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7 South Mine Groundwater Evaluation – Quinsam Mine

May, 2011



Enterprise Geoscience Services Ltd.



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1. Introduction



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1. Introduction

Quinsam Coal Corporation (QCC), and its parent company Hillsborough Resources Ltd. are proposing to develop the 7 South mine, which is a new underground mine that will extract coal from the No. 4 Coal Zone. Coal that is mined from the 7 South mine will be washed at the existing QCC coal processing facility and the clean coal will be hauled to the barge loading facility near the City of Campbell River. Coarse reject washed from the raw coal will be placed in underground mine voids and flooded to prevent acid generation and limit the rate of metal loading. A portion of this coarse reject will be placed in the west panel of the 7 South Mine. The 7 South Mine tailings are proposed to be placed in the 2 North Mine and 3 North Mine voids rather than in the 7 South mine. In addition, a small pit will be developed on the south east side of the proposed 7 South mine to expose the No. 4 Seam coal subcrop and to provide a staging area at the portal entrance to the new mine area.

Quinsam Coal Corporation (QCC) submitted an application to the Ministry of Energy Mines and Petroleum Resources (MEMPR) to amend the current Mine Permit No. C-172 with the inclusion of the proposed 7 South mine development. Following the review of the application, specific comments were raised by MEMPR (now Ministry of energy and Mines (MEM)). These comments were provided in their memorandum of June 16, 2010 (File C-172) as follows:

Geotechnical

21. Design information on the interaction of 7S and 5 South is required.
22. Records of subsidence monitoring undertaken to date on the 2-North and 5-South.

Geochemistry

32. Further work to determine whether future tailings could be PAG.
33. Further assessment to understand if elevated arsenic leaching from PAG CCR is a concern
34. What is the predicted effect to surface and ground water quality during operations and post-closure? Based on kinetic test work, water from the workings is expected to be elevated in sulphate, selenium, cadmium and boron. Based on elevated sulphide and

arsenic contents, what is the potential for arsenic leaching from the 7 South during operations and post closure?

35. What are the implications on long-term/post closure water quality if sections of the underground workings remain un-flooded (*i.e.* extreme southeast corner)?

An assessment of the geochemistry of the 7 South strata and mine waste, geochemical source terms of the underground mine waters, existing and post-mining groundwater conditions (both physical and groundwater quality) and predictions of seepage rates and mass loadings from the 7 South underground mine to receiving waters has been prepared for the Quinsam Coal Mine. The assessment was conducted jointly by Lorax Environmental Services Ltd (Lorax) and Enterprise Geoscience Services Ltd. (EGSL).

Coincident with this work, a geotechnical assessment of mine-induced subsidence has been carried out to develop an understanding of the potential interaction between subsidence associated with the adjacent 5 South mine and 7 South mine. The 5 South mine has developed the stratigraphically-lower No. 1 Coal seam and portions of the 5 South mine have been partially depillared. The geotechnical assessment was carried out by Michael Cullen Geotechnical Ltd. and relevant findings to the groundwater condition have been reported herein.

2. Environmental Setting



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2. *Environmental Setting*

The Quinsam Mine is located approximately 20 km west of Campbell River on the northwest end of the Comox Coal Basin, which is hosted within Nanaimo Group sedimentary strata, which extend south to Mud Bay along the east coast of Vancouver Island (Figure 2-1).

The proposed 7 South underground mine is located south of the Quinsam River, which is on the opposite side of the river from the existing 2 North and 3 North mine workings (Figure 2-2). The 7 South mine lies immediately south of the existing 5 South Phase 1 workings, however, unlike the 2 North, 3 North and 5 South mines that are stratigraphically positioned on the No. 1 Coal Seam, the 7 South Mine is positioned roughly 100 m above the No. 1 Coal Seam on the No. 4 Coal Zone. Access to the 7 South mine will be through a portal on the subcrop located along the southeast margin, at approximately 300 m elevation (Figure 2-2). A small surface pit will be developed to expose the No. 4 Coal Zone and provide a staging area for mining equipment at the entrance to the mine.

The Quinsam coal measures are located in the Comox Formation, which forms the base of the Nanaimo Group sedimentary wedge that unconformably overlies volcanic rocks of the Karmutsen Formation (Figure 2-3). The upper portion of the Comox Formation consists of hard, massive sandstone (Dunsmuir Member), hosting the No. 3, No. 4 and No. 5 coal seams along with minor siltstone interbeds. The underlying, less competent Cumberland Member is comprised of siltstone and shale and lies between the No. 1 and No. 2 coal seams. The base of the Comox Group, the Benson Member, consists of coarse sandstones and conglomerates.

The 7-South mine will develop the No. 4 coal zone, which ranges in thickness from 3.5 to 4.8 m. The No. 4 coal zone is comprised of the No. 4 Upper and Lower coal seams which are separated by a medial parting of sandstone and mudstone of 0.15-0.4 m thickness. The 4 Lower Coalbed is typically 0.9 m to 2.22 m thick and includes several sandstone and dirty coal / mudstone partings. The Upper No. 4 Coalbed contains few partings and is typically 2.2 to 2.5 m thick but thicknesses may increase to over 3 m. The roof of the 4 Coalbed has a sharp contact with the overlying silty sandstone. In the 7-South area, the No. 4 coal seam dips to the north (mine grid) with elevations of the top of the seam ranging from 285 m at the south end to 210 m at the north end (Figure 2-2).

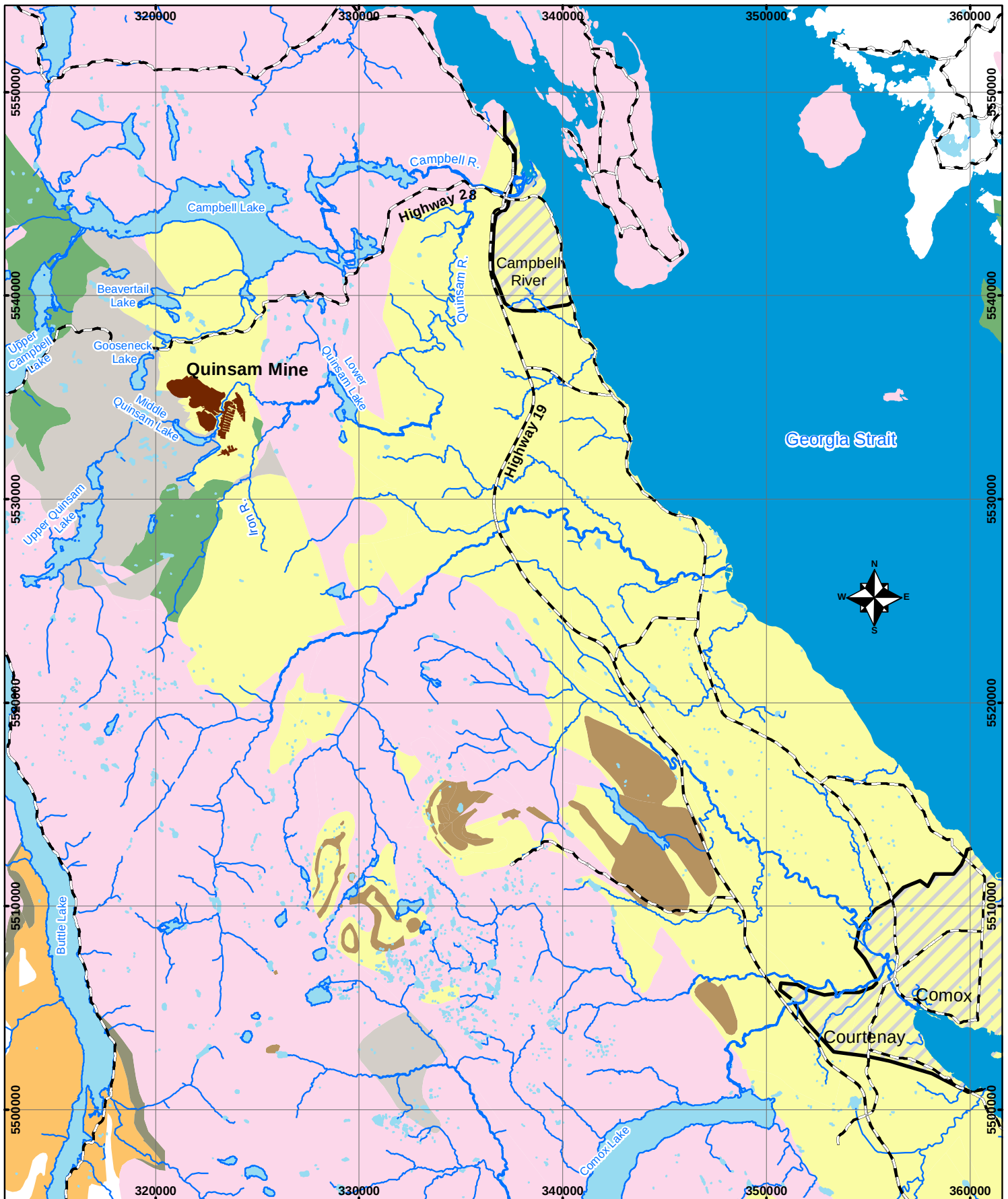
The stratigraphic separation between the No. 4 and No. 5 coal seams varies in thickness. Along the eastern margin of the 7-South area, the separation between the two seams is less than two meters, while along the western portion the separation is on the order of

25 meters. The top of the No. 5 coal seam subcrops at a depth of approximately 15m below ground surface at the southern end of the 7 South area and is completely eroded at the north end. The seam itself is approximately 0.5-0.7 meters thick.

The Comox Formation strata is overlain by a till veneer, which in the 7 South area covers virtually all bedrock, with the exception of localized outcrops occurring typically along steep slopes or on slope crests. The till typically ranges from 1.5 to 8 m in thickness in this mine area, but can range from 0 to 25 m. It is generally thinnest in the central and eastern portions of the 7 South mine area, and thickest in the southeastern and northern extremities of the 7 South area. It should be noted that the southern portion of the 7 South mine area is forested, while the northern half was logged in 2006-2007 (S. Gardner, pers. Communication).

The proposed 7-South is bound at its southern end by the Five South and Long Lake faults, to the east by the Boundary Fault and to the north by the Quinsam River (Figure 2-3). The northern portion of the mine is also transected by the Overlook Fault. The Boundary Fault is an east-dipping thrust fault, while the Overlook and Five South Faults are high-angle normal faults. The Long Lake fault, which offsets the Five South Fault, is a high angle thrust fault that dips to the south-east. The long axis of the mine follows the north-dipping limb of the Quinsam Syncline (mine grid), a broad synclinal fold that covers the northern portion of the Middle Quinsam area (Cathyl-Bickford, 2007). As such, the beds are tipped up along the subcrop on the east side of the proposed portal and dip as much as 15 degrees (Cathyl-Bickford, 2007).

The topography in the southern portion of the development is undulating, with highs ranging up to 316 m above sea level. This area represents a drainage divide between the Quinsam River to the north and east, and the Iron River 2.5 kilometres to the south. The majority of the runoff reports directly to the Quinsam River or on the eastern margin to ephemeral streams that flow through a wetland before entering the Quinsam River. Runoff from the extreme southern portion of the 7-South mine area drains into ephemeral streams which eventually feed the Iron River. The streams on the eastern margin appear to be gaining in their lower reaches. The northern portion of the mine slopes to the north at approximately 5 degrees, with the slope steepening to 8 degrees in the northernmost reach towards the flat river valley. The Quinsam River varies in elevation from 210 m at the northern end of the proposed mine area to 192 m where the ephemeral streams enter the river.



Stratigraphic Units

Bonanza Group	Mount Washington Plutonic Suite	Underground Mine Workings
Buttle Lake Group	Nanaimo Group	Highway
Buttle Lake Group Mount Hall Gabbro	Sicker Group	Rivers
Island Plutonic Suite	Vancouver Group	Municipality

Figure: 2-1

Title Regional Geology Map

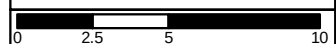
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Notes

1. Municipal boundaries are approximate
2. Geology Basemap Source: B.C. Digital Geology Maps (1.0. 20050, Ministry of Energy, Mines, and Petroleum Resources)



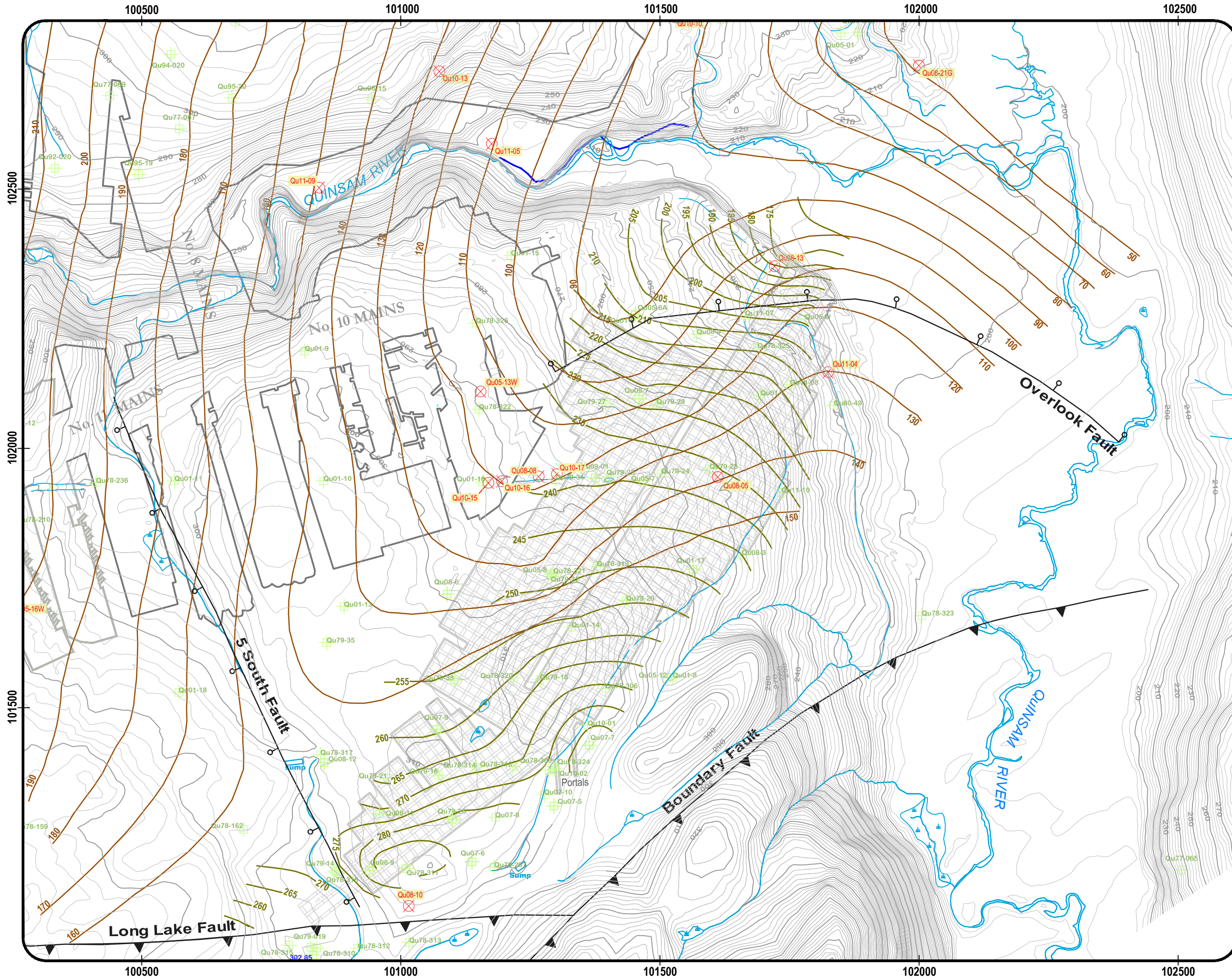
Units	Kilometers
Proj.	UTM Zone 10
Datum	NAD 1983
Date	April, 2011

Project No. **J885-1**

Project

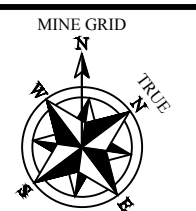


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Legend

- Proposed 7 South Workings
- Existing Mine Workings Outline
- Groundwater Well
- Boreholes
- Swamp/Marsh
- Thrust Fault
- High Angle Normal Fault
- Surface Water Body
- 1 Seam Contour
- 4 Seam Contour



Meters
0 100 200

Projection: Mine Grid Coordinates

Figure Title
7 South Coal Contours and Major Structural Features

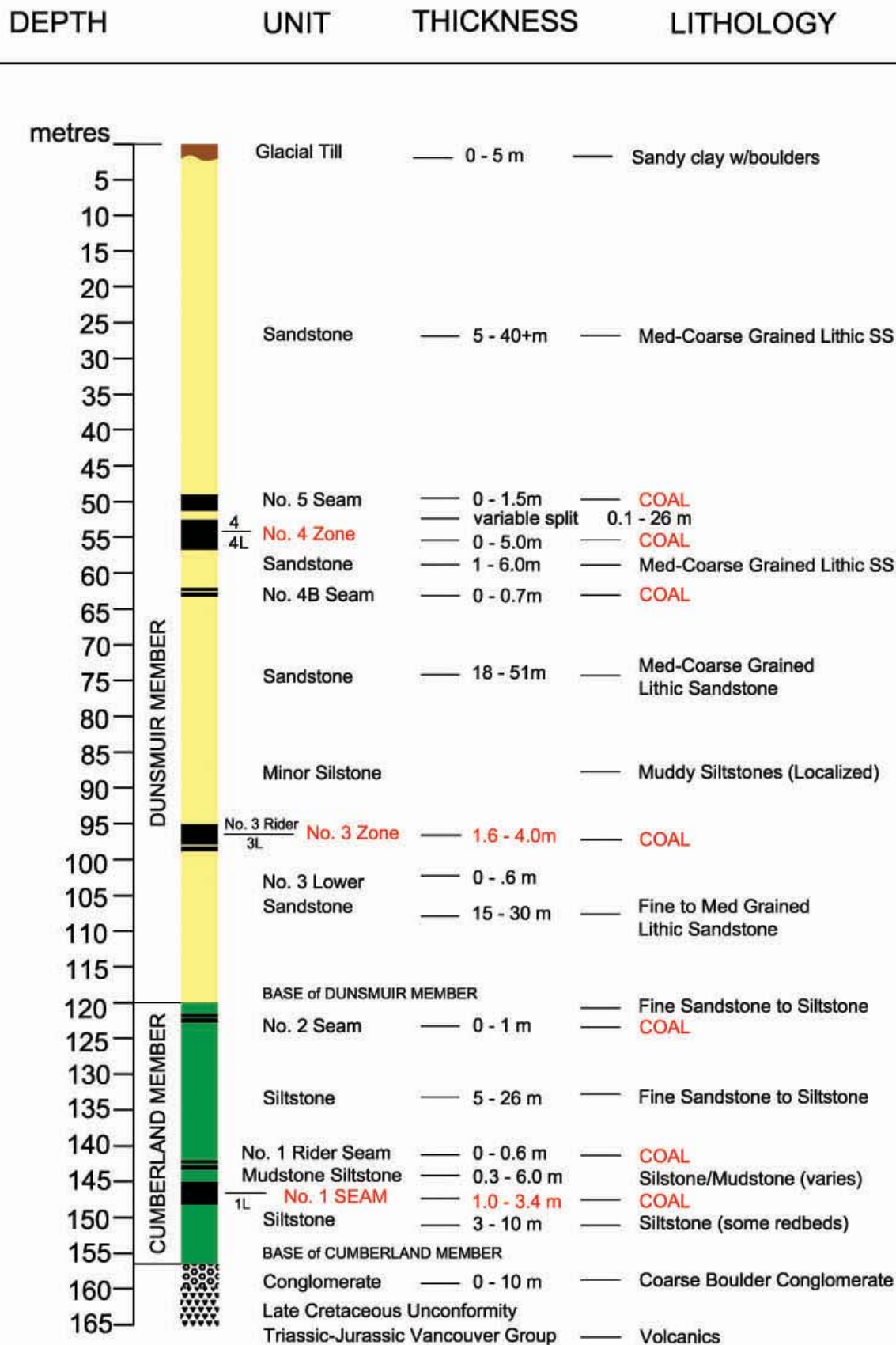
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Project No.
J885-1

Client
Hillsborough Resources

Date
Apr 25, 2011

GENERALIZED STRATIGRAPHIC SECTION - QUINSAM MINE



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DESIGNED BY

DWG. CHECK

DRAWN BY

SCALE: 1:1,000

PROJECT NO:

SSS

Oct 26, 2009

885-2

QUINSAM COAL CORPORATION

**Generalized Stratigraphic Section
7 South Mine Area**

FIGURE

2-3

REV.

3. Scope of Work



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3. Scope of Work

Numerous tasks were carried out to collect the information necessary to address the MEM comments presented in Chapter 1. The scope of work for the study included the following:

- Completion of several 2008 exploration boreholes with single or nested monitoring well installations;
- Drilling of boreholes in the 7 South area for characterization of the No. 4 coal seam subcrop;
- Conducting hydraulic response tests in monitoring wells to determine representative hydraulic conductivity values for 7 South area bedrock units. Hydraulic conductivity test results from coal seams and sandstones in other parts of the mine were also used to develop a representative database for use in estimating groundwater flow and mass flux from the 7 South mine;
- Water level monitoring of 7 South area monitoring wells;
- Sampling of monitoring wells for baseline groundwater quality;
- Literature review of previous consultants reports and data from QCC files on the 7-South area;
- Literature review regarding fracture flow, tracer tests and time of travel of groundwater in fractured rock for use in 7 South mine groundwater flow and contaminant transport assessment;
- Literature review regarding the geochemical evolution of coal mine pool water chemistry, for use in 7 South mine geochemical model development.
- Review and compilation of Water Survey of Canada data from Quinsam River to estimate flows downstream of the 7 South Mine.
- Review and compilation of QCC data from Quinsam River to estimate flows downstream of the 7 South Mine.
- Review and compilation of Quinsam River water quality data at the outlet of Middle Quinsam Lake (Site WB) and a location downstream of the 7 South area (Site 7SQR)
- Static testing of Dunsmuir strata overlying No. 4 Seam

- Ongoing leaching of 7 South coarse reject in saturated and unsaturated kinetic tests to evaluate metal release rates of coarse reject under both exposed and flooded conditions.
- Development of representative “geochemical source terms” for future conditions where the 7 South mine is used for disposal of coarse reject and allowed to re-flood.
- Determine NP depletion rates of coarse reject, raw coal and tailings from 7 South mine.
- Development of a conceptual model for groundwater flow to identify the flow paths from the 7 South workings to the ultimate receiving waters;
- Provide an overview of baseline groundwater quality in the 7 South mine;
- Estimation of groundwater seepage rates from the 7 South mine under fully flooded steady-state conditions;
- Estimation of the time required for seepage to reflood the mine;
- Estimation of mass flux from the underground workings for key chemical parameters associated with CCR drainage. Estimation of groundwater seepage rates and groundwater mass fluxes were determined using a Monte Carlo simulation method that accounts for the ranges in hydrogeologic parameters at the 7 South mine and surrounding area;
- Assessment of time of travel to the receiving waters and predicted effects in water quality in the receiving waters; and,
- Preparation of this report to address the requirements of MNRO as described above in Section 1.

4. Hydrogeology



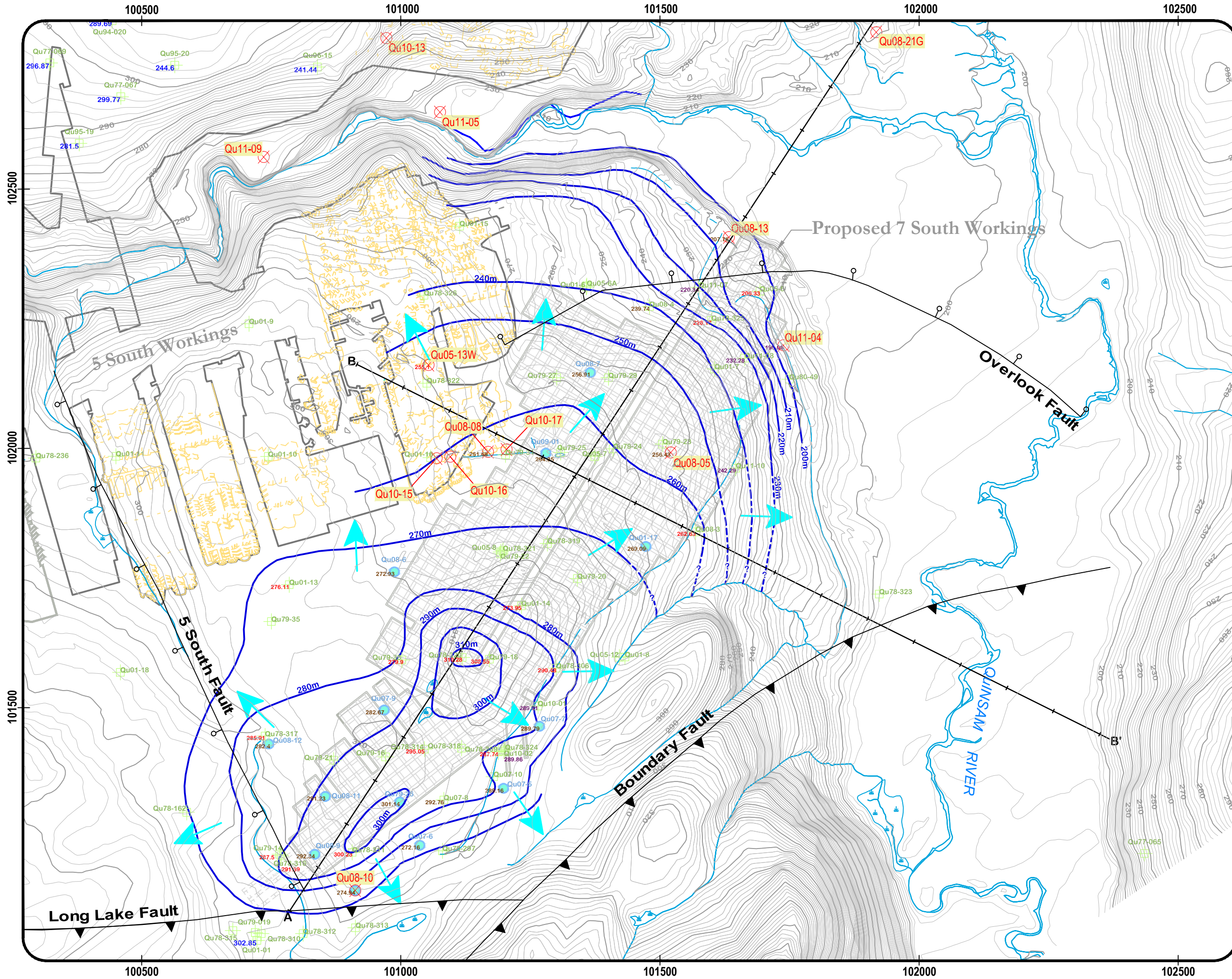
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4. Hydrogeology

Several sources of information have been reviewed for the hydrogeological assessment of 7 South mine. These sources of information include previous consultants' reports including Golder (2009) and Lorax (2009) and current and historic water level data compiled by QCC, Lorax and Golder. In addition, this review also includes results from the 7 South hydrogeological field investigation performed by Lorax in April-May 2010 and ongoing water level monitoring program. This section describes the groundwater flow system in the vicinity of the 7 South Mine, flow pathways to the receiving environment, hydraulic conductivity and flow gradients, and estimates of recharge rates to the mine.

4.1 Groundwater Flow System

Groundwater levels in the 7 South mine area have been contoured in Figure 4-1 and are summarized in Table 4-1. Hydrogeological cross sections along lines A-A' and B-B' are illustrated in Figures 4-2 and Figures 4-3. The contoured water levels reflect the "pre-mine" water table for the 7 South area and *exclude* current influences of mining from 5 South. The data have been compiled from three sources: monitoring of open boreholes performed by QCC and Golder (summarized in Golder (2009)), recent water level monitoring in 2010 and 2011 open boreholes performed by Lorax and QCC and water levels noted from geophysical logs of exploration boreholes at the end of drilling (dating back to 1978). All of these water level measurements have been measured in open boreholes and as such may not represent the true water table elevation. The water column in an open hole is influenced by differing fluid potentials at different depths, and, depending on vertical hydraulic gradients, may be higher or lower than the actual water table elevation. Nevertheless, the water level data were carefully scrutinized and are believed to represent a reasonable approximation of the groundwater flow patterns in the 7 South area. The most credence was given to the April 2009 Golder data. Most boreholes were monitored for at least one year prior to this date and the trends indicate that the water levels had stabilized from drilling. Further, there was no indication of declining water level trends based on the 2009 data to suggest drawdown influence from operation of the 5 South mine. These water levels were in turn used to vet water levels from the geophysical logs at the exploration holes. Post-drilling water levels can be unreliable as it can take several weeks for the water level to climb or recede to a representative static after drilling in tight formations with low hydraulic conductivity (as seen recently at QU11-02 in the 4 South area). The recent water levels taken in QU10-01 and QU10-2 are assumed to be representative as they have had several months to stabilize. The QU11 series boreholes have had less than a month to stabilize, however, they appear reasonable in relation to the topography.



Legend

- GOB
- Surface Water Body
- Definite Groundwater Equipotential
- Inferred Groundwater Equipotential
- Thrust Fault
- High Angle Normal Fault
- Hydrogeologic Cross Section A-A'
- Groundwater Well (Qu08-13)
- Boreholes (Qu11-08)
- Swamp/Marsh
- Boreholes with Continuous Monitoring (Qu08-07)
- Inferred Groundwater Flow Direction
- Pre Mine Water Level From Lorax 2011 (220.34)
- Pre Mine Water Level From Drill Record (226.17)
- Pre Mine Water Level From Golder 2009 (256.91)

MINE GRID

0 100 200 Meters

Projection: Mine Grid Coordinates

Figure Title
7 South Groundwater Equipotentials

Figure Number
4-1

Project No.
J885-1

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Date
Apr 25, 2011

**Table 4-1:
Pre-mining Water Levels in the 7 South Area.**

Borehole	Ground Surface Elevation (m Mine Grid)	Depth to Bedrock (m)	Bedrock Elevation (m Mine Grid)	Total Depth (m)	Premine WL (m Mine Grid)	Premine WL Source
QU78-306	301.7	8.8	292.6	41.2	290.5	drill record
QU78-309	300.8	4.6	295.7	44.2	287.7	drill record
QU78-311	301.7	5.8	295.7	22.9	300.2	drill record
QU78-314	310.9	3.4	307.2	54.0	295.1	drill record
QU78-316	296.3	3.0	292.3	48.8	291.4	drill record
QU78-317	301.7	4.6	297.0	78.6	285.9	drill record
QU78-320	316.7	0.6	315.6	67.1	310.3	drill record
QU78-325	235.0	5.5	228.8	78.9	226.2	drill record
QU79-14	295.0	3.4	292.6	28.4	287.5	drill record
QU79-18	314.6	1.2	312.7	58.2	308.5	drill record
QU79-33	304.9	2.4	301.8	61.6	279.9	drill record
QU01-13	306.1	12.5	292.9	173.2	276.1	drill record
QU01-14	313.0	3.7	308.7	110.7	273.9	drill record
QU05-5	222.1	1.9	219.5	103.9	206.3	drill record
QU05-13W	289.3	5.4	283.2	179.7	255.1	drill record
QU08-3	268.0	6.9	260.5	35.8	262.6	drill record
QU79-26	313.7	5.2	307.8	41.1	301.1	Golder, 2009
QU01-17	282.2	0.0	281.5	135.5	269.1	Golder, 2009
QU07-5	300.7	11.6	288.4	22.9	289.2	Golder, 2009
QU07-6	304.4	17.0	286.7	33.5	272.2	Golder, 2009
QU07-7	299.2	7.8	290.7	27.2	289.8	Golder, 2009
QU07-8	307.2	25.1	281.5	33.9	292.8	Golder, 2009
QU07-9	310.1	0.6	308.8	58.7	282.7	Golder, 2009
QU08-4	243.4	3.8	239.0	161.5	239.7	Golder, 2009
QU08-5	272.2	1.5	270.0	44.7	256.4	Golder, 2009
QU08-6	299.7	5.5	293.5	61.1	272.9	Golder, 2009
QU08-7	273.2	3.0	269.6	56.2	256.9	Golder, 2009
QU08-8	287.9	4.8	282.4	60.3	261.7	Golder, 2009
QU08-9	296.9	6.3	295.7	23.9	292.3	Golder, 2009
QU08-10	295.7	6.5	288.5	30.9	274.9	Golder, 2009
QU08-11	307.4	3.0	303.7	47.1	291.2	Golder, 2009
QU08-12	301.3	3.0	297.6	44.8	282.4	Golder, 2009
QU08-13	221.1	25.2	195.2	54.5	207.8	Golder, 2009
QU09-01	284.4	0.6	283.1	50.7	264.4	Golder, 2009
QU10-01	303.2	7.0	296.2	38.7	289.9	Lorax, 2011
QU10-02	302.7	5.0	297.7	31.6	289.9	Lorax, 2011
QU11-04	203.2	15.9	187.4	59.9	196.1	Lorax, 2011
QU11-07	227.8	10.0	217.9	39.0	220.3	Lorax, 2011
QU11-08	237.2	4.7	232.4	31.4	232.3	Lorax, 2011
QU11-10	254.1	28.4	225.7	30.8	242.3	Lorax, 2011

Water levels have been recalculated using more current ground surface elevations.

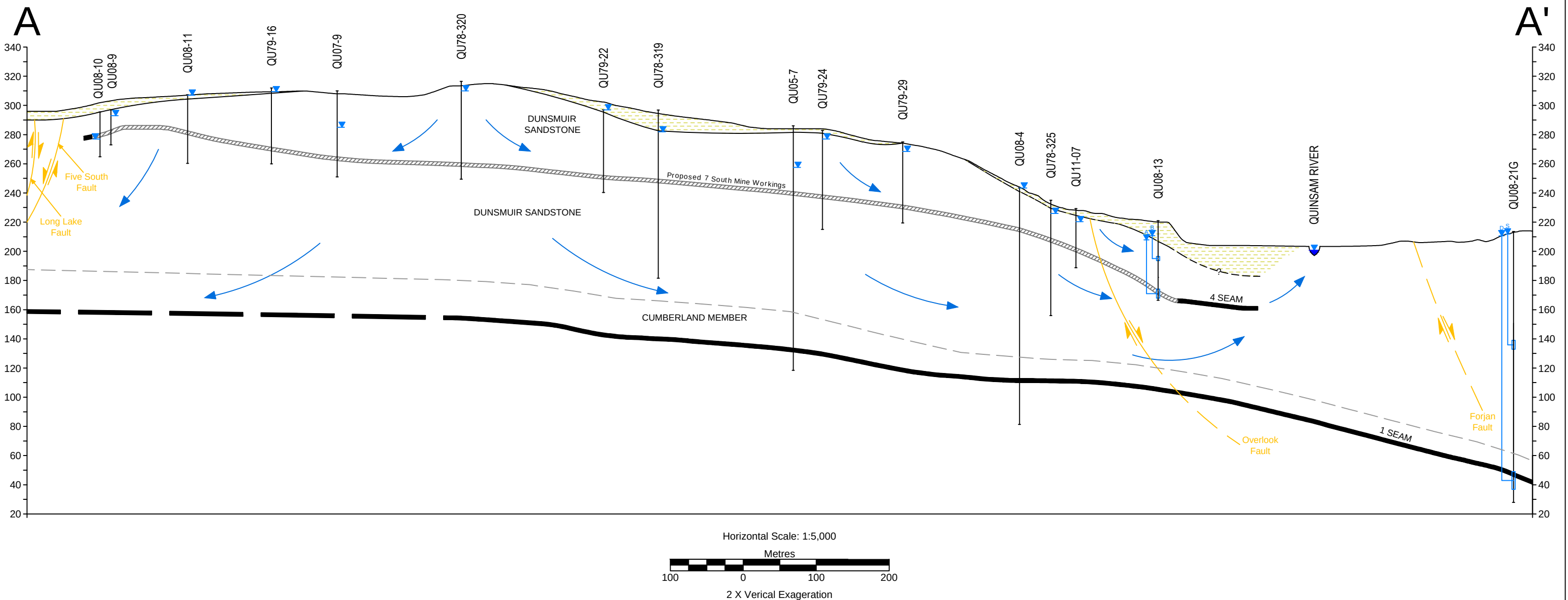
Overburden-bedrock interface is approximate

The groundwater contour map indicates that the water table is highest at the southern end of the proposed mine with isolated areas displaying water levels exceeding 300 to 310 meters (mine grid) (Figure 4-1). These areas are more or less consistent with topographic highs. Groundwater flows radially from this mound, with most groundwater eventually reporting to the Quinsam River as baseflow (Figures 4-2, 4-3). The 7 South mine is located in an area of groundwater recharge with radial flow directions from the mine as noted above. As there are no components of groundwater flux into the mine area from surrounding lands, groundwater seepage from the mine originates solely from infiltration of precipitation and snowmelt within the footprint of the mine. Since this groundwater mound straddles a drainage divide, some of the groundwater draining the southernmost portion of the mine reports also to the Iron River drainage (Figure 4-1). Near the southeast margin of the mine area (near the proposed portal), groundwater seepage may drain into two small ephemeral creeks which ultimately report to the Quinsam River. These drainages are thought to be gaining in their lower reaches only. Likewise, groundwater seepage may also report to the creeks flanking the southernmost margin of the mine. Groundwater data has not been evaluated for the Iron River drainage, but it should be noted that the confluence of the Iron and Quinsam Rivers is approximately 2.5 km southeast of the 7 South area.

Previous hydrogeological assessments of the 7 South area had indicated that the No. 4 coal seam was under saturated conditions for most of the mine footprint, with exception to a localized area on the southeastern edge of the mine (Lorax, 2009). Since this time, the footprint of the mine has been revised, the water level database has been expanded and the groundwater equipotentials have been revised (Figure 4-1). Under this new configuration, the No. 4 seam is entirely saturated in the proposed mine footprint area, implying that the 7-South mine void should remain saturated in the long term. Critical to maintaining saturated conditions is to ensure that mining does not breach the subcrop of the coal seam along the eastern margin of the mine (Figures 4-1, 4-3). Breaching the barrier pillar would create preferential flow paths from the mine into the till, likely resulting in higher seepage rates and potentially dewatered conditions post-mining. The mine has recently undertaken a drilling program to better delineate the subcrop in the northeast portion of the proposed mine including boreholes at QU11-04, QU11-07, QU11-08 and QU11-10.

The steep groundwater gradients in the southern portion of the mine are likely associated with the presence of Long Lake, Five South and/or Boundary faults. Luscar (1978) indicated that zones of groundwater depression occur directly over known fault zones, which may be significantly more permeable than the surrounding bedrock. The Overlook Fault in the north is also thought to be a highly transmissive feature which is believed to hydraulically isolate the northernmost tip of the mine area. This is evidenced by distinct groundwater chemistry in the monitoring wells installed at QU08-13 (see Chapter 8).

