geochemical characterization, including Acid Base Accounting (ABA) analysis, Shake Flask Extraction (SFE) analysis, and whole rock metals analysis as per the guidelines outlined in Price (2009). Selected samples may be submitted for kinetic test work to verify assumptions from the static test work. Prior to being submitted for analysis, the samples will be described geologically, specifically noting the presence of sulphide or carbonate minerals. The geological description will be compared to the descriptions and results of samples submitted for geochemical analysis in previous years.

2.3.2 Monitoring of Quantity and Quality of Leachate

Once the mine process plant is in operation and tailings/waste rock are being produced and placed in the DSTF or underground test stope, water samples will be collected for laboratory analysis from any water draining from the tailings and waste rock. Comparative analysis of volumes and contaminant concentrations will be completed for the leachate water prior to and following placement of the tailings and waste rock.

The test stope set-up prior to placement of tailings and waste rock will be developed to facilitate the monitoring of leachate from the stope as illustrated in Figure 1. The stope set-up will include placement of perforated leachate collection pipes, covered in burlap or geofabric, in the lowest elevation of the stope, which will be covered with non-potential acid generating waste rock. Multiple pipes will be placed to ensure redundancy in the system. The volume of flow will not be monitored unless the stope has sufficient inflow of water to allow drainage and subsequent measurement. Any leachate will be allowed to drain from the stope through the bulkhead to a sump. The leachate will then be pumped to surface for treatment, if required, and discharged to the reservoir.

Based on the current humidity test cell results, it is anticipated that during the initial leaching of the water from the tailings and waste rock, the natural pH buffering will still be active and ARD/ML will not occur.

It is further noted that the current understanding of the groundwater and permafrost conditions indicate that minimal groundwater is anticipated to enter the stopes located above the water table. It is anticipated that the moisture content of the tailings placed underground may result in some initial leaching as the tailings settle and the remaining void water drains out.

The water quality parameters that will be monitored include pH, sulphate concentration, and dissolved metals as these are indicators of ARD/ML.

2.3.3 Groundwater Monitoring

Once the underground development is completed, and prior to underground backfilling and test stope monitoring, more accurate information on the flow of groundwater around the underground excavations will be available. The current understanding of rock mass permeability indicates that the analysis of groundwater may not produce any results suitable for long-term water quality prediction. However, once mining commences and a better understanding of the permeability of the rock and chemistry are achieved then modelling of groundwater flows and quality will be undertaken to better understand the potential transport of any contaminants to receiving water bodies.

Groundwater monitoring will be ongoing throughout the life of mine to refine the groundwater modelling process and to detect any groundwater changes. The groundwater monitoring will include the following:

- Piezometric monitoring of water levels in boreholes from surface and underground; and
- Collection of groundwater samples for laboratory analysis.

2.3.4 Monitoring Timeline

Table 1 shows the proposed timeline for each of the proposed monitoring programs.

Table 1: AMP Proposed Monitoring Program and Schedule

Program	Monitoring Type	Monitoring Frequency and Location	Monitoring Timeline
Tailings and waste rock geochemistry	Static testing of tailings and waste rock	Four samples each of tailings and waste rock during placement in the test stope	During backfill placement only
	Kinetic testing	Once the mine is operating, ongoing humidity cell testing of tailings and waste rock	3 years
Underground backfilled test stope	Leachate chemistry	Weekly leachate sample for physical parameters, monthly sample for metals	3 years
	Leachate volume	Determine flow through bulkhead. Initially weekly, depending on actual volumes	3 years
	Oxygen content of sealed backfilled stope	Weekly reading of oxygen probe	3 years
	Temperature of tailings and waste rock in underground backfilled stope	Weekly reading of temperature probe	3 years
Underground backfilled test stope – groundwater wells	Piezometric readings	Monthly	3 years
	Groundwater chemistry	Monthly	3 years
Underground role out of backfilling the stopes above the water table (if executed), based on the results of test stope	Geochemistry of backfilled material	Ongoing static testing for backfill characterization as per MEND guidelines	Life of the mine
	Leachate chemistry	Weekly sample from underground water sumps	Life of the mine*
	Piezometric readings of groundwater	Quarterly	Life of the mine*
	Groundwater chemistry	Quarterly	Life of the mine*
Control stope not backfilled	Leachate chemistry	Weekly sample for physical parameters, monthly sample for metals	3 years

* Post closure monitoring will be undertaken as described in the closure plan

2.4 Test Stope Sampling System Design

2.4.1 Monitoring the Test Stopes

The underground leachate sampling system for the backfilled stope will include a perforated pipe, installed in the stope to capture leachate, which will be installed pass through the bulkhead. There will be a valve to control the flow of leachate from the stope and instrumented to collect flow measurements and leachate samples. The analysis of the leachate samples will consist of a standard suite of metal and anion concentrations, metals of concern as well as pH and conductivity.

2.4.2 Underground Stope Without Backfill (Control Stope)

During mining of the control stope, water will likely drain from the stopes which will be directed to underground sumps for re-use, or treatment and discharge to the reservoir. Once mining of the control stope has ceased, monitoring of any leachate will commence by collecting water samples from sumps located near the base of the stope.

2.4.3 Interpretation of Monitoring Results

The results of the monitoring will be used to determine the acceptability of underground co-disposal of tailings and waste rock located above the water table. It is anticipated that underground co-disposal of tailings and waste rock will proceed; subject to some revisions in the tailings and waste rock management process. Such revisions may include measures such as capping of the tailings and waste rock with impervious material, controlled drainage and pumping, and treatment of leachate from the stopes for a duration of time until the acid production cycle is completed. The placement of passive treatment such as limestone drains for long term mitigation of acid leachate from the backfilled stopes above the water table is also a possible measure.

2.5 Evaluating of ARD/ML Effects

Satisfactory mitigation of ARD/ML effects from the underground tailings and waste rock disposal areas will be achieved by ensuring that environmental risks are limited to an acceptable level and that the discharge from the storage areas can be managed or treated to meet the conditions established in the water licence issued by the Yukon Water Board. The water quality objectives for the test stope will be determined in line with the ongoing mine water balance model during operations. The target parameters will be based on the modelled dilution and any water treatment requirements and the conditions of the water licence.

During monitoring of the test stope the real-time data will be used for subsequent decisions related to the commencement of tailings and waste rock disposal in stopes above the water table. These data will be used to determine the potential volume and chemistry of stope leachate as well as groundwater flows and impacts from the test stope.

3.0 TRIGGERS FOR ADAPTIVE MANAGEMENT FOR UNDERGROUND DISPOSAL OF TAILINGS AND WASTE ROCK

Any potential contamination from the underground storage of waste rock and tailings will be detected in contaminated water leaching from the backfilled stopes or in contaminated groundwater percolating through the rock mass surrounding the stopes. Ongoing monitoring at the selected sampling and monitoring points will provide data to be used to assess if ARD or Metal Leaching are occurring.

NATC has proposed triggers for the AMP when comparing water quality parameters to the Metal Mining Effluent Regulations (Department of Fisheries and Oceans 2002). NATC proposes that if the concentrations of metals measured in the leachate reach 80% of the MMER effluent quality criteria then the contingency measures discussed in Sections 5 and 6 of the AMP will be implemented.

During operations the allowable concentrations of contaminants of potential concern will be a function of water treatment, dilution and attenuation within the mine water balance, as illustrated in Figure 4.

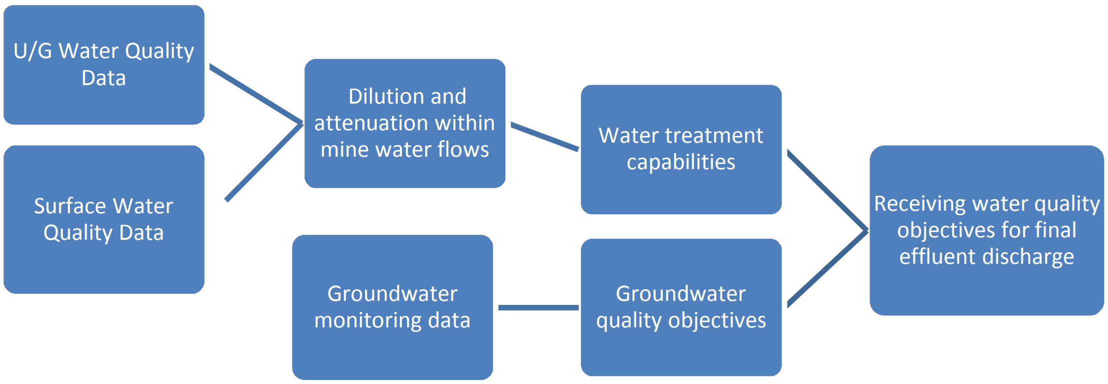

Figure 4: Underground and Surface Water Management Relationship and Water Quality Objectives

4.0 UNDERGROUND TEST STOPE ARD/ML MITIGATION MEASURES

If the underground test stope produces leachate in volumes and with chemistry that indicate that target final effluent concentrations will be exceeded as described in Section 3, then NATC will implement mitigation measures for the test stope, depending on how the stope is affecting groundwater, i.e., through percolation of the leachate through the rock mass or leachate water through the bulkhead. The feasibility of the following mitigation measures will be further investigated to mitigate ARD/ML.

4.1 Groundwater

If groundwater quality is shown to be affected by the test stope, then NATC will consider implementation of one or more of the following measures:

- Flood the stope with water or place a capping of impervious material over the upper exposed tailings and waste rock to limit ARD/ML;
- Pump and treat contaminated groundwater, via wells drilled to intercept the contaminant plume; and
- Divert groundwater around the stope through pumping grout above the stope to create a grout "curtain".

All of the above measures are applicable to operations and temporary closure, though the cost of pumping and treating during temporary closure may result in a preference for passive options. In addition, if other mitigation alternatives are identified during mining operations they will be evaluated and considered at that time.

Grouting around underground excavations is commonly practiced in deep underground mines. Daw and Pollard (1986) describe basic techniques for the use of grouting for groundwater control in underground mines for various requirements and for different types of excavations.

4.2 Test Stope Seepage

Bulkheads will be installed and sealed to bedrock and the seepage collection system will be designed such that any water or leachate should be diverted through a pipe and captured in a sump. The bulkhead will be inspected regularly for seepage through and around the structure.

Any water or leachate received in the sump, located near the base of the test stope, will be pumped to surface for treatment. In addition, the following measures could be undertaken:

- Divert underground water sources, including groundwater, away from the stope; and
- Use passive treatment through the placement of buffering material in channels or trenches in which the leachate flows underground.

During operations all underground water will be continually pumped to surface for potential treatment or disposal via the reservoir, as required.

5.0 ALTERNATIVE CONCEPTUAL PLAN NOT INCLUDING UNDERGROUND BACKFILL ABOVE THE WATER TABLE

In the event that results from the test stope do not demonstrate the effectiveness of ARD/ML mitigation through co-disposal of tailings and waste rock underground, NATC is committed to increasing the capacity of the DSTF to accommodate all tailings and waste rock from above the natural water table for the life of the mine.

Figure 5 shows the conceptual mass balance for mining operations at Mactung. If underground backfilling is not undertaken then the DSTF will be re-designed to accommodate 4.5 million cubic metres of material.

The additional design requirements for increasing the capacity of the DSTF include:

- Considerations for slope stability for the larger DSTF; and
- Diversion trench design to be adapted to accommodate the larger DSTF.

Figure 6A and 6B illustrate the currently planned DSTF design and the potentially larger DSTF, should there be a requirement to increase the size of the DSTF by adding the tailings and waste rock originally destined for underground backfill. The potential new design is feasible and the dump stability class would change from Class II to Class III. The related failure hazard rating would change from “Low” to “Moderate”, based on the BC Mine Waste Rock Pile Research Committee Interim Guidelines (1991). This change in hazard rating does not affect considerations such as earthquakes or floods but is an indication of the additional design work and monitoring effort that would be required for the newly sized facility. The run-off diversion trenches around the DSTF would be adjusted to accommodate the revised DSTF footprint.

6.0 FRAMEWORK FOR TAILINGS, WASTE ROCK AND SITE WATER MANAGEMENT

Figure 7 outlines the geochemical and water monitoring framework for site water management. The framework includes direct monitoring of various water flows where possible, and the use of these data to model flows that cannot be directly measured (i.e. groundwater). It also includes monitoring and modelling of the geochemistry of tailings and waste rock leachate and underground backfill material leachate (for stopes below the water table). The results of this work will help to determine whether metal concentrations from various components of mine site operations pose a risk to the overall water management system.

The current conceptual framework for site water management includes the following provisions:

- Diversion of natural surface water drainages and groundwater around the mine site catchment into Tributary C;
- Collection of all undiverted waters at the mine site in the reservoir;
- Re-use of reservoir water for operational needs;
- Collection and containment of seepage from the reservoir; and
- Discharge of water meeting the target effluent concentrations into Tributary C.

If the alternative management plan to dispose of all waste rock and tailings in the DSTF located at the surface is employed, then the ongoing geochemical characterization and monitoring program for the DSTF will be updated.

6.1 Geochemical Monitoring

There will be ongoing sampling, testing, analysis of waste rock excavated during mining operations. The information collected will be compared to preliminary characterization test work completed to date, including ongoing humidity test cell analysis on waste rock material. This information will be evaluated and used to inform waste rock disposal options. NATC assumes that if separation of NAG and PAG material during mining operations is feasible then the PAG material will be disposed of in the DSTF and NAG material will either be disposed of in the DSTF or used on site for fill material. If separation of NAG and PAG material during mining operations is not feasible then all the material will disposed of in the DSTF.

Prior to placement, both tailings and waste rock material will be sampled for geochemical characterization. Samples collected will be analyzed using a standard suite of static test work for geochemical characterization, including ABA analysis, SFE analysis, and whole rock metals analysis as per the guidelines outlined in Price (2009). Prior to being submitted, the samples will be described geologically, specifically noting the presence of sulphide or carbonate minerals. The geological description will be compared to information from samples collected and submitted for geochemical analysis in previous years.

Ongoing sampling and analysis will be undertaken on a monthly basis to maintain a record of changing conditions, specifically sulphate production and carbonate reduction in the waste rock and tailings.

6.2 Water Quality Monitoring

Water quality monitoring is an important component of determining the site water management aspects of the AMP. Ongoing sampling and analysis will include pH, total suspended solids, acidity and total and dissolved metals. Monitoring stations will be established throughout the mine site to identify potential contamination sources.

6.2.1 Triggers and Criteria for Implementation of Mitigation Measures

The primary trigger for the implementation of mitigation measures is the identification of the potential for waste rock or tailings to produce acidic conditions or leach metals at concentrations that could negatively affect the environment. Trigger criteria are established based on objectives for target effluent discharges as estimated in the water quality modelling. The modelling helps to determine the maximum allowable input terms that are feasible in order to stay within the final effluent limits.

Monitoring of water quality will occur at both the ravine dam discharge point and in the receiving waters downstream of the reservoir. The receiving water baseline quality and the maximum allowable variation from this will drive the final effluent quality objectives. The final effluent quality will direct the desired water quality at various point sources within the mine water balance.

NATC has established triggers for the AMP when comparing water quality parameters against the Metal Mining Effluent Regulations (Department of Fisheries and Oceans 2002). NATC proposes that if the concentrations of metals measured in the leachate reach 80% of the MMER effluent quality criteria then the contingency measures discussed in the AMP will be implemented.

NATC will establish specific discharge points on the edge of the waste rock and tailings management facilities to monitor potential contaminants of concern in the leachate and run-off. If the discharge collected and analyzed exceeds pre-established criteria, then the implementation of mitigation measures will be implemented.

6.3 Contingency Measures for Surface Waste Rock and the DSTF

The following mitigation measures will be undertaken to manage the quality of water associated with the surface temporary waste rock facility and the DSTF:

1. Isolation of Point Sources

If the waste rock or tailings stored in the DSTF are found to produce acidic leachate or elevated metal concentrations the following additional actions can be taken:

- Excavation of diversion trenches for leachate to containment ponds, where pH modification for the precipitation of metals can be undertaken prior to a controlled release to the reservoir; and
- Diversion of leachate to the water treatment facility for treatment and controlled discharge to the reservoir or downstream environment, as required.

2. Active Water Treatment Measures

NATC has committed to the installation of a water treatment facility at the outset of operation. The water treatment plant is considered to be an additional contingency in the unlikely event that surface water or groundwater related to future mine operations requires active treatment measures. The conceptual design criteria for the treatment facility have been established in other documents submitted to YESAB.

3. Passive Water Treatment Measures

The possibility of liming the reservoir prior to discharge of water has been considered as a means of semi-passively treating water that may not meet the discharge criteria.

7.0 CLOSURE

We trust this Adaptive Management Plan meets your current needs. If you have any questions or comments, please contact the undersigned.

Respectfully submitted,
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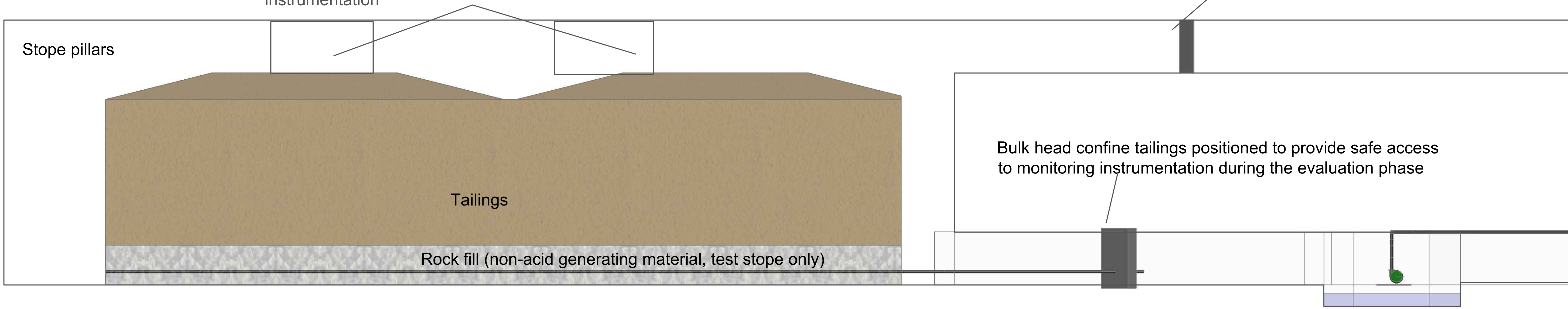
FIGURES

Long section of conceptual test stope showing how piping will be placed to facilitate monitoring of backfill leachate quality



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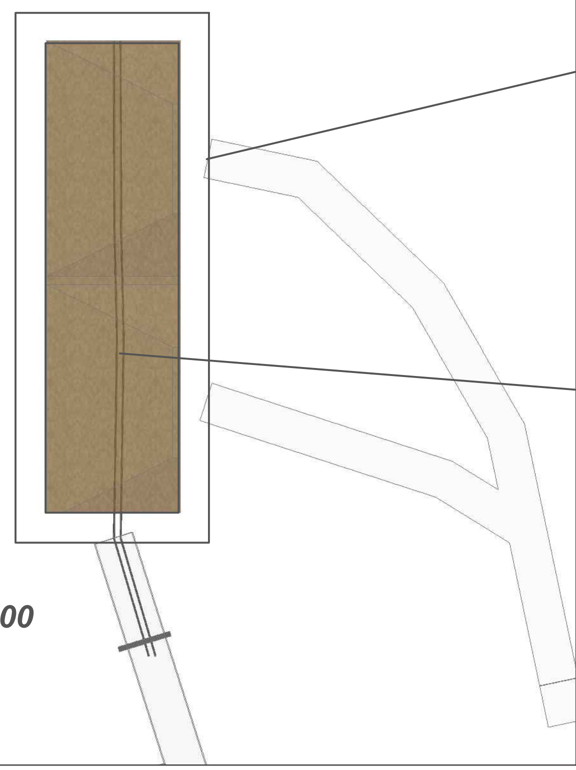
Plan view of conceptual test stope for monitoring of backfill leachate



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NOT FOR CONSTRUCTION

NOTES

This drawing is of a conceptual stope layout based on the mining methods described in the Amended Technical Report on the Mactung Property, 2009. Wardrop.

STATUS

ISSUED FOR USE

CLIENT

NORTH AMERICAN TUNGSTEN CORPORATION LTD

eba A TETRA TECH COMPANY

MACTUNG

Underground Backfill Test Stope Layout

PROJECT NO.	DWN	CKD	REV	
W23101211.004	MPH	LR	0	Figure 1
OFFICE	DATE			
VANC	September 11, 2013			

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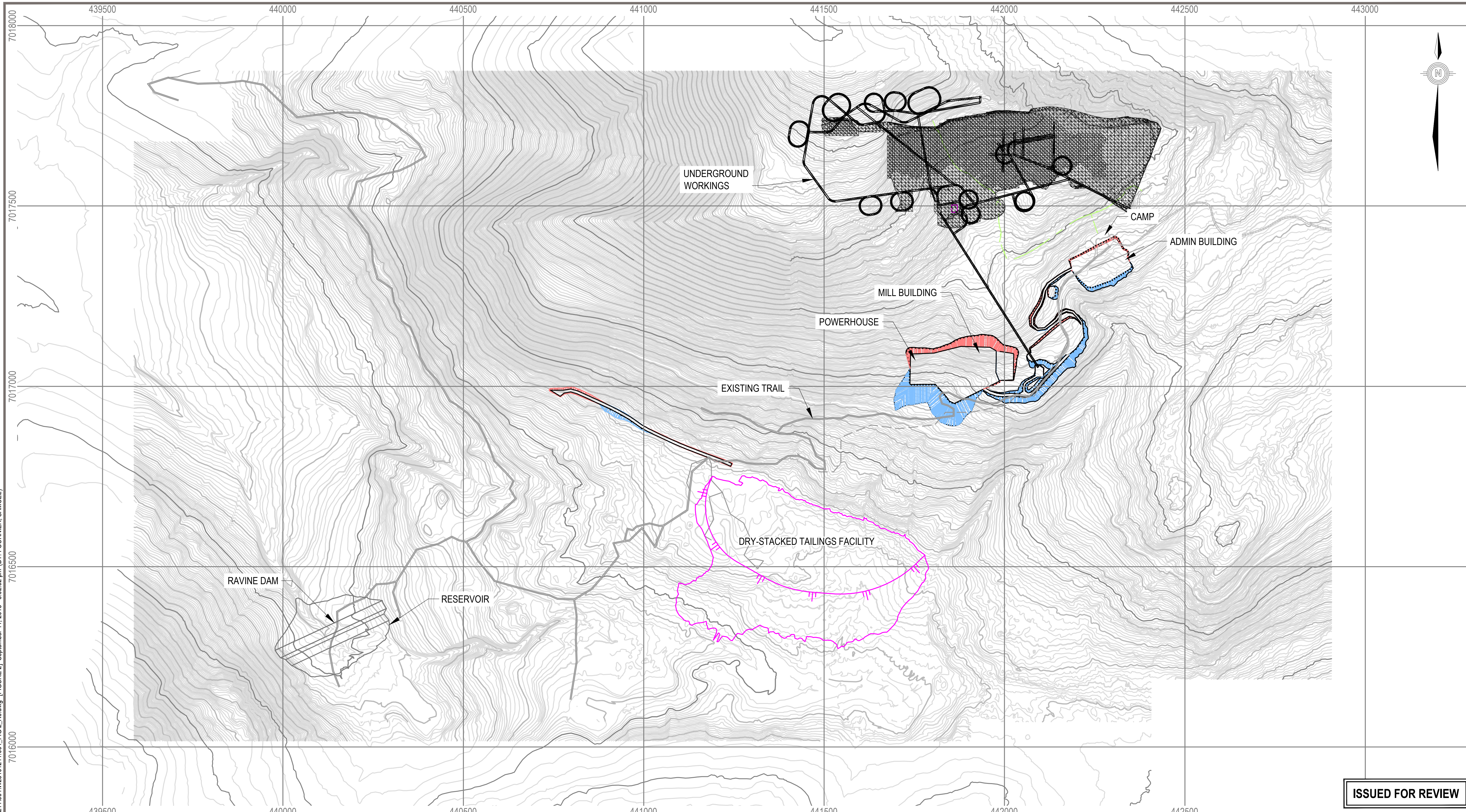

Q:\Vancouver\Drafting\Environmental\W231\W23101211\004\W23101211.004_FIG 2_R0.dwg [FIGURE 2] September 11, 2013 - 3:02:02 pm (BY: FOURNIER, SAMUEL)

LEGEND

- Topographic Contours
- Underground Workings
- Tailings Outline
- Fill
- Cut
- Pipe