Elevation
(metres)



LEGEND

Borehole With
Water Level

Monitoring Well
With Water Level

Coal Seam

Inferred
Coal Seam

Proposed Mine
Workings

Fault

Projected Fault

Groundwater Flow

Till

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LORAX
ENVIRONMENTAL

HORIZONTAL SCALE: 1:5,000

VERTICAL SCALE: 1:2,500

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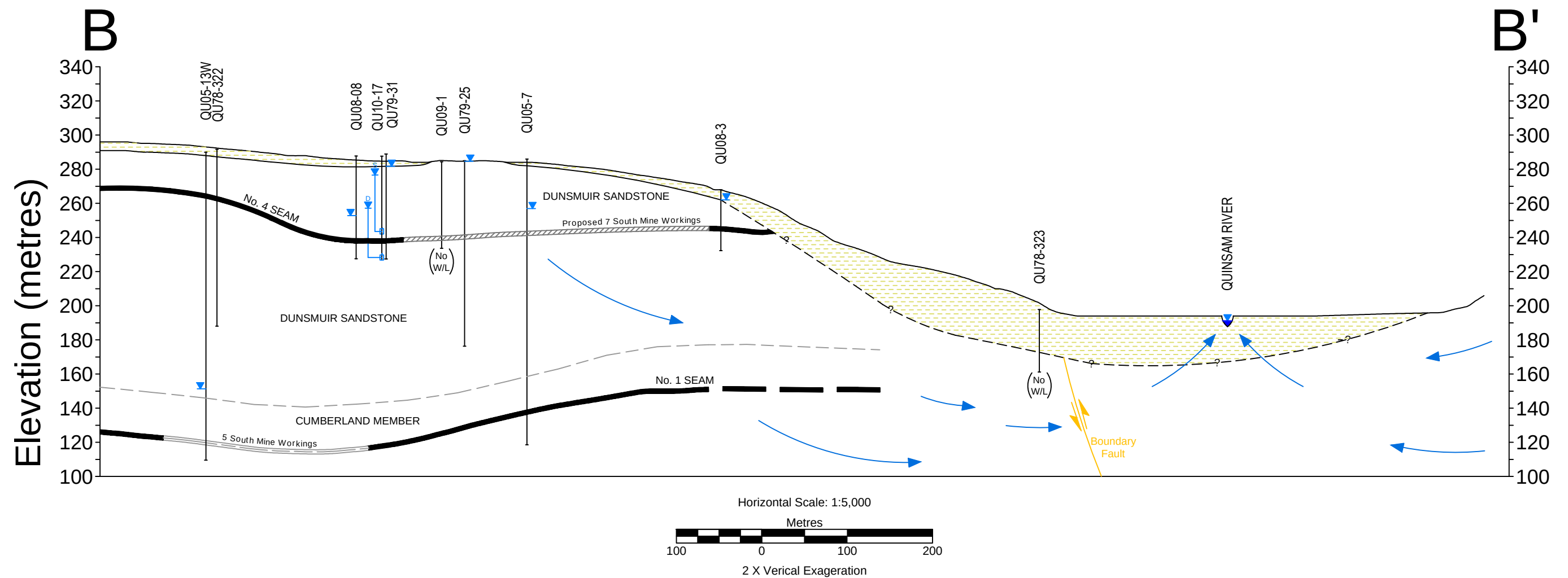
Figure 4-2: 7 South Hydrogeology Section A-A'

PROJECT: Quinsam Coal - Assessment of Underground Disposal of Coarse Coal Refuse

CREATED BY: VV

PROJECT NO. J885-1

DATE: Apr 26, 2011



LEGEND

Borehole With
Water Level

Monitoring Well
With Water Level

Coal Seam

Inferred
Coal Seam

Existing Mine
Workings

Proposed Mine
Workings

Groundwater Flow

Fault

Till

HILLSBOUROUGH
Resources Limited

LORAX
ENVIRONMENTAL

HORIZONTAL SCALE: 1:5,000
VERTICAL SCALE: 1:2,500

Hillsborough Resources

Figure 4-3: 7 South Hydrogeology Section B-B'

PROJECT: Quinsam Coal - Assessment of Underground Disposal of Coarse Coal Refuse

CREATED BY: VV PROJECT NO. J885-1 DATE: Feb 7, 2011

In April and May of 2010, Lorax undertook a field investigation in the 7 South area and installed PVC wells in several 2008 exploration boreholes (see Appendix A-1 for installation logs). These wells were slug tested to measure hydraulic conductivity and have been monitored for water quality and water levels on a quarterly basis. Water level hydrographs from these wells and the open boreholes monitored by Golder are shown in Figures 4-4 and 4-5. There are two notable water level trends in the 7 South area. First, water levels in several wells/drillholes in the northern portion of the proposed mine (*i.e.*, QU08-07, QU08-08B, QU-09-01 and QU-08-05) have been increasing since early 2009. This may be related to recovery of water levels in the 5 South mine or potentially to changes in infiltration and the water budget due to logging of this area in 2006-2007. Second, water levels in a few boreholes in the southern region of the proposed 7-South mine have been declining since early 2009, in some cases by ten or more meters (QU07-09, QU08-06 and QU08-12) (Figure 4-5). The close proximity of QU08-12 to the Five South Fault might suggest that this fault is propagating some hydraulic influence from mining in the 5 South area. However, boreholes QU07-09 and QU08-06 are located hundreds of meters away from this fault and the 5 South workings. At this point, the cause of the declining water levels in the southern part of the 7 South Mine is unclear.

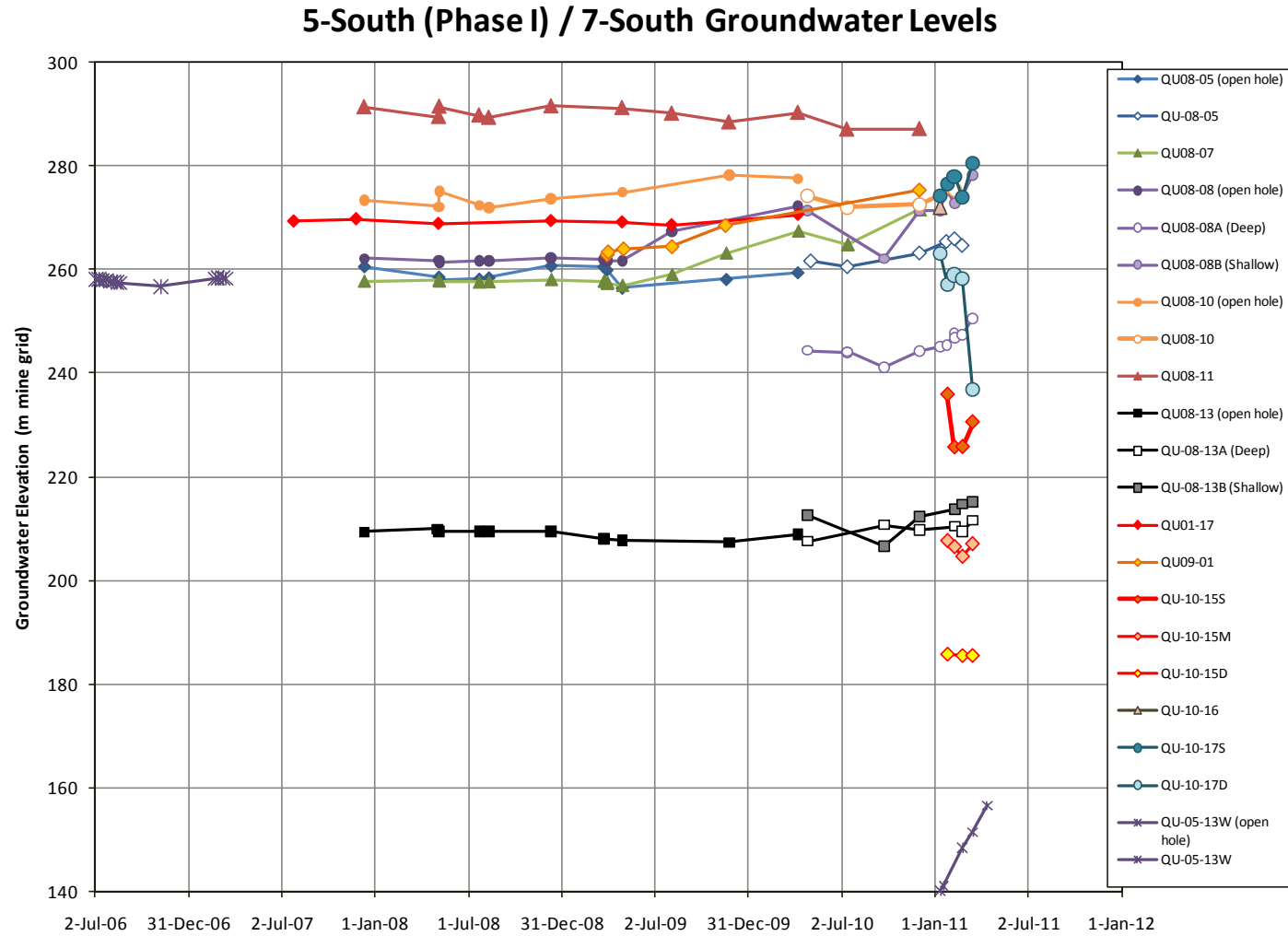


Figure 4-4: Water level hydrographs in the northern portion of the 7 South mine area (and along the margin of the 5 South Phase 1 mine).

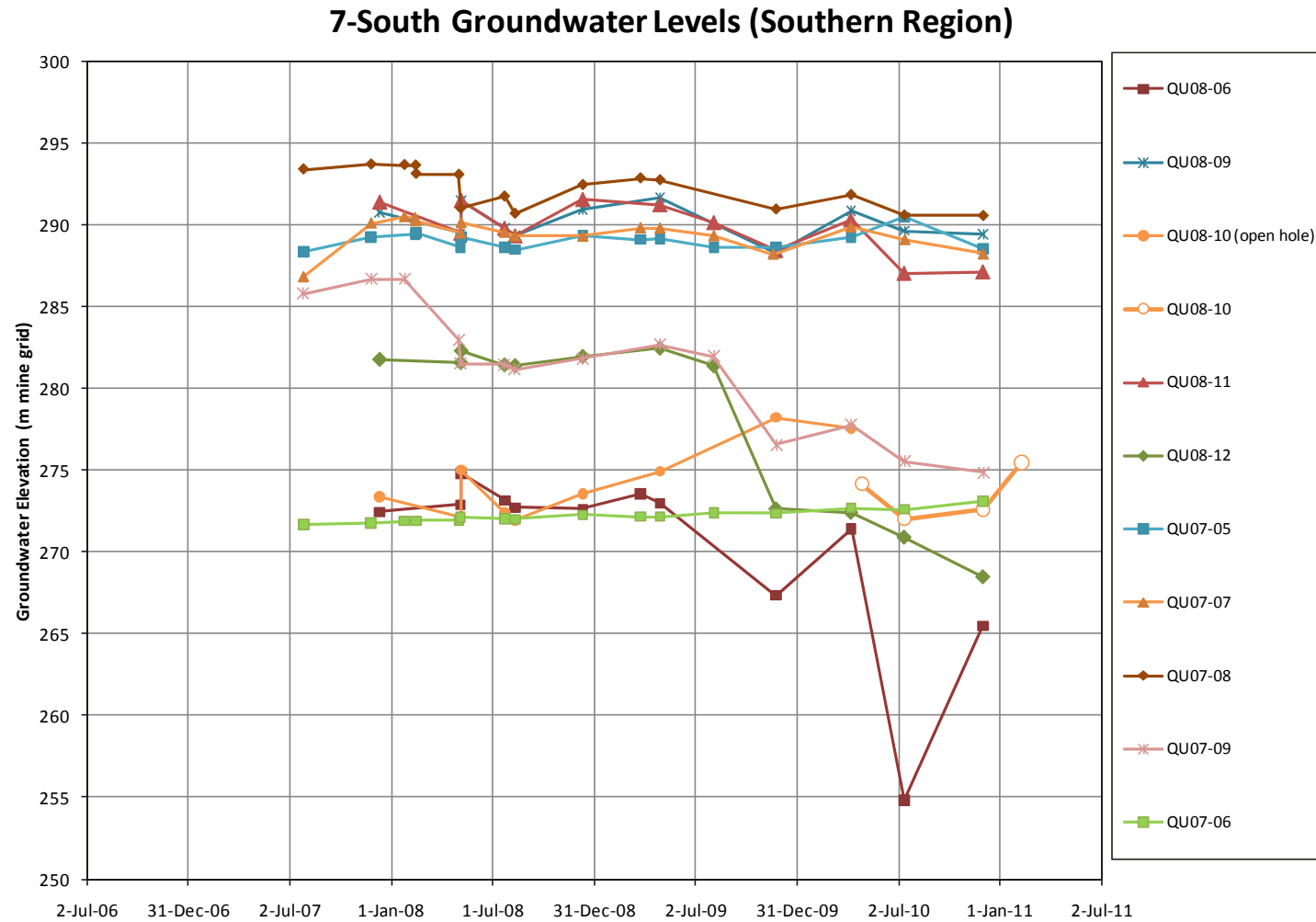


Figure 4-5: Water level hydrographs in the southern portion of the proposed 7 South mine.

4.2 Hydrogeologic Parameters

Calculations of groundwater fluxes and travel times from the 7 South area post-mining are reliant on both the hydraulic characteristics and physical dimensions of the groundwater flow system. These aspects of the 7 South mine area are discussed in detail below.

4.2.1 Hydraulic Conductivity of Coal, Sandstone and Till

Through this hydrogeological assessment and others, numerous hydraulic conductivity measurements in coal and other units have been performed at the Quinsam mine site. The formation permeabilities are used to estimate seepage rates and contaminant mass fluxes out of the proposed 7 South mine workings (Chapter 9). Appendix A-2 contains a compilation of all of the test results for coal seams, sandstone and till across the site. Data sources for these measurements include packer testing (open boreholes) and slug testing (completed wells) performed by Lorax in 2010 and 2011; recovery tests on open boreholes performed by Golder in 2009 and pump tests performed by Brown and Erdman compiled in 1982. To date, the database for coal hydraulic conductivity measurements contains 19 measurements from coal seams No. 1 through No. 5; nine of these measurements are on the No. 4 (+/- No. 5) coal seam in 7 South. While only the No. 4 seam will be mined in the 7 South area, all tests from other coal seams were included in the database to provide a more robust representation of hydraulic conductivity. Inclusion of hydraulic conductivity test results from other coal seams was considered justified based on examination of the data indicating no obvious differences in coal hydraulic conductivity from one seam to the next. Based on compilation of all available coal seam hydraulic conductivity data for Quinsam Coal, the values range from a minimum of 4×10^{-10} m/s to a maximum of 9.8×10^{-5} m/s with a geometric mean of 1.5×10^{-7} m/s. The hydraulic conductivities of the coal seams are expected to be controlled by the degree of fracturing with higher values representing a greater frequency of interconnected fractures.

Fewer measurements of sandstone permeability are available for the Quinsam mine site; these values have also been tabulated in Appendix A-2. The permeability of the sandstone overlying the 7 South mine will ultimately determine how quickly it refloods (Section 4.3). The permeability of the sandstone underlying the mine will influence the rate of downward vertical seepage from the mine footprint which contributes to groundwater mass loadings from underground disposal of CCR (Section 9). A total of nine sandstone permeability measurements have been taken by Lorax in the 2010 and 2011 field investigations; however the permeability of the sandstone was below the resolution of the packer testing method in five of these measurements. For the purpose of this assessment, a hydraulic conductivity one half order of magnitude smaller than

reported method resolution has been assumed for these five measurements. The four remaining measurements range from a maximum of 8×10^{-5} m/s in fractured sandstone (4 South) to a minimum of 6.5×10^{-9} m/s (7 South). Since the high conductivity (8×10^{-5} m/s) from 4 South was measured in shallow, fractured sandstone; it is thought to be unrepresentative of the bulk sandstone properties in 7 South and is excluded from subsequent data analysis. Based on these assumptions, the resultant geometric average of sandstone hydraulic conductivity is 6×10^{-9} m/s.

Till represents another important hydrostratigraphic unit in the 7 South mine area. Groundwater that discharges from the No. 4 seam coal and sandstone subcrop along the northern and eastern margins of the mine area will flow through till en route to the Quinsam River (Figure 4-3). A few measurements of till hydraulic conductivity have been performed across the site, including one measured at QU08-13B in 7 South and two measured at wells installed near the 2 North sump (Appendix A-2). All three hydraulic conductivity measurements are within the same order of magnitude; their geometric average is 4×10^{-6} m/s.

For the purpose of predictive calculations of seepage flux, the geometric means of 1.5×10^{-7} m/s for coal and 6×10^{-9} m/s for sandstone have been used to estimate the expected seepage flux from the 7-South.

4.2.2 Hydraulic Gradients

Lateral hydraulic gradients vary widely across the 7 South area (Figure 4-1). Measured between the 300 m equipotential centered at QU78-320 and the Quinsam River Valley, average hydraulic gradients are shallower (~5-8%) along the western margin of the proposed mine and moderate (8-12%) towards the northern and northeastern margins. These gradients steepen as the land surface falls toward the Quinsam River. Steep gradients (20-30%) occur along the southern margin of the mine area, which appears to drain towards the Iron River. As discussed previously, the presence of potentially higher conductivity faults (Five South, Long Lake and Boundary) may be responsible for these steeper gradients near the southern margin of the mine.

With respect to vertical gradients, the nested piezometers along the shared margins of the 5-South and 7-South mines (QU08-08A/B, QU10-15S/M/D, QU10-17S/D) indicate strong downward gradients (near unity) which are likely influenced by dewatering of the No. 1 seam in the 5 South Phase 1 mine (Figure 4-4). As the water levels continue to recover in the 5-South mine (see QU05-13W in Figure 4-4), it is expected that the strong downward gradients will decrease. QU08-13A/B, which lies well outside of the 5 South area also displays downward gradients, however much more subdued (~14%). This gradient is considered to be more representative of vertical gradients in other portions of

the 7 South mine since this area as a whole is a topographic high and thus a groundwater recharge area (as indicated by downward groundwater flow directions in Figures 4-2 and 4-3). There are no nested piezometers located in the southern portion of the mine to quantify vertical gradients in this area.

4.2.3 Cross Sectional Area of Seepage from 7 South Workings

There are two components of seepage expected from the 7 South workings. The first is horizontal seepage through the No. 4 seam from the perimeter of the mine. Thus the cross sectional area of horizontal flow out of the mine is a product of the height of the workings and the portion of the perimeter through which seepage will potentially leave the workings. Since the groundwater flows radially from the 7 South footprint area, the entire perimeter of the workings (approx. 4070 m) may contribute to seepage from the mine and contaminant loading. Discussions with the mine have indicated that average height of the 7 South workings will be approximately four metres (S. Gardner, per. comm.). In addition to horizontal seepage out of the mine perimeter, downward seepage is expected through the floor of the mine. Thus the entire footprint area of the mine (~422,250 m² or 42 ha) is considered as a pathway for downward vertical seepage through the underlying sandstone.

4.2.4 Effective Porosity

Effective porosity is the percentage of the rock/overburden comprised of interconnected pore space that contributes to groundwater flow. Effective porosity is required to estimate groundwater flow velocity and to determine the time for contaminants to travel from the workings to the Quinsam River. Effective porosity is difficult to measure in the field, thus a representative value for bedrock was based on a literature review of studies where values have been determined at the field scale (*i.e.*, flowpath lengths of hundreds of meters). Based on a review of all current literature, an effective porosity of 0.001 (0.1 %) is considered representative for the Dunsmuir Sandstone (L. Smith, per. comm.). An effective porosity of 30% is believed to be representative for the till, based on the experience of the author.

4.3 Hydrogeological Analysis

4.3.1 Seepage Rates Under Natural Gradients

4.3.1.1 Calculations of Seepage Flux From Hydraulic Conductivity

Seepage from the 7 South mine area can be calculated according to the following equation:

$$Q = K_{\text{coal}} \cdot i_h \cdot A_{\text{perimeter}} + K_{\text{sandstone}} \cdot i_v \cdot A_{\text{footprint}}$$

where Q is the groundwater flux in m^3/d , K is the hydraulic conductivity in m/s of coal and sandstone, respectively, i is the hydraulic gradient (horizontal and vertical) and A is the cross-sectional area of flow (perimeter and footprint areas). This is shown schematically in Figure 4-6. As discussed in Section 4.2, hydraulic conductivity of the coal and sandstone can vary over orders of magnitude and hydraulic gradient (i) also varies, although to a lesser extent. To account for these ranges in hydrogeological properties, the Oracle Crystal Ball (OCB) software was used to estimate potential seepage rates from the mine. OCB software is a spreadsheet-based tool that is widely used throughout industry for predictive modelling, forecasting and simulation. Using Monte Carlo simulation, OCB produces a range or distribution of outcomes based on a large number of calculations selected at random based on user-defined distributions for the input parameters (*i.e.* K , i , A). As discussed in Section 4.2.1, geometric mean values have been used for K_{coal} and $K_{\text{sandstone}}$ while simple triangular distributions have been assumed for hydraulic gradients. Since the horizontal gradient varies markedly over the mine area, the perimeter of the mine has been divided into three segments with a distinct hydraulic gradient distribution attributed to each section for calculation of the seepage flux through the No. 4 Coal seam over the perimeter of the mine (Figure 4-7). The 14% downward gradient at QU08-13A/B was assumed to apply to the entire mine footprint for calculation of the vertical seepage flux from the floor of the mine.

The resultant median seepage flux (*i.e.* expected value) out of the mine is calculated to be $\sim 50 \text{ m}^3/\text{d}$; with approximately $20 \text{ m}^3/\text{d}$ attributed to horizontal seepage out of the perimeter through the coal and $30 \text{ m}^3/\text{day}$ through the floor of the mine over the 42 ha footprint. Of this total seepage from the mine, approximately $3 \text{ m}^3/\text{day}$ or 6 % flows southward towards the Iron River watershed and may discharge directly into the Quinsam River or into the Iron River and then ultimately to the Quinsam River.

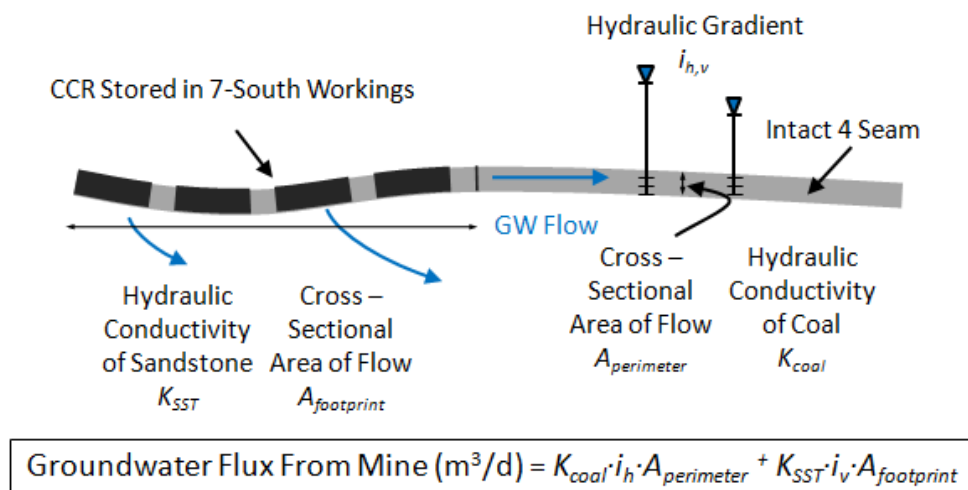


Figure 4-6: Schematic of groundwater flux calculations from the proposed 7 South Mine.

fluxes from the proposed mine. The reader is referred to Section 8.1 for a detailed discussion of the hydrology of the Quinsam River.

The 7 South Mine lies between two Water Survey of Canada hydrometric stations located on the Quinsam River at Argonaut Bridge (Station WA) and the outlet of Lower Quinsam Lake (Station WE) (Section 8, Figure 8-1). The average monthly flow based on approximately 15 years of data indicates that there is very little gain in the Quinsam River ($0.03 \text{ m}^3/\text{s}$) between these two stations during the lowest flow period in August. At this time of year precipitation and surface water runoff to the Quinsam River is limited, it can be assumed that the $0.03 \text{ m}^3/\text{s}$ gain is primarily the result of groundwater discharge to the river. The watershed area contributing to Station WA is 84 km^2 while the watershed area contributing to Station WE is 217 km^2 . If it is assumed that the entire area of the watersheds contributes groundwater baseflow to the Quinsam River, the groundwater flow per unit area of watershed (in m^3/s per m^2) between these two stations can be calculated according to the following equation:

$$Q_{\text{gw}}/A_{\text{watershed}} = 0.03 \text{ m}^3/\text{s} / (\text{Area}_{\text{WatershedWA}} - \text{Area}_{\text{WatershedWE}})$$

The calculated groundwater yield per unit area of watershed is $\sim 2 \times 10^{-5} \text{ m}^3/\text{s}$ per m^2 . When this areal-weighted groundwater flux is applied to the proposed 7 South mine area (42 ha), the resultant total groundwater flux from the mine is calculated to be on the order of $8 \text{ m}^3/\text{d}$. This compares to the seepage rate of $\sim 50 \text{ m}^3/\text{d}$ calculated for the 7 South mine using the hydrogeologic properties noted above in Section 4.3.1.1.

Although groundwater baseflow yields are dependent on soil cover and bedrock geology, which are variable across the Quinsam River watershed (Figure 2-1), and flows will be affected by storage and evaporation effects in Lower Quinsam Lake, the $8 \text{ m}^3/\text{d}$ groundwater flux calculated for the 7 South area is believed to be a reasonable order-of-magnitude lower bound on groundwater fluxes from the 7 South mine area.

4.3.1.3 Assessment of Seepage Rates from Precipitation and Infiltration

As described previously in Section 4.1, the 7 South mine is located in an area of groundwater recharge with a radial pattern of seepage from the mine area. Virtually all seepage from the mine will originate from infiltration of precipitation and snowmelt over the mine footprint. Based on field observations and the experience of the authors, infiltration rates at the 7 South mine are expected to be relatively low when expressed as a percentage of annual precipitation. Review of drillhole data and site reconnaissance indicate the mine area has a thin cover of colluvial or till soils and exposures in road cuts indicate shallow groundwater seepage tends to flow over the bedrock surface at the soil/bedrock interface.

Mean annual precipitation at the Quinsam Mine was previously determined by analysis of long-term records from weather stations and correlation with a shorter period of record from climate observations at the mine (Lorax, 2009a). Based on this analysis, mean annual precipitation was determined to be 1,034 mm/yr. Total daily precipitation over the entire footprint of the mine equates to approximately 1,200 m³/day. Assuming all seepage through the mine originates as precipitation and snowmelt, the 50 m³/day seepage rate determined from seepage calculations translates to an infiltration rate of approximately 4% which is relatively low and is consistent with expected conditions from field observations.

For assessment of contaminant loading rates from the 7 South mine, calculations have been performed representing “most likely” or expected conditions and “upper bound” or worst case conditions. For the purpose of predictive estimates of groundwater loadings, we have not used the lower bound estimates of seepage rates determined from baseflow (*i.e.* 8 m³/day) as this represents a rough “order of magnitude” assessment. We have used a seepage flux of 50 m³/day as the expected case based on median values determined by seepage calculations discussed in Section 4.3.1.1. To represent an upper bound estimate of seepage rates, and using professional judgement, we have assumed 10% of total annual precipitation could infiltrate and recharge the groundwater system over the 7 South mine which equates to an upper bound seepage rate of 120 m³/day.

4.3.2 Travel Time To Quinsam River

Seepage from the 7 South mine area will travel to the Quinsam River via groundwater flow through coal, sandstone and/or till and potentially as surface water where seepage may daylight in ephemeral creeks flanking the eastern margin of the mine. In the bedrock, groundwater flows through interconnected fractures which form the effective porosity of the rock. The travel time for groundwater is calculated according to the following equation:

$$t = d / v = d / (K \cdot i / n)$$

where d is the path length (m), v is the groundwater velocity (m/s), K is the hydraulic conductivity (m/s), i is the hydraulic gradient (m/m) and n is the effective porosity (dimensionless). As discussed previously, groundwater flows radially from the 7 South mine area. For the purpose of this analysis, the smallest travel times are estimated for the two shortest path lengths.

The first path length extends eastward from QU11-10 to the meander in the Quinsam River (Figure 4-1). As depicted in the B-B' cross section (Figure 4-3), seepage from the mine is expect to travel a nominal distance in the intact No. 4 coal seam, before exiting at

the subcrop and flowing through the till towards the Quinsam River. Along this flowpath, the median travel time to the Quinsam River is estimated to be approximately 6 years.

The second groundwater flow path is from the northern margin of the mine to the Quinsam River. Here, groundwater is expected to travel predominantly in sandstone before reporting to the Quinsam River. Along this second flowpath, the median travel time to the Quinsam River is approximately 36 years.

Based on this analysis, the shortest travel time to the Quinsam River from the 7 South mine is expected to be in the order of six years. Longer flow paths from locations farther from the Quinsam River would take proportionately longer.

4.3.3 Recharge Rate to a Fully Dewatered Mine

An estimate of the recharge rate to the mine under fully dewatered conditions is undertaken to estimate the time required to flood the mine void. This time is of interest as the potentially acid generating CCR could produce acidic drainage if the mine is not flooded in a period of two or three years following placement of CCR. Two calculations have been performed to determine lower and upper bounds for reflooding rates for the mine void.

As discussed in Section 4.3.1, groundwater flux (Q) is a product of hydraulic conductivity (K), the hydraulic gradient (i) and the area perpendicular to flow (A). In the situation where the mine void is reflooding, estimation of the seepage rate can be simplified by assuming that the hanging wall rock has remained saturated and is draining under a unit gradient into the mine void below. Thus i is equal to one and A is equal to the footprint area of the mine ($\sim 422,250 \text{ m}^2$). As the hanging wall rock is sandstone, the geometric average hydraulic conductivity of sandstone ($6 \times 10^{-9} \text{ m/s}$) discussed in Section 4.2.1 is used in the calculation. The resultant groundwater flux into the dewatered mine is estimated to be $\sim 200 \text{ m}^3/\text{d}$. At this recharge rate, the entire volume of the 7 South mine void ($\sim 1,100,000 \text{ m}^3$) would reflood in approximately 5,500 days or 15 years.

However, based on the assessment of recharge rates expressed as a percentage of annual precipitation, this calculated vertical seepage rate exceeds the estimated recharge rates. Therefore, the infiltration rates of 3% and 10% of annual precipitation (*i.e.* $50 \text{ m}^3/\text{day}$ and $120 \text{ m}^3/\text{day}$) were used to bound the time for reflooding of the mine. Based on these rates, the time for reflooding would be in the order of 25 to 60 years. This analysis indicates the reflooding time is much longer than the time required to initiate the onset of acidic drainage from PAG CCR and indicates that assisted flooding of the mine is required.

5. Geotechnical Characterization of Subsidence



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5. Geotechnical Characterization of Subsidence

Michael Cullen Geotechnical Ltd. recently completed a detailed assessment of mining induced subsidence at the Quinsam Mine (MCG 2011). The work included assessment of the following:

- Records of subsidence monitoring undertaken to date above the 2 North and 5 South Mines.
- An assessment of the hydrologic changes to the rock induced by subsidence.
- Design information on the interaction between 7 South and 5 South Mines

The information presented below is a summary of mine subsidence concepts presented in the MCG report that is pertinent to the interaction between the 5 South and 7 South mines. The reader is referred to this report to obtain additional background information and other details of the completed work.

5.1 Subsidence Monitoring Undertaken at the 5-South and 2-North Mines

The location of active and proposed subsidence monitoring stations above the 5 South Mine and the River Barrier Pillar Panel (RBPP) are shown on Figure 5-1. To date level surveys have not recorded any measurable ground subsidence in these areas. Foot traverses completed by Michael Cullen over the 5 South Mine have not identified any indications of surface subsidence such as cracks or hollows.

In addition to the current and proposed subsidence monitoring at 5 South, an extensive subsidence monitoring and research program was completed above the 2 North and 2 South Mines between 1994 and 1996 (Cullen, 2002). The relevant conclusions from this work are as follows:

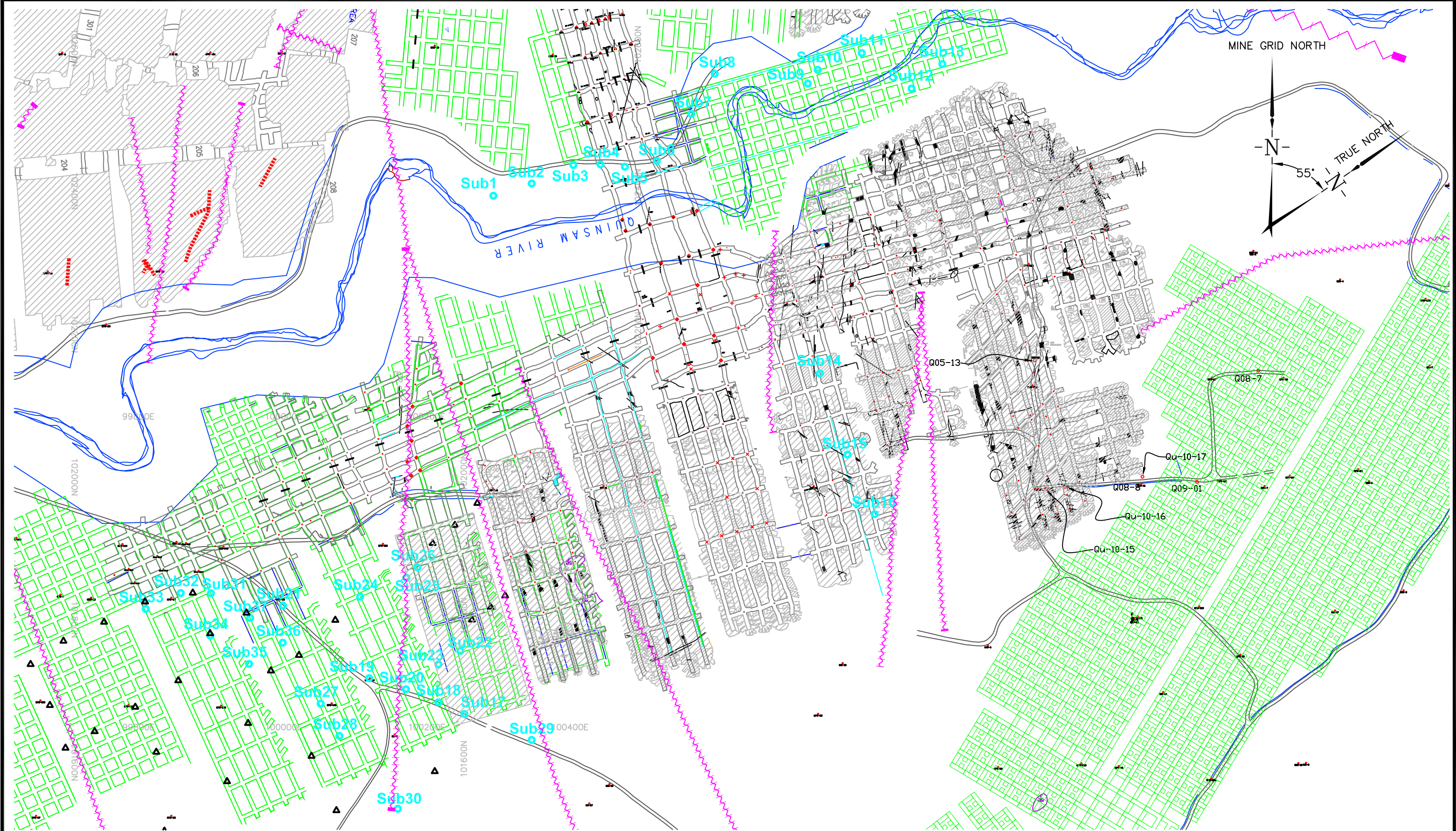
Where the depth of cover is less than 100m, and where no significant faults occur:

- The angle of draw has a mean value of 0.6° and a range of 0° to 5° .
- The angle of draw increases with increasing depth of cover.
- The angle of fracture has a mean value of -1.9° and a range of 0° to -10° . The angle of fracture defines the lateral extent of the fracture zone (shear failure boundary). Ground movements that occur beyond the angle of fracture are expected to be small and continuous as compared to those occurring within the angle of fracture.

- The subsidence factor (ratio of vertical surface movement to mined thickness) has a mean value of 0.31 and a range of 0.05 to 0.64. The subsidence factor decreases with increasing depth.
- The caving zone may extend to a height of 11 times the mined thickness. Where the caved zone extends to surface sinkholes may occur.
- The fractured zone may extend to a height of 30 times the mined thickness. Where the fractured zone extends to surface discontinuous surface subsidence may occur.
- Beyond a height of 20 times the mined thickness surface fractures are typically only found above the edges of the gob or in the vicinity of significant faults.
- Full caves do not occur until pillar extraction creates open spans with hydraulic radius (ratio of area/perimeter) greater than $7.8\text{m}^2/\text{m}$ which is equivalent to a span of 31m by 31m.
- The maximum extent of ground subsidence and surface cracks typically occur within 2 months of the full cave occurring.
- Thick till layers will bridge over and/or blind off fractures.

Significant faults is the term used to identify faults that may result in anomalous subsidence and changes to hydrologic properties. Based on experience at the Quinsam Mine significant faults typically have the following attributes:

- Extend through both the Cumberland and Dunsmuir Formation.
- Have greater than 1m vertical offset.
- Are open.
- Have trace length greater than one hundred meters.
- Result in distinctive linear features on surface such as thick surficial till layer and swamp systems.



LEGEND:

	Proposed Mining		Coal Pillar		Sub30 Active Subsidence Station
	GOB (mined out)		Existing Mining		Proposed Subsidence Station
	Surface subsidence cracks		Significant faults		

0 100m
SCALE 1:5000

MICHAEL CULLEN GEOTECHNICAL LTD.

CLIENT	HILLSBOROUGH RESOURCES QUINSAM COAL MINE		
DATE	2010/01/07	DWN. JMG	CHKD. MC

PROJECT	QUINSAM COAL MINE SUBSIDENCE ASSESSMENT		
TITLE	PLAN VIEW SHOWING ACTIVE & PROPOSED SUBSIDENCE STATIONS		
FILE NO.	2009-16	FIGURE 5.1	

5.2 Assessment of the Hydrologic Changes to the Rock Induced by Subsidence

It is well documented that high extraction underground mining that uses caving methods (e.g. longwall or retreat pillar mining) may cause significant changes to the hydrologic properties of the overlying rock, most notable are increases in transmissivity and water storage. These changes may have an impact on the ground water table elevations, ground water movement, and water inflow to the mine. The magnitude of the changes is a function of many factors including rock properties (strength, modulus, weathering characteristics), mine depth, extraction ratio, excavation size, mining method, and topographic setting. Figure 5-2 illustrates the generally accepted model of subsidence zones and hydrologic response above high extraction mining. The various zones are discussed in detail in Table 5-1.

When room and pillar mining is carried out with room spans and pillar dimensions appropriately sized to prevent major roof collapse, there will be minimal changes to the rock hydrologic properties, and the changes that do occur are typically restricted to the rocks immediately adjacent to the mined out areas. Non caving room and pillar mining is planned for the 7 South Mine such that significant hydrologic changes are not expected.