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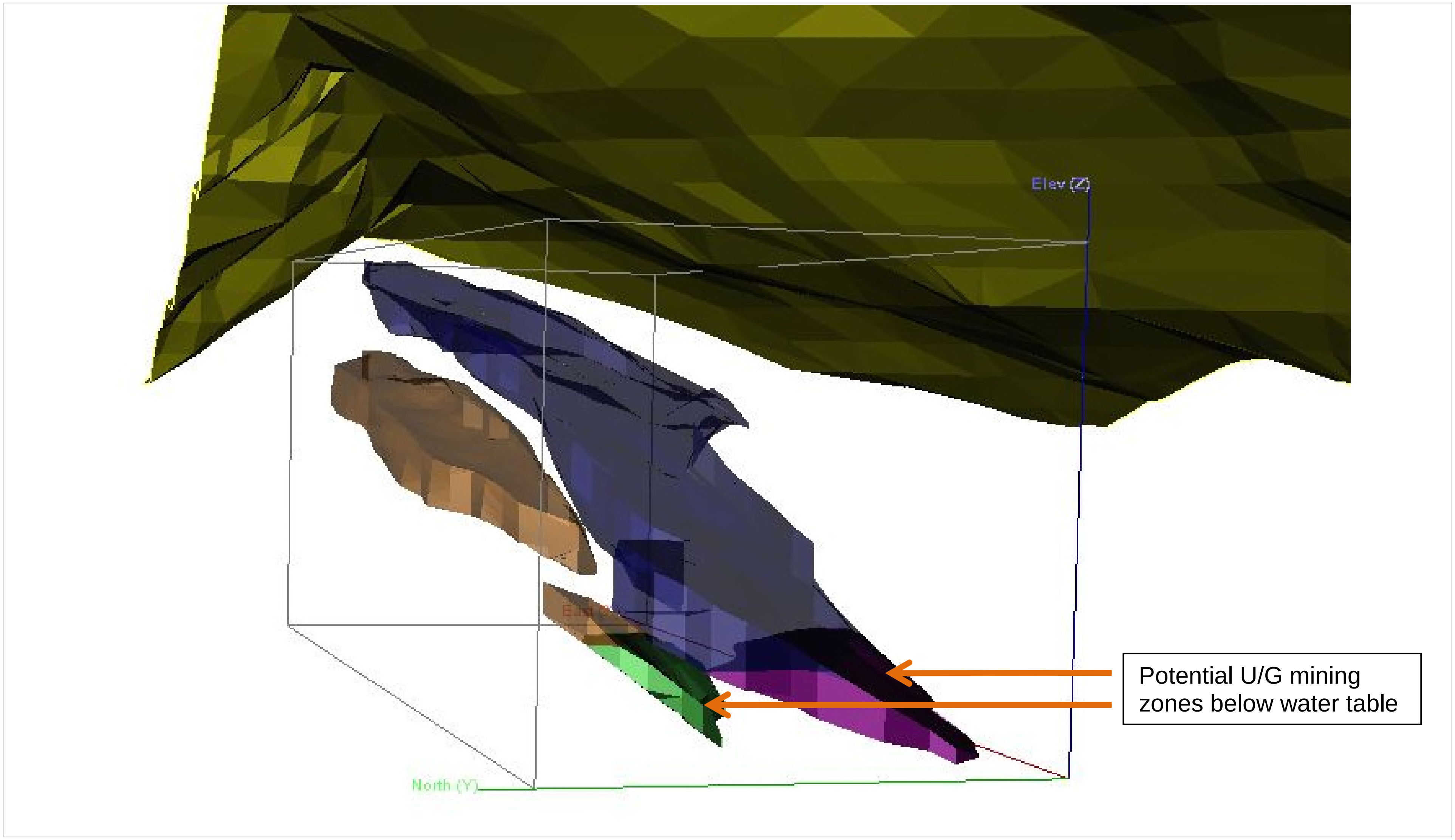
MACTUNG

Underground Workings and Surrounding Land Use Plan

PROJECT NO.	DWN	CKD	REV
W23101211.004	SF	MH	0

OFFICE	DATE
VANC	September 11, 2013

Figure 2



LEGEND

NOTES

STATUS
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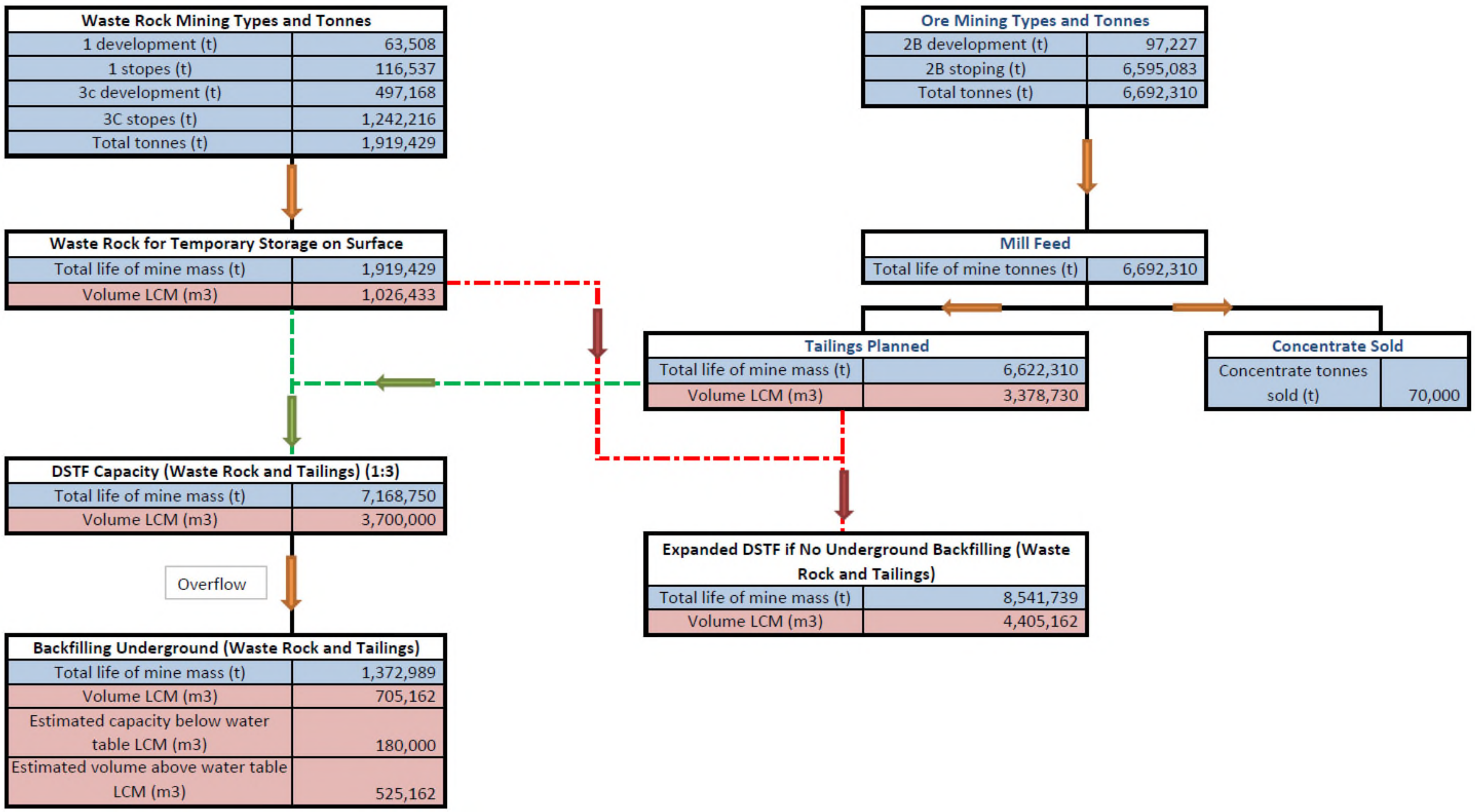
MACTUNG

Mineralized Zone Showing Stopes Above and Below the Water Table

PROJECT NO.	DWN	CKD	APVD	REV
W23101211.004	SF	MH	RH	0

OFFICE	DATE
EBA-VANC	September 11, 2013

Figure 3



LEGEND

Scenario 1: Underground Backfilling — — —

Scenario 2: No Underground Backfilling — · — ·

NOTES

STATUS
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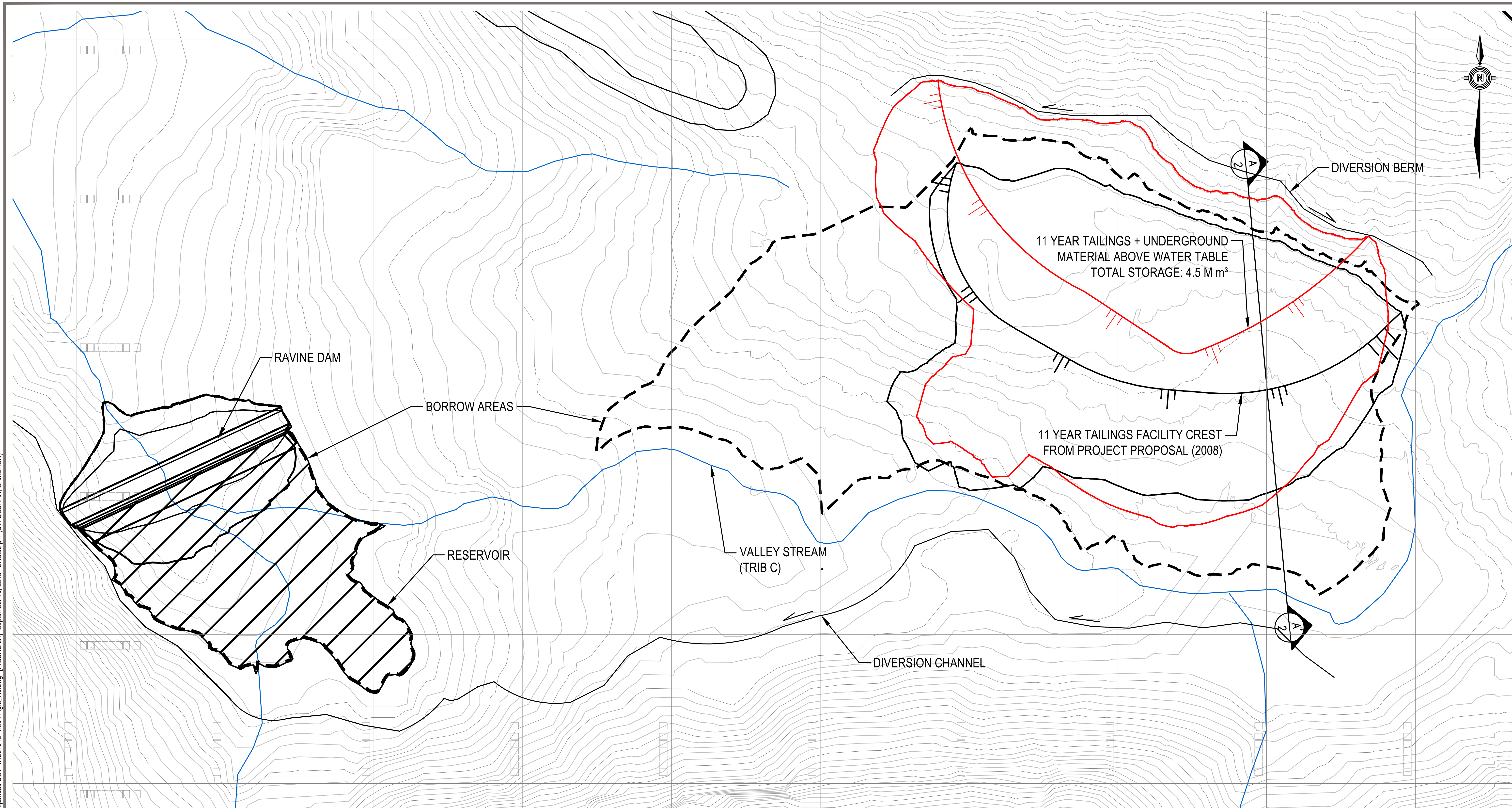
MACTUNG

Mass Balance for Tailings and Waste Rock over Life of Mine

PROJECT NO.	DWN	CKD	APVD	REV
W23101211.004	MH	MH	RH	1

OFFICE	DATE
EBA-VANC	September 11, 2013

Figure 5



Q:\Whitehorse\Data\0201drawings\MacTung\W23101211.004 Expanded DSTF\W23101211.004 Fig.6_R0.dwg [FIGURE 6A] September 10, 2013 - 2:48:53 pm (BY: BUCHAN, CAMERON)

STATUS
FOR DISCUSSION ONLY

LEGEND:

DIVERSION CHANNEL DIRECTION OF FLOW

0 250

Scale: 1: 5 000 (metres)

NOTES

THIS FIGURE WAS PRODUCED IN COLOUR, REPRODUCTIONS MAY NOT BE REPRESENTATIVE OF ORIGINAL

5 m CONTOURS SHOWN FOR REFERENCE

11 YEAR TAILINGS STORAGE: 2.2 M m³

11 YEAR TAILINGS + UNDERGROUND: 4.5 M m³

11 YEAR TAILINGS STORAGE AREA: 22.3 ha

11 YEAR TAILINGS + UNDERGROUND AREA: 26.9 ha

CLIENT

NORTH AMERICAN TUNGSTEN CORPORATION LTD

eba A TETRA TECH COMPANY

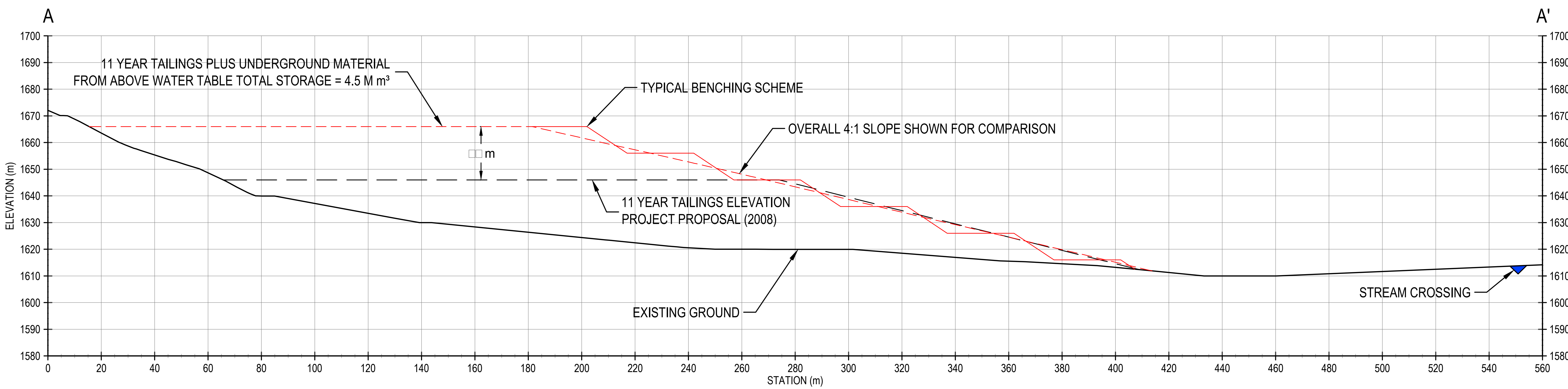
MACTUNG

SITE PLAN SHOWING
DRY-STACKED TAILINGS FACILITY EXPANDED WITH
UNDERGROUND MATERIAL FROM ABOVE WATER TABLE

PROJECT NO.	DWN	CKD	REV

OFFICE	DATE
	September

Figure 6A



STATUS
FOR DISCUSSION ONLY

0 50
Scale: 1: 1 500 (metres)

NOTES

THIS FIGURE WAS PRODUCED IN COLOUR, REPRODUCTIONS MAY NOT BE REPRESENTATIVE OF ORIGINAL
5 m CONTOURS SHOWN FOR REFERENCE

11 YEAR TAILINGS STORAGE: 2.2 M m³
11 YEAR TAILINGS + UNDERGROUND: 4.5 M m³

11 YEAR TAILINGS STORAGE AREA: 22.3 ha
11 YEAR TAILINGS + UNDERGROUND AREA: 26.9 ha

CLIENT

NORTH AMERICAN TUNGSTEN CORPORATION LTD

eba A TETRA TECH COMPANY

MACTUNG

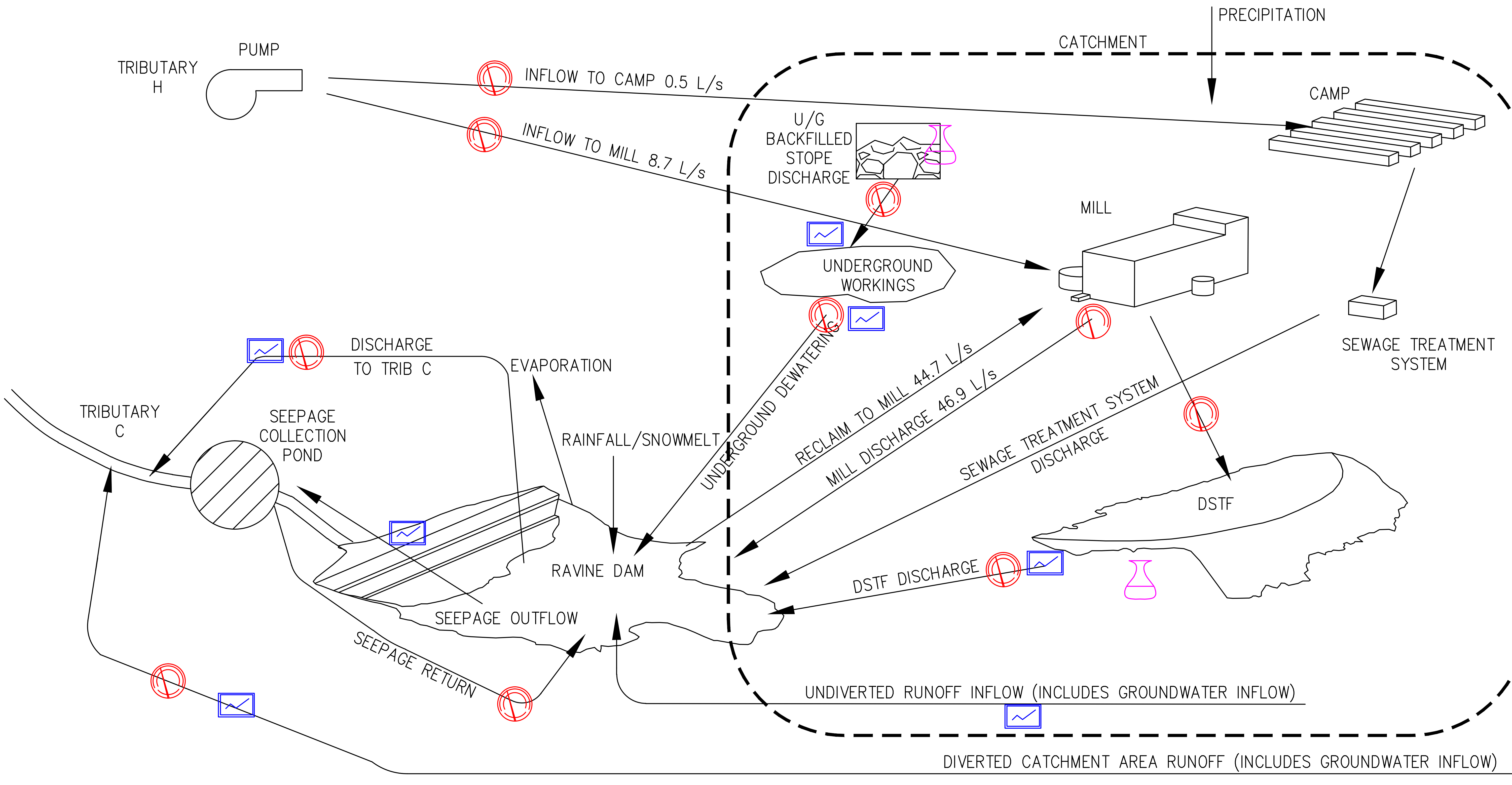
DRY-STACKED TAILINGS FACILITY, EXPANDED WITH UNDERGROUND MATERIAL FROM ABOVE THE WATER TABLE
CROSS SECTION A - A'

PROJECT NO.	DWN	CKD	REV
[illegible]	[illegible]	[illegible]	[illegible]

OFFICE	DATE
[illegible]B[illegible]-[illegible] [illegible]S[illegible]	September [illegible], [illegible]

Figure 6B

Q:\Whitehorse\Data\0201drawings\MacTung\W23101211.004 Expanded DSTF\W23101211.004 Fig.6_R0.dwg [FIGURE 6B] September 10, 2013 - 2:49:22 pm (BY: BUCHAN, CAMERON)



LEGEND

- Monitored water flow
- Modelled water flow
- Monitoring of geochemistry

NOTES

Based on Mactung Conceptual Water Balance Model, 2011. EBA

STATUS

ISSUED FOR USE

CLIENT

NORTH AMERICAN TUNGSTEN CORPORATION LTD

EBA A TETRA TECH COMPANY

MACTUNG

Framework for Geochemical Monitoring and Modeling

PROJECT NO.	DWN	CKD	REV
W23101211.004	MPH	RH	0

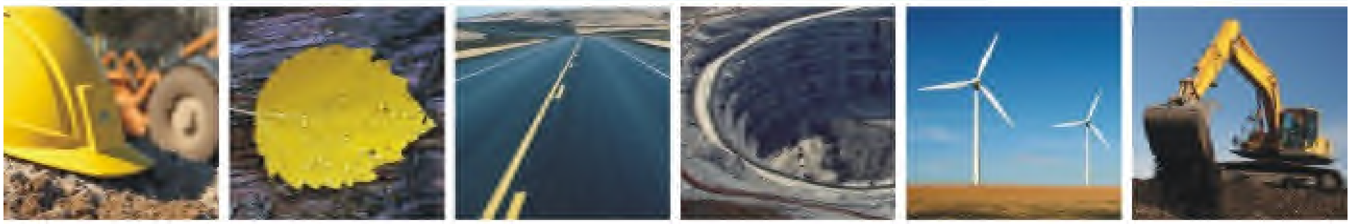
OFFICE	DATE
EBA-VANC	September 11, 2013

Figure 7

C:\Users\mark.horan\Documents\MACTUNG Backfill\Final document\Figure 7.dwg [FIGURE 7] September 11, 2013 - 11:12:48 am (BY: HORAN, MARK)

NORTH AMERICAN TUNGSTEN CORPORATION LTD.

MACTUNG MINE TEMPORARY CLOSURE PLAN RESPONSE TO YESAB EXECUTIVE COMMITTEE SUPPLEMENTARY INFORMATION REQUEST R15



REPORT

OCTOBER 2013
ISSUED FOR USE
EBA FILE: 704-W23101211.004

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eba
A TETRA TECH COMPANY

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EBA Engineering Consultants Ltd. operating as EBA, A Tetra Tech Company
61 Wasson Place
Whitehorse, YT Y1A 0H7 CANADA
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TABLE OF CONTENTS

TABLES

FIGURES

ACRONYMS & ABBREVIATIONS

ARD/ML	Acid rock drainage and metal leaching
DSTF	dry stacked tailings facility
EBA	EBA Engineering Consultants Ltd. operating as EBA, A Tetra Tech Company
NATC	North American Tungsten Corporation Ltd.
NAG	not potentially acid generating
PAG	potentially acid generating
WRSA	waste rock storage area
YESAB	Yukon Environment and Socio-Economic Assessment Board Executive Committee

1.0 INTRODUCTION

In response the Yukon Environment and Socio-Economic Assessment Board Executive Committee's (YESAB) Request for Supplementary Information, Project Assessment 2008-0304, published on January 4, 2013, North American Tungsten Corporation Ltd. (NATC) is submitting this report to outline and describe the Temporary Closure Plan for the proposed Mactung Mine. EBA Engineering Consultants Ltd. operating as EBA, A Tetra Tech Company (EBA) was retained by NATC to prepare the document.

This report presents a formal response to the supplementary information request R15, described as:

> *"Provide a plan for the temporary closure or suspended operations of the mine site. Include within the temporary mine closure plan measures to monitor and mitigate the potential ARD/ML conditions of the DSTF and WRSA during temporary closure."*

This Temporary Closure Plan has been prepared based on the Project Proposal submitted to YESAB (EBA 2008a) and the current mine plan as presented in the project Feasibility Study prepared by Wardrop Engineering (Wardrop 2009). This plan will be updated following detailed engineering design and future project permit conditions including the Water Use Licence and Quartz Mining Licence.

Territorial Policies, including the Yukon Mine Site Reclamation and Closure Policy (Yukon Government 2006) and the Reclamation and Closure Planning for Quartz Mining Projects (Yukon Energy Mines and Resources, August 2013) were consulted in the development of the Mactung Mine Temporary Closure goals and commitments.