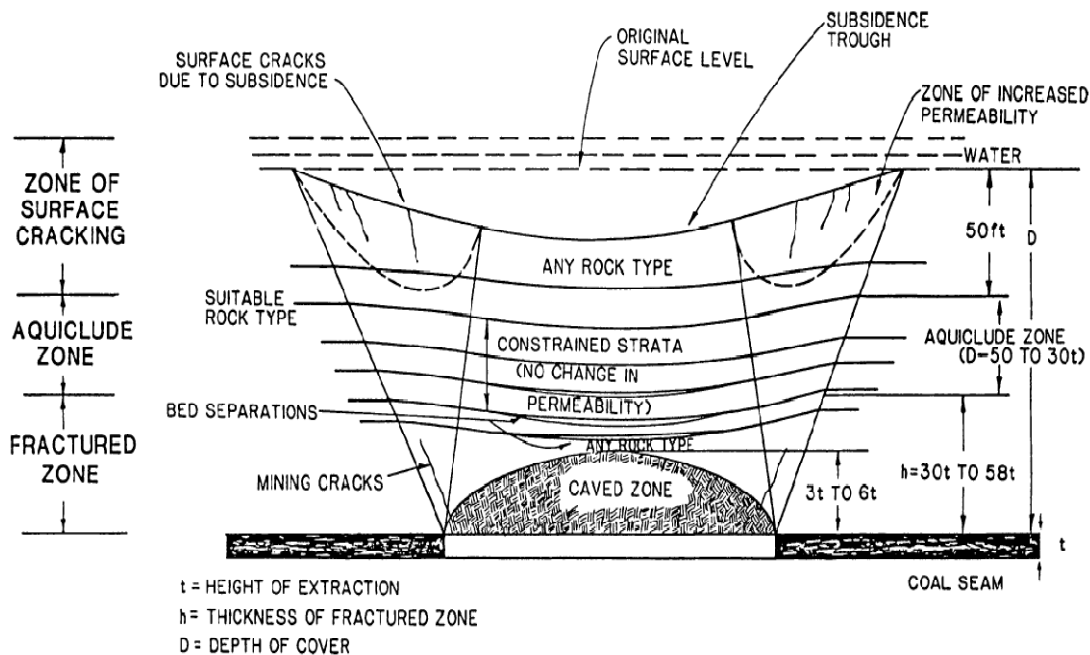


Figure 5-2: Conceptual Model of Subsidence Zones above High Extraction Coal Mines.

from Kendorski F., 2006 "Effect of Full-Extraction Underground Mining on Ground and surface Waters: a 25 Year Retrospective"
Proc 25 Conf on Ground Control in Mining, ed S.Peng

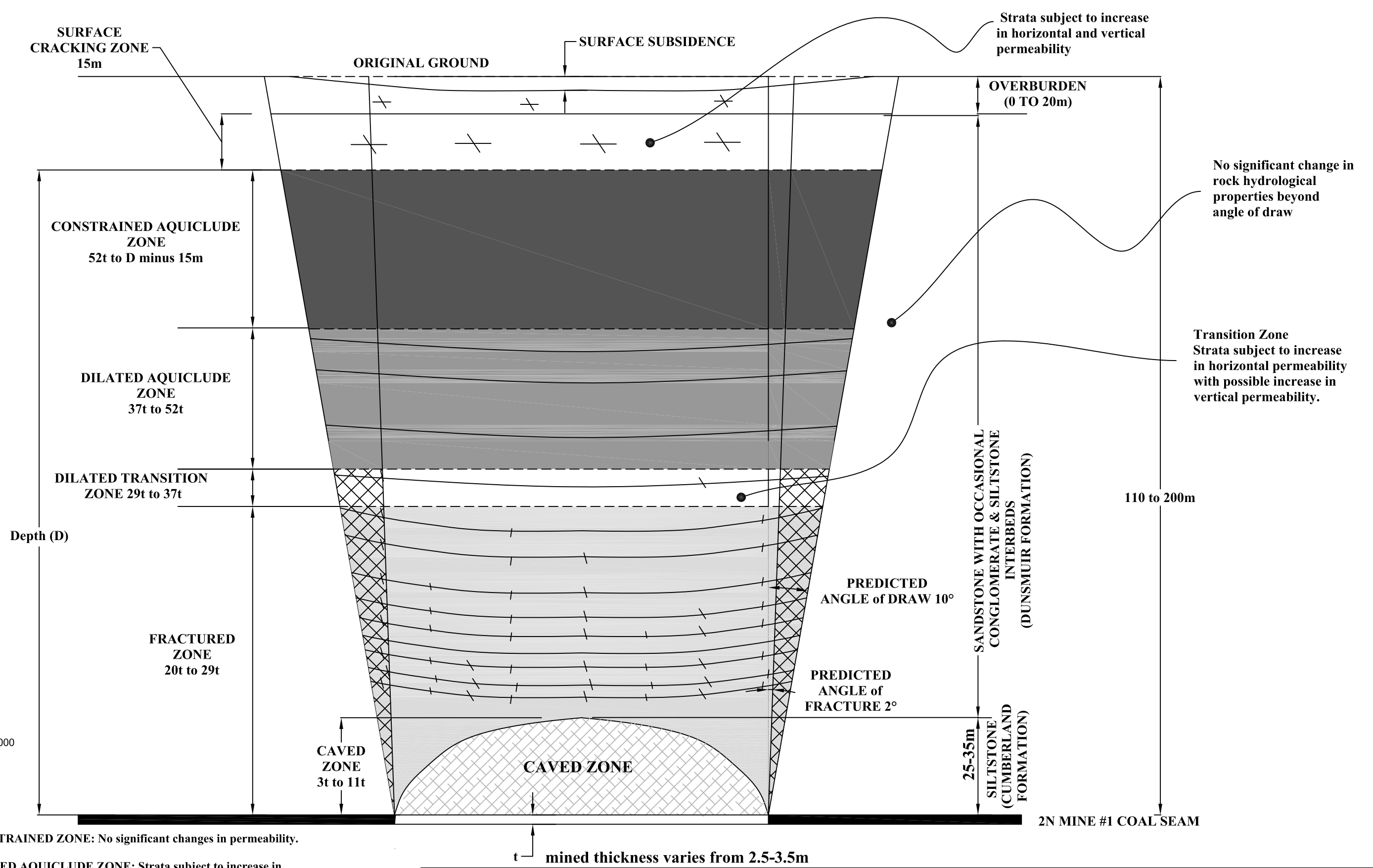
**Table 5-1:
Description of Subsidence Zones and Hydrologic Changes above a High Extraction
Mining Area**

Zone	Description	Hydrologic Changes	Height above mine in terms of height of extraction (t) or meters (m)
Surface Cracking	High tensile strains result in bed separation and rock fractures. Greatest disturbance occurs at gob edge where highest strains prevail.	Increased permeability and storage. May experience drop in GWT that recovers with time	upper 10m to 20m of bedrock
Constrained Aquiclude	Compression zone	No significant change in permeability or storage	60t to bedrock surface less 15m
Dilated Aquiclude	Bed separation with horizontal fractures.	Increase in horizontal permeability and storage. May experience initial drop in GWT that recovers with time.	
Dilated Transition	Transition Zone Bed separation with horizontal fractures. Vertical fractures common at bottom, less common to nonexistent at top.	Increase in horizontal permeability and storage. Increase in vertical permeability that diminishes with height above the fractured zone, and also diminishes with time.	30t to 60t
Fractured	Bed separation and vertical fractures	Increased horizontal and vertical permeability. Drains to mine workings.	6t to 30t but may extend to 60 t
Caved	Zone of complete disruption		3t to 10t

Experience in Australia is that there is typically no hydraulic connection between surface and underground where the mining depth exceeds 100m. US experience is that the distance to prevent hydraulic connection will typically vary from 90 to 150m but can be as little as 60m.

The extent to which hydrologic changes extend out laterally is generally defined by the angle of draw. Previous measurements at the Quinsam Mine show that the angle of draw has a range of between 0.6 and 5 degrees at depths less than 100m. Based on a review of literature and site experience the angle of draw is expected to range between 5 and 10 degrees for depth of cover up to 200m.

A detailed investigation program of hydrologic changes caused by mining induced subsidence was recently completed at the Quinsam Mine. Details of the program are provided in MCG 2011. The investigation program determined that, at the Quinsam Mine, the strata can be divided into 5 zones similar to those shown in Figure 5-2. The specific zones for the Quinsam Mine are illustrated on Figure 5-3 and listed in Table 5-2. In addition, Photos 5.1 to 5.6 illustrate features observed in the different zones within the drillholes completed for the investigation.



- CONSTRAINED ZONE:** No significant changes in permeability.
- DILATED AQUICLUDE ZONE:** Strata subject to increase in horizontal permeability.
- FRACTURED ZONE:** Strata subject to increase in horizontal and vertical permeability; direct hydraulic connection to mine.
- Strata movement in area between angle of draw and angle of fracture is primarily bending and bed separation resulting in an increase in horizontal permeability only.

MICHAEL CULLEN GEOTECHNICAL LTD.				PROJECT QUINSAM COAL MINE SUBSIDENCE ASSESSMENT		
CLIENT HILLSBOROUGH RESOURCES QUINSAM COAL MINE				TITLE SUBSIDENCE ZONES ABOVE #1 SEAM		
DATE	2011/02/01	DWN.	JMG	CHKD.	MC	FILE NO. 2009-16
					FIGURE 5.3	

**Table 5-2:
Subsidence Zones Determined for the #1 Seam at Quinsam Mine.**

Zone	Description	Hydrologic Changes & K value ⁴	Height above mined out seam in terms of mined height (t) or meters (m)
Surface Cracking	High tensile strains resulting in bed separation and fracturing.	Increased permeability. K ~5e-7 m/s	0 to 15m below bedrock surface
Constrained Aquiclude	No significant fractures or bed separation	No significant change in permeability K ~ 1e-9 m/s	52 t to bedrock surface less 15m <i>e.g.</i> if t = 3m zone will be between 156m above the mine to 15m below the ground surface
Dilated Aquiclude	Bed separation and creation of horizontal fractures.	Increase in horizontal permeability. K _h ~ 1e-6 m/s K _v ~ 1e-9 m/s	37 t to 52 t <i>e.g.</i> if t = 3m zone will be between 111m and 156m above the mine elevation
Dilated Transition	Bed separation with horizontal fractures. Vertical fractures common at bottom, less common to nonexistent at top.	Increase in horizontal permeability. Increase in vertical permeability that diminishes with height above the fractured zone. K _h ~ 1e-6 m/s K _v ~ 1e-9 m/s to 1e-6 m/s	29 t to 37 t <i>e.g.</i> if t = 3m zone will be between 87m and 111m above the mine elevation
Fractured	Bed separation and vertical fractures	Increased horizontal and vertical permeability. Potential for hydraulic connection to mine workings. K > 1e-4 m/s	up to 29t if t =3m height may be up to 87m
Caved	Zone of complete disruption		3 to 11 t

Notes

1. Results are considered applicable to depth of 200m.
2. No information is available on impact to surficial till layer.
3. Significant faults may cause anomalous subsidence and changes to hydrologic properties
4. The hydraulic conductivity values given are average values of a very small data set. In most cases testing was completed in non saturated conditions. As such the results should be considered approximate only.

Insufficient information was available to complete a statistical evaluation on the height of each zone. As such, the zone height values presented in Table 5-2 are the maximum, or most conservative based on the collected information. The values given to the dilated transition zone are considered to have the greatest uncertainty; it is conceivable that some of this zone is within the dilated aquiclude zone such that the aquiclude zone would start at a height less than 37t.

The findings indicate that the depth of rock cover may need to be as much as 37t plus 15m in order to ensure development of an aquiclude zone. Where the depth of rock cover is less than that needed to develop an aquiclude zone there is potential for enhanced hydraulic connectivity between the ground surface and underground.

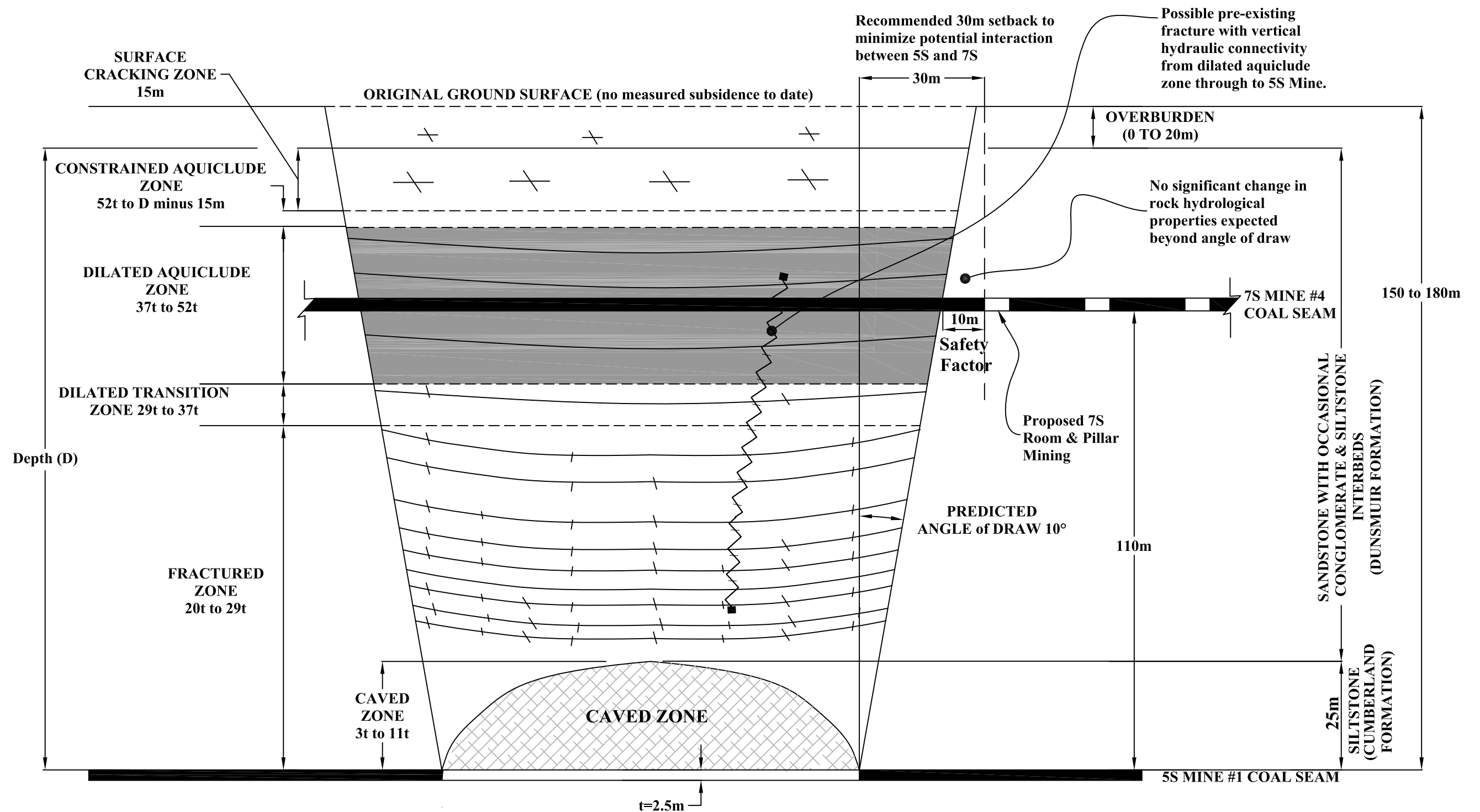
Based on the results of the current and previous investigations at the Quinsam Mine, and discussions with Quinsam Mine geologists, it is understood that potentially significant faults and fractures may be encountered throughout the mine site. The potential impact of significant faults on the subsidence zones and hydrologic properties should be assessed on a case by case basis.

5.3 Design Information on the Interaction between 7 South and 5 South Mines

The subsidence investigation program (MCG 2011) identified that interaction between the existing 5 South Mine and proposed 7S Mine may cause minor ground instability as well as result in enhanced hydraulic connectivity between the existing 5 South Mine and the overlying No. 4 Coal Seam.

As indicated on Figure 5-4 the portions of the No. 4 Coal Seam that lie above the 5 South Mine are within the dilated aquiclude zone; horizontal separation along bedding has occurred. Based on the recent investigation it is also conceivable that pre-existing geologic structure are present within this zone. Any mining that extends into the dilated aquiclude zone has the potential to create an enhanced hydraulic connection to the 5 South Mine: first by horizontal flow on the separated beds, followed by vertical flow on the pre-existing fractures as illustrated in Figure 5-4.

To prevent this possible hydraulic connection the Quinsam Mine has elected to modify the layout of the proposed 7 South Mine to exclude the area within the dilated aquiclude zone. A 30m horizontal setback from the edge of the 5 South mining area has been established as indicated on Figure 5-4 and 5-5. The setback is based on a 10 degree maximum angle of draw plus an additional 10m “safety factor”.-



LEGEND:



DILATED AQUICLUDE ZONE - Strata subject to increase in horizontal permeability.

SCALE 1:1000

MICHAEL CULLEN GEOTECHNICAL LTD.

CLIENT

HILLSBOROUGH RESOURCES QUINSAM COAL MINE

DATE

2011/02/01

DWN.

JMG

CHKD.

MC

PROJECT

QUINSAM COAL MINE SUBSIDENCE ASSESSMENT

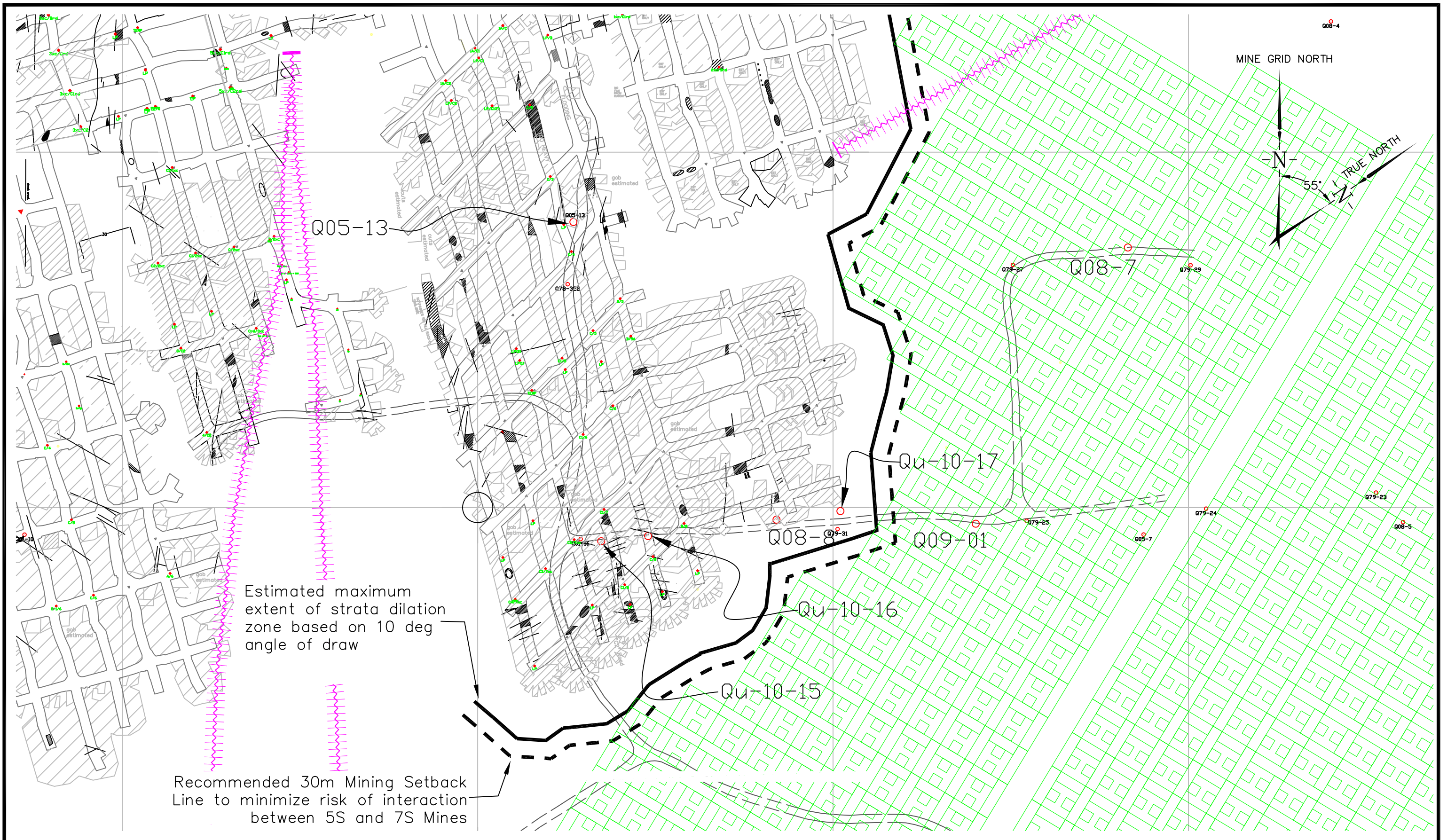
TITLE

SUBSIDENCE ZONE
INTERACTION BETWEEN 5S & PROPOSED 7S MINES

FILE NO.

2009-16

FIGURE 5.4



LEGEND:		MICHAEL CULLEN GEOTECHNICAL LTD.		PROJECT	
	Proposed Mining		Existing Mining	QUINSAM COAL MINE SUBSIDENCE ASSESSMENT	
	GOB (mined out)		Significant faults	TITLE	
	Surface subsidence cracks			RECOMMENDED SETBACK TO MINIMIZE INTERACTION POTENTIAL FROM 5S TO PROPOSED 7S MINE	
		0 50m SCALE 1:2000		DATE	2010/01/07
		DWN. JMG		CHKD.	MC
		FILE NO.		2009-16	
				FIGURE 5.5	

Photos

Photo 5.1: DH Qu10-15 26m depth.

Surface fracture zone. Fractures appear new but on pre-existing weakness plane.

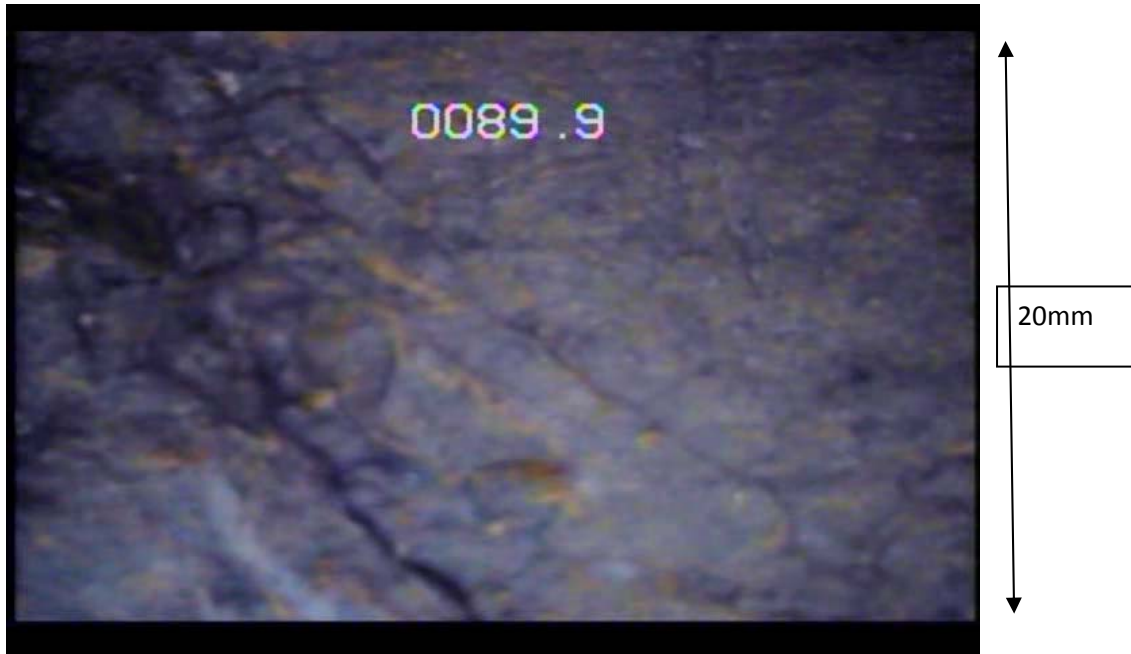


Photo 5.2: DH Qu10-15 40m depth.

Constrained zone, no new fractures



Photo 5.3: DH Qu10-15 41m depth.
Constrained zone. Pre-existing fracture, open and fe stained.

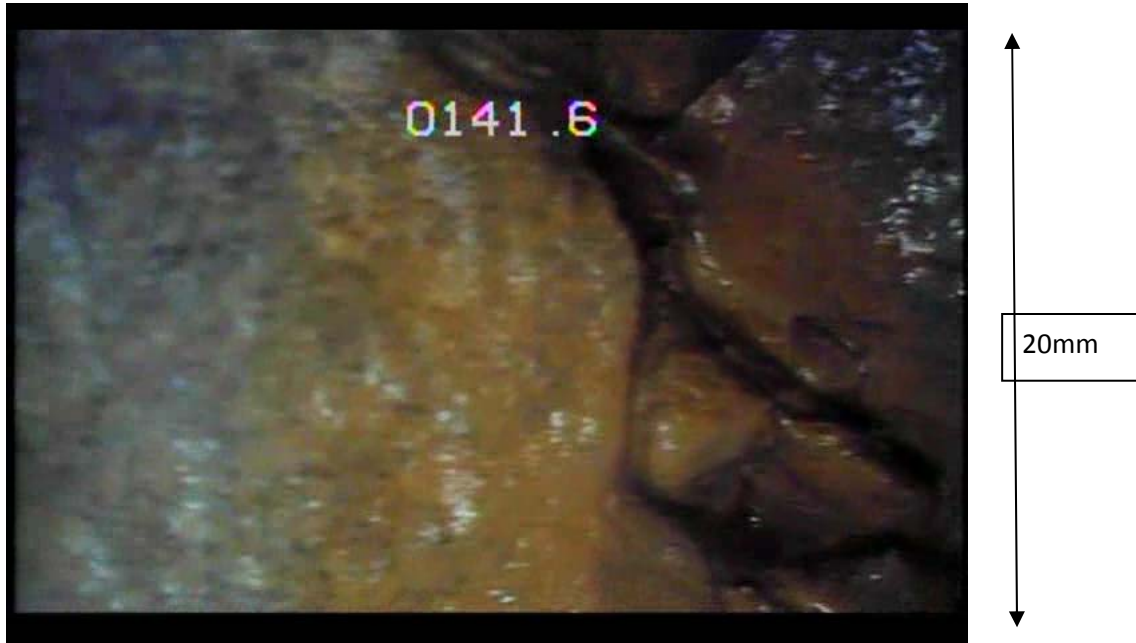


Photo 4: DH Qu10-17 14m depth.
Constrained zone. Pre-existing fracture encountered large inflow of water during drilling.



Photo 5.5: DH Qu10-17 48m depth.
Dilated aquiclude zone. Open bedding plane fractures.



Photo 5.6: DH Qu10-14 100m depth.
Caved or lower fractured zone. Rubble.



6. Geochemical Characterization



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6. Geochemical Characterization

The geochemical evaluation specifically investigates the:

- sulphur distribution in the proposed mine workings,
- solid phase and leaching characteristics of coarse reject and tailings from the 7 South mine areas, and
- geochemical characteristics of the hanging wall strata overlying the mine area.

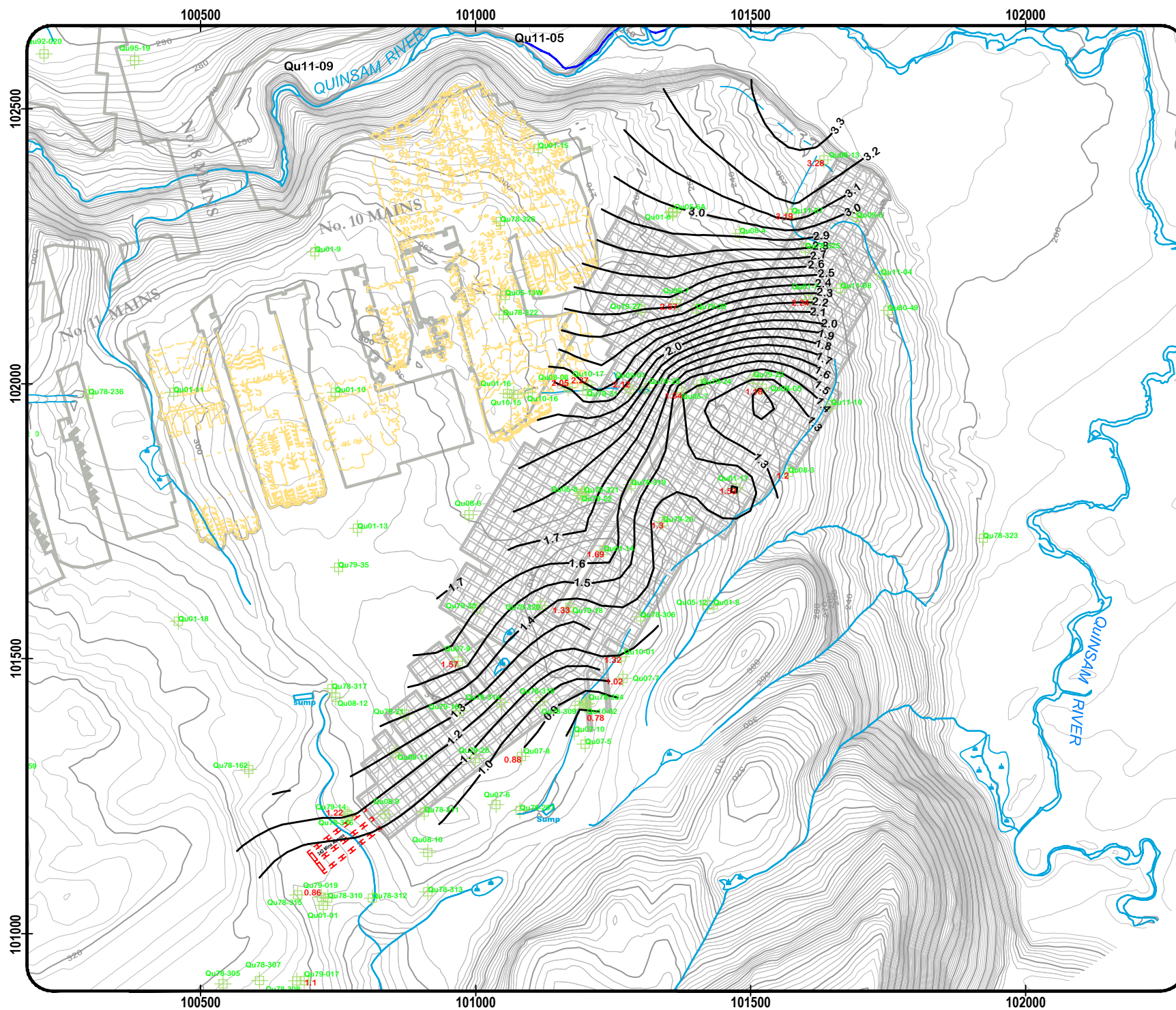
Sulphur in the form of pyrite is the major contributor to potential acid generation and metal leaching in the coal and rock strata of the Quinsam Mine. Understanding the distribution of the sulphur helps identify the level of risk from each mine area. Sulphur distribution in the No. 4 Coal Zone is discussed in Section 6.1.

Section 6.2 discusses the solid phase chemistry and leaching characteristics of the 7 South coarse reject and tailings that were undertaken to evaluate how placing this material in the underground mine voids could alter the existing groundwater chemistry.

The geochemistry of the hanging wall strata overlying the coal seams is discussed in Section 6.3 to evaluate the potential this material may have on drainage chemistry.

6.1 Sulphur Distribution in Coal

Quinsam mine geologists compiled the available sulphur content data collected from exploration drill core that was part of the coal quality evaluation completed in advance of mining. Figure 6-1 illustrates that the sulphur content of No. 4 Seam varies from 0.8 %S to 3.3 %S in the proposed 7 South mine footprint. This level of sulphur content is higher than observed in the No. 1 Seam that was mined in the 2 North and 3 North mine areas, which is consistently < 1.0 %S. However, these values are lower than the sulphur content reported for No. 3 Seam in the 4 South mine.



Legend

-

Data Source:
Quinsam Coal Corporation



Projection: Mine Grid Coordinates

Figure Title

Sulphur Distribution of Raw Coal in 7 South

Figure No. 6-1

Project No. J885-1

Client
Hillsborough Resources

Date Apr 27, 2011

6.2 7 South Coarse Reject and Tailings

Coarse reject and tailings will be produced during the mining of No. 4 Coal zone in the proposed 7 South Mine. The majority of the coarse reject and tailings are expected to be PAG. Following a brief overview of the mineralogy of the No. 4 Coal Zone, this section compares the sulphur content of the No. 4 Coal zone (which includes coal and partings) with the solid phase characteristics of the fine components of the coal refuse to assess the quantity of PAG tailings that can be expected from the 7 South mine. The rate of neutralization potential (NP) depletion is assessed from both coarse reject and tailings from leaching rates measured in unsaturated columns and humidity cells. Finally estimates of saturated water chemistry from coarse reject are presented. A complete geochemical characterization of the 7 South coarse reject and tailings is presented in Appendix B1, the analytical methods used at SGS laboratories in Burnaby are presented in Appendix B3, and the supporting mineralogy reports are provided in Appendix B4.

6.2.1 Mineralogy

Calcite is the primary neutralizing phase in the No. 4 Coal zone with measurable quantities of dolomite. The No. 4 Coal Zone only contains minor to trace amounts of siderite.

The No. 4 Coal zone contains sulphur primarily as pyrite. Pyrite is present as discrete textured porous grains, equant anhedral grains and framboidal forms. Higher concentrations of pyrite are noted in the No. 4 Upper Zone compared to the No. 4 Lower Zone. The pyrite fragments may be mantled by a thin rind of Fe-sulphate, which contains minor and varied concentrations of Mg and As. Pyrite phases themselves do not contain detectable As. The As mineral safflorite $[(Co,Fe)As_2]$ that was noted in the 5 South coal was not identified during petrographic evaluation of the 7 South CCR samples.

In addition to pyrite, petrographic observations identified minor amounts of sulphur hosted by barite ($BaSO_4$) and Fe-sulphate. Additionally, organic sulphur is present in coal. In general, coal fragments that contain pyrite have higher organic sulphur contents than coal fragments that lack pyrite.

6.2.2 Acid Generating Potential

The ABA analyses indicate that the sulphide content of the coarse reject and tailings will be similar or greater than the sulphur content of the raw coal (*i.e.* 0.8 to 3.3 %S). The analyses also confirm the presence of non-acid generating organic S, which is present in tailings at quantities up to 0.45 %S. Neutralization potential values are typically < 85 kg $CaCO_3$ /t for the 7 South strata, with higher NP values indicated for the No. 4

Upper Coal Seam. Washing of the raw coal appears to concentrate carbonates in the fine fraction of the coal washing by-products, thus, tailings are expected to have a higher neutralization potential than the coarse reject or the raw coal that it was derived from. This trend is also observed in operational monitoring of coarse reject and tailings from No. 1 Seam.

NPR values < 2.0 were consistently observed for the raw coal, coarse reject from the No. 4 Coal Zone, indicating that subaerial storage of these waste products or extended exposure of this material in underground mine workings at the 7 South mine will eventually produce acidic drainage if not flooded to limit the rate of sulphide oxidation.

The concentration of carbonate in the washed coal fines (tailings) may result in a portion of the No. 4 Seam tailings to be NAG. A comparison of the NPR values for the tailings samples with the raw coal sulphur content from which the tailings samples were produced is illustrated in Figure 6-2 to assess a sulphur content cut-off for raw coal that will produce non-acid generating (NAG) tailings.

The data presented in Figure 6-2 support the following statements:

- a. raw coal samples containing < 1.0 %S produce NAG tailings ($\text{NPR} > 4$), even in material with NP values of < 100 mg CaCO_3/t ;
- b. raw coal samples containing between 1.0 and 1.5 %S produce NAG tailings ($\text{NPR} > 2$), if modified NP values are > 100 mg CaCO_3/t ;
- c. raw coal samples with > 1.5 %S will generally produce PAG tailings ($\text{NPR} < 2$); and
- d. raw coal samples with > 1.5 %S and modified NP values > 160 mg CaCO_3/t can produce tailings with $\text{NPR} > 2$.

Although the ABA data referred to in statement (d) above, indicate that $\text{NPR} > 2.0$ may be present in tailings containing > 2.0 %S, tailings with this high level of sulphur are considered as PAG. The high reactivity of the porous and framboidal pyrite contained in the tailings has the potential to release iron at high rates, which could precipitate on carbonate mineral surfaces and prevent complete dissolution of these carbonate mineral phases. The incomplete dissolution of carbonate minerals results in a portion of the measured NP to be unavailable. This process is more likely to be prevalent in tailings with higher S content due to the increased levels of iron released from pyrite oxidation in these materials.

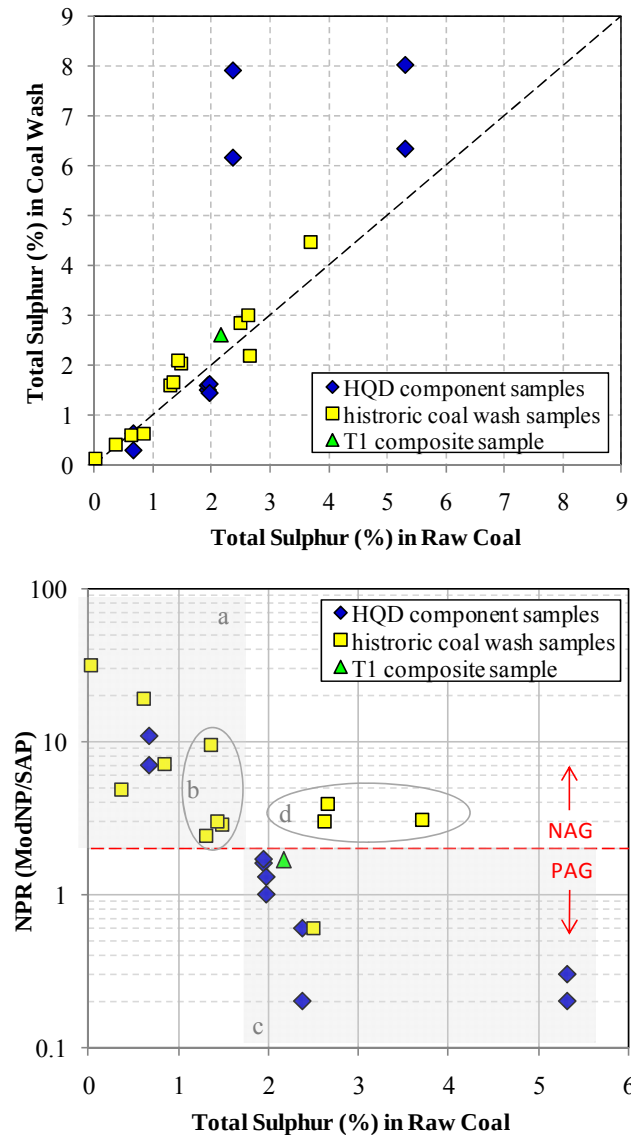


Figure 6-2: a) Total sulphur in raw coal vs total sulphur in coal wash fines and b) NPR values for tailings versus raw coal sulphur concentrations.

The following criterion to define PAG tailings from NAG tailings is based on the total sulphur content of the raw coal. This total S criterion is used to assess the quantity of PAG tailings that may be produced and the tailings storage requirements at this pre-mining stage in the development of the 7 South Mine. The design criterion for tailings storage is that raw coal containing < 1.0 %S will produce NAG tailings and raw coal containing > 2.0 %S will produce PAG tailings. Coal containing between 1.0 and 2.0 %S will produce tailings with an uncertain ARD designation, thus, for tailings storage design purposes all raw coal with > 1% S should be assumed to require flooded PAG storage.