2.0 CLOSURE TERMS AND DEFINITIONS

The Yukon Government has defined the term *Temporary Closure* as "a closure that exceeds six months and is not expected to last longer than five years" (Yukon Mine Site Reclamation and Closure Policy: Financial and Technical Guidelines, Yukon Government 2006).

For the purposes of this Temporary Closure Plan, NATC will adopt the meaning of *Temporary Closure* as a planned, or unplanned, stoppage of ore mining and processing activities at the mine site which exceeds three months and is not expected to last longer than three years, with the intent to recommence operations. The period for temporary closure has been modified from the Yukon Government definition to reflect a manageable time frame for transition and site maintenance activities. The reasons for temporary closure may include, but are not limited to: annual/planned maintenance, seasonal closure, undesirable market conditions, or regulatory related suspension.

A Closure Transition is adopted herein as the period overlapping active operations and temporary or planned closure (i.e. seasonal closure, planned maintenance, or permanent closure) and would typically span a period of two weeks to less than three months. This period may include progressive shut-down activities in transition to the anticipated longer term closure.

Permanent closure is adopted herein to mean a planned stoppage of ore mining and processing activities at the mine site at the end of the scheduled mine life as determined in the Quartz Mining License, or a definite stoppage of mining and processing activities prior to the scheduled mine life due to an unplanned, or uncontrolled, external influence. This would require a Certificate of Closure (s137 Yukon Quartz Mining

Act). The planned procedures for this type of closure are not described in this document but were included in the "*Mactung Mine Decommissioning and Closure Plan, EBA, December 2008*" as Appendix M within the "*Mactung Mine Project Proposal, YESAB-Executive Committee Submission, EBA, December 2008*".

Emergency Closure is not described or included within this plan.

Progressive reclamation is used within the document to mean reclaim activities in areas that are no longer required for mine operations during the production phase.

A visual guide to the terminology defined above is presented in Figure 1.

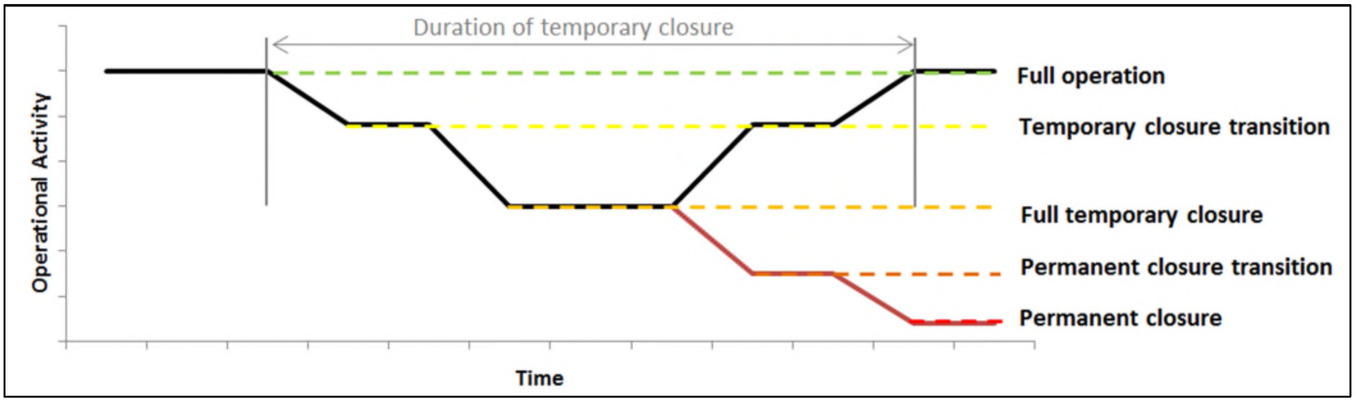

Figure 1: Visual guide to closure terminology used in this document

3.0 GOALS OF TEMPORARY CLOSURE

The temporary closure plan has been developed with the overall goal of managing potential negative effects from the project on the surrounding environment and to protect human health during the transition and temporary closure periods. In order to achieve this goal NATC is committed to the following:

- Maintaining physical and chemical stability of mine waste and other mine-related surface disturbances;
- Continuing environmental management including monitoring, reporting and treatment in compliance with regulatory and licensing requirements;
- Maintaining site infrastructure and equipment in useable condition to prevent injury to human health, prevent negative impacts to the local environment and to facilitate rapid re-commencement of mining operations;
- Securing the premises to control access to the site;
- Maintaining site and access roads;
- The continued de-watering of the underground workings, as required; and
- Employing, where possible, local labour to complete progressive reclamation, continue with site maintenance and general site repair.

Following the designated period of temporary closure, NATC will either seek an extension of the temporary closure with the Yukon Government Chief Mining Inspector or implement the established Decommissioning and Closure Plan. During the temporary closure, NATC will maintain closure bond commitments in agreement with established terms with the Yukon Government (Yukon Government 2006).

4.0 TEMPORARY CLOSURE PLAN

The temporary closure plan is designed to implement the necessary steps for the continuation, reduction or cessation of mining related activities, as and when required, based on the activity's function and level of maintenance expected to adhere to permitting and regulatory obligations. The site layout has been classified into the Reclamation Units as originally presented in the Reclamation and Closure Plan (EBA, 2008) which is summarized in Table 1. Areas requiring ongoing monitoring and inspection throughout the temporary closure are discussed in further detail in Sections 5.1 through 5.4. A description of the minimum on site staff anticipated to be required to maintain the site during temporary closure is found in Section 5.5.

Table 1: Estimated Activity and Schedules during Temporary Closure by Reclamation Unit

Reclamation Unit (EBA, 2008)	Temporary Closure Activity	Estimated Schedule of Activity	Responsible Personnel
Erosion Control and Sediment Management	monitor stability and removal of obstructions	continuous with operational schedule	geotechnical engineer
Camp and Ancillary Infrastructure	maintain operational status	continuous with operational schedule	general caretaker
Access and Haul Roads	maintain operational status	continuous with operational schedule	contractor
Explosives Storage Facilities	secured, inventory and removed from site if required	as soon as site conditions permit upon temporary closure	site manager/mine supervisor
Processing Plant and Ancillary Infrastructure	progressive reduction of water consumption, drainage of processing circuit, secure facility	as soon as site conditions permit upon temporary closure	senior plant engineer
Underground Access and Workings	secure, inspect and monitor stability, pump development water drainage to reservoir	as soon as site conditions permit upon temporary closure	mine supervisor/shift boss, environmental technician,
Dry Stacked Tailings Facility	inspect and monitor stability, monitor effluent water quality	continuous with operational schedule	environmental technician, geotechnical engineer
Ravine Dam	monitor stability, sample effluent	continuous with operational schedule	geotechnical engineer, environmental technician,
Diversion Channel	monitor stability	continuous with operational schedule	geotechnical engineer

Table 1: Estimated Activity and Schedules during Temporary Closure by Reclamation Unit

Reclamation Unit (EBA, 2008)	Temporary Closure Activity	Estimated Schedule of Activity	Responsible Personnel
Borrow Areas	monitor stability	continuous with operational schedule	geotechnical engineer
Hess River South Tributary Pumping Station	continue to draw water as required	continuous with operational schedule	environmental technician
Infrastructure Pads	no activity planned	not applicable	not applicable
Contaminated Soils	no activity planned	continuous with operational schedule	not applicable
Post-Closure Monitoring Programs	not applicable	not applicable	not applicable

4.1 Management of the Dry Stacked Tailings Facility

During temporary closure, the surface dry-stacked tailings facility (DSTF) will continue to be monitored by qualified onsite technicians at a frequency consistent with the operational sampling and monitoring plan.

Run-off from the DSTF will be diverted to a collection ditch and to the reservoir where water quality will be monitored in accordance with the applicable permit and licensing requirements based on the Metal Mining Effluent Regulations (MMER, Department of Fisheries and Oceans, 2002), and the Canadian Council of Ministers of the Environment guidelines for the protection of freshwater aquatic life (CCME 2013) or other site specific values where applicable. Should chemical instability such as ARD/ML be detected, appropriate measures will be taken to encourage source control. Following a year and half of Temporary Closure activities, the sampling frequency of the DSTF effluent will be increased to allow for monitoring for subtle chemical changes possible after the extended atmospheric exposure period of the materials. If required, the onsite water treatment plant will remain in operation during the temporary closure to maintain compliance with regulatory water quality requirements.

Water quality samples will be collected from the pre-determined baseline collection locations around the toe of the DSTF and the results will be compared against baseline and loading limit values to track chemical change indicators and potential ARD/ML reactions. If a progressive decrease in pH level or increase in metal constituent concentrations, or loading, is identified then appropriate mitigation procedures will be implemented.

Physical stability measurements of the DSTF will be collected from the established equipment monitoring locations to determine the overall stability of the DSTF. Periodic visual assessment and recording of the surface erosion for assessment of any impairment, change or negative impact due to frost penetration and heaving will be conducted. If progressive changes are noticed relative to measurement records, then appropriate mitigation procedures will be implemented.

All drainage diversions, collection ditches and conveyance channels for the DSTF will be inspected to ensure there are no impediments to flow of water. Any conditions affecting the planned flow of water will be recorded and appropriate actions will be implemented.

4.1.1 Geochemical Stability Mitigation Measures for the DSTF

The DSTF will be compacted and constructed from the bottom-up. This construction method will significantly reduce the effective hydraulic conductivity of the material and facilitate progressive reclamation of the DSTF as the stack volume increases. Liner and soil covers used in the progressive reclamation activities on completed DSTF lift sections should reduce the exposed surface area of tailings during temporary closure and reduce, or eliminate, the amount of oxygen and water that will infiltrate the tailings. Water run-off, residual pore moisture and any other effluent contact water will be channeled to a collection ditch at the base of the DSTF prior to being discharged to the reservoir.

Diversion of non-contact waters around the DSTF towards the reservoir for collection, containment and treatment will reduce, or temporarily eliminate, the amount of potentially impacted water.

Limited laboratory test work for ARD/ML characterization and prediction has conservatively estimated that the tailings could become acid based on fixed laboratory conditions (EBA 2009, Cell No. T1, 50051-001 Drill Core Composite Mill Tailings); however, it is unlikely that the exposed tailings will produce acid within the temporary closure timeframe under the actual site conditions. During the temporary closure the DSTF will remain uncovered and will be monitored as described above. If during the temporary closure a chemical change indicator exceeds a prescribed threshold in accordance with the established Water Use Licence, NATC will implement appropriate action to encourage source control. Control measures may include installation of a passive treatment system within the collection ditch, and/or the installation of a temporary impermeable clay or geosynthetic liner to eliminate additional infiltration and oxidation of the active layer in the tailings.

4.2 Management of the Surface Waste Rock Storage Facility

A maximum of approximately 124,000 m^3 of development waste rock material is planned to be temporarily stored on surface in two locations for up to five years. The waste rock that has been characterized as PAG material will be relocated to the DSTF at the onset of temporary closure to isolate PAG material at a single facility for monitoring. It is reasonable to expect that the material can be moved to this facility within a short timeframe during the temporary closure transition period using the mining equipment available on site. Consolidation of acid generating materials will isolate the potential source, increasing the effectiveness of treatment. Relocation of the material will be considered permanent and will conform to a stable geotechnical design which may include structural application or anchoring of synthetic liners.

If segregation of PAG and NAG waste rock material that is temporarily stored on surface has been successful during operations, the NAG material may not be required to be relocated to the DSTF. This material may be used for construction or fill purposes during the temporary closure period, such as surface drainage diversion structures, road maintenance or structural support to the DSTF.

4.3 Management of the Reservoir

The reservoir levels are controlled predominantly by direct precipitation, the influx of run-off from the local drainage and controlled plant discharges. During the temporary closure period, the only significant change to the site water balance is expected to be the effluent and reclaim water volumes required for plant operations. As the processing operations will be suspended, it is anticipated that the reservoir will receive less input from plant effluent and the chemical stability of the reservoir will require ongoing water quality monitoring.

Water levels and water quality will continue to be monitored at the Ravine Dam discharge point and the reservoir drainage will continue to be regulated by a head pressure controlled discharge valve. If the reservoir reaches a static level below the minimum operating level, water quality samples will be collected and analyzed from the reservoir and water will be treated, if necessary, before discharge.

4.4 Management of Mill and Process Plant

For a planned temporary closure period of less than one year, the mill will be secured and maintained so it can be restarted efficiently. The plant circuit will be cleared allowing for existing in-stream feed materials to pass through the varied processing stages. Pumping volumes for water reclaim and supply will be gradually reduced. Water can be temporarily stored in the plant water tank, including fresh and reclaimed process water, if necessary. The power supply would remain active to the plant.

The following temporary measures would be implemented at the processing plant during this period:

- Tanks containing materials (slurries) that have a risk of solid settlement, or sanding out, should be emptied, the slurries may be diverted to the tailings thickener and then filtered, or may be discharged into an emergency pond if available;
- Any recycled water may be reclaimed either from concentrate/tailings thickeners or from the tailings filters and diverted to the reservoir;
- Fuel, chemicals, and reagents should be secured and kept in the original containers;
- The pumping system for site water management including dewatering and reclaiming from the reservoir (if applicable) should continue to operate at a reduced rate; and
- Motors and pumps will be turned periodically to ensure that the systems remain operational.

For a temporary closure period that extends beyond one year, the mill facilities will be secured and maintained so that it can be restarted after a short period. Longer term preparations will take effect to ensure the security of the site and to maintain good repair of the plant equipment. Chemicals and reagents will be removed from the site and either returned to their supplier or disposed at a government approved facility, as deemed appropriate.

4.5 Management of Underground Workings

During temporary closure, the underground mine access will be gated with controlled access for frequent investigation, stability monitoring/testing and maintenance of ancillary systems, where required, within the main development. Unfinished stopes will be secured with backfill to prevent access to stope entrances. Emergency refuge and egress will be maintained to meet the established permitting and regulations of the Mines Act. Large mobile mining and fleet equipment will be parked on surface. The underground mine will be continued to be dewatered, with water being discharged to the reservoir, or treated as necessary.

Underground water sampling from designated sumps and pumping locations and will be measured against baseline and loading limit values to track chemical change indicators and potential ARD/ML reactions. If a progressive decrease in pH level or increase in metal constituent concentrations, or loading, is identified, then appropriate mitigation procedures will be implemented, including pumping the water to the surface water treatment plant, if necessary. Sampling will be conducted in continuity with the scheduled operational sampling and monitoring plan.

4.6 Management of General and Ancillary Infrastructure

General and ancillary infrastructure not in use during the temporary closure period will be secured with controlled access, where applicable. The access and site roads will be maintained to the same state as required during active operations to allow for safe passage of vehicles accessing the site. Only sufficient fuel will be stored on site for the essential ongoing activities, including heating, site transportation and power generation.

Monthly site and building inspections will be conducted by a Professional Structural Engineer to ensure for safety and compliance with applicable regulations, permits and licences of onsite infrastructure.

4.7 Facilities to Remain in Operation During Temporary Closure

The following facilities will remain active and maintained according to operational procedures during the temporary closure period:

- Main access road (to be gated and secured);
- Camp and ancillary infrastructure (including sumps, pumps, water treatment and sewage collection);
- Light duty vehicles;
- Reservoir and reclaim pipelines and pumps;
- Underground dewatering pipelines and pumps;
- Fuel storage facility;
- Water treatment plant (as required);
- Power generating facility;
- Small maintenance work shop; and
- Communications system.

Active water and solution piping will be monitored for freezing and ice build-up as per operational procedures. Where it is determined that the piping is not necessary for temporary closure, the system will be drained using appropriate diversion, collection and/or treatment procedures to prevent unnecessary freezing and pipe breakage.

4.8 Staffing Requirements

NATC will ensure that qualified staff is available on a rotating schedule to manage ongoing monitoring and mitigation activities on site. A minimum skeleton staff of seven personnel will be available to the site throughout temporary closure. NATC may apply to Yukon Government Chief Mining Inspector in writing to request a reduced requirement for onsite staff during a winter closure period. Available staff will include a site manager, underground mine/shift supervisor, plant engineer, environmental technician, small maintenance tradesperson, a general caretaker and cook. The staff will have appropriate technical qualifications and at least person will have the appropriate occupational health and safety training to satisfy the established mine permits and regulations.

5.0 CLOSURE

We trust this report meets your present requirements. If you have any questions or comments, please contact the undersigned.

Respectfully submitted,
EBA Engineering Consultants Ltd.

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REFERENCES

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Veolia Water Solutions and Technologies Industrial Applications

Manitoba Science, Technology, Energy and Mines
Mines Branch
July 6, 2009

VEOLIA WATER

COMPANY OVERVIEW

COMPANY OVERVIEW

WORLD LEADER IN ENVIRONMENTAL SERVICES

Present in more than 100 countries
with 310,000+ employees.
2008 Revenue = $42 billion

VEOLIA WATER SOLUTIONS AND TECHNOLOGIES

The technological **division of Veolia Water,** VWS is **the leader** in terms of:

- volume of activity
- number of references
- quality of offer (technology portfolio)

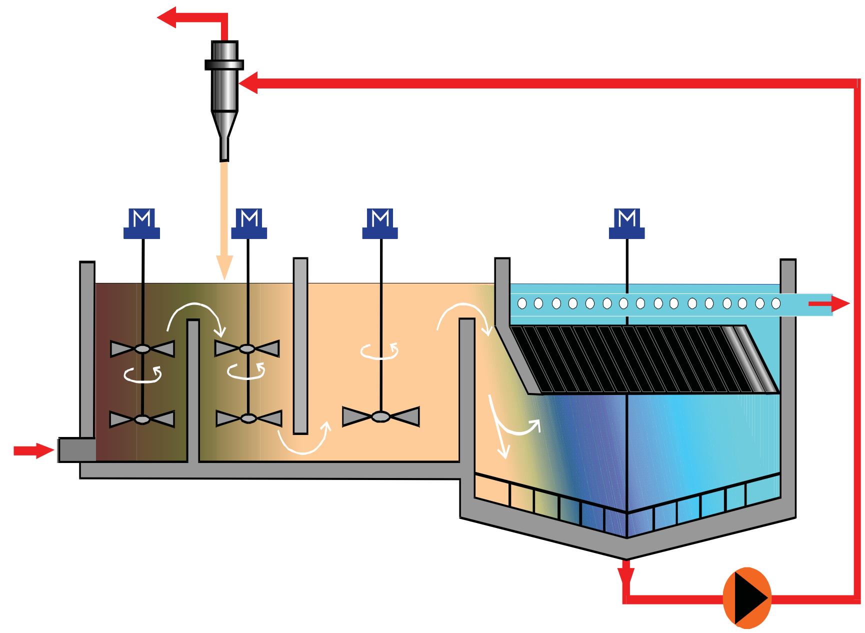
➔ **120 subsidiaries** in **over 55 countries**

➔ **$2.8 billion** in revenue **in 2008**

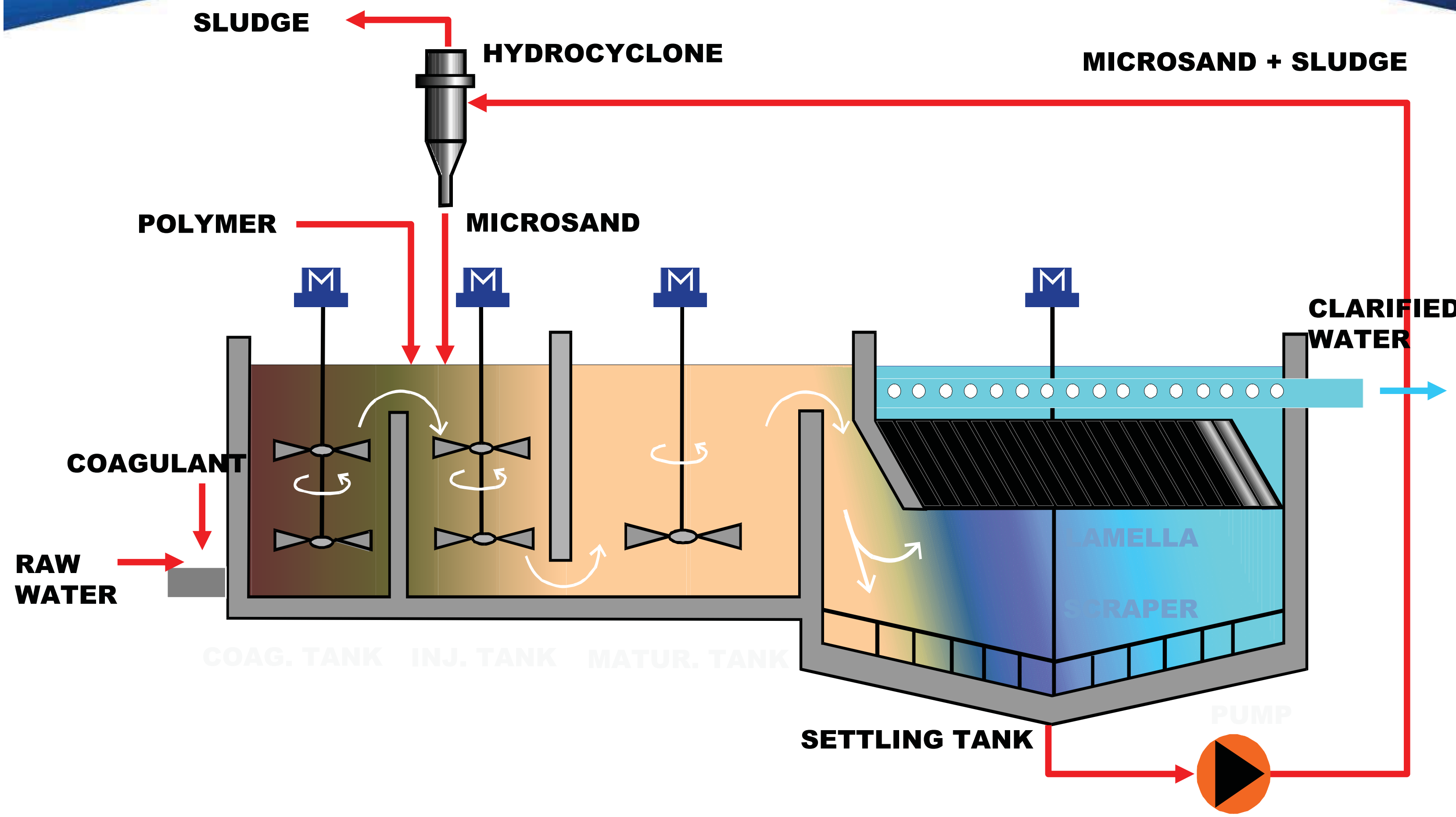
TECHNOLOGIES

ACTIFLO is a patented clarification process that relies on :

- Efficient coagulation
- Enhanced flocculation
- Ballasted floc
- Lamella tube settling
- Microsand recirculation



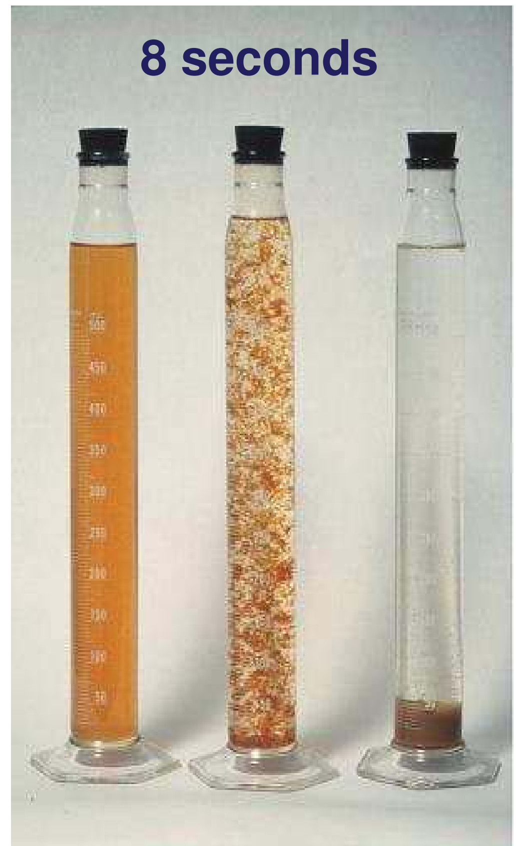
TECHNOLOGIES: ACTIFLO



VEOLIA
WATER

ACTIFLO® Treatment Simulation

Left to right (Conventional, polymer assisted, and ballasted sedimentation)



VEOLIA WATER

ACTIFLO®
Relative Installed Footprint Comparison

TECHNOLOGIES: ACTIFLO

Parameters		Units	Mixed 95% FC/ 5% SM
Operational parameters			
1011 dry polymer dosage		mg/L	0.65
Total neutralization time		min.	6
Neutralization time in the tank		min.	4
Set pH in the neutralization tank		--	10.5
Flow rate		m^3/h	39
Rise rate		m/h	52
Analytical parameters			
Total suspended solids*	AFW	mg/L	147
	CW	mg/L	3.3
	Removal	%	→ **98**
Nickel*	AFW	TCU	7.89
	CW	TCU	0.19
	Removal	%	→ **98**
Copper*	AFW	mg/L	0.287
	CW	mg/L	0.048
	Removal	%	→ **83**
Iron*	AFW	mg/L	27.6
	CW	mg/L	0.26
	Removal	%	→ **99**
Turbidity	AFW	NTU	110
	CW	NTU	0.764
	Removal	%	→ **99**
Alkalinity (as $CaCO_3$)	AFW	mg/L	100
	CW	mg/L	80
Temperature	CW	ºC	1.7
Calcium*	AFW	mg/L	386
	CW	mg/L	369
Sulfates*	AFW	mg/L	1539
	CW	mg/L	1482
pH	CW	--	10.6

Mining Application

Actiflo Results

Nickel 98% removal

Copper 83% removal

Iron 99% removal

Turbidity 99% removal

Temperature near freezing!