An operational monitoring program will be necessary to define the most appropriate criterion to segregate non acid generating tailings from PAG tailings during the production of tailings from the 7 South mine.

6.2.3 Time to NP Depletion for Exposed No. 4 Zone Raw Coal and Coarse Reject

The rate of sulphide mineral oxidation and associated acid production are determined from the unsaturated column tests by the sulphate measurements in weekly leachates. Similarly, the relative rate of NP consumption is calculated from the rate of sulphate production and release rates of major cations such as Ca and Mg that are derived from the congruent dissolution of neutralizing carbonate minerals. Thus, when considered together, the weekly leachate concentrations of Ca, Mg, and SO₄ can be used to calculate the carbonate molar ratio (CMR), as expressed in the following form:

Equation 1:

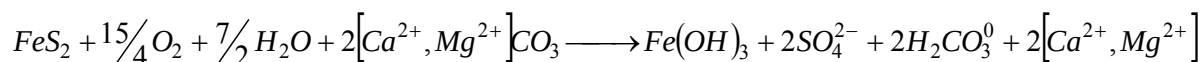
$$CMR = \frac{[Ca^{2+}] + [Mg^{2+}]}{[SO_4^{2-}]}$$

The CMR indicates the actual rate of carbonate dissolution (NP depletion) and sulphide oxidation occurring in the laboratory test reactor, assuming that the base cations are derived only from the NP source and the sulphate is derived from the oxidation of pyrite. A direct comparison can be made between the CMR and NP/AP ratio, since both parameters represent normalized ratios. The premise of the comparison is that if the NP/AP ratio of a sample exceeds the CMR value, the sample is non-acid generating because the laboratory-measured rates (CMR) are sufficiently low to ensure that NP will remain in the sample once the sulphide has completely oxidized.

In theory, CMR values could range from 1.0 to 2.0 due to the pH sensitive nature of carbonate speciation in aqueous solutions. In the most simplistic scenario, two carbonate consumption reactions can describe the sulphide oxidation-neutralization process:

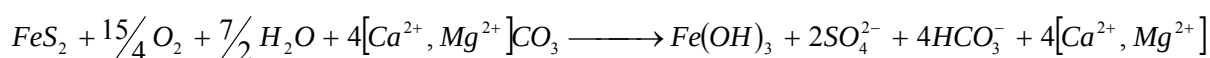
Equation 2:

at pH < 6.3:



Equation 3:

at 6.3 < pH < 10.3:



Neutralization of acidity up to pH levels of 6.3 produce one mole of Ca for each mole of SO_4 released, producing a $\text{CMR} = 1.0$. At pH levels above 6.3, H_2CO_3^0 is not the dominant form of inorganic carbon in an aqueous solution and the bicarbonate ion (HCO_3^-) is by far the most abundant. Thus, at near-neutral pH levels, calcium carbonate is less efficient at neutralizing acidity and twice as much carbonate is required to produce a balanced solution. Under these conditions, 4 moles of Ca (+ Mg) are released relative to 2 moles of SO_4 producing a $\text{CMR} = 2.0$. The relationships derived from these chemical equations assume that pyrite oxidation is the sole source of sulphur and iron in the product that take the form of sulphate and iron hydroxide, respectively. Thus, the oxidation of other sulphide minerals, dissolution of soluble sulphate minerals, or the formation of other secondary products may alter the relationship.

Direct measure of the CMR in the column solutions provides an indication of the actual rate of carbonate dissolution (NP consumption) relative to sulphide oxidation, and thus can be used in estimating the time to onset of acid generation under laboratory conditions. Furthermore, when these laboratory conditions are met, the CMR can be compared directly to the critical NPR value obtained via acid base accounting to delineate potentially acid generating material from non acid generating material, since both parameters represent normalized ratios.

No. 4 Coal Zone Exposed Raw Coal (Col 1) and Coarse Reject (Col 2 & 3)

The rate of sulphide oxidation is estimated from sulphate analyses of column leachate. Figure 6-3 provides time series plots of pH, sulphate production and CMR values for the raw coal and coarse reject kinetic tests. Table 6-1 provides the average sulphate production rates for the 7 South coal and coarse reject unsaturated columns, based on leachate results from cycles when the weekly input volumes were increased to 1000 mL (*i.e.*, cycles 45 to 79) to ensure all sulphate is released to the leachate and is not retained in sulphate products such as gypsum. Note that because Col 3 went acidic after cycle 53 (Figure 6-3), only cycles 45 to 53 are used to calculate averages and predict timing to NP depletion.

Based on the leachate results produced under the conditions of the unsaturated column tests, sulphate production rates for the 7 South coal is 152 mg/kg/wk when initial total sulphur concentrations are 2.15 %S. Col 3 (No. 4L Seam), which has an initial total sulphur value of 2.8 %S has a sulphate production rate of 319 mg/kg/wk (for cycles 45 – 53). Col 2 (No. 4U Seam), which has a higher initial total sulphur concentration of 4.0 %S has a lower sulphate production rate of 289 mg/kg/wk.

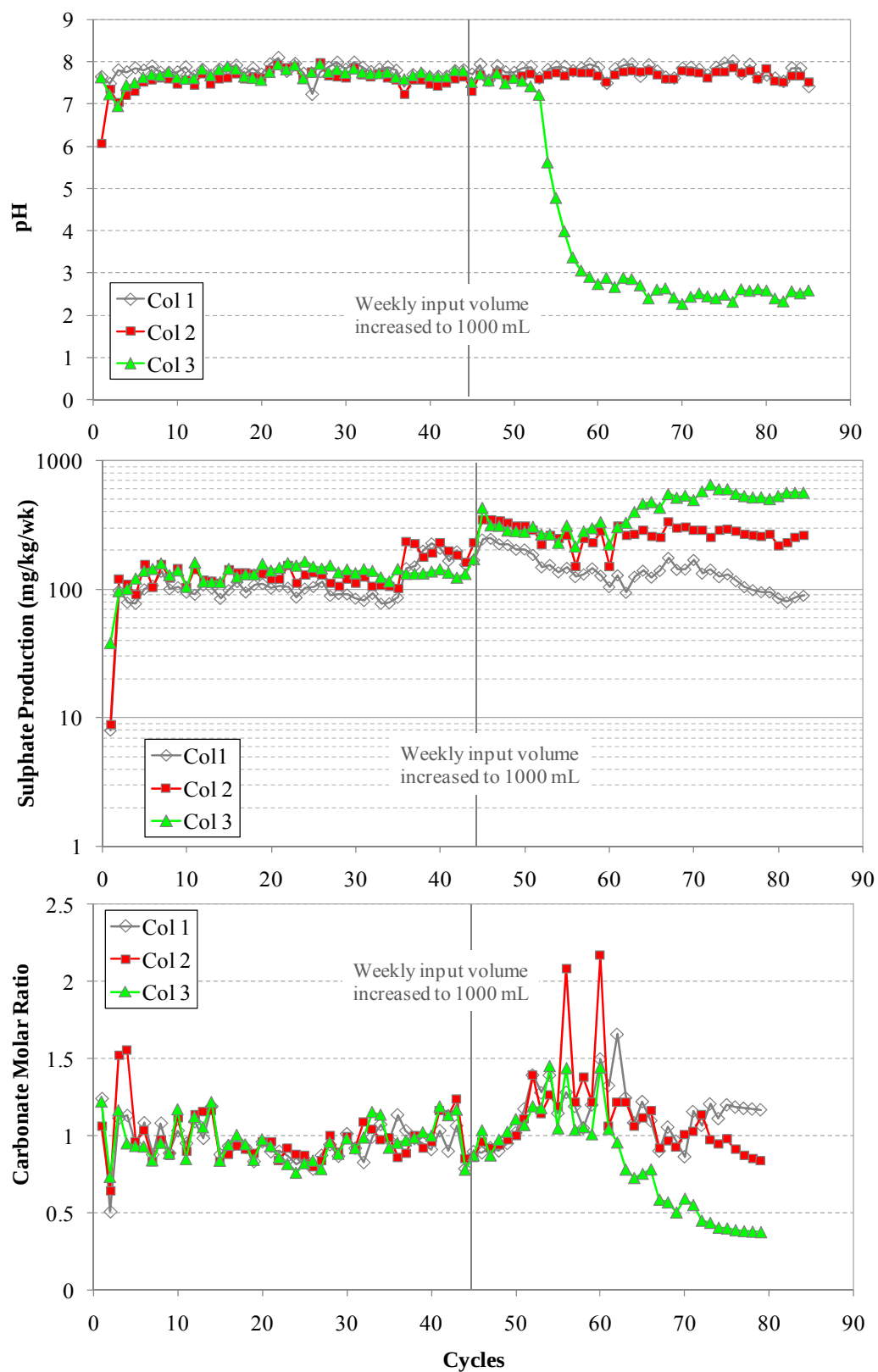


Figure 6-3: pH, sulphate production and carbonate molar ratios in leachate from the 7 South exposed coal and coarse reject.

**Table 6-1:
Calculation of NP Depletion Time for 7 South Mine Coal and
Coarse Reject Kinetic Tests.**

	Units	Col 1 raw coal test cycles 45 - 79	Col 2 CCR (high S) test cycles 45 - 79	Col 3 CCR (moderate S) test cycles 45 - 53
Initial Total Sulphur ¹	%S	2.17	4.03	2.82
Sulphate Production Rate ²	mg/kg/wk	152.0	289.2	319.8
CMR ³	mol/mol	1.13	1.04	1.00
NP Depletion Rate ⁴	kg CaCO ₃ /t/wk	0.17	0.31	0.33
Initial NP (modified) ¹	kg CaCO ₃ /t	36.3	84.9	24.3
NP Depleted ⁵	kg CaCO ₃ /t	13.8	24.6	17.5
NP Remaining ⁶	kg CaCO ₃ /t	22.5	60.3	6.8
Time to Deplete NP	weeks	208.4	272.9	73.8
Time to Deplete NP	years	4.0	5.2	1.4
Available NP ⁷	kg CaCO ₃ /t	29.5	78.1	17.5
Time to Deplete NP	weeks	169.1	250.9	53.0
Time to Deplete NP	years	3.25	4.83	1.02

- Notes:**
1. Derived from ABA analysis of solids;
 2. Calculated from average of indicated test cycles of kinetic tests;
 3. Carbon molar ratio ((Ca+Mg+Sr)/SO₄), calculated from average of indicated test cycles of kinetic test;
 4. Calculated as sulphate production rate in mmol/kg * CMR (average of test cycles) / 1000 to convert to kg CaCO₃/t; and
 5. Calculated as NP Depletion Rate * total number of indicated test cycles;
 6. Calculated as Initial NP - NP Depleted after indicated test cycles; and
 7. Initial NP – NP remaining in Col 3 after 53 cycles (i.e., when column became acidic (pH < 6)).

The rate of NP depletion is assessed using the CMR. Table 6-1 lists the average CMR values using the same cycles used to calculate sulphate production. The coarse reject samples have similar NP depletion rates of 0.31 and 0.33 kg CaCO₃/t/wk for Col 2 and Col 3, respectively, despite the higher initial sulphur and NP concentrations of Col 2. The carbonate mineral assemblage is the most reactive form of NP identified in the 7 South coarse reject and acidic conditions may develop once the carbonate minerals have been depleted. It is believed that the modified NP method conducted by SGS-CEMI provides the most accurate measure of NP contained in the coarse reject carbonate mineral assemblage. Estimates for the time to onset of acidic conditions from the coarse reject, assume that acidic drainage will be generated when all NP, as determined by the modified NP method, is depleted.

A number of assumptions are inherent in the estimation, including:

- all sulphide-S initially present is available for oxidation and production of acid;
- all sulphate produced in the column leachate is from sulphide oxidation;

- all sulphate produced from sulphide oxidation is released to the leachate and is not retained in the column as secondary minerals such as gypsum; and
- average sulphate production rates and NP depletion rates observed in the selected test cycles will continue indefinitely until all NP is depleted.

Calculation of the time to onset of acidic drainage is conducted by adjusting the sulphate loading rate to NP units of kg CaCO₃/t and normalizing them to the relative cation release rate provided by the CMR. Table 6-1 provides the calculations used to determine the amount of time required to deplete the NP present in the 7 South coal and coarse reject samples. Mine waste drainage will not acidify as long as the rate of acid neutralization equals or exceeds the rate of acid production. However, this is to a large degree dependent upon the relative surface areas of sulphide and carbonate minerals available for reaction (Lapakko *et al*, 1998). Precipitates may gradually accumulate over time on the surfaces of both sulphide minerals and acid neutralizing minerals, which can inhibit the reactivity of the minerals on which they form. If coatings form on the acid-neutralizing minerals and sulphide oxidation continues, the coated portion of the NP will become unavailable and drainage from the waste will become acidic. The occlusion of carbonate minerals appears to have occurred in Col 3 when acidic conditions developed following the completion of 53 cycles. At cycle 53, only 72% of the initial measured modified NP (24.3 mg CaCO₃/t) was consumed, indicating that 6.8 mg CaCO₃/t of the initial NP measured in the Col 3 sub-sample is unavailable for neutralization of acid in the 7 South coarse reject. To provide a more conservative time estimate for NP depletion of Col 1 and Col 2, “available NP” values were calculated by subtracting the unavailable NP in Col 3 after 53 cycles (before it produced acidic drainage) from the initial NP values measured in Col 1 and Col 2. Under the conditions of the column tests, the available NP (78.1 mg CaCO₃/t) in the high sulphur coarse reject (Col 2) is estimated to be depleted in < 5 years and the available NP (29.5 mg CaCO₃/t) in the raw coal (Col 1) will be depleted in 3.25 years.

No. 4 Coal Zone Exposed Tailings (T1)

Figure 6-4 provides time series plots of pH, sulphate production and CMR values for the tailings (T1) kinetic test. Table 6-2 provides the average sulphate production rates for the 7 South tailings humidity cell, based on leachate results from cycles 5 to 81. Note that the first few cycles were not included in the average due to initially high sulphate production values in leachate, which may be a result of flushing of existing surface products (Figure 6-4). Sulphate production rates for tailings sample T1 under the conditions of the humidity cell test are 88.5 mg/kg/wk for an initial total sulphur concentration of 2.6 %S.

This rate is lower than that observed for the coal and coarse reject kinetic tests with similar or lower total sulphur values.

Table 6-2 also lists the average CMR values for cycles 5 - 81. Tailings sample T1 has the lowest NP depletion rate (0.15 kg CaCO₃/t/wk) compared to the raw coal and coarse reject kinetic test samples composed of like material, despite the considerably higher initial NP concentration measured for sample T1 (135 kg CaCO₃/t). As previously indicated, the carbonate mineral assemblage is the most reactive form of NP identified in the 7 South samples and acidic conditions may develop once the carbonate minerals have been depleted. Estimates for the time to onset of acidic conditions from the tailings, assume that acidic drainage will be generated when all NP, as determined by the modified NP method, is depleted. Note that the same assumptions outlined for the coal and coarse reject estimations are inherent for estimating timing to NP depletion of the tailings. However, unlike the coal and coarse reject samples, all carbonates included in the modified NP value for the tailings sample are assumed to be available for neutralization of acidity.

Table 6-2 provides the calculations used to determine the amount of time required to deplete the NP present in the 7 South tailings sample. The data presented in Table 6-2 demonstrate that, at current sulphide oxidation rates and NP depletion rates, NP in the tailings test T1 will be depleted after 17.5 years.

Extrapolation of NP Depletion Times Based on Initial NP Values

The high sulphate concentrations in the unsaturated raw coal, coarse reject and tailings samples indicate that the pyrite contained in the No.4 coal and partings oxidizes at an accelerated rate. However the > 7.5 pH demonstrates that the carbonate minerals are initially capable of buffering pH in an acceptable range despite the accelerated sulphide oxidation kinetics of the reactive pyrite. When the carbonate minerals are depleted, acidic conditions are anticipated to prevail, as is observed for the unsaturated 4L coarse reject sample (Col 3). It is anticipated that similar trends would be observed if or when PAG coarse reject or raw coal is exposed to the atmosphere for a sufficient period of time to allow acidic conditions to develop.

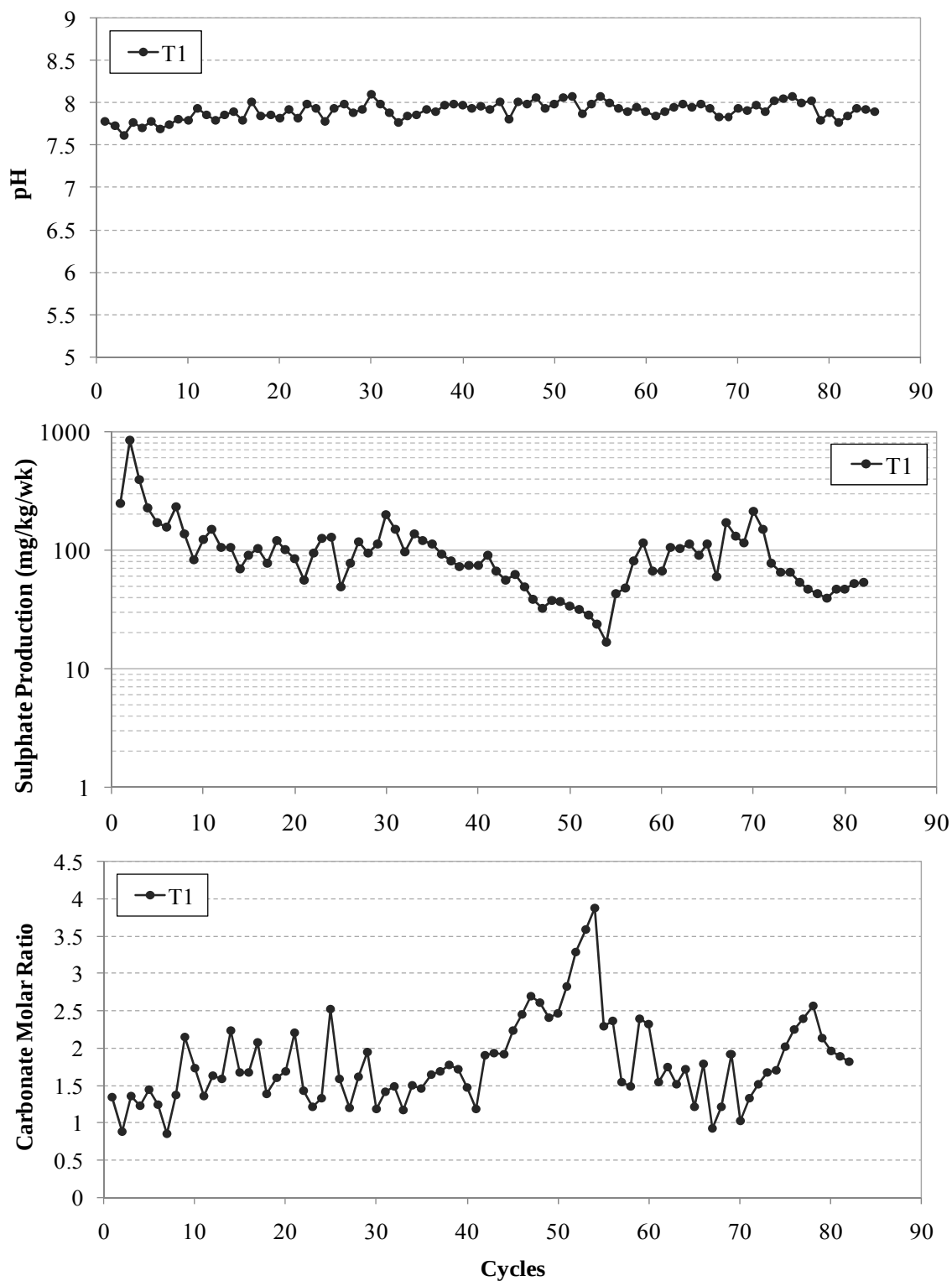


Figure 6-4: pH, sulphate production and carbonate molar ratios in leachate from the 7 South tailings (T1).

**Table 6-2:
Calculation of NP Depletion Time for 7 South Mine Tailings Kinetic Test.**

	Units	T1 test cycles 5 - 81
Initial Total Sulphur ¹	%S	2.6
Sulphate Production Rate ²	mg/kg/wk	88.5
CMR ³	mol/mol	1.84
NP Depletion Rate ⁴	kg CaCO ₃ /t/wk	0.15
Initial NP (modified) ¹	kg CaCO ₃ /t	134.9
NP Depleted ⁵	kg CaCO ₃ /t	12.0
NP Remaining ⁶	kg CaCO ₃ /t	122.9
Time to Deplete NP	weeks	908.4
Time to Deplete NP	years	17.5

Notes:

1. Derived from ABA analysis of solids;
2. Calculated from average of indicated test cycles of kinetic tests;
3. Carbon molar ratio ((Ca+Mg+Sr)/SO₄), calculated from average of indicated test cycles of kinetic test;
4. Calculated as sulphate production rate in mmol/kg * CMR (average of test cycles) / 1000 to convert to kg CaCO₃/t.
5. Calculated as NP Depletion Rate * total number of indicated test cycles; and
6. Calculated as Initial NP - NP Depleted after indicated test cycles.

The time for NP depletion is evaluated for a range of initial NP values that could be present in the No. 4 Seam coal zone and for a range of NP depletion rates which are defined by the range of sulphide oxidation rates measured in the kinetic tests (Tables 6-1 and 6-2). By extrapolating the NP depletion rates measured in the kinetic tests to the range of possible NP values for coarse reject and tailings, a range of time estimates for the onset of acidic conditions is presented in Figure 6-5. The results of the calculations indicate that PAG raw coal or tailings contain an initial NP of 60 kg CaCO₃/t would produce acidic drainage within 6 to 7 years, respectively. Higher sulphide oxidation and NP depletion rates were observed from the coarse reject and the results indicate PAG coarse reject with the same initial NP of 60 kg CaCO₃/t would become acidic within three years.

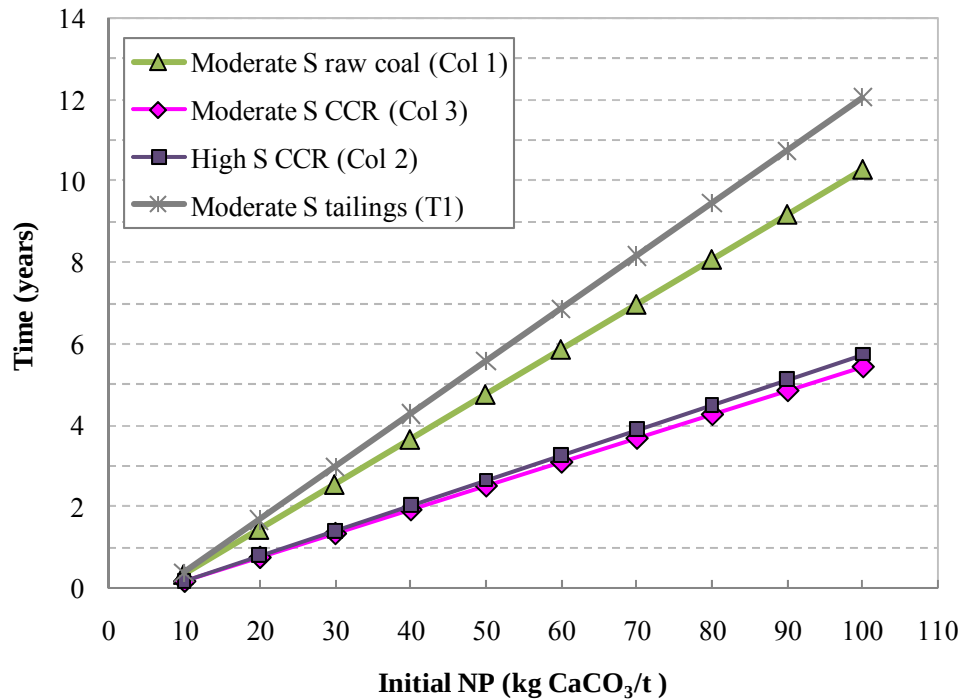


Figure 6-5: NP Depletion Time Estimates for a Range of Initial NP and Sulphur Values for the 7 South coarse reject, raw coal and tailings.

As would be expected, materials with higher initial NP values have longer depletion times. PAG coarse reject with an initial NP of 100 kg CaCO₃/t is predicted remain pH – neutral for 5.5 years. Raw coal and tailings with this amount of NP would be expected to remain pH neutral for > 10 years prior to the onset of acidic conditions.

6.2.4 Metal Leaching Potential and Source Terms from Flooded Underground Mine

Estimates of the 7 South mine water chemistry are derived in part from the 7 South saturated column test leachate data and also from measured groundwater chemistry from the mature 4 South mine pool (Lorax, 2011). The estimates are made assuming that coarse reject is placed in the mine void and becomes inundated by water pumped into the mine. An overview of both water chemistries that provide the basis for the source terms (*i.e.* columns and existing mine pools) is provided below followed by a discussion of source terms for three scenarios.

Basis for Source Terms

The leachate results for saturated columns (HQA and HQC) were used to assess the quality of drainage that will be produced from saturated coarse reject submerged in the underground workings. The columns contain coarse reject derived from No. 4 Seam coal zone in the 7 South Mine area. Details on sample components are in Appendix B1.1 and

the geochemical characteristics is presented in Appendix B1.2. The leachate results from these columns are presented in Appendix B1.3.1.2. Initially, column leachate from the saturated No. 4 Coal Zone coarse reject were slightly acidic (< 6.5) and contained sulphate and dissolved metal(loid) concentrations (As, B, Cd, Cr, Co, Cu, Fe, Mn, Ni, Se and Zn) elevated above maximum provincial guidelines. This initial depressed pH and elevated concentration of metal(loid)s in solution is likely the result of dissolution of surface oxidation products during saturation of the test samples. This condition would also be expected from coarse reject that is stored unsaturated in the mine void or in surface stockpiles prior to being flooded. Following the first few weeks of column testing, pH increases rapidly to slightly alkaline conditions (7 – 8) and concentrations of sulphate and metal(loid)s decrease by one to two orders of magnitude by the 20th week to stabilize at values below guidelines. Only concentrations of dissolved As remain elevated. The As associated with the Fe-sulphate phase mantling some of the pyrite grains may be more susceptible to desorption reactions under the circum neutral and reducing conditions in the column. However, the observed range of arsenic concentrations in the columns is still within the baseline range of 0.063 mg/L to 0.568 mg/L that were typically measured in the 7 South baseline groundwater quality monitoring program.

Existing mine pool water chemistry from the 4 South mine was presented in Lorax, 2011a. The mature mine pool waters were observed to be anoxic, circum-neutral and contain elevated levels of sulphate, reduced iron and traces of dissolved sulphide. Thermodynamic controls on the water quality measured in mine pool samples QU-11-01 and QU-78-161-72m are evaluated using PHREEQC. The mature mine pool water chemistries and mineral saturation indices are provided in Appendix B6. PHREEQC is a computer program designed by D.L. Parkhurst (1995) to simulate low-temperature aqueous geochemical reactions. In this application the program was used to calculate the aqueous speciation of mine waters and determine the saturation indices of minerals that might form from each of the solutions. To perform the speciation calculations, PHREEQC solves sets of nonlinear mole-balance and mass-action equations that define an ion-association model. The saturation index (SI) is a numerical expression that shows whether a water will tend to dissolve or precipitate a particular mineral. Negative values indicate the mineral is undersaturated in solution and the mineral will tend to dissolve. A positive SI indicates the solution is supersaturated with respect to the mineral, which will tend to precipitate. SI is calculated by comparing the activity of the dissolved ions of the mineral [ion activity product (IAP)] to the solubility product (K_{sp}), where $SI = \log(IAP/K_{sp})$.

Notable PhreeqC model results include:

- Numerous sulphide minerals are super saturated including As, Cd, Cu, Co, Mo, Ni, Pb and Zn sulphides.
- Iron mono-sulphide FeS and mackinawite (FeS) are saturated or slightly undersaturated ($SI < 0.5$) in QU-78-161-72m but undersaturated in QU-11-01 due to lower dissolved sulphide concentrations measured in QU-11-01.
- Gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) is slightly undersaturated ($SI < 0.5$) in both samples.
- Siderite (FeCO_3) is saturated in QU-78-161-72m and slightly undersaturated in QU-11-01.

The implication of these results is that sulphate and iron concentrations observed in these samples are likely maximum values being limited thermodynamically by the precipitation of gypsum and siderite and/or iron mono-sulphide. In addition, concentrations of metal(oids) may also be limited by metal sulphide precipitation, however, since these sulphide minerals are super saturated the formation of these sulphides may be kinetically limited and may require longer time frames to reduce concentrations of these metals in an anoxic mature mine pool.

Source Term Description

Source term concentrations are presented in Table 6-3 for three possible scenarios.

Scenario 1 is essentially a worst case scenario where a portion of the coarse reject becomes acidic prior to being flooded. Under this condition abundant secondary oxidation would be available to resolublize and release metals and sulphur into the mine pool. The terms used for Scenario 1 are a combination of the maximum concentrations measured from the 4 South mine pool and the 90th percentile concentrations of the entire saturated column test record. When the 90th percentile concentrations exceed the maximum concentration in the 4 South mine pool the column concentrations are used, otherwise the maximum 4 South mine pool concentrations are used.

Scenario 2 is the expected condition when PAG coarse reject is placed in the mine void and flooded prior to the onset of acidic conditions from the coarse reject. Under this scenario it is conservatively estimated that the coarse reject would need to be stowed and flooded in the underground mine within 2 years of being produced. Two years is the time to onset for acidic conditions from PAG coarse reject that contains 40 kg CaCO_3/t , thus, under the 2 year time frame essentially all coarse reject will remain pH neutral. To qualify the previous statement it should be noted that the static test data presented in Appendix B1 indicate that on average coarse reject is expected contain 60 to

80 kg CaCO₃/t NP, which has a time to onset of 3 to 4 years. If coarse reject remains unflooded for a time duration greater than 4 years, the majority of the coarse reject is not expected to contain sufficient NP to maintain pH neutral conditions although a portion would be acidic, which would drive the concentrations from those stated in Scenario 2 towards the higher concentrations associated with Scenario 1. Scenario 2 geochemical source terms are based on the 90th percentile concentrations of the entire saturated column test record.

Scenario 3 is the expected long term concentrations from the flooded coarse reject following the complete dissolution of stored oxidation products and the mine water influenced by the dissolution has been discharged from the mine or restabilized as metal sulphides within the flooded underground workings. The expected long term concentrations are based on the average from the latter portion of the column tests when the release of metals stabilized.

**Table 6-3:
Worst-Case Best-Estimate and Long Term Source Terms
for 7 South Mine Containing Saturated Coarse Reject.**

Sample ID	units	Scenario 1 (Acidic CCR before flooding) ¹	Scenario 2 (CCR not acidic before flooding) ²	Scenario 3 (Long term chemistry following flooding) ³
pH	pH	5.43	6.48	7.49
Acidity (as CaCO ₃) (pH 8.3)	mg/L	446		
Fluoride (F)	mg/L	1.0	0.6	0.1
Sulphate (SO ₄)	mg/L	2060	1260	22
Aluminum (Al)-D	mg/L	0.024	0.009	0.005
Arsenic (As)-D	mg/L	0.19	0.190	0.099
Boron (B)-D	mg/L	0.98	0.98	0.13
Cadmium (Cd)-D	mg/L	0.0002	0.0002	0.000012
Cobalt (Co)-D	mg/L	0.063	0.062	0.0003
Copper (Cu)-D	mg/L	0.0564	0.001	0.0002
Iron (Fe)-D	mg/L	257	6.705	0.015
Manganese (Mn)-D	mg/L	5.97	2.885	0.08
Nickel (Ni)-D	mg/L	0.122	0.122	0.0009
Selenium (Se)-D	mg/L	0.004	0.004	0.0001
Zinc (Zn)-D	mg/L	0.088	0.088	0.004

6.3 Hanging Wall Bedrock Characterization

The No. 4 Coal zone lies within the Dunsmuir sandstones of the Comox Formation. Solid phase analyses were conducted on the QU-10-01 and QU-10-02 holes samples to determine the composition of this bedrock hanging wall strata. The geochemical characteristics of the rock strata and overburden that overly the No. 4 Coal zone are of interest due to the planned mining of a small pit that will provide a staging platform and highwall to develop a portal to the No. 4 Zone. The geochemical characterization also provides supporting information in the interpretation of the current groundwater quality.

A complete geochemical characterization of the 7 South overburden and hangingwall strata is presented in Appendix B2, the analytical methods used at SGS laboratories in Burnaby are presented in Appendix B3, and the supporting mineralogy reports are provided in Appendix B4.

6.3.1 Mineralogy

XRD analysis of composite samples of the Dunsmuir sandstone determined that quartz and kaolinite are the predominant minerals in the hanging wall strata as would be expected from a lithic sandstone (Appendix B2 and B4). Similar to the No. 4 Coal zone, carbonate minerals are also present in the strata. However, unlike the No. 4 Coal zone, the iron-carbonate minerals siderite and ankerite-dolomite are the primary carbonate phases present in the Dunsmuir sandstone rather than calcite.

XRD analyses of the composite samples detected both pyrite and marcasite iron-sulphide phases in the sandstone. In hand specimen, the occurrence and distribution of both carbonate and iron-sulphide phases are observed to be controlled stratigraphically by the extent of a particular bed (*i.e.* intimately associated with the grains and matrix that comprise the sandstone, with the abundance of these minerals observed to vary within individual beds). Conversely, geologic logging of borehole Qu-11-07 identified a subvertical white calcite vein oriented perpendicular to the bedding planes of the primary lithologies (Figure 6-6). The calcite vein also contained a red mineral that was identified by XRD analysis to be the arsenic sulphide, realgar (AsS). The occurrence of realgar is consistent with previous reports of its presence in the Nanaimo Group sediments (Massey, 1989).

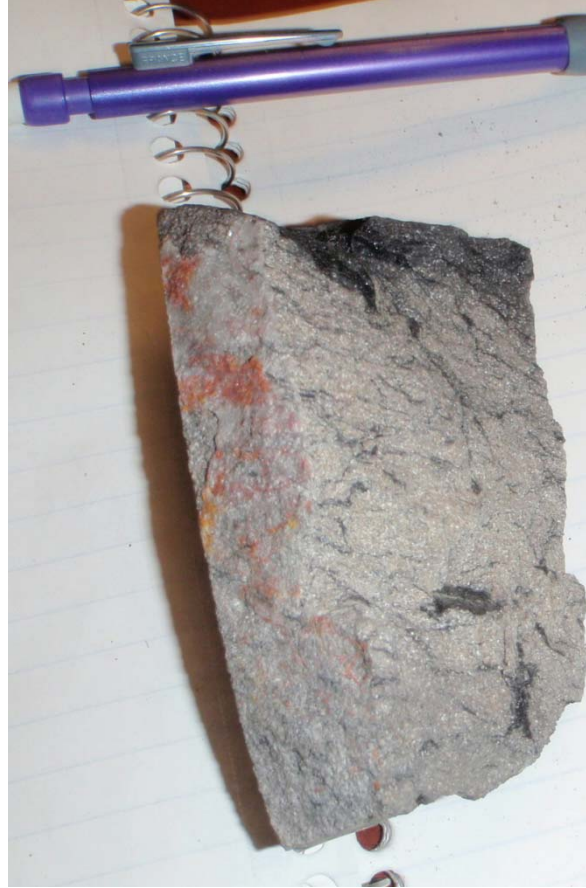


Figure 6-6: Realgar (AsS) in calcite vein in Dunsmuir Sandstone.

6.3.2 Static Test Analysis

ABA analysis of the Dunsmuir strata was undertaken from boreholes QU-10-01 and QU-10-02 in the area of the proposed portal pit. In this area, No.5 Seam lies within 1 m above the No. 4 Coal zone (Appendix B2.1-1). The ABA analysis indicated that the 10 m thick stratigraphic interval above No. 5 Seam is comprised predominately of potentially acid generating (PAG) sandstone (Appendix B2.3-1). Sulphur content is greatest immediately above No. 5 Seam (up to 5 %S) but is more typically in the range of 0.8 %S to 1.3 %S in the 10 m interval above the coal zone. Of note is that several PAG sandstone samples already displayed paste pH < 5.5 with modified NP values 4 to 10 kg CaCO₃/t and CaNP values > 10 kg CaCO₃/t. The depressed Paste pH and significant NP is due to the predominance of siderite in these strata that does not effectively buffer pH in the neutral range.

Solid phase metal content of the Dunsmuir strata indicated that arsenic was consistently elevated above average concentrations of the continental crust (Appendix C2.3-2).

7. Groundwater Quality



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7. Groundwater Quality

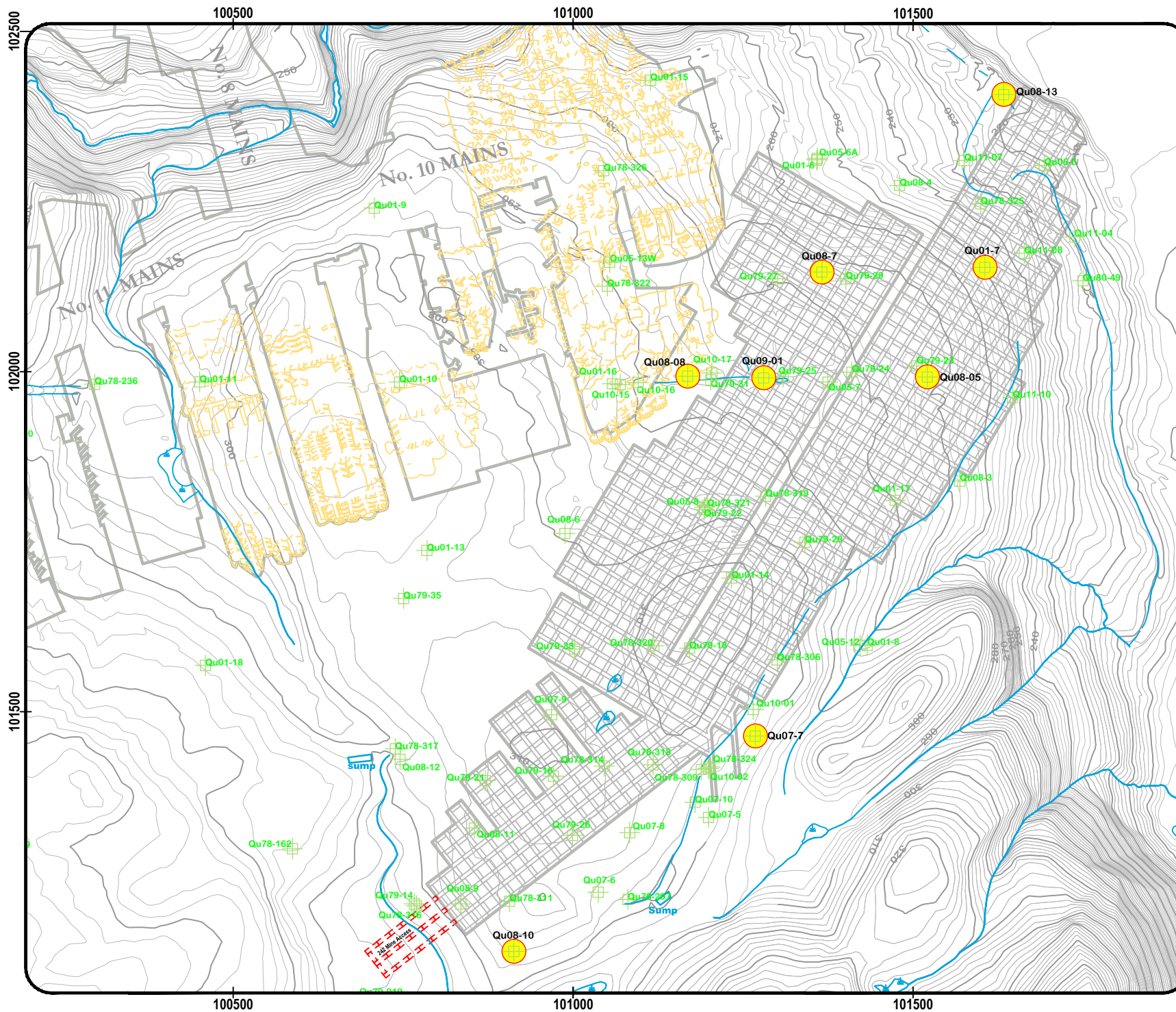
A hydrogeological field investigation to characterize groundwater quality in the proposed 7 South Mine area was initiated in April 2010 and has continued through January 2011. The investigation included the installation, development and sampling of monitoring wells. In addition, QCC has been monitoring the water quality of boreholes and wells since 2009 and the data from this program is also included in this report. The well descriptions are provided in Section 7.1 below. Section 7.2 discusses the water quality results and the conclusions are summarized in Section 7.3.