VEOLIA WATER

Mining

96% Arsenic Removal

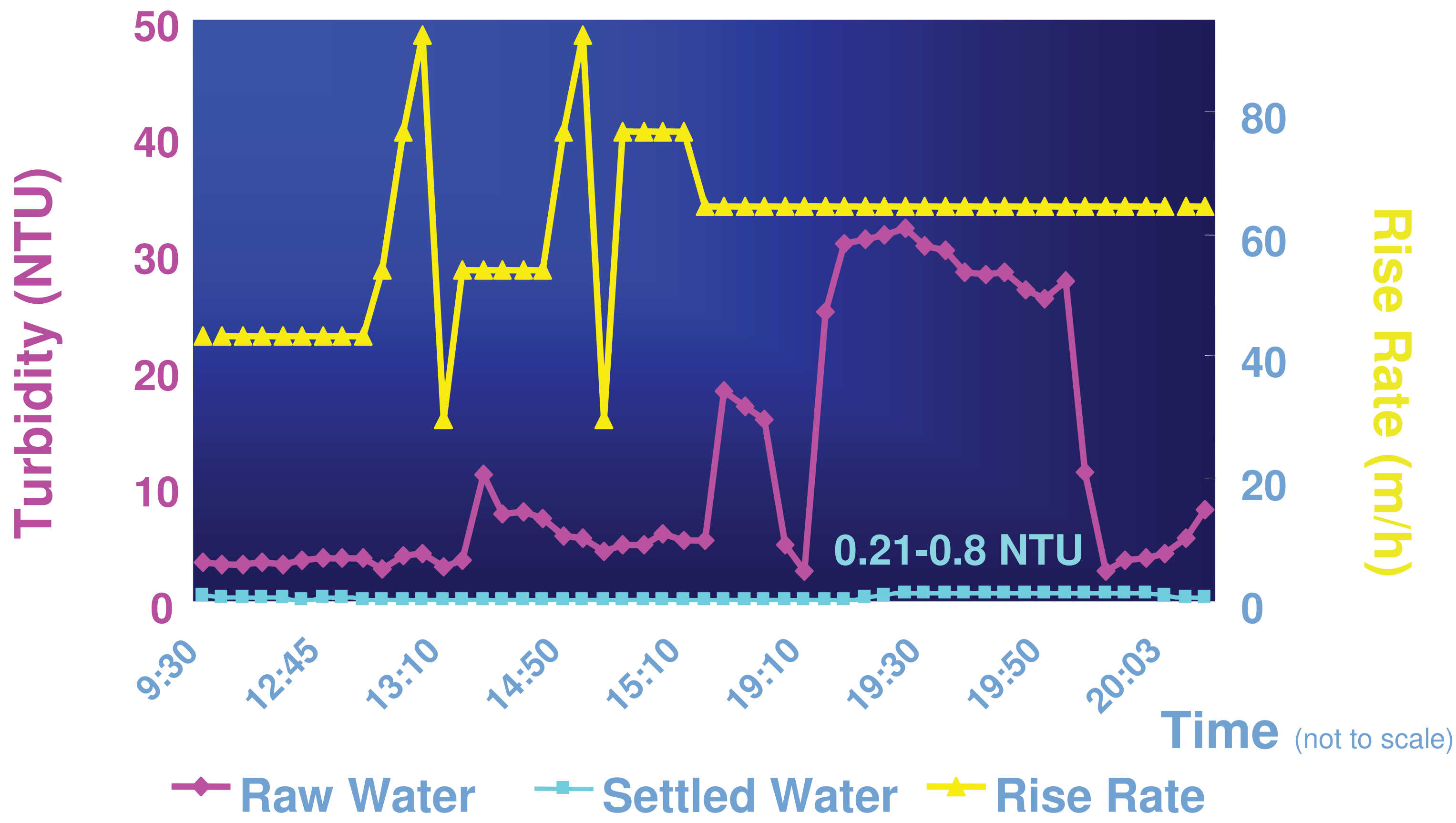
Parameters		Units	Oxidant		
			$KMnO_4$		NaOCl
Coagulant	Type	--	$FeCl_3$	$FeCl_3$	$FeCl_3$
	Dosage	mg/L	30	30	30
Polymer	Type	--	1011	1011	1011
	Dosage	mg/L	0.2	0.2	0.2
Oxidation	Type	--	$KMnO_4$	$KMnO_4$	NaOCl
	Dosage	mg/L	0.25	0.5	1.25
	Contact time	min.	2	2	5
PH	RW	--	7.63	7.63	7.63
	CW	--	7.08	7.22	7.02
Turbidity	RW	NTU	1.84	1.84	1.84
	CW	NTU	1.60	2.03	0.93
	% removal	%	**13.0**	**NA**	**49.5**
Apparent colour	RW	ACU	41	41	41
	CW	ACU	20	25	22
	% removal	%	**51.2**	**39.0**	**46.3**
Total arsenic*	RW	mg/L	0.686	0.586	0.686
	CW	mg/L	0.028	0.028	0.017
	% removal	%	**95.9**	**95.9**	**97.5**
Total iron	RW	mg/L	1.89	1.89	1.89
	CW	mg/L	0.39	0.22	0.31
	% removal	%	**79.4**	**88.4**	**83.6**
Total manganese	RW	mg/L	0.2	0.2	0.2
	CW	mg/L	0.106	0.14	0.119
	% removal	%	**47.0**	**30.0**	**40.5**

Actiflo Data: Mining

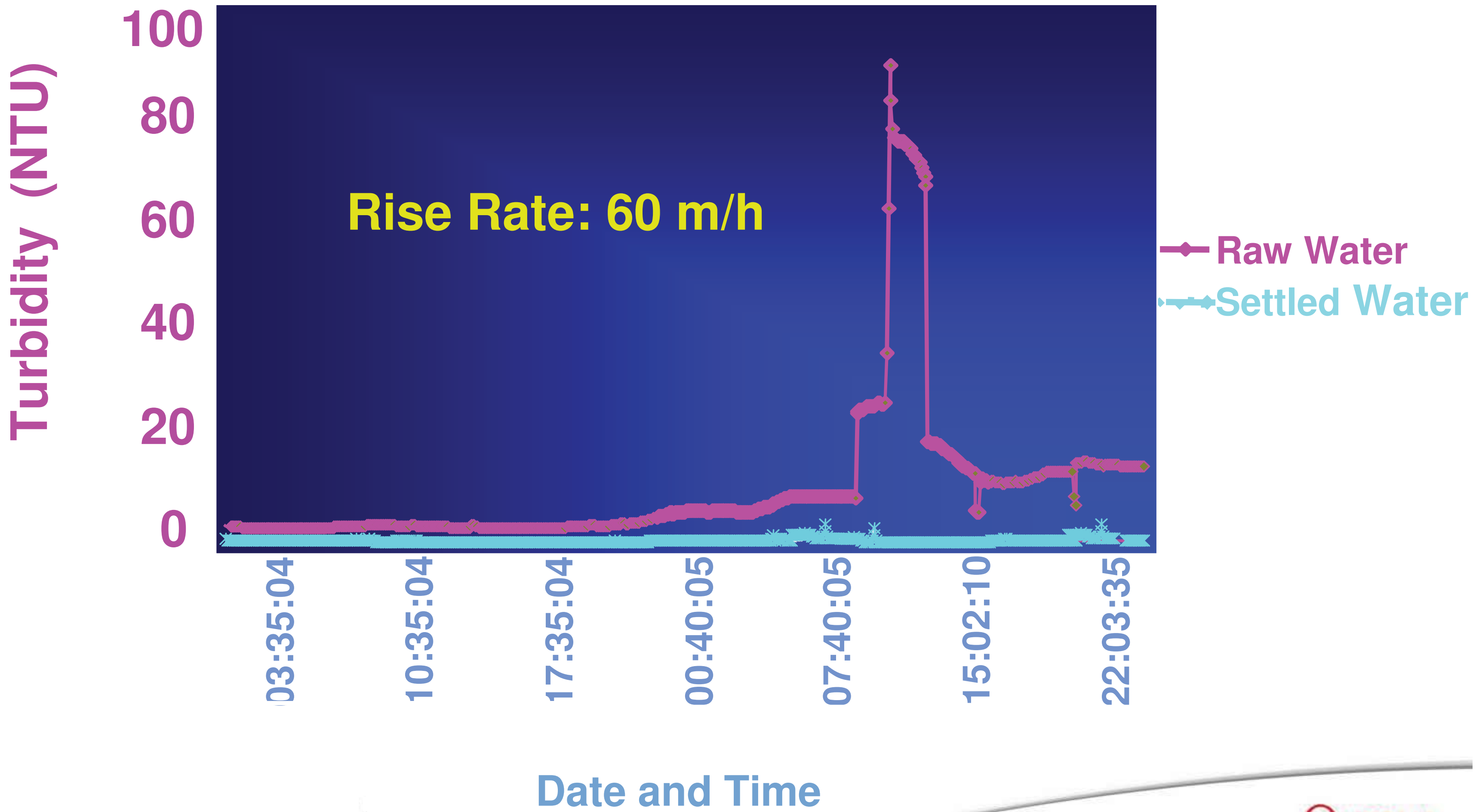
Sb, Mo, Cu Removal

Coagulant-lime addition sequence			Simultaneously	Coagulant : 5 min Lime : 5 min.
Coagulant	Type Dosage	-- µL/L mg/L Fe	$Fe_2(SO_4)_3$ 325 60	$Fe_2(SO_4)_3$ 325 60
Lime	Dosage	mg/L	120	120
Polymer	Type Dosage	-- mg/L	Magnafloc 10 0.5	Magnafloc 10 0.5
pH	ETP CW	--	7.46 6.90	7.46 7.10
Turbidity	ETP CW **Removal**	NTU NTU **%**	1.39 0.28 **79**	1.39 0.31 **77**
Total Arsenic (As)*	ETP CW **Removal**	mg/L mg/L **%**	0.009 0.002 **77**	0.009 0.001 **88**
Total Antimony (Sb)*	ETP CW **Removal**	mg/L mg/L **%**	1.96 0.22 **88**	1.96 0.17 **91**
Total Copper (Cu)*	ETP CW **Removal**	mg/L mg/L **%**	0.23 0.05 **78**	0.23 0.01 **95**
Total Lead (Pb)*	ETP CW **Removal**	mg/L mg/L **%**	< 0.01 < 0.01 **--**	< 0.01 **< 0.01** **--**
Total Mercury (Hg)*	ETP CW **Removal**	mg/L mg/L **%**	< 0.1 < 0.1 **--**	< 0.1 < 0.1 **--**
Total Molybdenum (Mo)*	ETP CW **Removal**	mg/L mg/L **%**	1.61 0.24 **85**	1.61 0.42 **73**
Total Nickel (Ni)*	ETP CW **Removal**	mg/L mg/L **%**	0.24 0.16 **33**	0.24 0.06 **75**
Total Zinc (Zn)*	ETP CW **Removal**	mg/L mg/L **%**	0.03 < 0.01 **> 66**	0.03 < 0.01 **> 66**