7.1 Well Description

The groundwater sampling locations are presented in Figure 7-1. Groundwater quality monitoring of 7 South was initiated by QCC in March 2009 with boreholes QU-01-07, QU-07-07, QU-08-05, QU-08-07, QU-08-08 and QU-09-01. Table 7-1 describes the general location and coal seams intersected by the boreholes. Since July 2010 groundwater water quality monitoring in 7 South was refined to include only boreholes QU-07-07, QU-08-07, and QU-09-01, and well QU-08-08A. The boreholes are lined with a 6" diameter steel casing that extends from the ground surface to 1 metre below bedrock however below this depth the boreholes are not lined. The water quality in each borehole is expected to represent water from the borehole intersected bedrock strata with the highest hydraulic conductivity, which based on experience at the Quinsam Mine is generally the coal zones .

**Table 7-1:
Location of 7 South water quality monitoring boreholes and the coal seams intersected by borehole.**

Borehole ID	7 South Location	Coal Seam(s) Intersected
QU-01-07	Footprint of proposed workings	No. 4, No. 5
QU-07-07	Eastern margin of proposed workings	No. 4, No. 4B, No. 5
QU-08-05	Footprint of proposed workings	No. 4, No. 5
QU-08-07	Footprint of proposed workings	No. 4, No. 5
QU-08-08	Western margin of proposed workings	No. 4, No. 5
QU-09-01	Footprint of proposed workings	No. 4, No. 5



Legend

-  Mine Workings Outline
-  GOB
-  7 South Workings
-  Boreholes
-  Swamp/Marsh
-  Groundwater Sampling Locations

MINE GRID



Meters

0 100 200

Projection: Mine Grid Coordinates

Figure Title

**7 South Groundwater
Sampling Locations**

Figure No.

7-1

Project No.

J885-1

Client

Hillsborough Resources

Date

Apr 7, 2011

In April 2010, wells constructed of PVC pipe screened at specific depths were installed in selected boreholes within the 7 South proposed mine area to monitor the water quality and hydraulic conductivity in No.4 and No. 5 coal seams, the overlying sandstone, and the interface between the sandstone and the overburden (Table 7-2). QU-08-08 and QU-08-13 were completed with two monitoring wells each, while QU-08-05 and QU-08-10 were completed as single well installations. Well installation and development is discussed previously in Chapter 3 and the well completion logs are presented in Appendix A1. During subsequent sampling, the QU-08-05 and QU-08-10 wells were noted to have slow recharge rates, and QU-08-08B contained elevated suspended solids with an opaque milky-grey appearance suggesting significant bentonite grout leakage into the well screen.

Table 7-2:
Location, target zones and observations of 7 South water quality monitoring wells.

Borehole ID	7 South Location	Well ID	Target Zone for Water Quality Monitoring	Well Observations
QU-08-05	Footprint of proposed workings	QU-08-05	Sandstone overlying No. 4 Coal Seam	Slow recharge
QU-08-08	Western margin of proposed workings	QU-08-08A	No. 4 Coal Seam	Slow recharge
		QU-08-08B	No. 5 Coal Seam	Fast recharge, grout affected
QU-08-10	Southern margin of proposed workings	QU-08-10	No. 4 Coal Seam	Slow recharge
QU-08-13	Downstream of proposed workings	QU08-13A	No. 4 Coal Seam	Fault separated groundwater flow path
		QU08-13B	Interface between Overburden and Sandstone	

7.2 Water Quality Characterization

The groundwater sampling methods and a discussion of the quality control on the data is presented in Appendix C1. The 7 South groundwater water quality data presented in Appendix D2 were reviewed to detect trends and anomalies in the water quality based on borehole location, lithological formation, major ion chemistry and relevant British Columbia water quality guidelines. As described in Appendix C1 the water quality of four samples (QU-08-05 May 2010, QU-08-08B all samples) was influenced by chemical artefacts of well installation and though data for these samples were included in Appendix C-3 they were excluded from the 7 South water quality characterization. The water quality of 7 South groundwater is summarized in terms of major ion chemistry, general characteristics and parameters of concern. Several location or parameter specific trends were observed and are described.

7.2.1 Major Ion Chemistry

The relationship of major ion charge equivalents is presented in a trilinear Piper plot (Figure 7-2) showing the groundwater is predominantly calcium bicarbonate. As indicated in the plot there is no significant chloride present in the 7 South groundwaters. Water quality samples collected from QU-08-13A and QU-08-13B show significant sodium influence; the water at this location is suspected to follow a different flow path than other 7 South waters as a consequence of the overlook fault that separates the QU-08-13 location from the other water quality sampling locations. Borehole QU-07-07 water quality has consistently the largest sulphate influence, suggesting the groundwater at this location is influenced by the oxidation of sulphide minerals in the unsaturated zone. This is consistent with ABA test results measured in drill core from the nearby QU-10-01 and QU-10-02 boreholes.

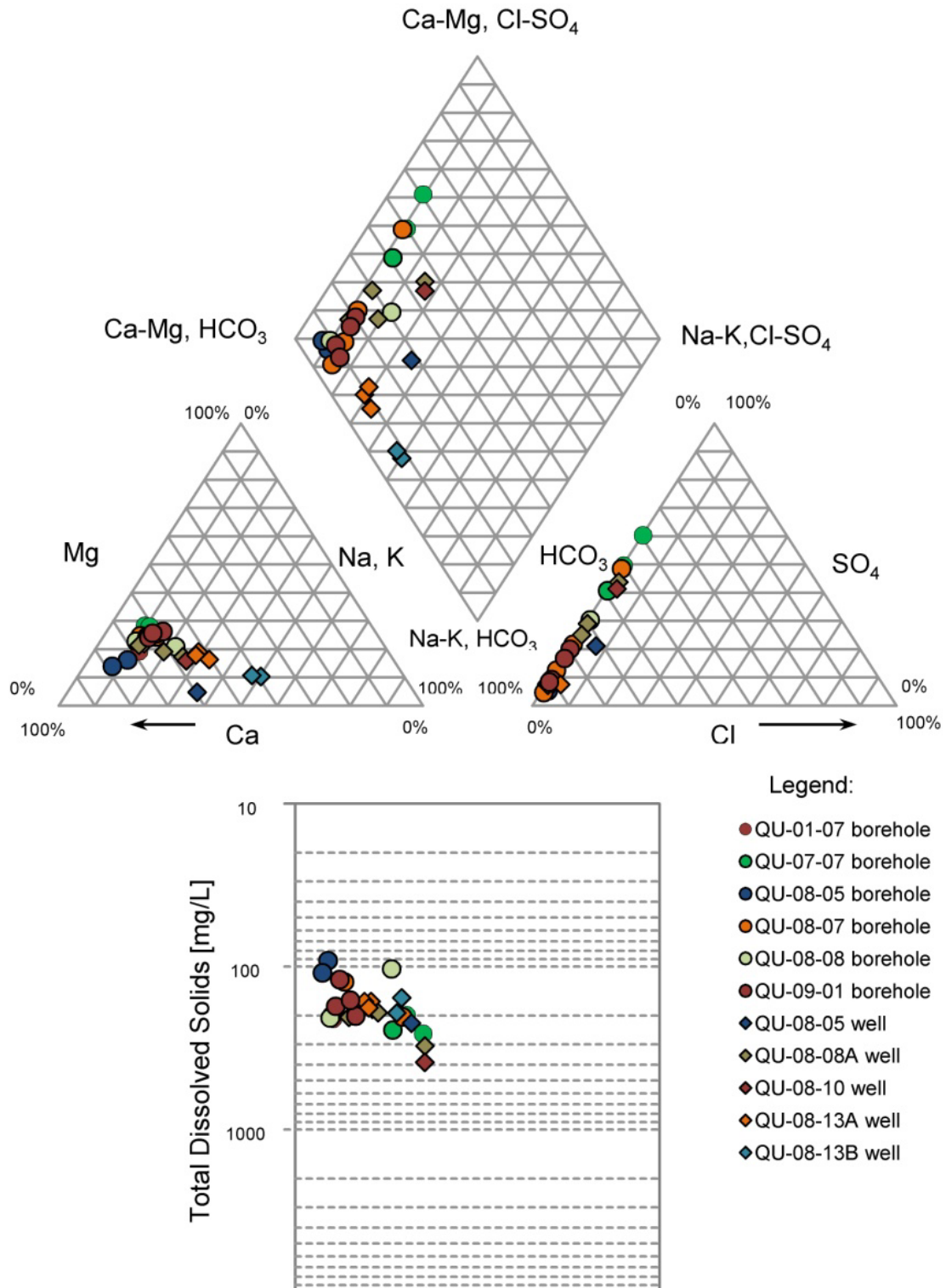


Figure 7-2: Piper plot of 7 South groundwater showing the predominantly calcium bicarbonate type water.

7.2.2 General Water Quality Characteristics

The 7 South groundwater chemistry is generally comparable for all boreholes and wells, therefore data from all representative samples were grouped together to show parameter concentration ranges of 7 South groundwater. For non-detected results the detection limit value is used for graphing and for comparison to permit and/or guideline levels. The parameter concentration ranges are shown as box plots and in some instances with scatter plots. The box plot depicts the concentration ranges in terms of data set percentiles; a shaded box is drawn between the 25th and 75th percentiles, the median (50th percentile) is shown as a long vertical line inside the box, outside the box short vertical lines are drawn at the 10th and 90th percentiles and connected to the box with a horizontal line (also referred to as “whiskers”). Individual sample data are plotted as discrete points overlaid on the box plot and show the scatter of data points for each parameter (Figure 7-3). The representative data set includes a total of 31 samples and the number of data points for each data set is either 30 or 31, depending on the availability of parameter specific test results.

The general groundwater characteristics are described in terms of conductivity, alkalinity, pH and reduction-oxidation (redox) tendency. Of these, the redox tendency is inferred by evaluating parameters associated with groundwater redox buffering reactions.

As shown in Figure 7-3 field conductivity data ranges from 172 $\mu\text{S}/\text{cm}$ (10th percentile) to 464 $\mu\text{S}/\text{cm}$ (90th percentile), with the elevated conductivity levels associated with elevated concentrations of major ions of QU-07-07, QU-08-08A, and QU-08-10. Alkalinity ranges from 123 mg/L to 170 mg/L (10th and 90th percentile respectively), the results are evenly distributed across the range with the two lowest values from QU-08-05 (March, 2009) 73.3 mg/L and QU-08-08 (November, 2009). Field pH data ranges from 7.05 to 7.94 (10th and 90th percentiles respectively) with values evenly distributed across the range.

The reduction-oxidation (redox) condition of groundwater is typically governed by redox buffering reactions of oxidizable or reducible chemical species present in the groundwater system, and can be evaluated by examining the presence of reduced species such as ammonia, ferrous iron and hydrogen sulphide (Drever, 1988). The progression of groundwater redox conditions leading to the formation of reduced species can be generally described as mildly reducing (ammonia), moderately reducing (dissolved iron) and strongly reducing (hydrogen sulphide). The presence of any of these species indicates the groundwater is anoxic. All three species were detected in 7 South groundwater with ammonia ranging from 0.012 mg/L to 0.154 mg/L, dissolved iron ranging from <0.03 to 0.403 mg/L and sulphide ranging from <0.002 mg/L to

0.151 mg/L, indicating overall the groundwater is anoxic and mildly to moderately reducing. The ammonia and sulphide data is limited to well samples only.

Dissolved iron was tested in all boreholes and wells and measured levels suggest some variations in groundwater redox chemistry related to the infiltration of oxic recharge waters and sulphide oxidation in the unsaturated zone. Under circumneutral oxic conditions dissolved iron is immobilized as hydrous ferric oxides, however under circumneutral reducing conditions dissolved iron remains mobile in groundwater systems and immobilized iron can be remobilized (Drever, 1988). The plot of dissolved iron against fluoride in Figure 7-4 shows that the older groundwater (with elevated fluoride levels) tends to have the highest dissolved iron content, consistent with a time dependent remobilization of hydrous ferric oxides. On the same plot, the elevated dissolved iron levels observed in the young groundwater at QU-07-07 are highlighted, and are likely due to nearby unsaturated zone sulphide mineral oxidation processes leading to lower groundwater pH and iron mobilization, with concurrent groundwater evolution to reducing conditions maintaining iron mobility in the circumneutral groundwater of QU-07-07. The scatter plot in Figure 7-4 shows dissolved iron below or near the detection limit at QU-08-05, QU-08-10 and QU-08-13B suggesting these wells may be influenced by oxic recharge water from the surface of the 7 South area.

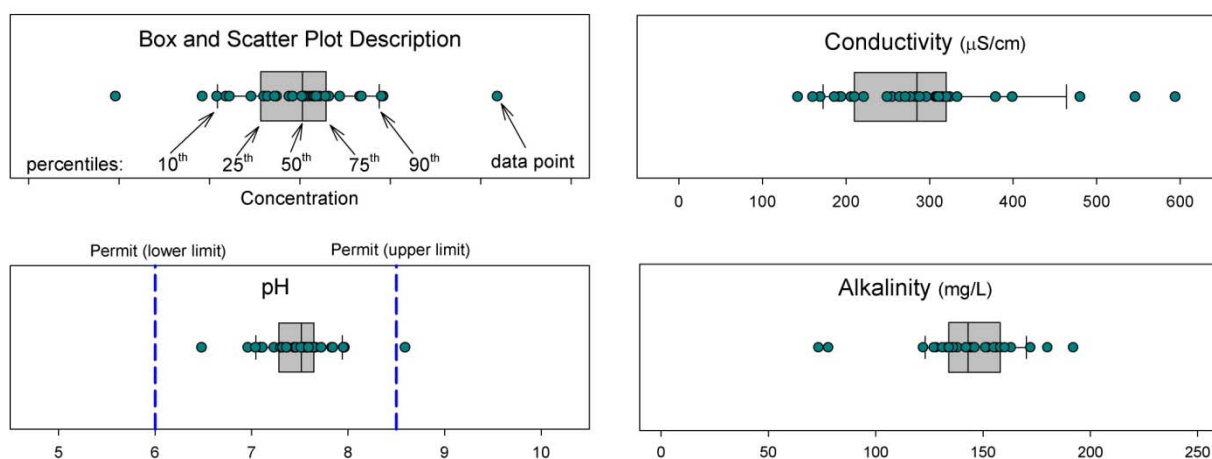


Figure 7-3: Alkalinity, pH and conductivity concentration ranges for the 7 South area. Each data set is presented as a scatter plot (individual results) overlaid on a box plot showing the 10th, 25th, 50th, 75th and 90th percentiles.

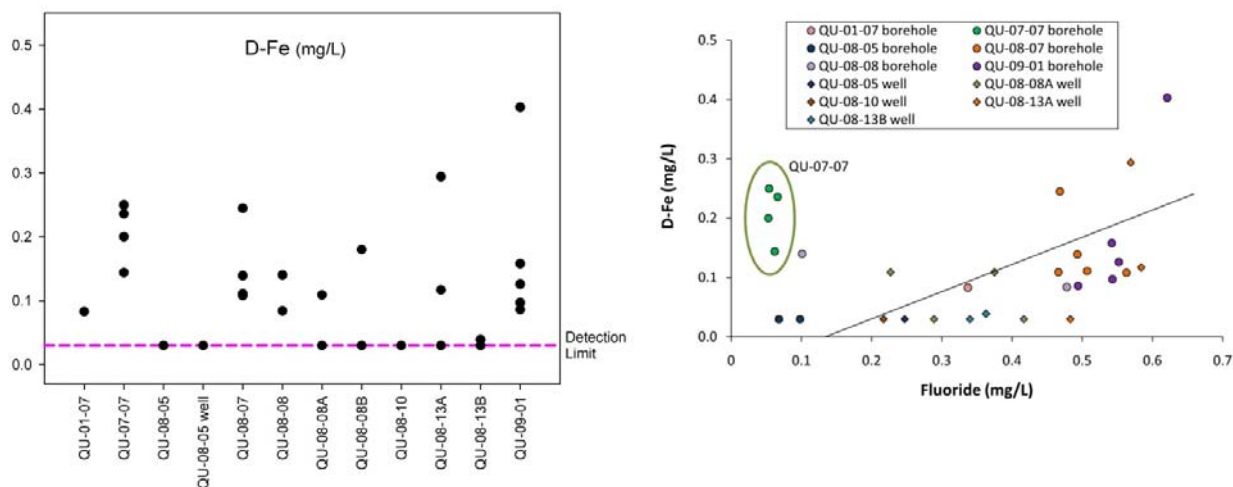


Figure 7-4: Scatter plot of dissolved iron at 7 South boreholes and wells, and a trend line plot of dissolved iron vs. fluoride showing the correlation of elevated dissolved iron with elevated fluoride concentrations.

7.2.3 Parameters of Concern

The parameters of concern are F, SO₄, Al, As, B, Cd, Co, Cu, Fe, Mn, Se, and Zn, which values are based on elevated concentrations observed in kinetic tests and the 4 South mine pool. The concentration ranges of the parameters of concern are shown in Figure 7-5 and are compared to QCC Effluent Permit PE-07008 limits and British Columbia Contaminated Sites Regulation Schedule 6 Aquatic Life guidelines (CSR-AW). The 10th to 90th percentile concentration ranges of all parameters of concern are below the CSR-AW guidelines and Permit limits, except dissolved arsenic, as described below.

Several parameters of concern (fluoride, dissolved arsenic and dissolved boron) are present at elevated concentrations in 7 South groundwater produced from the Nanaimo Group sediments. Elevated fluoride and boron concentrations in groundwater have been previously observed in the Nanaimo Group sandstone and mudstone lithology (Earle, 2006), and realgar, an arsenic bearing sulphide mineral, was reported in the Nanaimo Group Haslam formation by Massey (1989) and also observed in Dunsmuir Sandstone at the Quinsam Mine. Figure 7-5 illustrates that fluoride data ranges from a 10th percentile of 0.063 mg/L to a 90th percentile of 0.568 mg/L and dissolved boron 10th and 90th percentiles are 0.100 mg/L and 0.638 mg/L respectively. Dissolved arsenic in a majority of the 7 South groundwater samples exceeds the CSR-AW guideline (0.05 mg/L) with data ranging from 10th percentile of 0.005 mg/L to a 90th percentile of 0.464 mg/L.

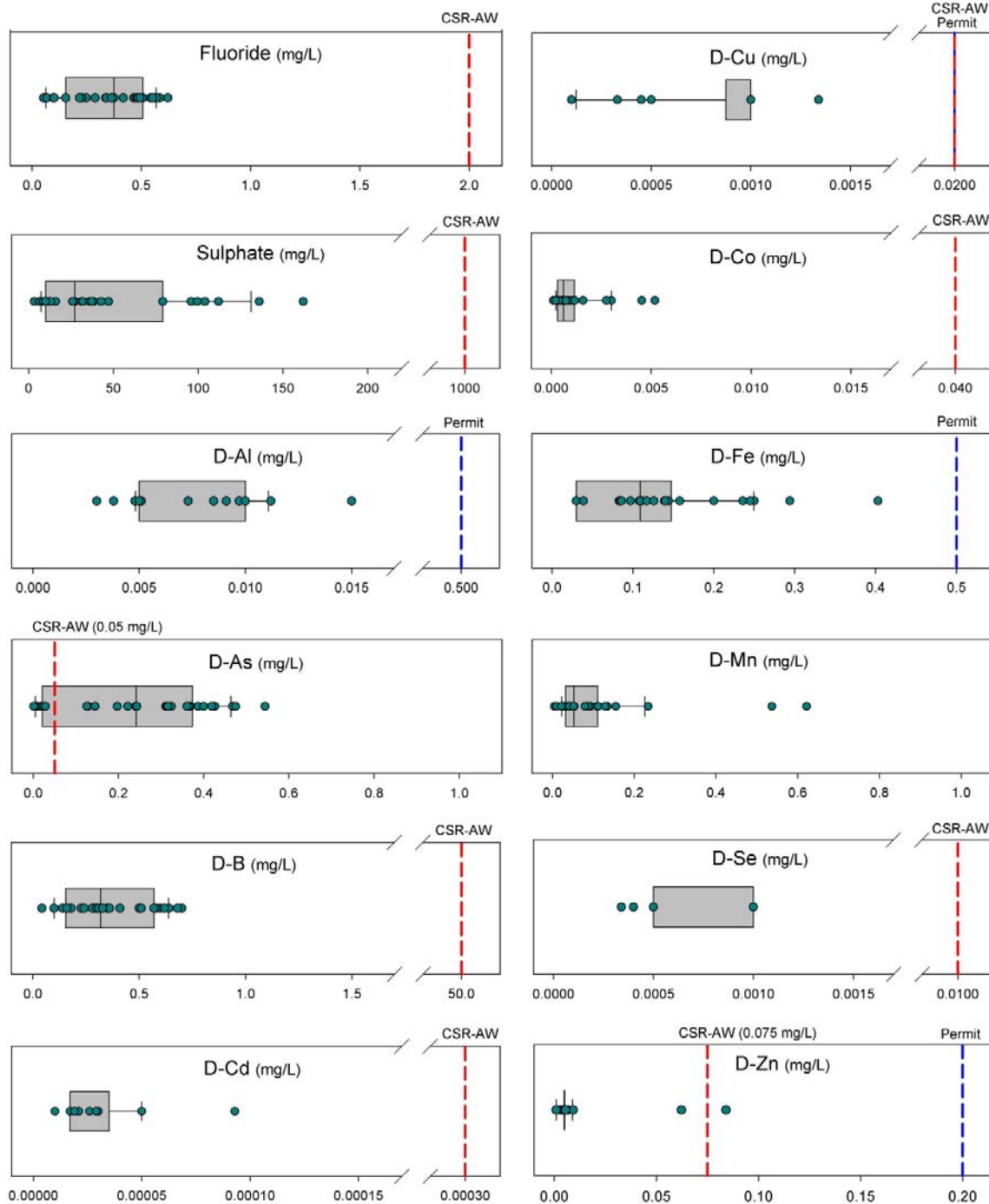


Figure 7-5: Concentration ranges for the 7 South parameters of concern. Each data set is presented as a scatter plot (individual results) overlaid on a box plot showing the 10th, 25th, 50th, 75th and 90th percentiles.

There is a strong relationship between dissolved arsenic and fluoride concentrations with elevated dissolved arsenic levels generally associated with elevated fluoride levels as shown in Figure 7-6. Fluoride concentrations are generally dependent upon aquifer groundwater residence times with longer residence times leading to higher fluoride concentrations (Brunt, 2004). Dissolved arsenic levels are highest at the QU-08-13 wells (ranging from 0.419 mg/L to 0.544 mg/L) that are separated by a fault from the other 7 South wells and boreholes. The fluoride levels are also elevated in both of these wells indicating a longer groundwater flow path at this down gradient 7 South location. The QU-08-13A well fluoride levels (ranging from 0.483 mg/L to 0.584 mg/L) and shallower well QU-08-13B fluoride levels (0.340 mg/L and 0.363 mg/L) are consistent with a greater influence of younger recharge waters expected at the overburden/sandstone interface intersected by QU-08-13B.

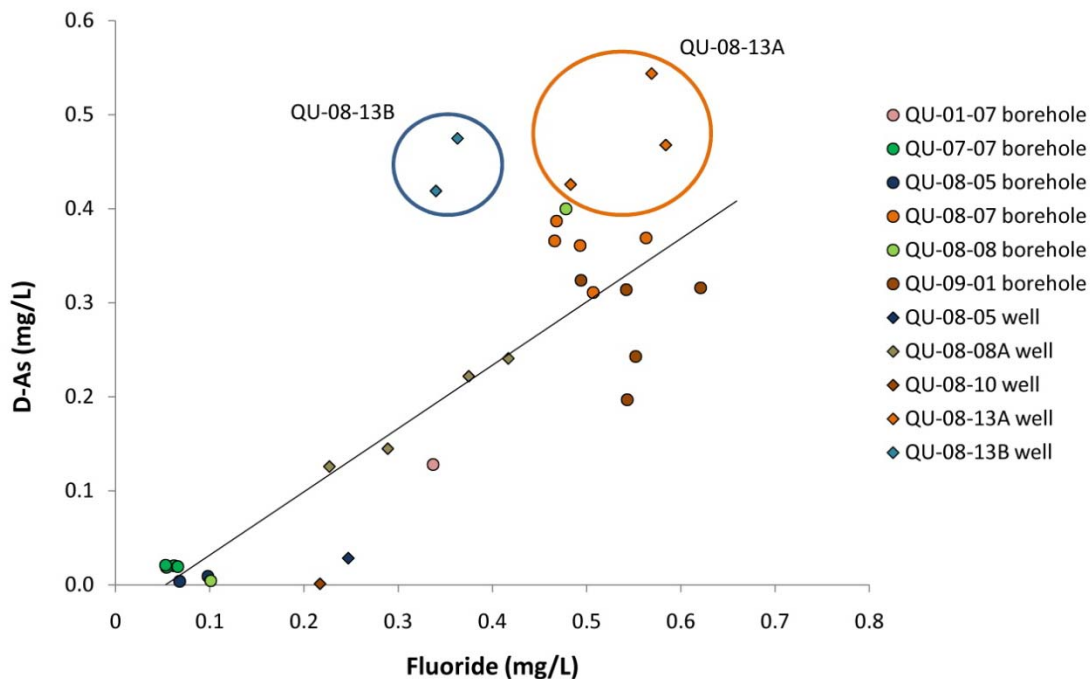


Figure 7-6: A trend line plot showing the relationship between dissolved arsenic and fluoride concentration in 7 South groundwater, and the elevated dissolved arsenic in the QU-08-13 wells.

The sulphate data set shows an uneven distribution as is reflected in the median value of 27.1 mg/L while the 10th and 90th percentiles are 7.30 mg/L and 131 mg/L respectively (Figure 7-5). The highest sulphate concentrations were observed at three sampling locations. Sulphate levels at QU-07-07 are elevated in all samples (ranging from 79.1 mg/L to 162 mg/L) consistent with groundwater influenced by the oxidation of sulphide minerals in the unsaturated zone as was noted in Section 7.2.1. At QU-08-08A

the April and May 2010 samples has sulphate levels of 136 mg/L and 99.5 mg/L respectively, with levels declining to 25.9 mg/L in the January 2011 sample. Only one sample was collected at QU-08-10 (May 2010), with an elevated sulphate concentration of 112 mg/L.

Dissolved cobalt data ranges from a 10th percentile of 0.00023 mg/L to a 90th percentile of 0.00301 mg/L (Figure 7-5) with eight results non-detect and detection limits ranging from 0.00010 mg/L to 0.00050 mg/L. Elevated levels were observed at QU-09-01 with dissolved cobalt levels ranging from 0.00118 mg/L to 0.00519 mg/L and the single sample at QU-08-10 with 0.00300 mg/L of dissolved cobalt.

The distribution of dissolved iron data ranges from a 10th percentile of 0.03 mg/L to a 90th percentile of 0.250 mg/L (Figure 7-5) with seven results not-detect at a detection limit of 0.03 mg/L. As shown in Figure 7-4 elevated dissolved iron concentrations are consistently observed at QU-07-07 (0.144 mg/L to 0.250 mg/L), QU-08-07 (ranging from 0.108 mg/L to 0.245 mg/L) and QU-09-01 (ranging from 0.086 mg/L to 0.483 mg/L). The elevated iron levels at QU-07-07 are likely influenced by the oxidation of sulphide minerals in the unsaturated zone noted in Section 7.2.1.

As shown in Figure 7-5 dissolved manganese data ranges from a 10th percentile of 0.022 mg/L to a 90th percentile of 0.226 mg/L. The QU-08-10 sample (May 2010) dissolved manganese level was elevated at 0.622 mg/L, as was the QU-08-08A May 2010 sample at a level of 0.537 mg/L.

Dissolved zinc ranges from a 10th percentile of 0.0010 mg/L to a 90th percentile of 0.0089 mg/L, substantially overlapping the 0.001 mg/L to 0.005 mg/L detection limit range for this parameter. The data for 23 samples were non-detect and were generally assigned a value of 0.005 mg/L. Two samples in the data set were significantly elevated above the 90th percentile; QU-08-08A (May, 2010) dissolved zinc was 0.0623 mg/L and QU-09-01 (November, 2009) was 0.0841 mg/L. The latter value exceeds the CSR-AW dissolved zinc guideline of 0.075 mg/L. The outlying dissolved zinc results of these two samples are not considered to represent the dissolved zinc water quality of 7 South since these two samples are well outside the range of zinc observed throughout the 7 South area (Figure 7-5).

All remaining parameters of concern (aluminum, cadmium, copper and selenium) were detected at or near the detection limit of each parameter, and the 10th to 90th percentile concentration ranges substantially overlap the range of reported detection limits. As a consequence of assigning detection limit values to non-detect results numerous samples in each data set have identical values leading to overlap in some of the percentile values, therefore the box plots in Figure 7-5 do not show the 90th percentile whiskers or the 50th

percentile line that were plotted on top of the 25th or 75th percentile lines. Dissolved aluminum data ranges from a 10th percentile of 0.0048 mg/L to a 90th percentile of 0.011 mg/L with 19 results non-detect and detection limits generally equal to 0.005 but ranging from 0.003 to 0.010 mg/L. Dissolved cadmium data ranges from 0.000017 mg/L to 0.000050 mg/L (10th and 90th percentiles respectively) with detection limits generally at 0.000017, but ranging as low as 0.000010 and as high as 0.000050 mg/L for the 23 non-detect results. The 10th percentile and 90th percentile for dissolved copper data are 0.00012 mg/L and 0.00100 mg/L respectively with 25 non-detect results and detection limits generally at 0.0010 mg/L, but ranging as low as 0.0001 mg/L. Dissolved selenium data ranges from a 10th percentile of 0.0005 mg/L to a 90th percentile of 0.0010 mg/L with detection limits generally at 0.0010 mg/L but ranging as low as 0.0001 for the 28 non-detect results.

7.3 Summary

The 7 South groundwater is characterized as circum-neutral, anoxic, mildly to moderately reducing and generally calcium bicarbonate type water with the exception of sulphate enriched water at borehole QU-07-07 and sodium enriched water at borehole QU-08-13. The coal seams of 7 South are in arsenic, boron and fluoride enriched strata of the Nanaimo Group formation and these parameters are present at naturally elevated levels in the groundwater. All parameters of concern, except arsenic, are below QCC Effluent Permit PE-07008 limits and British Columbia Contaminated Sites Regulation Schedule 6 Aquatic Life guidelines (CSR-AW). Additional observations are summarized below:

- Dissolved arsenic in a majority of the 7 South groundwater samples exceeds the CSR-AW guideline (0.05 mg/L) with data ranging from 10th percentile of 0.005 mg/L to a 90th percentile of 0.464 mg/L. There is a strong relationship between dissolved arsenic and fluoride concentrations with elevated dissolved arsenic levels generally associated with elevated fluoride levels.
- Fluoride is a suitable indicator of the relative age 7 South groundwaters. Fluoride concentrations are generally dependent upon aquifer groundwater residence times with longer residence times leading to higher fluoride concentrations (Brunt, 2004). Under the current anoxic and reducing conditions of 7 South groundwater elevated fluoride levels are generally associated with elevated dissolved arsenic and dissolved iron levels, indicating that arsenic and iron concentrations are generally governed by groundwater age-related mobilization processes. An exception is observed at QU-07-07 where elevated iron levels are attributed to relatively rapid sulphide oxidation processes.

- Well QU-08-08B is significantly grout affected as demonstrated by the elevated total suspended solids in all samples (ranging from 1620 mg/L to 6470 mg/L), elevated total aluminum (ranging from 34.5 mg/L to 106 mg/L), elevated dissolved sodium (ranging from 40.1 mg/L to 142 mg/L) and field observations of the groundwater appearance (opaque milky-grey). This well is not suitable for water quality monitoring.
- There is evidence that the oxidation of sulphide minerals in the groundwater unsaturated zone is occurring to a limited extent in the 7 South area. Acid-base accounting (ABA) test results measured in drill core from QU-10-01 and QU-10-02 boreholes indicate the near-surface presence of sulphide minerals near borehole QU-07-07. The groundwater collected at borehole QU-07-07, at the eastern margin of the proposed 7 South workings, has consistently the largest sulphate influence, elevated iron levels and lowest fluoride levels suggesting the groundwater at this location is younger and influenced by sulphide mineral oxidation processes.
- The borehole at QU-08-13 is separated from all other 7 South water quality monitoring locations by a fault that crosses the northern margin of the proposed 7 South workings and the groundwater is suspected to follow a different flow path than at all other monitoring locations. The groundwater from the wells at this borehole has a significant sodium influence, and the highest dissolved arsenic levels (ranging from 0.419 mg/L to 0.544 mg/L). The fluoride levels are also elevated (ranging from 0.340 mg/L to 0.584 mg/L) indicating a longer groundwater flow path at the down gradient 7 South location of QU-08-13.

8. Surface Water Characterization



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8. Surface Water Characterization

A study of the Quinsam River was undertaken to evaluate flow and baseline water quality in the vicinity of the proposed 7 South Mine. The study included Water Survey of Canada (WSC) and QCC flow monitoring records, which are analysed and discussed in Section 8.1. Water Quality data for the parameters of concern are presented in Section 8.2.

8.1 Flows in the Quinsam River

Site-specific data collected by the QCC staff and regional-scale data collected by the WSC were inspected to assess overall integrity and usability to interpolate flows from gauged to ungauged locations on the Quinsam River to support the mass loading analysis. With the data available, two options existed to reconstruct flow conditions at detection points of interest. One option focused on isolating predictive relationships from Water Survey of Canada hydrometric data and reconstructing flows using downstream regional data as the input. The second option used predictive relationships ascertained from site-specific flow data. The following sections of the report summarize the following: site naming conventions and data sources; the approaches used to reconstruct flows; relevant results; and the monthly and low flow values entered into the mass loading model.

8.1.1 Overview of Sites and Data

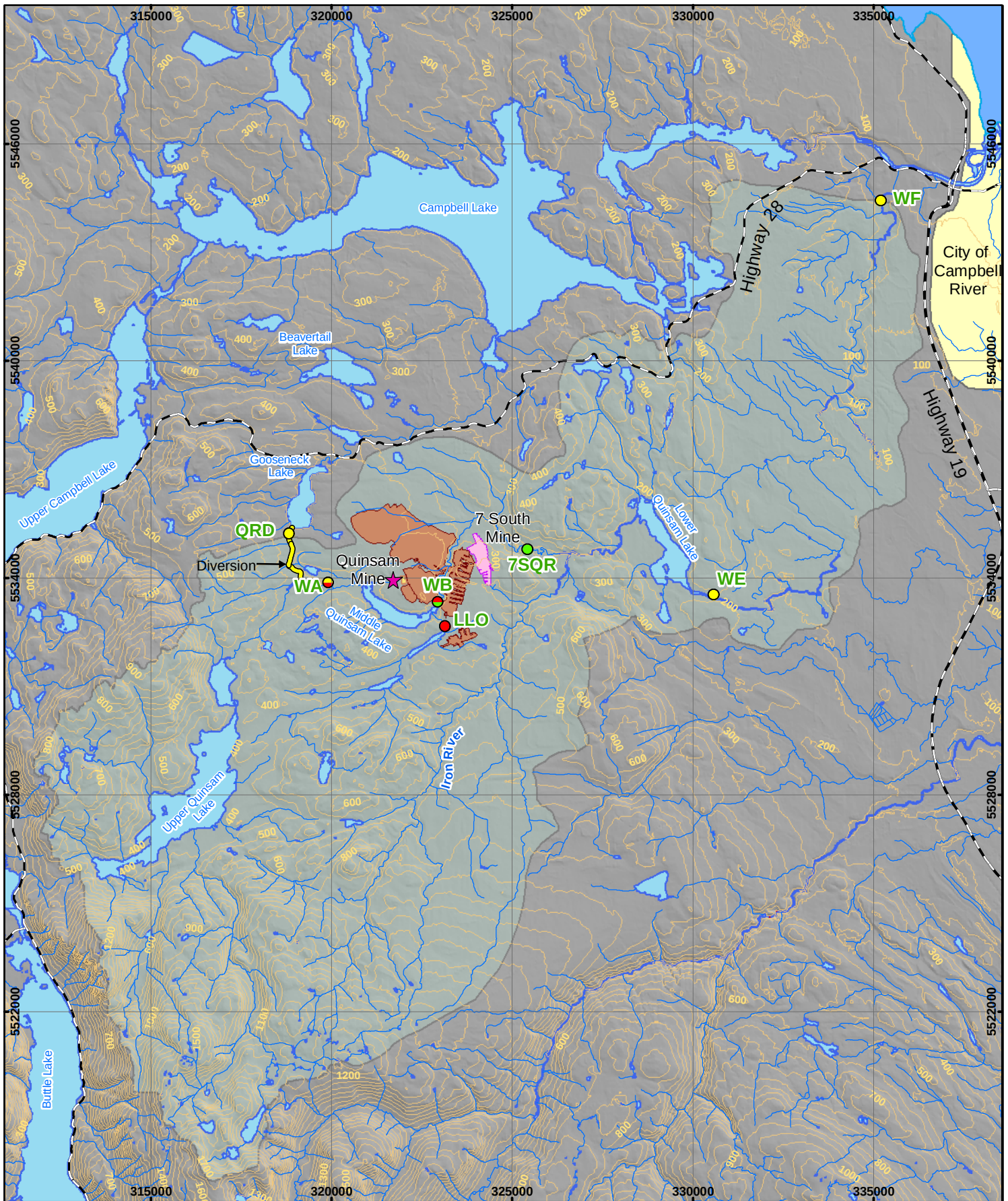
REGIONAL DATA – WATER SURVEY OF CANADA

The WSC has four active stations in the vicinity of the mine site (Figure 8-1; Table 8-1). Three stations are on the main channel of the Quinsam River and the fourth station is located on a diversion channel that diverts water during periods of high flow from the Quinsam River to the hydroelectric reservoir in the adjacent Campbell River watershed. Hydrometric data has been collected on Quinsam River at Argonaut Bridge since 1993, and discharge data for the Quinsam River Diversion and Quinsam River at Lower Quinsam Lake outlet have been measured since 1997. In addition, the Water Survey of Canada maintains a hydrometric station named Quinsam River at Campbell River that has been operational since 1956. In the context of this report, the Quinsam Diversion, Quinsam at Argonaut Bridge, Quinsam at Lower Quinsam Lake and Quinsam at Campbell River hydrometric stations are referred to herein as QRD, WA, WE and WF respectively.