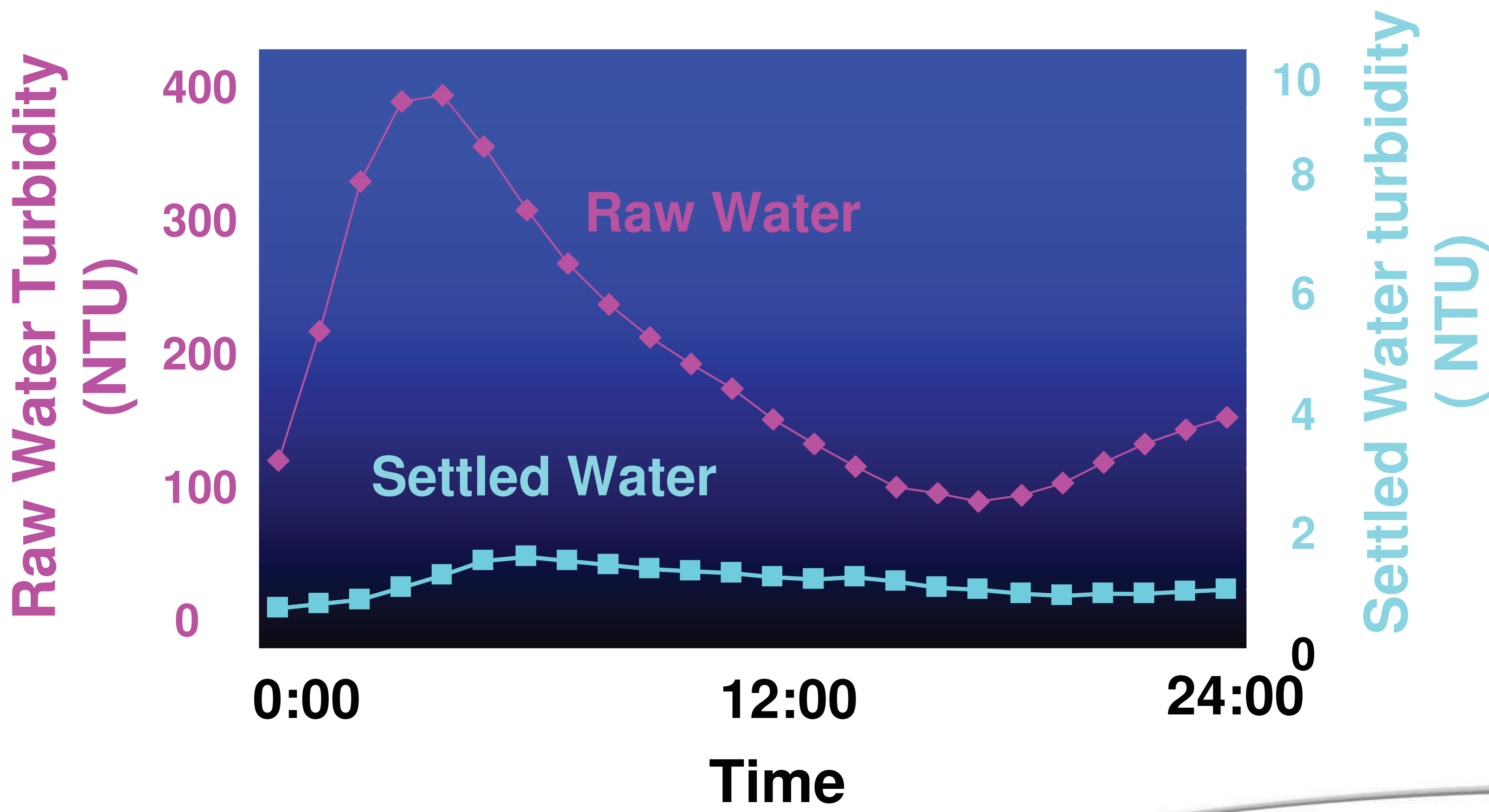
Stability


Turbidity (NTU)
50
40
30
20
10
0
80
60
40
20
0
Rise Rate (m/h)
0.21-0.8 NTU
9:30
12:45
13:10
14:50
15:10
19:10
19:30
19:50
20:03
Time (not to scale)
Raw Water
Settled Water
Rise Rate

Stability in Turbidity Spike



Stability in Turbidity Spike



Packaged Systems

Hi flow, low footprint, portable, packaged plants for any application.

VEOLIA WATER

TECHNICAL SERVICES

TREATABILITY STUDIES & PILOT PLANTS

ACTIFLO Pilot Plant (0.7 MGD)

PILOT PLANTS

goldcorp inc.

teckcominco

INCO

VEOLIA WATER

REFERENCES

METALS AND CYANIDE

GOLDCORP

- Mercury, Arsenic and other metals
- Start up Spring 2009

ACTIFLO - Arsenic

Goldcorp Wilanour Mine

- 8000 m^3/d (2 MGD)
- dual train, concrete Actiflo
- Arsenic reduced from 2 mg/L down to 0.02 mg/L

Start-up spring 2006

goldcorp inc.

Goldcorp Red Lake Mine

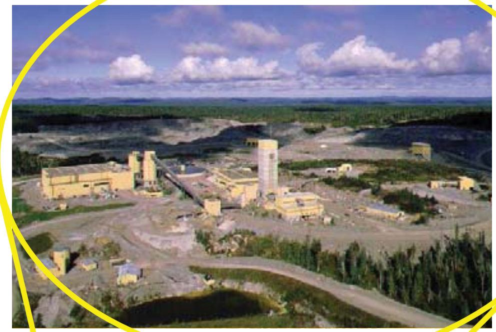
- 30,000 m^3/d (8 MGD)
- dual train Stainless Steel Actiflo Packaged Plant.
- Each unit 15’W x 38’L
- Arsenic reduced from 2 mg/L down to 0.02 mg/L

Start-up spring 2007

Barrick Gold Williams Mine

- 2000 m^3/d
- Tailings Effluent Treatment
- Single train Actiflo Packaged Plant
- TSS, Mo and Sb removal with option for sludge recirc

Start-up Winter 2010



VEOLIA WATER

Campbell Resources– Gold Mine

Actiflo Pilot Trailer (Mobile) 2100 m^3 per day

Application: Mine Shaft Dewatering - TSS

Package Plants

Troilus Mine – Northwest Quebec

Model: Actiflo ACP-750 (3500 gpm - 5 MGD)

Application: Mining Effluent - TSS

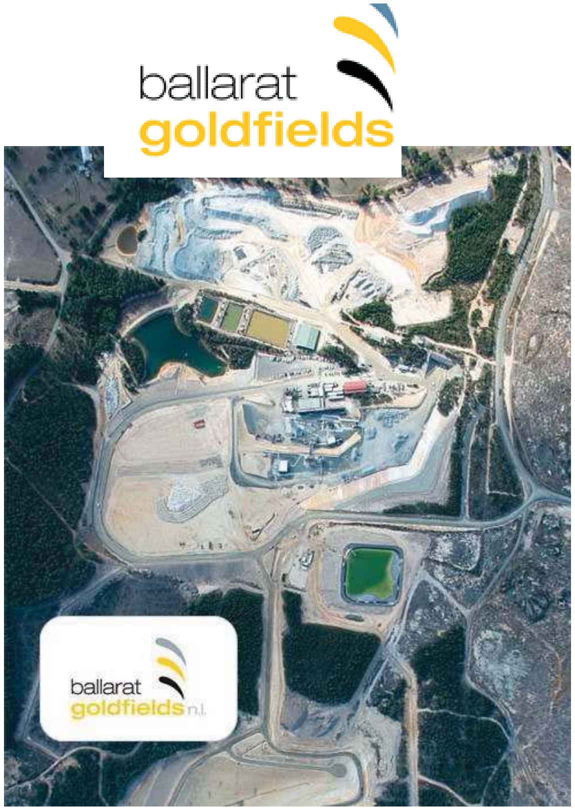
Redcorp Resources-Tulsequah Chief Mine

- 8000 m^3/d (2MGD)
- Dual train, packaged Actiflo and Filters
- Metals Removal to meet BC MEND Effluent Limits

Start-up summer 2009

ACTIFLO® HEAVY METALS REMOVAL

- **Project:** Ballarat Goldfield
- **Location:** Melbourne Aus.
- **Application:** Actiflo/Actidisc Treatment of underground mine water at the Ballarat Goldfields to remove heavy metals, arsenic, iron, manganese and other contaminants, with discharge to environment.
- Flow Rate**:** The new plant with a capacity of 3.89 ML/day



VEOLIA WATER

ACTIFLO® - Full Scale Turnkey Installation

STORA-ENSO
Port Hawksbury, NS
Paper Plant

- Turnkey, process water plant
- Guaranteed flow: 60,000 m^3/d (16mgd)
- Guaranteed performance: < 0.25 NTU Color < 5 UCV
- Commissionning: 2002
- Equipment: Actiflo®, Dusenflo®, dosage, pumping, instrumentation & control.
- Scope of work: Engineering, excavation, construction, electricity, building, operation assistance

Project Value: $7 600 000

STORAENSO

VEOLIA WATER

PROCESS WATER: URANIUM MINE

Project: SXR Uranium One –
VWS South Africa : Finance, Build, Operate, Maintain – 5 years

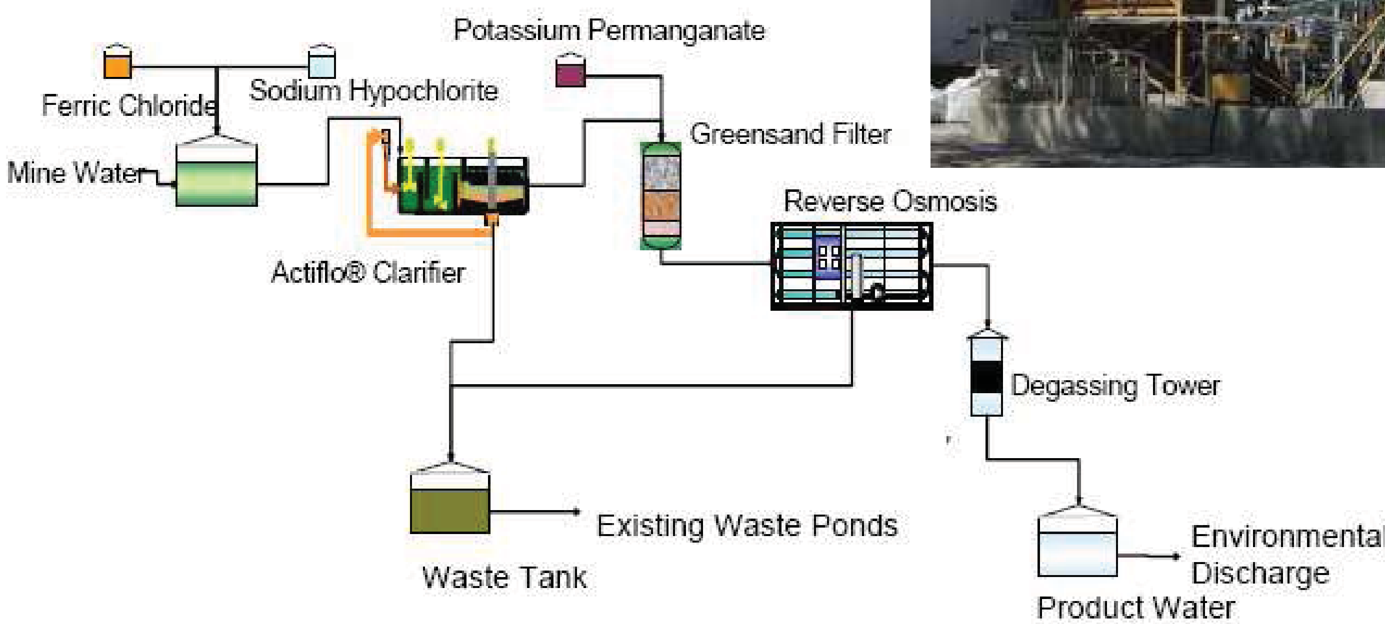
Location: Dominion South Africa
Start up: 2006
Application: Plant Process Water production

VEOLIA WATER

METALS REMOVAL

Bendigo Gold Mine – Australia

7000 m^3/d (2 MGD) Metals removal



VEOLIA WATER

2003 Turnkey design of 7.0 MGD 2-Stage Acid Mine Drainage Treatment System Horseshoe Bend WTP, Butte Montana

More efficient use of neutralizing agent
Reduces the volume of sludge generated from treating metal bearing wastewater
Reduces the quantity of filter cake generated (50 % decrease)
Reduces sludge dewatering time
For mine drainage wastes, provides capability to remove manganese and iron at a reduced pH
Consistent pH control
Decreases sludge blanket in clarifiers
Generates a metal oxide that may be reclaimed
Reduced scaling from gypsum formation