SITE-SPECIFIC (QCC) HYDROMETRIC DATA

Since 1996, hydrometric data has been collected in the vicinity of Middle Quinsam Lake by the mine at three stations (see Figure 8-1; Table 8-1). Routine measurements of stage (*e.g.*, at times as frequently as weekly) were read from staff gauges installed at sites abbreviated to WA_S, WB and LLO. The WA_S site is located immediately adjacent to the WSC station WA. WA_S characterizes the hydrology in the Quinsam River upstream of Middle Quinsam Lake, whereas WB is located on the Quinsam River at the outlet of Middle Quinsam Lake and LLO is located near the Long Lake outlet. The flows observed at the WB site are for all intents and purposes equal to the sum of discharges observed at the WA_S and LLO stations.

Periodically, field measurements of discharge were taken by mine staff and consultants using the velocity area method. These discharge estimates were used to produce rating curves and weekly measurements of stage were used to compute discharge from these site-specific rating curves. Over the last 15 years, on the order of 500-600 estimates of discharge have been computed for the WB and LLO sites. The WA_S hydrometric record consisted of stage measurements only (*i.e.*, no rating curve work was undertaken by the mine at this location). Although the measurements made at WA_S compared extremely well with discharge measurements made by the Water Survey of Canada at WA, the WA_S dataset did not provide any additional information beyond that contained within the WSC WA record. As such, WSC data collected at WA was used to represent site hydrology upstream of Middle Quinsam Lake.



Legend

--- Highway

Quinsam River Watershed

7 South Mine

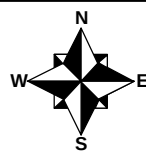
Existing Underground Mine Workings

Hydrology Station

WSC Hydrometric Station

QCC Hydrology Monitoring Station

Predicted Flow Location



Note: Municipal boundaries are approximate

Figure: 8-1

Title Hydrometric Stations Quinsam River

Units 0 1 2 4 Kilometers

Proj. UTM Zone 10

Datum NAD 1983

Date April, 2011

Project No. J885-1

Project

Client

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LORAX ENVIRONMENTAL

**Table 8-1:
Summary of hydrometric stations, naming conventions and period of record for
sites on and adjacent to the Quinsam River.**

Hydrometric Station ID	Description	Period of Record	Type of Measurements	Ownership/ Maintenance	Drainage area (km ²)	Elevation a.s.l. (m)	Incorporated into Study
QRD	Quinsam River Diversion	1997-present	Daily flow	Water Survey of Canada	na	312	TRUE
WA	Quinsam River at Argonaut Bridge	1993-present	Daily flow	Water Survey of Canada	84	290	TRUE
WE	Quinsam River at Lower Quinsam Lake	1997-present	Daily flow	Water Survey of Canada	217	180	TRUE
WF	Quinsam River at Campbell River	1956-present	Daily flow	Water Survey of Canada	278	23	TRUE
LLO	Long Lake Outlet	1996-2010	Weekly flow	Mine site	25	299	TRUE
WA _s	Middle Quinsam Lake Inlet	1996-2010	Weekly flow	Mine site	84	290	FALSE
WB	Middle Quinsam Lake Outlet	1996-2010	Weekly flow	Mine site	111	280	TRUE

8.1.2 Flow Reconstructions Based on Water Survey of Canada Data

Water Survey of Canada hydrometric data collected at the WA, WE and WF sites were used to predict mean monthly and 7Q10 low flows at two prediction points (WB and 7SQR). The WB site is situated at the Middle Quinsam Lake outlet, whereas the 7SQR site is positioned downstream of discharge from the 7 South mine and upstream of the Quinsam River-Iron River confluence. Monthly flow statistics for the WA site and mean monthly flows for WA, WE and WF are shown in Figure 8-2 for context. Flows in the Quinsam River are on average highest during the Nov-Mar period, and exhibit a defined period of low flow during the months of Jul-Sep.

Of note is that a portion of the Quinsam River flow is diverted out of the Quinsam River watershed immediately upstream of WA. Flow is diverted during periods of high flow but water is not diverted during periods of low flow in the months of July through October. Volumes of discharge diverted at QRD for the period 1997-2009, lowered the mean annual flow at WA from 3.11 m³/s to 2.04 m³/s (*i.e.*, expected flow vs. recorded flow) or from 1,168 to 765 mm per year (*i.e.*, 42% difference). However, the effects of these diversions diminish with distance downstream and associated increases in contributing area. By means of example, the effects of the diversion lower runoff from 1097 to 941 mm per year (15% difference) and from 1107 to 986 mm per year (12% difference) at the WE and WF sites respectively. Based on a coarse scaling of these runoff amounts, the 7SQR prediction point should see runoff on the order of 830 mm per year – or 3.6 m³/s.

PREDICTING MONTHLY FLOWS USING WATER SURVEY OF CANADA DATA

To predict mean monthly flows at Quinsam River water quality monitoring stations (WB and 7SQR), mean monthly flow data for the WA, WE and WF sites were plotted against drainage area to obtain a predictive relationship (Figure 8-3 upper). In doing so, linear relationships were obtained for nine months of the year (Jan-Jun and Oct-Dec), where slopes of best fitting lines were greatest for months showing highest flows (*e.g.*, Nov, Dec, Jan). Unique regression equations were derived for each of these nine months, and mean monthly flows were computed for WB and 7SQR based on appropriate drainage areas (Table 8-2).

Flow : drainage area relationships were non-linear between stations WA and WF during low flow conditions for the months of Jul, Aug and Sep (Figure 8-3 lower). Although WA-WE and WA-WF data showed similar strengths in their regression for the month of July, WA-WE regression models were considerably more robust than WA-WF regressions for the months of August and September (Figure 8-4). These plots indicate that the hydrology of the WA and WE sites are more similar than a comparison between WA and WF. Therefore, lines of best fit drawn between WA-WE flow-drainage area data were used to compute mean monthly flows for July, August and September (Table 5-2). Predicted flows for the WB and 7SQR sites are plotted with reference to the WA, WE and WF sites in Figure 8-5.

The dissimilarities during low flow between the stations may be influenced by evaporative lake effects and the rate of groundwater discharge. Figure 8-3 lower indicates there is only a slight increase in flow between WA and WE (*e.g.*, $<0.1 \text{ m}^3/\text{s}$ for the month of August) but a significantly greater flow rate increase observed between WE and WF ($1.3 \text{ m}^3/\text{s}$). The slight increase in flow on the Quinsam River reach between WA and WE indicate that flow may be influenced by lake storage and evaporation effects and/or only minimal flow gains are realized from groundwater discharge to the river. Using a monthly free-water evaporation estimate of 117 mm for the month of August (Lorax memo, 2010) suggest that $\sim 90,000$ and $170,000 \text{ m}^3/\text{month}$ could be removed from Middle Quinsam and Lower Quinsam Lake by evaporation, respectively. These evaporative losses translate to monthly average flows of 0.03 and $0.06 \text{ m}^3/\text{s}$, respectively. However, the evaporative effect from Middle Quinsam Lake will be realized at 7SQR and evaporation from Lower Quinsam Lake comprises at most 6% of the mean monthly flow estimated at 7SQR. With respect to groundwater, the elevation difference between WA and WE is significantly greater than between WE and WF and the effects of elevation support that groundwater discharge to the lower reaches of the Quinsam River are greater than rates of inflow between WA and WE.

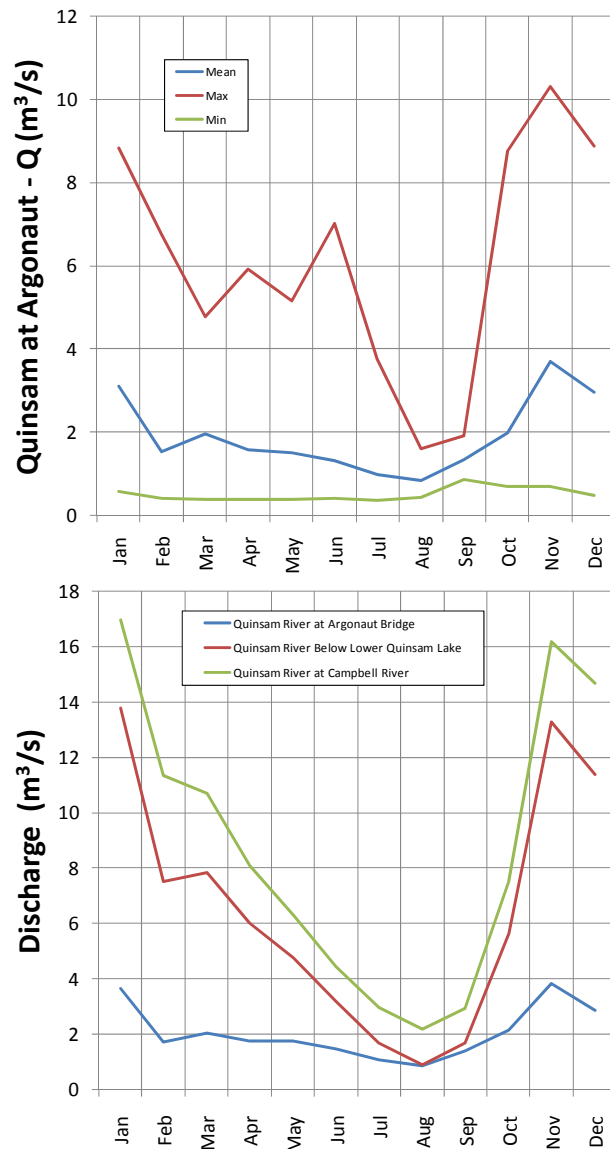


Figure 8-2: Monthly flow statistics (1997-2009) for the WA (Quinsam River at Argonaut Bridge) station (upper plot) and mean monthly flows (1997-2009) for the WA, WE and WF site (lower plot).

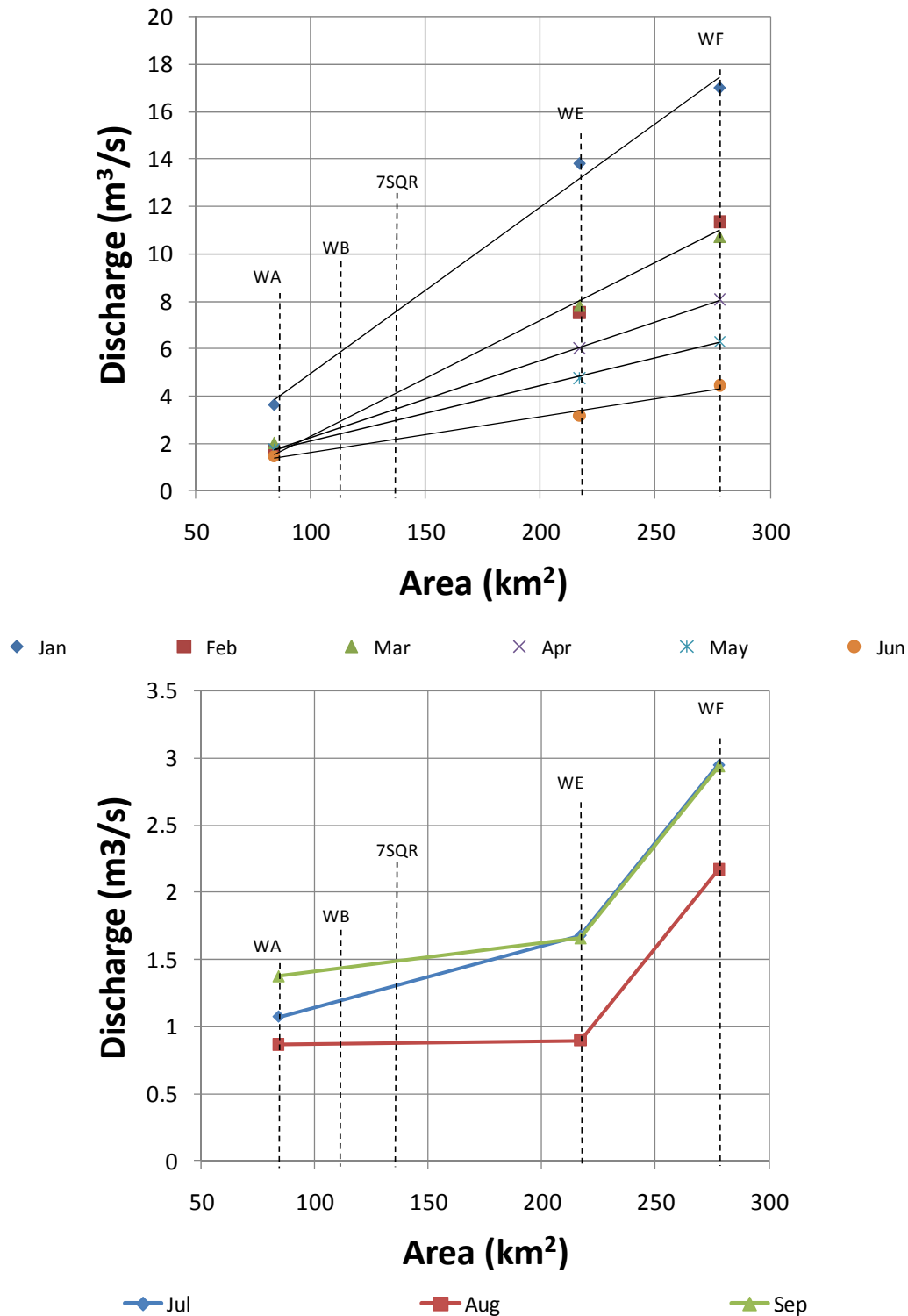


Figure 8-3: Relationships between mean monthly discharge and drainage area for the WSC stations and prediction points of interest. In the upper plot, highly predictable and linear relationships were achieved. For the months Jul, Aug and Sep (lower plot), relationships were non-linear.

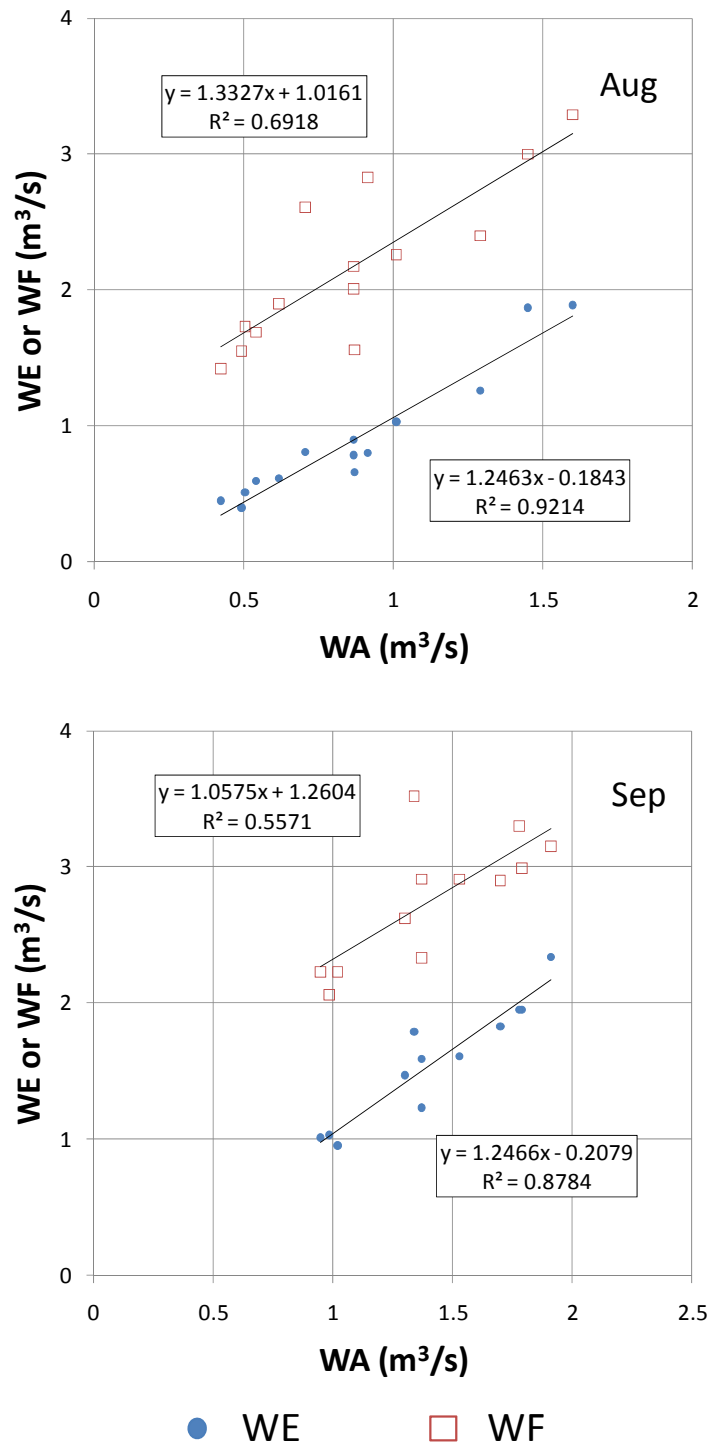


Figure 8-4: A comparison of WA-WE and WA-WF regressions for the months of August (upper) and September (lower). The purpose of the plots was to elucidate whether the WA hydrograph showed more similarity to WE or WF during periods of low flow (Jul, Aug, Sep).

Table 8-2:
Summary of mean monthly flows predicted for detection points using Water Survey of Canada data.

	Discharge (m ³ /s)				
	WA	WB	7SQR	WE	WF
Jan	3.6	5.7	7.6	13.8	17.0
Feb	1.7	2.9	4.1	7.5	11.4
Mar	2.0	3.2	4.4	7.8	10.7
Apr	1.7	2.6	3.4	6.0	8.1
May	1.7	2.3	2.9	4.8	6.3
Jun	1.5	1.8	2.2	3.2	4.4
Jul	1.1	1.2	1.3	1.7	3.0
Aug	0.9	0.9	0.9	0.9	2.2
Sep	1.4	1.4	1.5	1.7	2.9
Oct	2.1	2.8	3.6	5.6	7.5
Nov	3.8	5.8	7.5	13.3	16.2
Dec	2.9	4.6	6.2	11.4	14.7
Annual	2.0	2.9	3.8	6.5	8.7
Drainage (km ²)	84	111	137	217	278

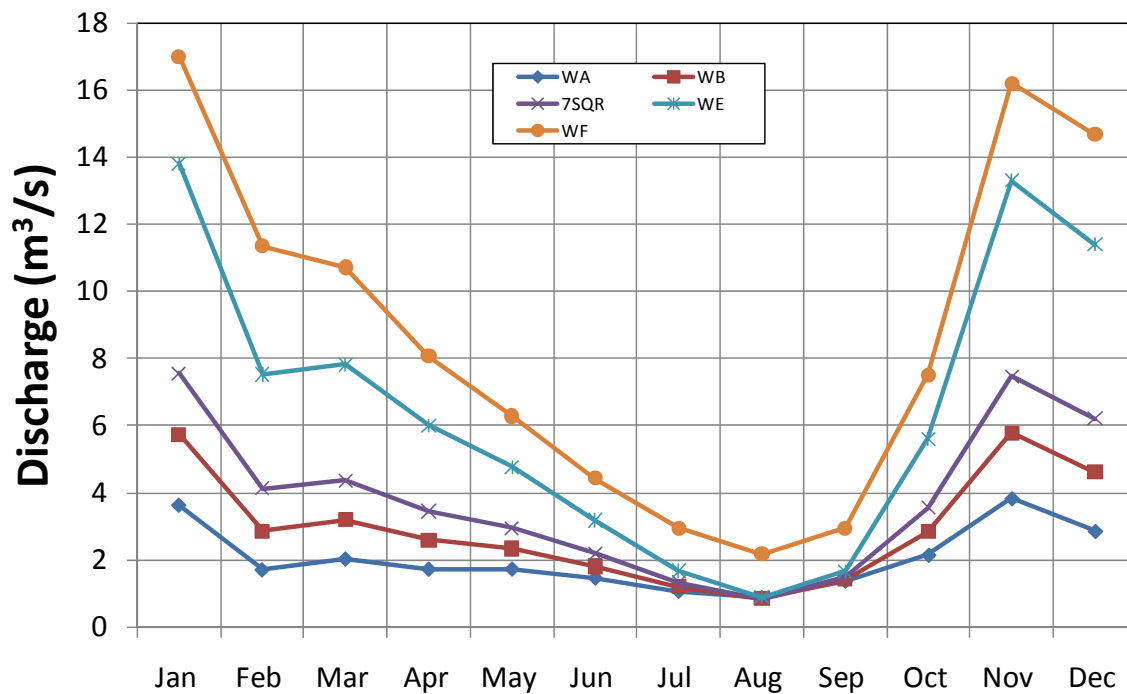


Figure 8-5: Illustration of the predicted flows obtained using regional flow data. Predicted flows (WB and 7SQR) are shown with reference to Water Survey of Canada flow records for the WA, WE and WF sites.

8.1.3 Flow Reconstructions Using Quinsam Mine Data

Staff gauge measurements at the WB site have been recorded by QCC staff since the late 1990s. Inspection of the daily discharge data calculated from the staff gauge readings indicated that the calculated flows greater than 10-m³/s did not compare favourably to hydrometric data from nearby locations (*e.g.*, WSC data at WA and WE for corresponding dates). This discrepancy was attributed to limited stage-discharge measurements at high flow underpinning the WB rating curve. Due to poor definition of the WB rating curve, it was not possible to resolve monthly, annual- or long-term summaries of discharge using the WB data directly. Instead, monthly flow summaries were calculated using a relationship observed between continuous flow measurements at the WSC station at WA and the WB discharge estimates.

PREDICTING MONTHLY FLOWS USING SITE DATA

WB discharges were compared to WA for corresponding dates to establish a predictive relationship that could be used to estimate mean monthly discharges at WB. As shown in Figure 8-6 (upper), comparisons of discharge at the WA and WB sites returned a predictive relationship with r^2 of 0.72 and slope 1.26. This predictive relationship was used in conjunction with mean monthly flow estimates for WA to estimate mean monthly flows at WB for the months of October through June. Detailed inspection of the site data revealed that monthly flows at the WA and WB sites were consistently lowest between July and September each year, and a separate relationship applies to this data. Figure 8-6 (lower) compares discharges from WA and WB during the lowest flow months of July through September, a relationship that shows an r^2 of 0.72 and slope 1.60. Predicted flows at 7SQR were computed by rescaling the WB predictions based on 7SQR drainage area (Table 8-3; Figure 8-7).

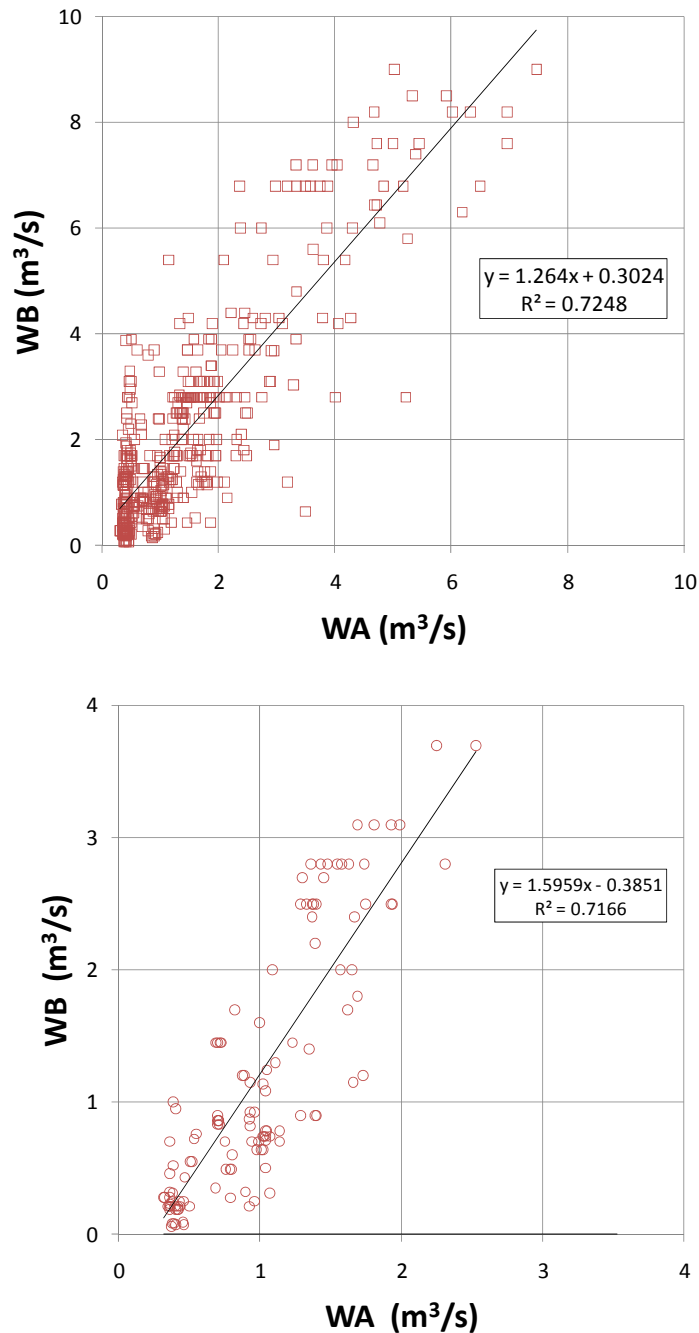


Figure 8-6: Predictive relationships based on hydrometric data collected at the WA and WB sites. In the upper plot, a relationship based on data collected in all months of the year is shown (n = 506). In the lower plot, a relationship is shown based on data collected for the months of July, August and September only. Data from 1996-2009 was used to construct this relationship.

Table 8-3:
Summary of mean monthly flows predicted for detection points using Quinsam Site data.

	Discharge (m ³ /s)				
	WA	WB	7SQR	WE	WF
Jan	3.6	4.9	6.1	13.8	17.0
Feb	1.7	2.5	3.0	7.5	11.4
Mar	2.0	2.9	3.5	7.8	10.7
Apr	1.7	2.5	3.1	6.0	8.1
May	1.7	2.5	3.1	4.8	6.3
Jun	1.5	2.2	2.7	3.2	4.4
Jul	1.1	1.3	1.6	1.7	3.0
Aug	0.9	1.0	1.2	0.9	2.2
Sep	1.4	1.8	2.2	1.7	2.9
Oct	2.1	3.0	3.7	5.6	7.5
Nov	3.8	5.1	6.4	13.3	16.2
Dec	2.9	3.9	4.8	11.4	14.7
Annual	2.0	2.8	3.5	6.5	8.7
Drainage (km ²)	84	111	137	217	278

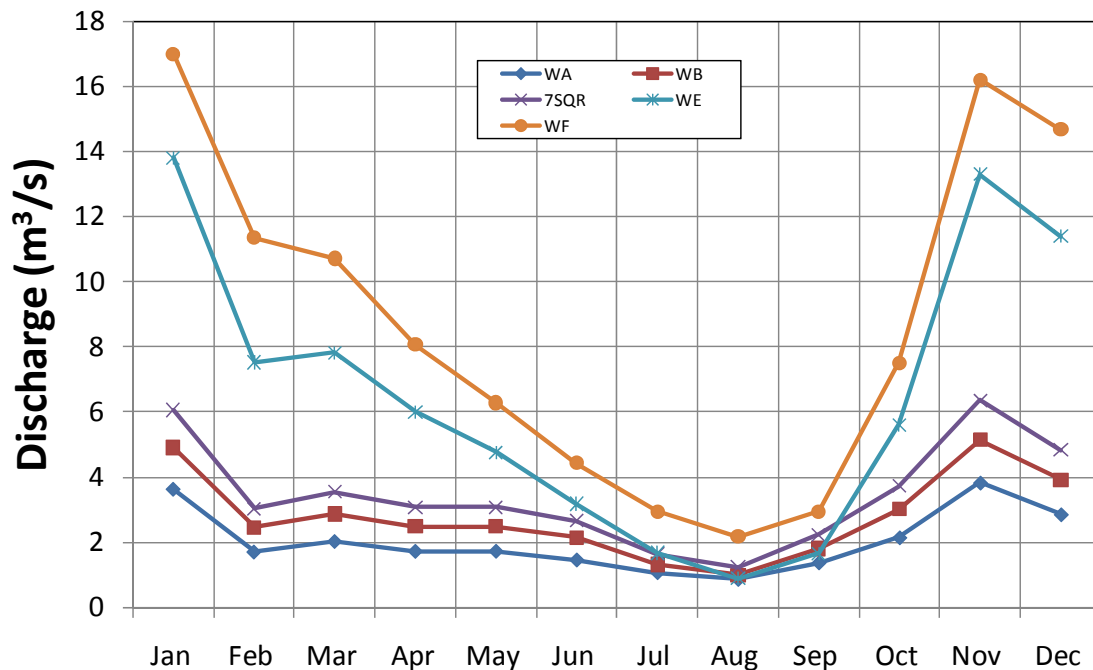


Figure 8-7: Illustration of the predicted flows obtained using site flow data. Predicted flows (WB and 7SQR) are shown with reference to Water Survey of Canada flow records for the WA, WE and WF sites.

8.1.4 Estimates of 7Q10 Low Flow

In addition to the computations of mean monthly flow, a 7Q10 value was computed for the Quinsam River near the mine site. Firstly, daily discharge data for the WA and WE sites was downloaded, plotted and inspected. Next, 7-day averages for the period of record were computed and a pivot table was used to isolate the lowest 7-day average discharge event calculated for each year. 7Q10 values were then sorted, ranked in exceedance format and fitted with a Log Pearson 3 distribution using EasyFit. The ten-year return periods based on the 7Q10 series were estimated to be 0.32 and 0.3 m³/s for the WA and WE discharge records respectively. A value of 0.32 m³/s was used to depict a 7Q10 low flow at the 7SQR prediction point.

8.1.5 Estimates of Discharge for Mass Loading Model – WB and 7SQR

With the relationships obtained from regional- and site data (Figures 8-3 and 8-6), it was possible to predict discharge series for the WB and 7SQR sites two different ways. The predicted flows based on regional- and site hydrometric data appear reasonable: the mean annual flows predicted by the WSC and site-specific approaches using QCC data compare within 8% (3.8 vs. 3.5 m³/s); there are apparent commonalities in the annual distribution and shape of the predicted hydrographs; and the two approaches reproduce near-similar output during periods of low flow between Jul-Sep (see Figure 8-8). The main difference between the two approaches was that the flows predicted based on a regional approach are greater during periods of high flow (Oct-Mar).

Final monthly 7SQR flows entered into the mass loading model are reported in Table 8-4. The regional analysis using WSC data was selected to predict mean monthly discharges. During periods of high flow, there is a high degree of correspondence between discharge and drainage area in the Quinsam River. The analysis using WB discharge data collected by QCC was not selected because the monitoring protocols presently in practice require that instantaneous measurements of discharge from WB to be compared to daily averaged discharge values at WA in this study, which introduced a measure of uncertainty and ‘noise’ into the predictive relationship.

At periods of low flow, regional and QCC data yielded similar results for the WB (*e.g.*, 1.0 vs. 0.9 m³/s for August). However, the predicted discharges at 7SQR differed more so. Regional data indicate that during low flow periods, relationships between discharge and drainage area become non-linear and predicted flows at WB and 7SQR are similar in magnitude. Again the regional analysis using WSC data was selected to estimate flows for 7SQR during Jul-Sep period. The influence of evaporation from Lower Quinsam lake was shown to have a maximum possible effect of 6% of the low flow and it is plausible that groundwater base flow has a lesser influence on flows through this reach of the Quinsam River than the lower reach between WE and WF.

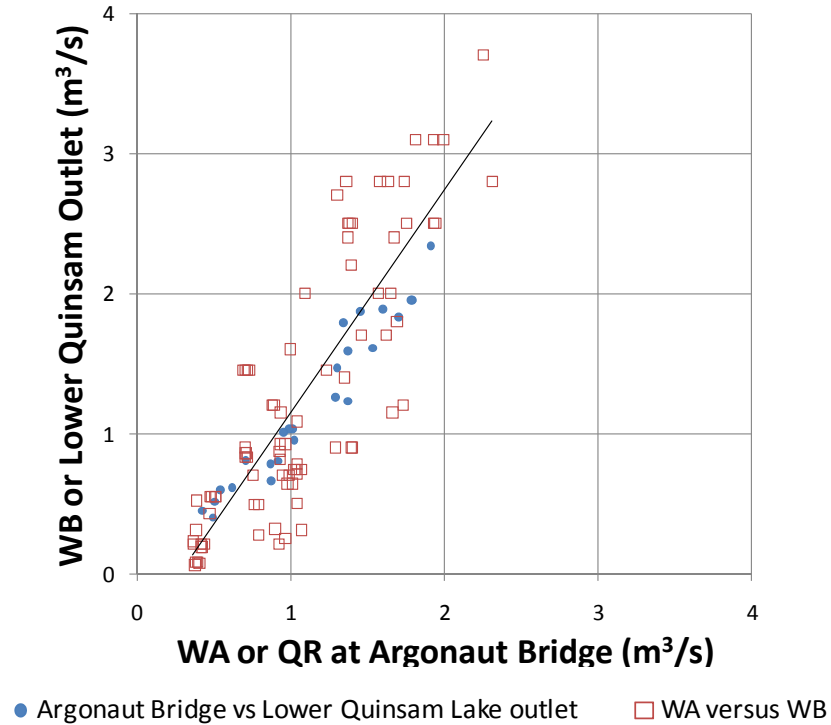


Figure 8-8: Comparison of the relationships obtained during August and September between WA-WB and WA-WE.

**Table 8-4:
Monthly flow values entered into the mass loading model.**

Discharge (m ³ /s)	
7SQR	
Jan	7.6
Feb	4.1
Mar	4.4
Apr	3.4
May	2.9
Jun	2.2
Jul	1.3
Aug	0.9
Sep	1.5
Oct	3.6
Nov	7.5
Dec	6.2
Annual	3.8

8.2 Quinsam River Water Quality

The main objective of the water quality analysis is to evaluate trends in the Quinsam River baseline water quality data and develop representative background concentrations for input to the mass loading model. The mass loading model is in turn used to assess the potential effect of geochemical loading from the proposed 7 South Mine on concentrations in the river downstream of the proposed mine.

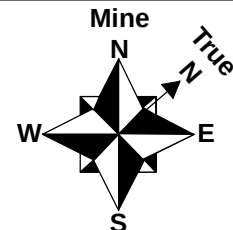
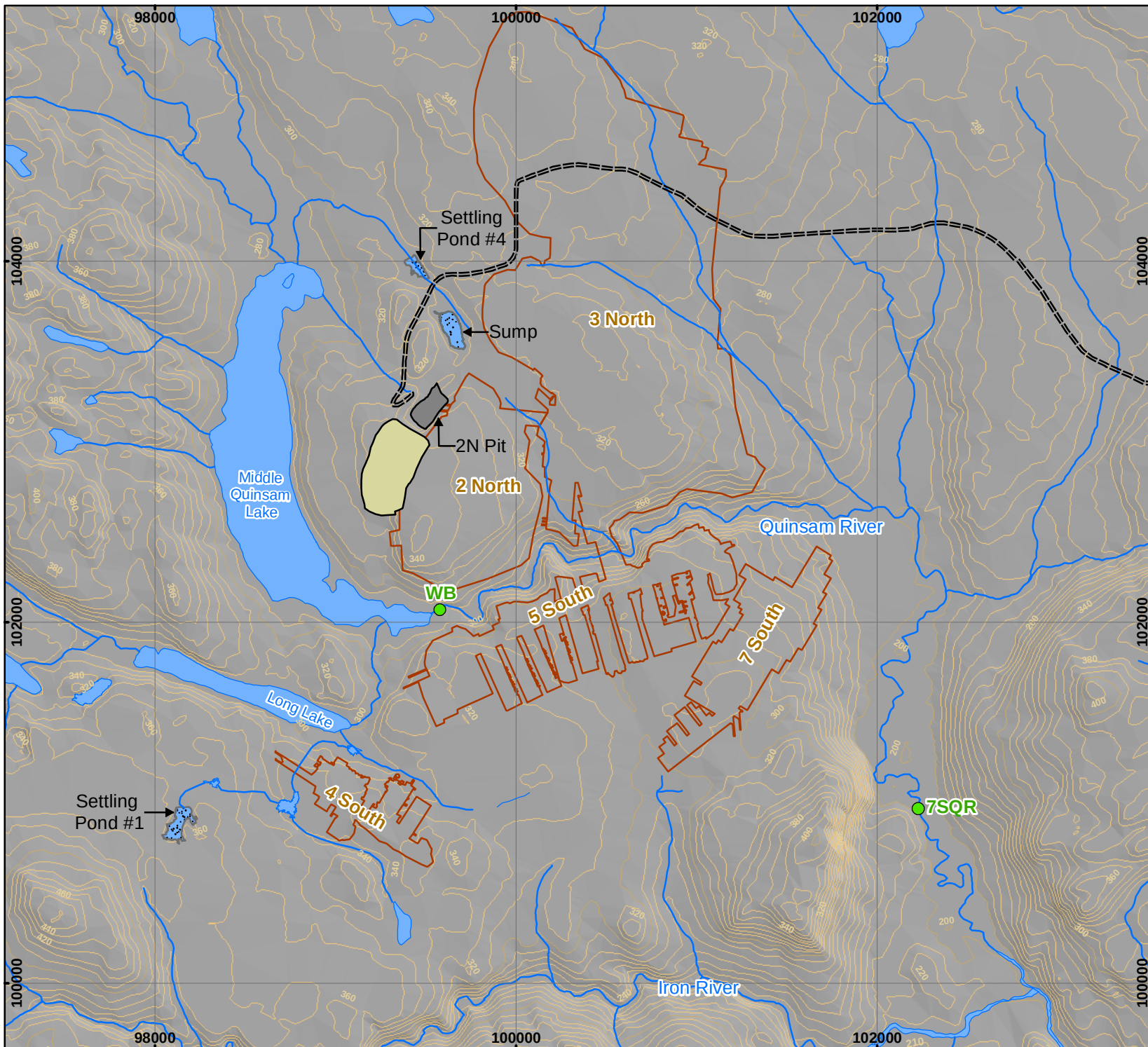
8.2.1 Sources of Data - WB and 7SQR

Water quality data analyzed in support of the 7 South mass loading model included two sites on the Quinsam River. Water quality sampling station WB is located at the outlet of Middle Quinsam Lake. Station 7SQR is located upstream of the confluence with the Iron River approximately 8 km downstream of WB at the same coordinates as the 7SQR hydrology site. The locations of both stations are illustrated in Figure 8-9 which also illustrates that both stations are positioned downstream of currently permitted surface water discharge from the Quinsam Mine. However, the proposed 7 South Mine portal will be positioned downstream of Site WB, thus, the ongoing water quality sampling at 7SQR will be important to monitor the effects of an operational 7 South Mine.

Water quality data has been collected at the WB site over a 23 year period extending from 1988 to 2011. By comparison, water quality monitoring at the 7SQR site was only initiated in 2007. A qualitative overview of the WB and 7SQR datasets (*i.e.*, period of record, parameters and detection limits) is summarized in Table 8-5 below.

**Table 8-5:
Qualitative Assessment of WB and 7SQR Sites Water Quality Data.**

Parameters of Interest	WB	7SQR
Period of record	1988 to present	2007 to present
Sulphate, Al, Fe and Mn	Usable data for considerable portions of the 1988-2011 period of record.	Sampled extensively between 2007 and 2011. Usable data for all of the period of record.
Hardness	Data reported sporadically between 1991-1993 and 1996-1999. Data reported frequently for the 2000-2011 period.	Data reported routinely during the period of record.
As, Cd, Co, Pb, Se and Zn	No data for the 1988-1999 period. Data usability for the 2000-2010 period constrained by higher detection limits. August 10, 2010 Lower detection limits	Data usability for the 2007-2010 period constrained by detection limits. November 16, 2010 Lower detection limits
Cu	Data usability for the 1998-2011 period constrained by detection limits.	Data usability for the 2007-2011 period constrained by detection limits.



Legend

- Surface Water Quality Station
- ==== Mine Road
- Tailings Impoundment
- Underground Mine Workings

Figure: 8-9

Title
Quinsam River Water Quality Monitoring Stations

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Notes

1

0 0.25 0.5

Units Kilometers

Proj. Mine Grid Coordinates

Datum

Date April, 2011

Project No. **J885-1**

Project



8.2.2 Site WB Water Quality

pH, HARDNESS AND ALKALINITY

Trends in pH, hardness and alkalinity for the WB site are shown in Figure 8-10. The predominant range of pH was between 6.5 and 7.5 for the 1988 to 1999 period, and more recently increasing slightly to range between 7.0 and 8.0 between 2000 and the present. There was limited hardness data for the early period of record at WB, but when data were available (*e.g.*, 1991, 1992, 1995) hardness values ranged between 20 and 40 mg/L. From 2000 to the present, hardness values have ranged from 20 to 70 mg/L, although data from 2007 to present show variability in hardness to be slightly less (*i.e.*, 20 to 50 mg/L). Hardness values also correlated well with sulphate, conductivity and flow trends (Figure 8-10 lower right; note that these flow-chemistry trends are discussed in more detail in the next section). Trends in alkalinity for the last five years indicate that values on the order of 15 to 40 mg/L are characteristic of the Quinsam River near the mine site.

SULPHATE, ALUMINUM, IRON AND MANGANESE

An extensive dataset is available at WB for SO₄, Al, Fe and Mn, which makes it possible to explore: long-term concentration trends; flow-chemistry relationships; and calculate average monthly concentrations for these parameters. The concentrations presented to in this section refer to total concentrations unless dissolved concentrations are specified.

Conductivity and sulphate correlate well at the WB site (Figure 8-10; lower right). The strong correlation allows for gaps in sulphate for the early period of record (1988-1992) to be inferred from conductivity data (Figure 8-11). Sulphate and conductivity increased from 1988 to the mid-1990s after which time the range and magnitudes of values stabilize, which corresponds to the period after the initiation of mining in 1986. Specifically, sulphate values were lower and varied little within a year during the late 1980s (less than 10 mg/L). Concentrations increased in magnitude to present levels by roughly 1994-5 (*i.e.*, sulphate presently ranges from 10-90 mg/L throughout the year).

Long-term trends for Al, Fe and Mn are illustrated in Figure 8-12. Similar to SO₄, inspection of the Fe and Mn datasets indicate that current day concentrations for these parameters are higher and more variable within a given year than observed 20-years ago (Figure 8-12). In the case of Al, it was not possible to discern a long-term trend in the data similar to that seen for SO₄, which may be in part due to the quality of record. Al data from 1988-1995 is sporadic which provides a lesser quality long-term record than seen for conductivity and SO₄.

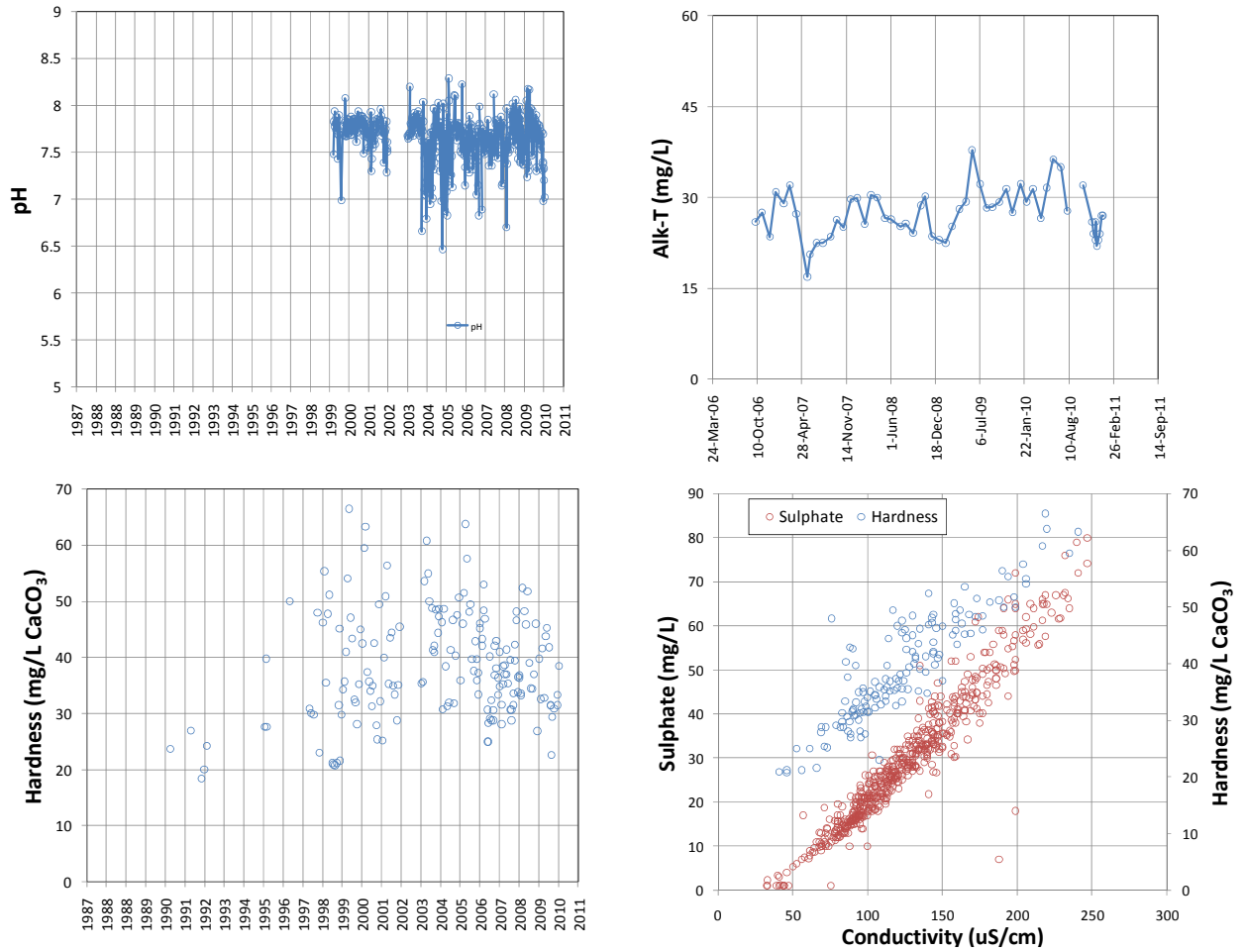


Figure 8-10: Summary of Site WB Water Quality - pH, alkalinity, hardness and conductivity.

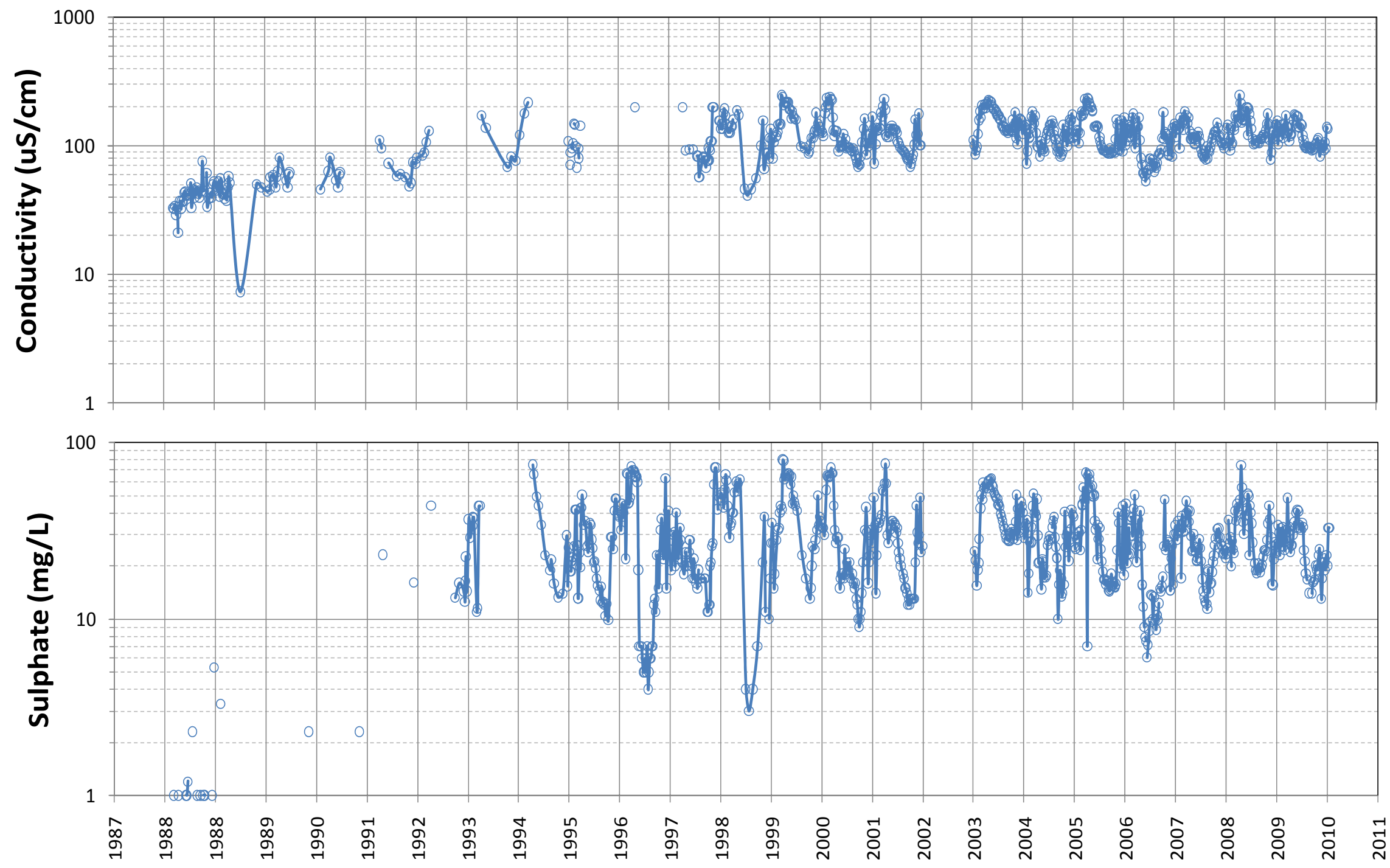


Figure 8-11: Time Series Plot of Conductivity and Sulphate at the WB Water Quality Site (1988-2011).

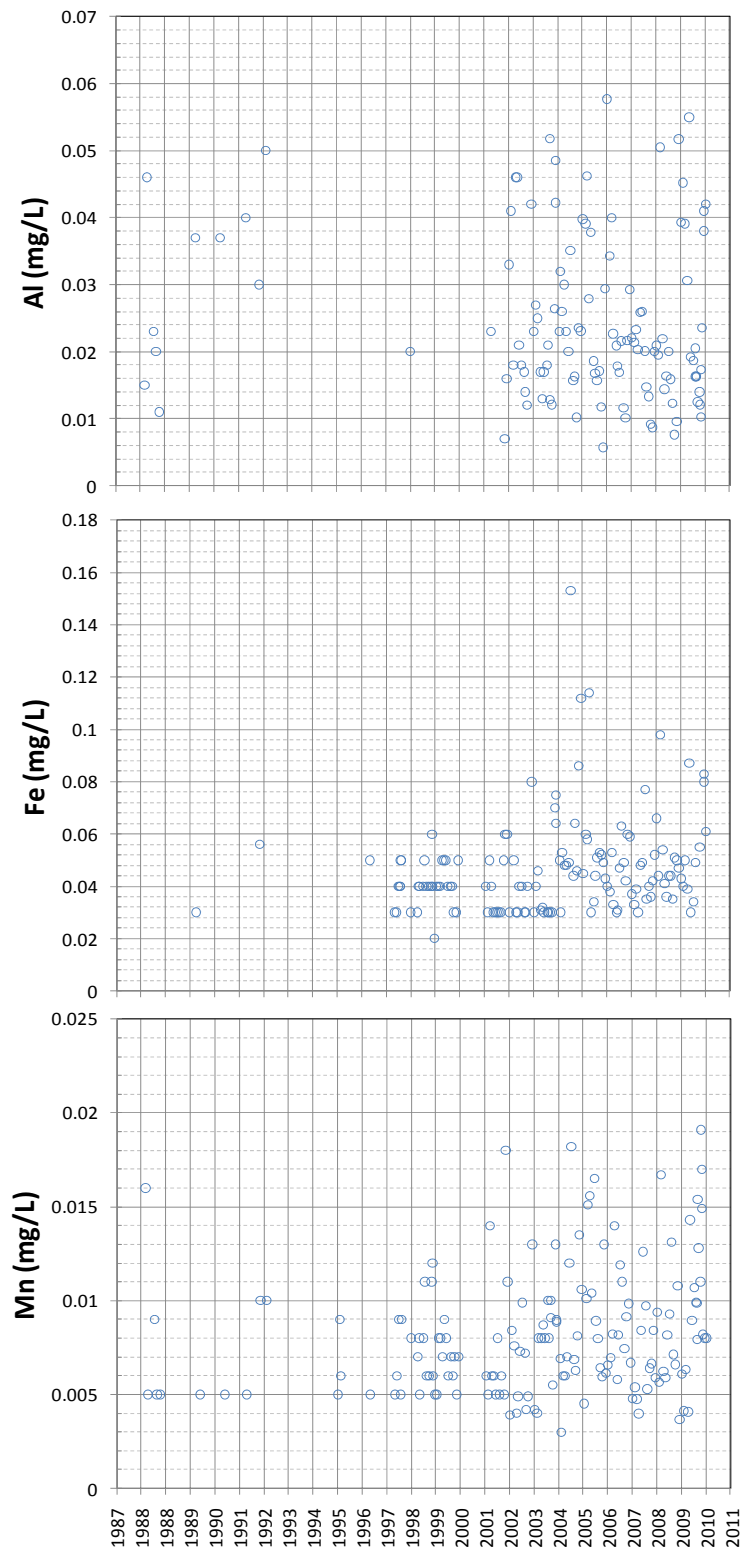


Figure 8-12: Time Series Plot of Al, Fe, Mn at Site WB.

Monthly baseline concentrations for SO₄, Al, d-Al, Fe and Mn were calculated from the monitoring record at station WB. Average monthly concentrations were based on data collected between 2000 and 2011 (Figure 8-13). The time slice was selected to balance a number of factors, including: adequate sample size; avoidance of low concentrations seen early in the site data records (*e.g.*, SO₄ for 1988 to mid-1990s); and to exclude data reported at or below a detection limit – a circumstance that arises more frequently in the pre-2000 data.

The average monthly concentrations are listed in Table 8-6. Each monthly concentration for SO₄ was computed using a minimum of 37 data points (*i.e.*, *n* ranged from 37 to 51 depending on month of year). In the case of Al, d-Al, Fe and Mn – average concentrations were computed using a minimum of 8 data points for a given month (*i.e.*, sample size (*n*) ranged from 8 to 14 for these parameters).

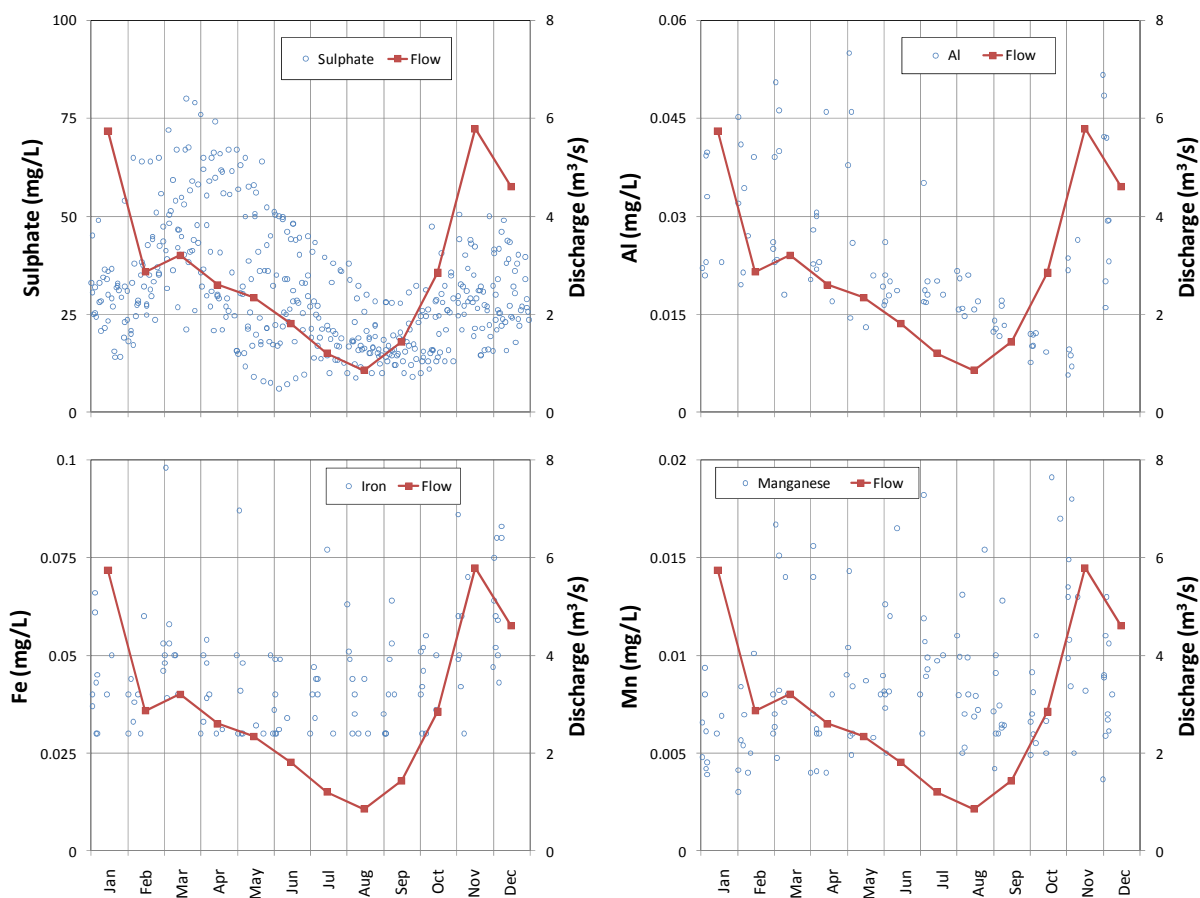


Figure 8-13: WB water quality data for sulphate, Al, Fe and Mn plotted by month of the year for the period of 2000 to 2011. Discharge data shown is mean monthly flow predicted at Site WB.

**Table 8-6:
Average Monthly Concentrations for SO₄, Al, d-Al, Fe and Mn at Site WB.**

Average (mg/L)					
Month	SO ₄	Al	d-Al	Fe	Mn
Jan	30	0.033	0.025	0.048	0.0060
Feb	36	0.032	0.029	0.079	0.0060
Mar	46	0.034	0.024	0.054	0.0095
Apr	43	0.027	0.020	0.049	0.0075
May	34	0.028	0.016	0.051	0.0081
Jun	32	0.020	0.018	0.040	0.0104
Jul	23	0.021	0.017	0.060	0.0103
Aug	18	0.017	0.016	0.043	0.0087
Sep	18	0.019	0.016	0.046	0.0075
Oct	22	0.011	0.010	0.045	0.0088
Nov	28	0.029	0.016	0.082	0.0144
Dec	30	0.033	0.026	0.069	0.0086

Count (n)					
Month	SO ₄	Al	d-Al	Fe	Mn
Jan	42	10	9	10	10
Feb	39	9	8	9	9
Mar	43	10	8	10	10
Apr	40	10	9	10	10
May	49	12	9	12	12
Jun	43	8	8	8	8
Jul	37	10	9	10	10
Aug	43	14	13	11	14
Sep	42	10	9	9	10
Oct	47	12	11	10	12
Nov	51	12	10	10	12
Dec	47	11	10	11	11

TRACE METALS AND METALLOIDS

A combination of low metal concentrations in the Quinsam River and analytical methods with detection limits greater than these concentrations has resulted in a relatively short period of record where many parameters were quantitatively determined at Site WB. Initially, during the 1988-1999 period, many parameters of interest were not sampled for at WB including As, Cd, Co, and Se and the detections limits used at this time prevented measured values for Al, Cu, and Pb to be reported. Subsequent to 1999, the number of

parameters analysed in WB water samples increased and routine sampling of As, Cd, Co, and Se commenced. Although analytical methods were adjusted to achieve lower detection limits, actual concentrations in the Quinsam River were still below detection limits for considerable portions of the period of record for As, Cd, Co, Cu, Ni, Pb, Se, Zn (see Figure 8-14). Only since November 2010 were the analytical detection limits sufficiently low to consistently detect concentrations of these metals.

The data was inspected and compared to water quality guidelines for concentrations that exceed the guidelines. For hardness based guidelines, the guidelines were based on a hardness value of 45 mg/L. With the exception of Cd, exceedances were limited to few and spurious exceedances in the 1988-2011 water quality dataset. In the case of Cd, most data collected for the 2000-2011 period is reported as less than the analytical detection limit. However, data collected since October 2010 show three exceedances of the Cd-guideline (Oct 15, Oct 23 and Nov 1, 2010). Although samples for these dates returned concentrations higher than reported for the previous five years (*i.e.*, Cd <0.000017 mg/L), these recent exceedances coincide with a switch to a new laboratory.

Due to the lack of consistently measured concentrations above the analytical detection limit, three methods were used to estimate average concentrations for As, Cd, Co, Cu, Ni, Pb, Se and Zn at site WB. The estimated concentrations are presented in Table 8-7. Firstly, the table presents the detection limit that constrained the data for the 2000- to 2010 time frame; secondly one-half the detection limit for each parameter; and finally an average of the most recent (*i.e.*, Nov 2010 to Feb 2011) data collected at the WB site. Note that in the latter case, one-half the detection limit was used in computations when concentrations were reported less than the detection limit.

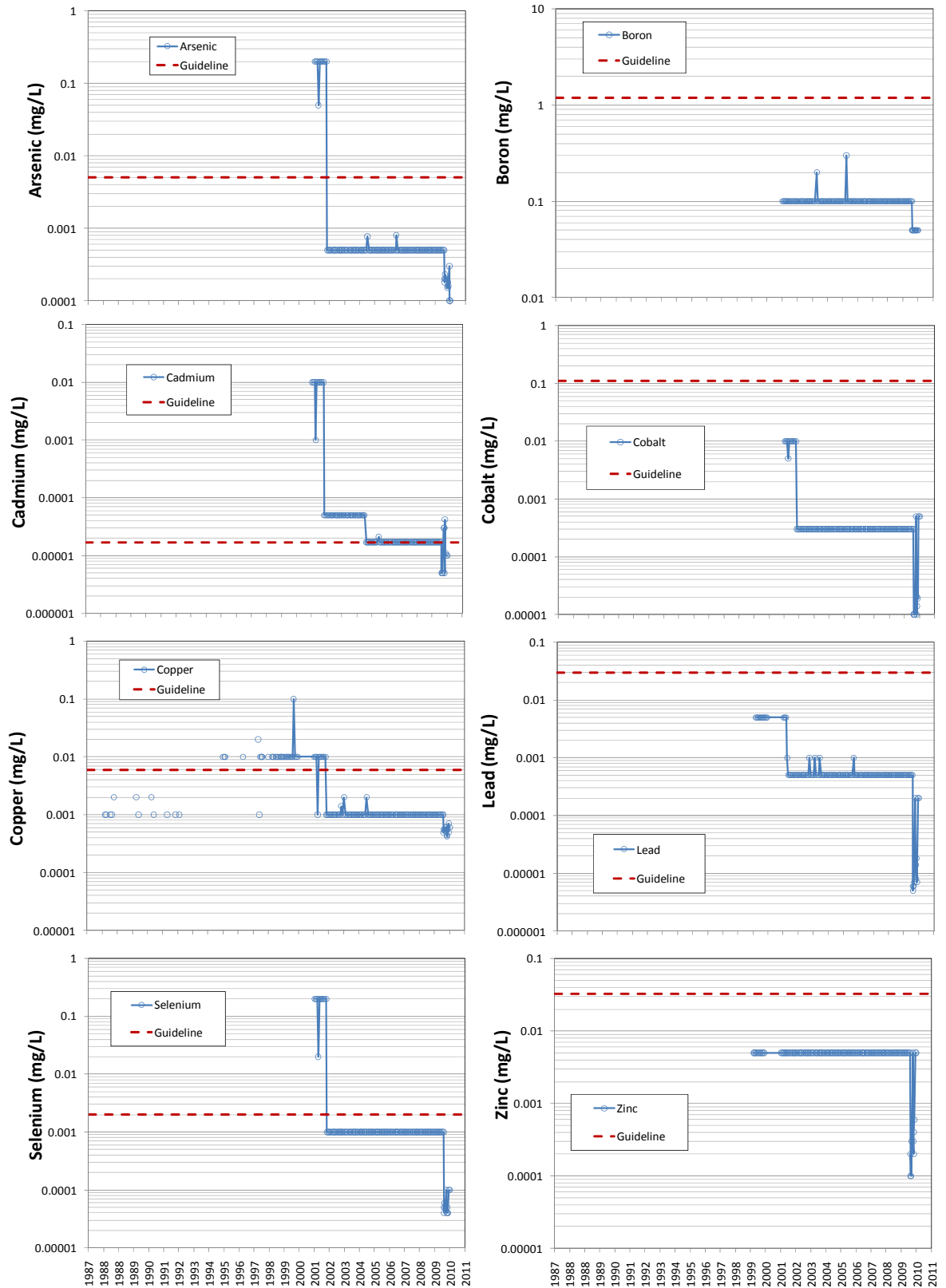


Figure 8-14: Time Series Plot of As, B, Cd, Co, Cu, Pb, Se and Zn at Site WB.

Table 8-7:
Estimates of Average Concentrations in Quinsam River at WB site.

	Detection Limit	1/2 Detection	Average Aug 2010 – Jan 2011	n	n detects
As-T	0.0005	0.00025	0.00018	12	11
B-T	0.005	0.0025	0.0025	12	0
Cd-T	0.000017	0.000009	0.000012	12	5
Co-T	0.0003	0.00015	0.00009	12	7
Cu-T	0.001	0.00050	0.00055	12	12
Ni-T	0.001	0.00050	0.00022	12	8
Pb-T	0.0005	0.00025	0.000039	12	7
Se-T	0.001	0.00050	0.000044	12	6
Zn-T	0.005	0.0025	0.0010	12	6

8.2.3 Site 7SQR Water Quality

Water quality records at the 7SQR site exist for a much shorter period of record than the WB site. 7SQR monitoring only occurred from 2007 to present (Table 8-5) and sampling over this period was less frequent than at Site WB. Although a continuous monthly monitoring did not occur at this site, concentrations of SO₄, Al, Fe and Mn were consistently detected at 7SQR, when sampled. A comparison of SO₄ concentrations at the WB and 7SQR sites in time series format provides an example of the similarities in the baseline water quality at the two Quinsam River stations downstream of the existing mine site (Figure 8-15). The figure illustrates that sulphate concentrations are similar or slightly lower at site 7SQR than concentrations measured at WB. The similarity in water quality between the two sites is also shown for conductivity, hardness, Al, Fe and Mn. Regressions of data collected for corresponding dates at the WB and 7SQR sites are shown in Figures 8-16. The plots illustrate that similar to sulphate, concentrations are similar or slightly lower at the 7SQR site. Only iron consistently had higher concentrations at the downstream 7SQR site. Based on the data available, average concentrations for SO₄, Al, Fe and Mn were calculated at the 7SQR site (Table 8-8).

Similar to the WB site, concentrations for the trace metals of interest for the 7 South loading study were below the analytical detection limit (*e.g.*, As, Cd, Co, Cu, Ni, Pb, Se, Zn). Owing to this, there was limited opportunity to calculate representative values for current water quality in the Quinsam River using data collected at the 7SQR station. In Table 8-8, baseline concentrations for As, Cd, Co, Cu, Ni, Pb, Se and Zn are reported in a manner similar to that presented for the WB site. The table summarizes the following: the detection limit that defined the 2007-2011 period of record for each parameter; a value

equal to $\frac{1}{2}$ the detection limit; and an average of most recent (between Nov 2010 and Feb 2011) data. Note that for Co, Pb, Se and Zn, most recent analyses were only reported to a detection limit – and therefore, values reported for $\frac{1}{2}$ detection limits and recent averages are the same. In the case of Cu and As at the 7SQR site, the average values were calculated from sampling records calculated from 3 dates.

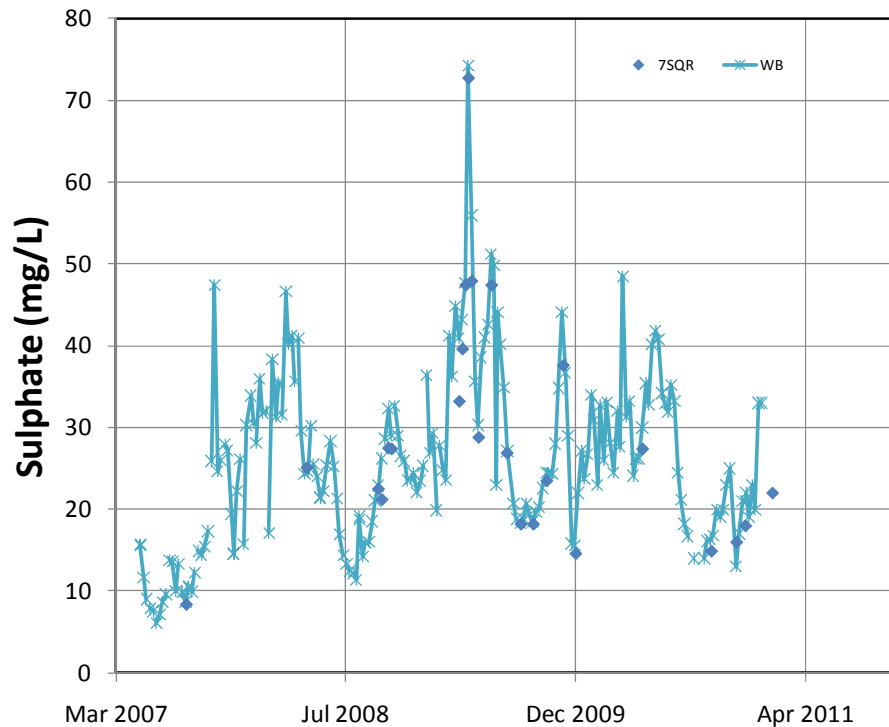


Figure 8-15: Time series plot comparing sulphate data for the WB and 7SQR monitoring stations (2007-2011).

**Table 8-8:
Estimates of Average Concentrations in Quinsam River at Site 7SQR.**

	Detection Limit	1/2 Detection	Average Nov 2010 – Jan 2011	n	n detects
As-T	0.00050	0.00025	0.00017	3	3
Cd-T	0.000017	0.000009	0.0000067	3	1
Co-T	0.00030	0.00015	0.00025	3	0
Cu-T	0.00100	0.00050	0.00077	3	3
Ni-T	0.00100	0.00050	0.00050	3	0
Pb-T	0.00050	0.00025	0.00010	3	0
Se-T	0.001	0.0005	0.00005	3	0
Zn-T	0.005	0.0025	0.0025	3	0

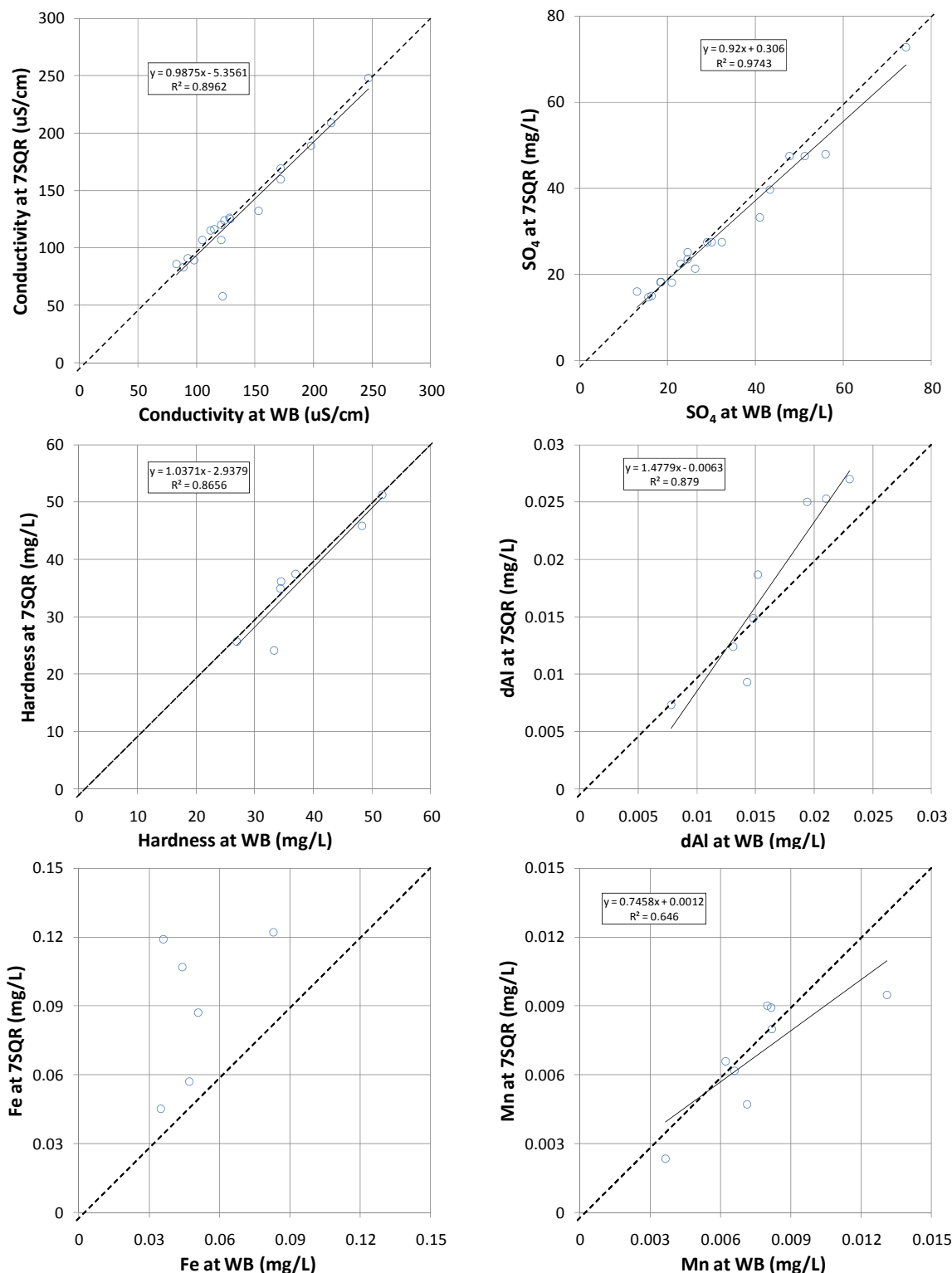


Figure 8-16: Comparison of conductivity, hardness, Fe, SO₄, d-Al and Mn at the WB and 7SQR water quality sites for corresponding dates between 2007 and 2011.

8.2.4 Quinsam River Baseline Concentrations in the Mass Loading Model

Water quality measured at the WB site was selected to represent baseline water quality in the mass loading model. Although WB is located upstream of the proposed 7 South Mine, water quality data for the WB and 7SQR stations compared very well for all parameters examined except iron. It is deemed that the WB station provides a more accurate measure of baseline conditions because of more frequent measurements at this site. The longer period of record and frequent measurements makes it possible to incorporate seasonal changes by calculating monthly averages for sulphate, Al, Fe, and Mn. In the case of metal(oid)s that were affected by detection limits, there was considerably more data to work with at the WB site compared to 7SQR site. As such, there was more confidence in the source terms computed using WB water quality data. With the development of the 7 South mine, continued monitoring at the 7SQR site will be necessary to document the overall effect on the Quinsam River of ongoing mine development by QCC.

The Quinsam River water quality baseline values input to the loading model include the Station WB monthly averages of SO₄, Al, d-Al, Fe and Mn concentrations (Table 8-6) and average annual estimates of As, B, Cd, Co, Cu, Pb, Se and Zn concentrations (Table 8-7).

9. Estimation of Groundwater Loadings to Receiving Waters



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9. *Estimation of Groundwater Loadings to Receiving Waters*

Groundwater loading estimates of potential contaminants of concern (COCs) from the 7 South mine (post-mining) to the Quinsam River have been calculated for the first two contaminant loading scenarios discussed in Chapter 6. Both scenarios assume a completely flooded mine void post-mining. In Scenario 1, acidic conditions develop in the 7 South workings prior to re-flooding of the mine. In Scenario 2, CCR is stowed and flooded before acidic conditions develop. QCC recognizes the importance of timely flooding of the mine void and have developed a mining and CCR disposal schedule to minimize the opportunity for mine wall and CCR oxidation. As such, Scenario 2 is considered the predicted future condition for the flooded 7 South mine.

9.1 *Loading Model Description*

Groundwater mass fluxes can be determined by multiplying groundwater volumetric fluxes (Q in m^3/d) by the predicted concentrations (C in mg/L) of the COCs for the 7 South mine pool, and accounting for consistency in units:

$$\text{Mass flux (kg/d)} = Q \cdot C_{\text{COC}} / 1000$$

The methods and assumptions used to calculate groundwater fluxes out of the 7 South mine area have been described in detail in Section 4.3.1. The groundwater fluxes were calculated using a probabilistic modeling approach utilizing Oracle Crystal Ball software. The calculated groundwater flux out of the 7 South area is presented as two numbers: an expected (median) groundwater flux of $50 \text{ m}^3/\text{d}$ based on geometric average hydraulic conductivity values for the coal and sandstone and an upper bound groundwater flux based on a 10% infiltration rate of mean annual precipitation (MAP). The source concentrations of the contaminants of concern predicted for the flooded 7 South mine under Scenarios 1 and 2 have been discussed in detail in Section 6.2.4 and are summarized in Table 6-3.

The average and upper bound mass fluxes for both Scenarios 1 and 2 are provided in Tables 9-1 and 9-2. The reported iron, manganese and sulphate loads for the two scenarios illustrate the importance of establishing saturated conditions within the mine void prior to initiation of acidic conditions. If acidic conditions develop prior to flooding (Scenario 1), the model predicts a likely (*i.e.* median value) release of 12 kg/d of iron and 100 kg/d of sulphate. In the unlikely event that the surrounding sandstone and coal is more permeable than anticipated (*i.e.* upper bound case), then the loads increase to 31 and 246 kg/d for iron and sulphate, respectively. Under the expected condition that the

CCR storage and flooding occurs before acidic conditions develop (Scenario 2), the calculated iron loads to the Quinsam River drop nearly 40 fold. Sulphate loads drop by a more modest 40% over Scenario 1 predictions; over 60 kg/d is still predicted to enter the Quinsam River under the expected (median) bedrock permeability conditions. This load may exceed 150 kg/d if the bedrock conditions are significantly more permeable than expected.

**Table 9-1:
Mass Fluxes - Scenario 1 Acidic Conditions with CCR Storage.**

Contaminant of Concern	Unit	Median (Based on K)	Upper Bound (Based on 10% MAP)
Aluminum (Al) Dissolved	kg/d	0.0012	0.0029
Arsenic (As) Dissolved	kg/d	0.0092	0.023
Boron (B) Dissolved	kg/d	0.047	0.12
Cadmium (Cd) Dissolved	kg/d	8.2E-06	2.0E-05
Cobalt (Co) Dissolved	kg/d	0.0030	0.0075
Copper (Cu) Dissolved	kg/d	0.0027	0.0067
Fluoride (F) Dissolved	kg/d	0.048	0.12
Iron (Fe) Dissolved	kg/d	12	31
Manganese (Mn) Dissolved	kg/d	0.29	0.71
Nickel (Ni) Dissolved	kg/d	0.0059	0.015
Selenium (Se) Dissolved	kg/d	2.1E-04	5.3E-04
Sulphate (SO4) Dissolved	kg/d	100	246
Zinc (Zn) Dissolved	kg/d	0.0043	0.011

**Table 9-2:
Mass Fluxes - Scenario 2 Non-Acidic (Expected) Conditions with CCR Storage.**

Contaminant of Concern	Unit	Median (Based on K)	Upper Bound (Based on 10% MAP)
Aluminum (Al) Dissolved	kg/d	4.2E-04	0.0010
Arsenic (As) Dissolved	kg/d	0.0092	0.023
Boron (B) Dissolved	kg/d	0.047	0.12
Cadmium (Cd) Dissolved	kg/d	8.2E-06	2.0E-05
Cobalt (Co) Dissolved	kg/d	0.0030	0.0074
Copper (Cu) Dissolved	kg/d	4.8E-05	1.2E-04
Fluoride (F) Dissolved	kg/d	0.024	0.060
Iron (Fe) Dissolved	kg/d	0.32	0.80
Manganese (Mn) Dissolved	kg/d	0.14	0.35
Selenium (Se) Dissolved	kg/d	0.0059	0.015
Nickel (Ni) Dissolved	kg/d	2.1E-04	5.3E-04
Sulphate (SO4) Dissolved	kg/d	61	151
Zinc (Zn) Dissolved	kg/d	0.0043	0.011

9.2 Predicted Effects in Quinsam River

The predicted concentrations in the Quinsam River receiving waters were estimated based on the contaminant loadings tabulated above and on the monthly average water quality in the Quinsam River (Section 8.2). The groundwater mass loadings represent a constant input (*i.e.* no seasonal variations) and are added to the existing baseline water quality in the Quinsam River assuming no attenuation of concentrations in the groundwater system and full mixing with the surface water. The modeled monthly contaminant concentrations in the Quinsam River for both Scenarios 1 and 2 are depicted graphically in Figures 9-1 through 9-4 and are tabulated in Appendix E. Note that to provide resolution of the predicted concentrations and to illustrate the water quality guidelines, results for manganese, arsenic, cobalt, selenium, boron and nickel are presented on a logarithmic concentration scale. The baseline water quality of the Quinsam River is shown in green, while the concentration increase due to groundwater loading from 7 South is shown in purple. The 7Q10 bar represents modeled concentrations for the 7-day, one in ten year low flow period determined from 17 years of records at WSC stations on the Quinsam River (spanning 1993 to present).

Assessment of the potential impact to receiving waters in the Quinsam River was determined by comparing the predicted water quality (*i.e.* baseline plus groundwater mass loading) to the most recent version of the provincial Approved and Working Water Quality Criteria for protection of freshwater aquatic life (MOE, last updated January, 2010). For most chemical parameters, guidelines are provided for both acute and chronic (30 day mean concentration) exposure.

Figure 9-1 illustrates predicted concentrations for sulphate, iron and aluminum. Note that the expected future concentrations (Scenario 2, median groundwater flux) are in the third column, highlighted grey. The predicted change in sulphate concentrations caused by loading from the mine are expected to be small under both scenarios 1 and 2 using mean groundwater fluxes; final concentrations in the Quinsam River remain below the BC chronic guideline (50 mg/L). If the bedrock surrounding the mine is more permeable than expected (*i.e.* upper bound groundwater flux), predicted sulphate concentrations still remain less than the BC chronic guideline under both Scenario 1 and 2. Predicted iron concentrations remain low and below the acute guideline for both loading conditions under Scenario 2 where mine flooding precedes the onset of oxidation. As described above, loadings of iron are significantly higher under Scenario 1 where onset of oxidation of mine walls and CCR occurs prior to flooding and in this case, predicted iron concentrations exceed the chronic guideline under low flow conditions and may exceed the acute guideline under the 7Q10 low flow using the upper bound groundwater flux.

Aluminum loadings are not expected to significantly effect water quality under any of the modeled conditions.

Figure 9-2 presents predicted concentrations for manganese, arsenic and cadmium. Predicted manganese concentrations are greater under Scenario 1 where oxidation occurs prior to mine flooding, although in all cases for both Scenario 1 and 2, predicted concentrations are less than the water quality guidelines. As discussed previously in Chapter 7, arsenic concentrations are naturally elevated in groundwater in the vicinity of the 7 South mine. Predicted concentrations increase somewhat in the Quinsam River during low flow periods when groundwater baseflow discharge represents a higher proportion of total flow in the river, although in all cases, concentrations are expected to be well below the water quality guidelines. Similar to aluminum, groundwater loadings of cadmium are not expected to significantly change the river water quality and all predicted concentrations are less than the water quality guideline.

Predicted concentrations for cobalt, copper and selenium are presented on Figure 9-3 and results for boron, zinc and nickel are shown on Figure 9-4. Modeling results for most of these parameters indicate no significant changes are expected in the Quinsam River due to groundwater loadings from the 7 South mine. Nickel, on the other hand, does show more noticeable impacts in the summer months and under 7Q10 low flow conditions, however the predicted concentrations remain well below the acute water quality guideline.

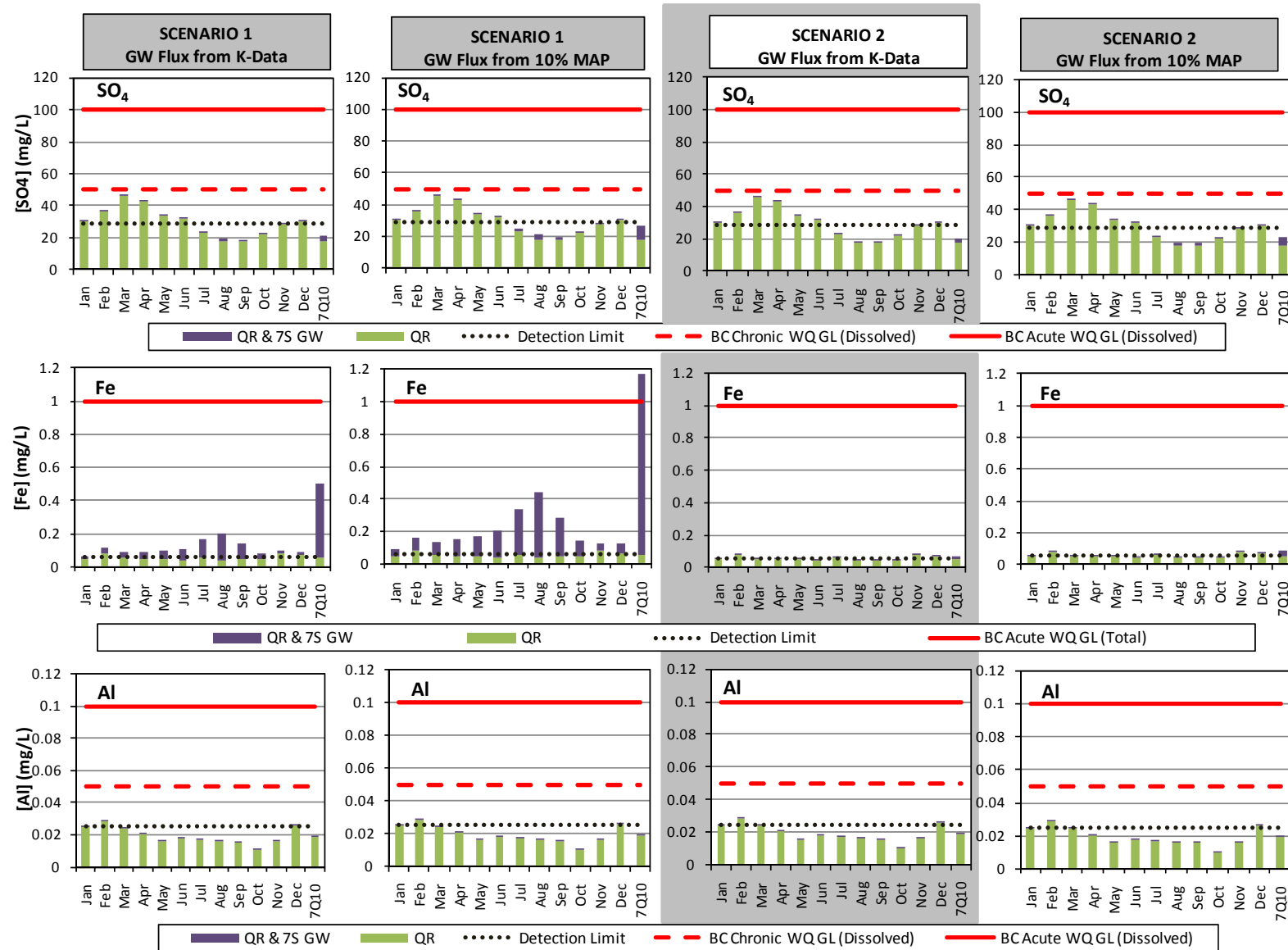


Figure 9-1: Predicted sulphate, iron and aluminum concentrations in the Quinsam River under Scenarios 1 and 2.

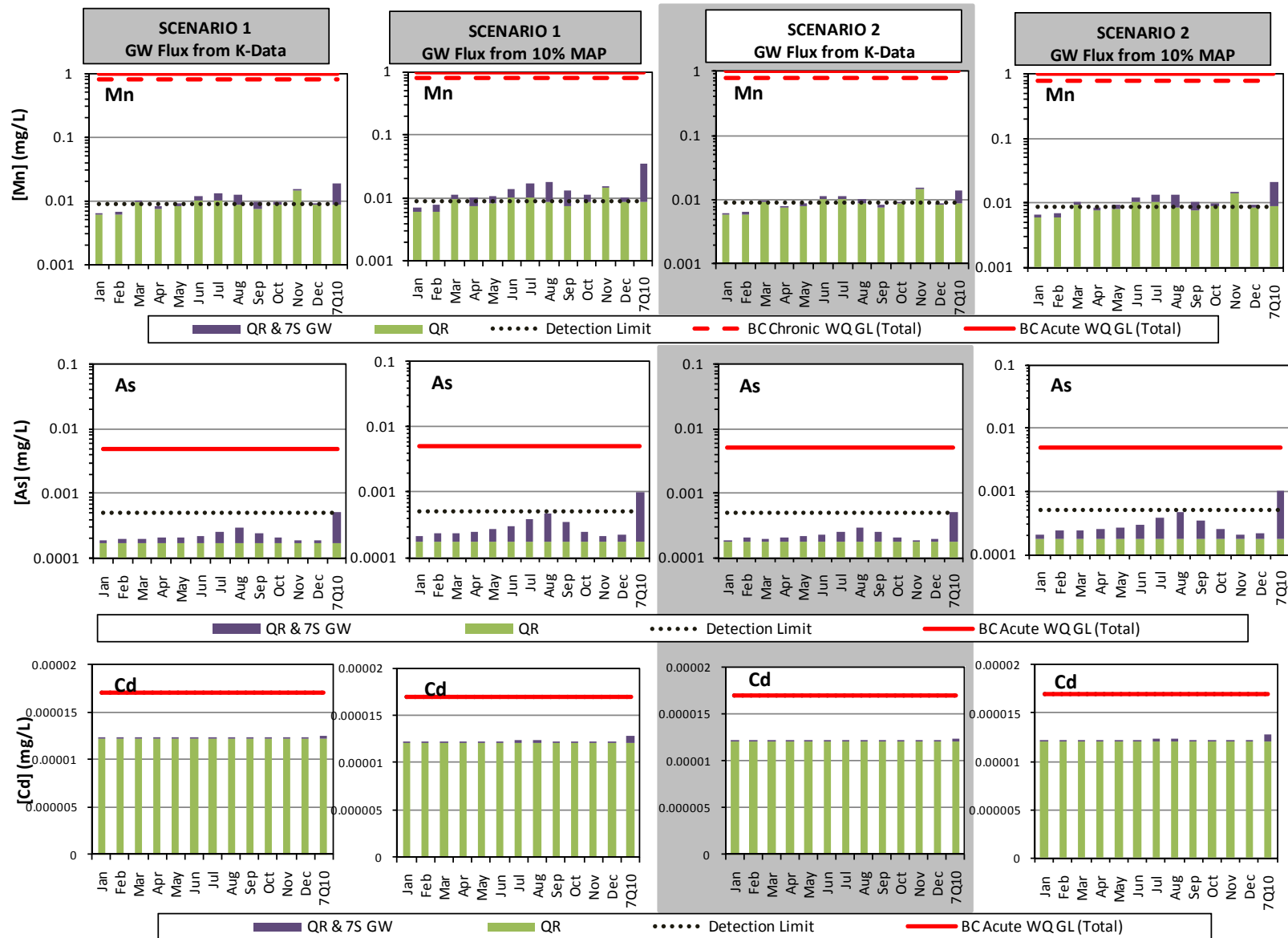


Figure 9-2: Predicted manganese, arsenic and cadmium concentrations in the Quinsam River under Scenarios 1 and 2.

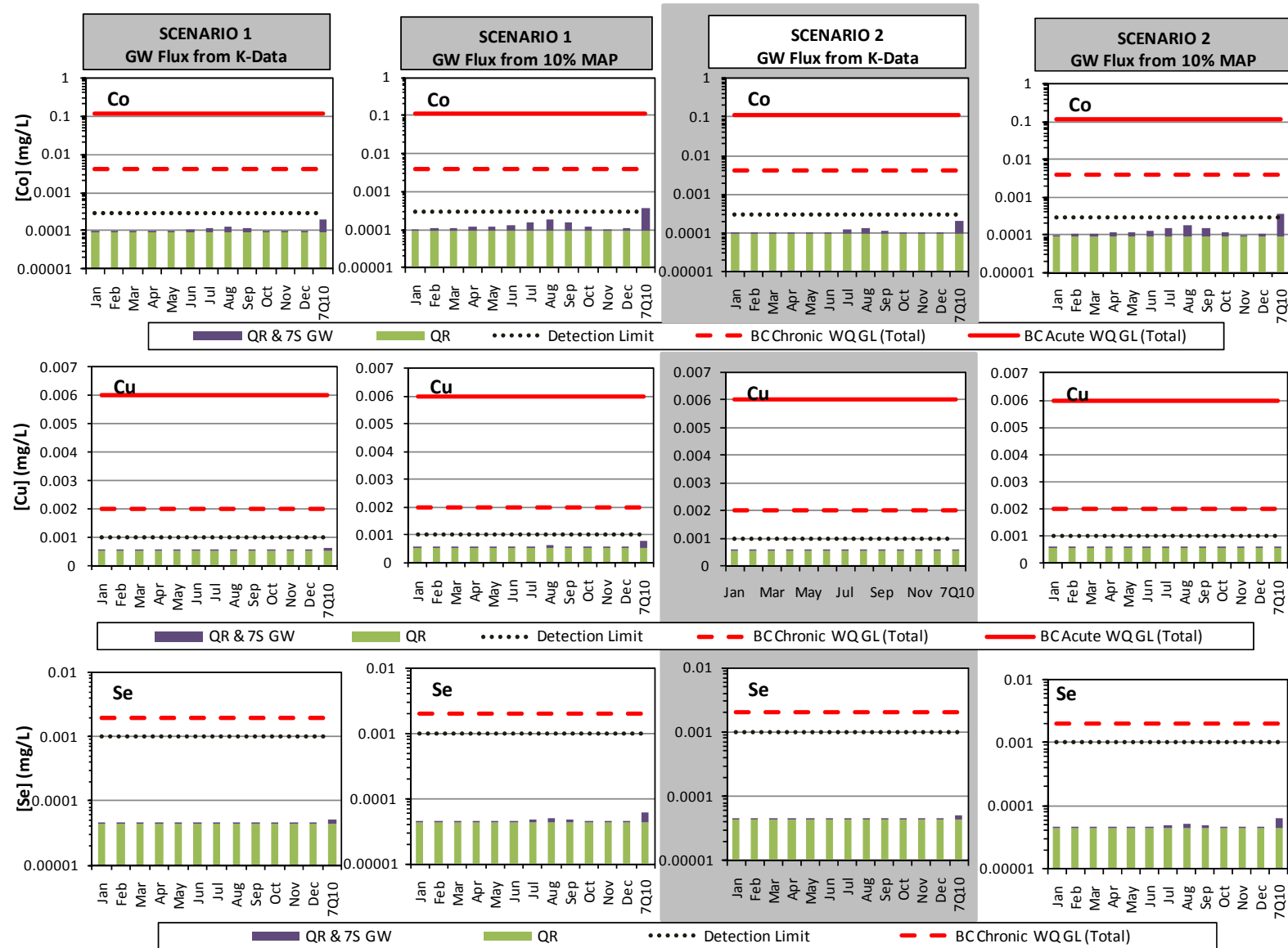


Figure 9-3: Predicted cobalt, copper and selenium concentrations in the Quinsam River under Scenarios 1 and 2.

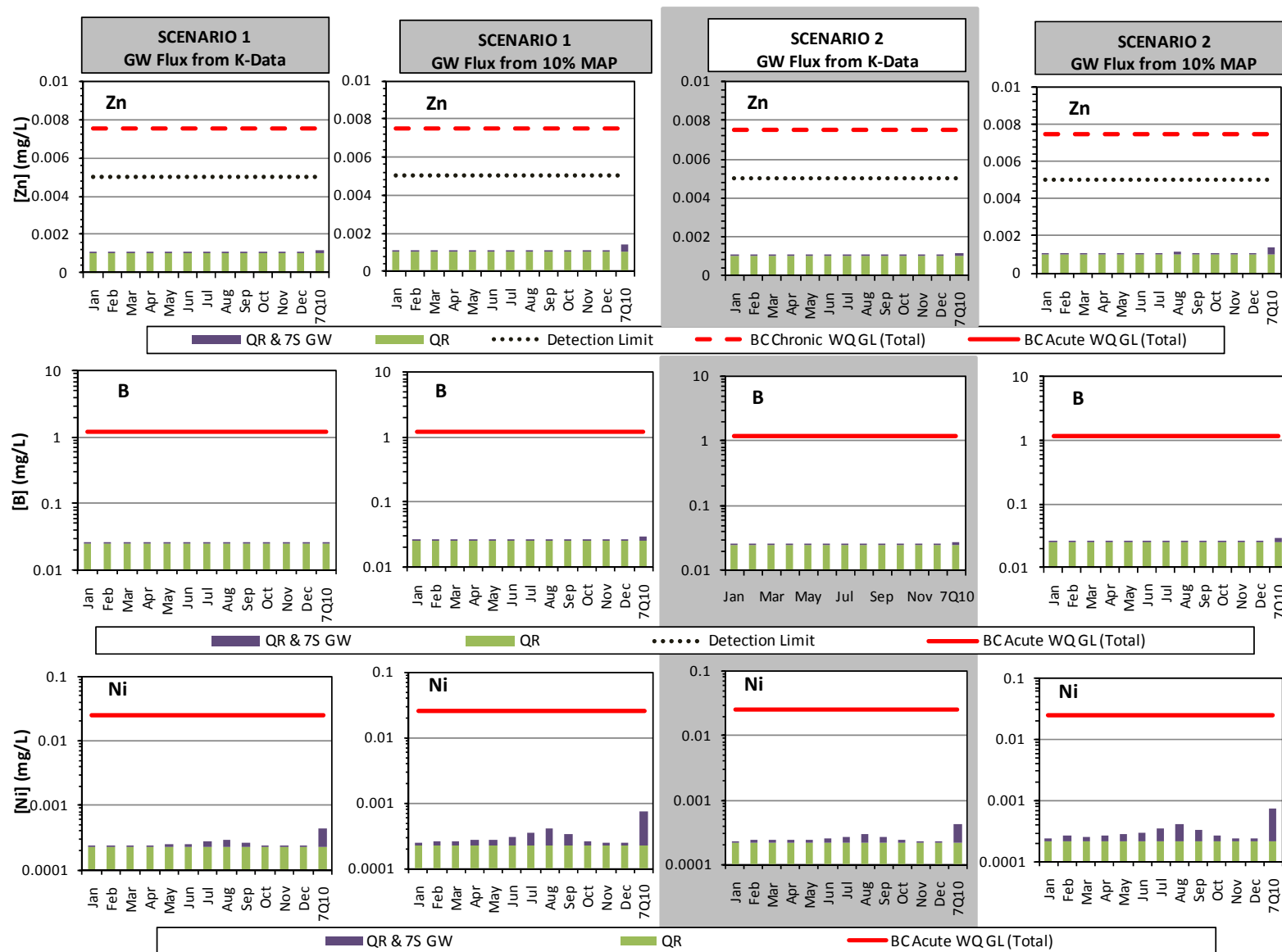


Figure 9-4: Predicted zinc, boron and nickel concentrations in the Quinsam River under Scenarios 1 and 2.

10. Summary and Conclusions



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10. Summary and Conclusions

A groundwater assessment has been conducted for the proposed 7 South Mine that will extract coal from the No. 4 Coal Zone which lies in the Dunsmuir Sandstone. The focus of the 7 South groundwater study was to evaluate the physical and chemical characteristics of the groundwater system in the 7 South Mine area and to make a predictive assessment of groundwater mass loadings under closure conditions on the water quality in the Quinsam River. Specifically, the study evaluated flow rates into and out of the mine void, the potential for 5 South mine subsidence to influence seepage rates from the 7 South Mine, the geochemical characteristics of the No. 4 Coal Zone and the Dunsmuir Sandstone that overlies the coal, how the drainage chemistry is expected to evolve over time from PAG coarse reject that will be stored in a portion of the mine void, the groundwater quality in the 7 South area, and the expected influence the mine water will have on the receiving environment.

The 7 South mine will develop the No. 4 coal zone and will be used for disposal of CCR from the 2 North, 7 South, 242 and 4 South underground mines. The 7 South mine is located on a hillslope and plateau south of the Quinsam River with the elevation of the No. 4 coal zone ranging in elevation from below the Quinsam River at the north end to approximately 80 m above river level at the south end.

Several sources of information have been reviewed for the hydrogeological assessment of 7 South mine. These sources of information include previous consultants' reports and current and historic water level data compiled by QCC, Lorax and Golder. In addition, this review also includes results from the 7 South hydrogeological field investigation performed by Lorax in April-May 2010 and ongoing water level monitoring program. Geochemical characterization was conducted on the hanging wall strata and the metal leaching potential of coarse reject produced from the 7 South mine was assessed. The results of the study support the following conclusions.

A conceptual groundwater model was formulated using pre-mine fluid levels in open boreholes and recent monitoring well water levels. The model indicates that the 7 South Mine is located in an area of groundwater recharge with radial flow from the circumference of the mine with seepage discharging to the Quinsam River except the southernmost portion of the mine that reports to the Iron River watershed. Current groundwater levels indicate that the No. 4 Seam saturated and post-mine groundwater levels would be expected to recover to this elevation, however, critical to this would be that the mine workings do not breach the subcrop of the coal seam that would likely result in higher seepage rates from the mine.

Field measurements at the Quinsam Mine indicate that the geometric mean (most likely value) of hydraulic conductivity of the coal seams, sandstone and till are expected to be on the order of 1.5×10^{-7} m/s, 6×10^{-9} m/s, and 4×10^{-6} m/s, respectively.

The low hydraulic conductivity of the coal and sandstone results in low rates of seepage into and out of the mine. Seepage flux from the proposed 7 South Mine area is expected to be approximately 50 m³/day. However, for the assessment of contaminant loading rates from the mine, the upper bound for seepage from the mine is estimated to be approximately 120 m³/day. The shortest travel time for groundwater to flow to the Quinsam River from the 7 South mine is approximately six years. Given the low seepage rate and low permeability of sandstones overlying the mine, it is expected that it would take more than 15 years to flood the mine under natural conditions.

To minimize the potential for a hydraulic connection between the 5 South and 7 South mines QCC has modified the layout of the proposed 7 South mine by establishing a 30 m horizontal setback from the edge of the 5 South mining area

Sulphur content of No. 4 Zone varies from 0.8 %S to 3.3 %S in the proposed 7 South mine footprint. This level of sulphur content is higher than observed in the No. 1 Seam that was mined in the 2 North and 3 North mine areas (< 1.0 %S) but lower than the sulphur content reported for No. 3 Seam in the 4 South mine.

Tailings and coarse reject are expected to have similar sulphur content as the raw coal they are derived from. However, neutralization potential is expected to be concentrated in the tailings relative to the raw coal or coarse reject. Raw coal containing < 1.0 %S is expected to produce NAG tailings and raw coal containing > 2.0 %S will produce PAG tailings. Coal containing between 1.0 and 2.0 %S has an uncertain ARD designation, thus, for tailings storage design purposes all raw coal with > 1% S should be assumed to require flooded PAG storage.

The time of exposure prior to the onset of acidic conditions is expected to be on the order of three years for PAG coarse reject with an NP of 60 kg CaCO₃/t. Sulphide reaction rates are somewhat slower for PAG raw coal stockpiles and tailings, thus onset of acidic conditions from these materials (NP of 60 kg CaCO₃/t) is estimated to be 6 and 7 years, respectively.

Concentrations of mine waters are predicted for three possible scenarios. Scenario 1 is essentially a worst case scenario where a portion of the coarse reject becomes acidic prior to being flooded. Scenario 2 is the expected condition when PAG coarse reject is placed in the mine void and flooded prior to the onset of acidic conditions from the coarse reject. Scenario 3 is the expected long term concentrations from the flooded coarse reject following the complete dissolution of stored oxidation products.

The No. 4 Coal zone lies within the Dunsmuir sandstones of the Comox Formation. Of relevance to the background water chemistry is that a subverticle calcite vein that cut across bedding planes was observed to contain the arsenic sulphide realgar (AsS). In general, the Dunsmuir strata contained As concentrations above average concentrations in the earth's crust.

The 7 South groundwater is characterized as circum-neutral, anoxic, mildly to moderately reducing and generally calcium bicarbonate type water with the exception of sulphate enriched water at borehole QU-07-07 and sodium enriched water at borehole QU-08-13. Dissolved arsenic exceeds the CSR-AW guideline (0.05 mg/L) in a majority of the 7 South groundwater samples with concentrations ranging from 10th percentile of 0.005 mg/L to a 90th percentile of 0.464 mg/L.

A unique groundwater chemistry is observed at the northern extent of the 7 South Mine (QU-08-13) which suggests that the water at this location evolved along a separate flow path than other 7 South water quality monitoring locations, which is consistent with the separation of this site by the Overlook Fault that crosses the northern margin of the proposed 7 South workings.

Water Survey of Canada hydrometric data collected at the three sites on the Quinsam River were used to predict mean monthly and 7Q10 low flows both upstream (Station WB) and downstream (Station 7SQR) of expected groundwater discharges from the 7 South Mine. Average annual flows on the Quinsam River downstream of the 7 South Mine are estimated to be 3.8 m³/s with highest flows observed in January and lowest flows in August. A 7Q10 flow for this stretch of the River is estimated to be 0.32 m³/s.

Water quality monitoring in the Quinsam River indicates that sulphate concentrations have increased in the river since the mining commenced in the late 1980's, although concentrations of most metals have remained below the analytical detection limits and site-specific aquatic life guidelines developed for Middle Quinsam Lake watershed.

Provided the PAG coarse reject is flooded prior to the onset of acidic drainage, mass loading predictions indicate that changes in Quinsam River water quality will be small and concentrations will remain below chronic and acute water quality objectives. If acidic drainage conditions are allowed to develop, iron loadings increase very significantly and may potentially exceed the water quality objectives. Quinsam mine personnel understand the importance of flooding the mine after completion and have develop a water management plan to achieve this.

11. Report Limitations



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11. Report Limitations

This report was prepared for the exclusive use of Hillsborough Resources Ltd. and Quinsam Coal for the purpose described in Section 1 of this report. Ministry of Energy and Mines and other government agencies involved with reviewing Hillsborough's applications may also rely upon this report; any other use or reliance on this report by any third party is at that party's sole risk. The authors accept no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions taken based on this report.

Respectfully submitted,

Original signed by:

Original signed by:

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Senior Environmental Geoscientist

John Balfour, M.Sc., P.Eng.
Senior Hydrogeologist

References



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Appendix A: Hydrogeological Data

Appendix A1: Borehole Logs

Appendix A2: Hydraulic Conductivity Calculation

Appendix A3: Mass Flux Calculations



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***Appendix A1:
Borehole Logs***



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Borehole ID: P08-13

Project #: 885-1

Project: Quinsam Coal Groundwater Monitoring

Client: Quinsam Coal/ Hillsborough Resources

Location: 7 South

Northing: 5535188

Easting: 323887

Ground Elevation: 220.40m

Steel Casing: 6 inch

Depth	Symbol	Description	Depth/Elev.	Well A	Well B	Observations
ft m		Ground Surface				
0 0		Overburden Glacial Till			Pea Gravel 0-2.0m	
2 2					Cement Grout 2.0m-4.0m	
4 4					Pea Gravel 4.0m-6.9m	
6 6						
8 8					Bentonite chips 6.9m-7.93m	
10 10					Pea Gravel 8.6m-13.72m	GW Elevation: 212.41m Well B (April 27, 2010)
12 12						
14 14					Bentonite Pellets 13.72m-14.94m	GW Elevation: 207.21m Well A (April 27, 2010)
16 16					Pea Gravel 14.94m-21.03m	
18 18						
20 20						

Drilled By: Drillwell Enterprises

Drill Method: Downhole Hammer

Geologists: M. Storey

Drill Date: March 3, 2008

Hole Size: 7 in (0-25.5m), 5.5 in (25.5m-EOH)

PVC Casing: Well A: 2 inch, Well B: 1-1/4 inch

Well Installation Date: April 20, 2010

Sheet: 1 of 3



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Borehole ID: P08-13

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Project: Quinsam Coal Groundwater Monitoring

Client: Quinsam Coal/ Hillsborough Resources

Location: 7 South

Northing: 5535188

Easting: 323887

Ground Elevation: 220.40m

Steel Casing: 6 inch

Depth	Symbol	Description	Depth/Elev.	Well A	Well B	Observations
67						
69						
71						
73	22					
75						
77						
79	24					
81						
83			25.2			
85	26	Sandstone				
87						
89						
91	28					
93						
95						
97						
99	30					
101						
103						
105	32					
107						
109						
111	34					
113						
115						
117						
119	36					
121						
123						
125	38					
127						
129						
131						

Drilled By: Drillwell Enterprises

Drill Method: Downhole Hammer

Geologists: M. Storey

Drill Date: March 3, 2008

Hole Size: 7 in (0-25.5m), 5.5 in (25.5m-EOH)

PVC Casing: Well A: 2 inch, Well B: 1-1/4inch

Well Installation Date: April 20, 2010

Sheet: 2 of 3



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Project #: 885-1

Project: Quinsam Coal Groundwater Monitoring

Client: Quinsam Coal/ Hillsborough Resources

Location: 7 South

Northing: 5535188

Easting: 323887

Ground Elevation: 220.40m

Steel Casing: 6 inch

Depth	Symbol	Description	Depth/Elev.	Well A	Well B	Observations
133						
135						
137	42					
139						
141						
143						
145	44				Bentonite Pellets 43.89m-45.11m	
147						
149					10/20 Filter Sand 45.11m-52.73m	
151	46		46.5			
153		Coal Seam 4 (upper)			Screen (46.02m-52.10m)	
155						
157	48					
159						
161						
163						
165	50	Mudstone	50.2			
167		Coal Seam 4 (lower)				
169						
171	52	Sandstone	52.0			
173					Bentonite Pellets 52.73m-54.80m	
175						
177	54					
179			54.9			
181					EOH	
183	56					
185						
187						
189	58					
191						
193						
195						
197						

Drilled By: Drillwell Enterprises

Drill Method: Downhole Hammer

Geologists: M. Storey

Drill Date: March 3, 2008

Hole Size: 7 in (0-25.5m), 5.5 in (25.5m-EOH)

PVC Casing: Well A: 2 inch, Well B: 1-1/4 inch

Well Installation Date: April 20, 2010

Sheet: 3 of 3



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Borehole ID: QU08-05

Project #: 885-1

Project: Quinsam Groundwater Monitoring

Client: Quinsam Coal/Hillsborough Resources

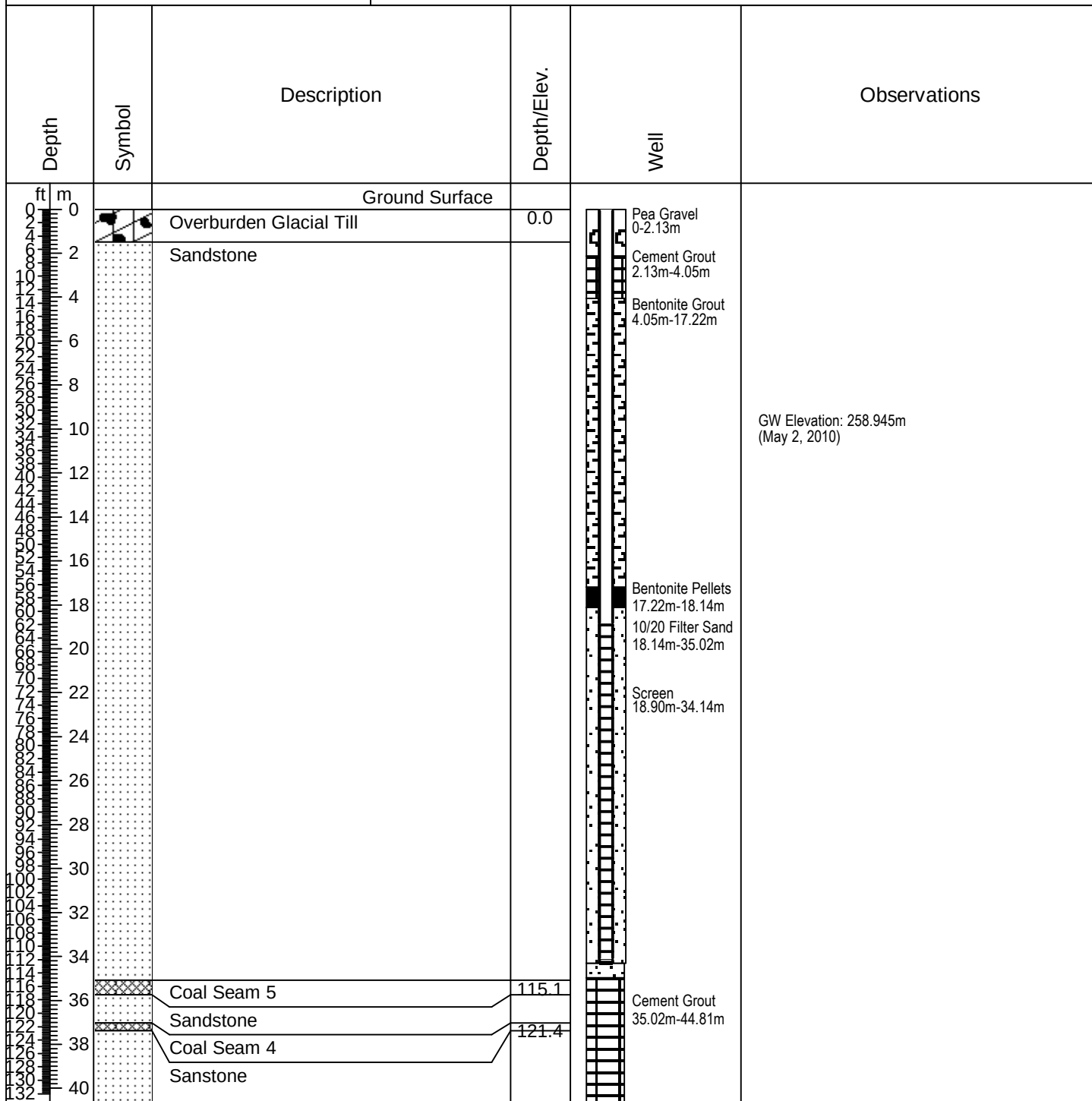
Location: 7 South

Northing: 324152

Easting: 55344849

Ground Elevation: 268.52m

Steel Casing: 6 inch



Drilled By: Drillwell Enterprises

Drill Method: Downhole hammer

Geologists: M. Storey

Drill Date: March 5, 2008

Hole Size: 7 in (0-1.5m), 6 in(1.5-30.3m), 5.5 in (30.3m-EOH)

PVC Casing: 2 inch

Well Installation Date: April 21, 2010

Sheet: 1 of 2



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Location: 7 South

Steel Casing: 6 inch

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Borehole ID: QU08-08

Project #: 885-1

Project: Quinsam Coal Groundwater Monitoring

Client: Quinsam Coal/Hillsborough Resources

Location: 7 South

Northing: 5534567.64

Easting: 323940.19

Ground Elevation: 287.19m

Steel Casing: 6 inches

Depth	Symbol	Description	Depth/Elev.	Well A	Well B	Observations
0		Ground Surface				
0		Overburden Glacial Till			Pea Gravel 0.0m-3.0m	
2						
4						
6						
8						
10						
12					Bentonite Pellets 3.0m-4.57m	
14						
16			4.8		Pea Gravel 4.57m-9.75m	
18		Sandstone				
20						
22						
24						
26						
28						
30						
32					Bentonite Pellets 9.75m-10.97m	
34						
36					Pea Gravel 10.97m-17.07m	
38						
40						
42						
44						
46						
48						
50						
52						
54						
56					Bentonite Pellets 17.07m-18.29m	
58						
60						
62						
64					Pea Gravel 18.29m-24.38m	
66						

GW Elevation: 269.55m Well B
(April 27, 2010)

Drilled By: Drillwell Enterprises

Drill Method: Downhole hammer

Geologists: M. Storey

Drill Date: March 9, 2008

Hole Size: 7 in (0-4.9m), 6 in (4.9m-45.8m), 5.5 in (45.8m-EOH)

PVC Casing: Well A: 2 inch, Well B, 1-1/4 inch

Well Installation Date: April 21, 2010

Sheet: 1 of 3



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Borehole ID: QU08-08

Project #: 885-1

Project: Quinsam Coal Groundwater Monitoring

Client: Quinsam Coal/Hillsborough Resources

Location: 7 South

Northing: 5534567.64

Easting: 323940.19

Ground Elevation: 287.19m

Steel Casing: 6 inches

Depth	Symbol	Description	Depth/Elev.	Well A	Well B	Observations
68		Sandstone				
70						
72	22					
74						
76						
78						
80	24				Bentonite Pellets 24.38m-25.6m	
82						
84					10/20 Filter Sand 25.6m-28.65m	
86	26				Screen 26.21m-27.74m	
88			27.2			
90		Coal Seam 5	27.7			
92	28	Sandstone			Bentonite Pellets 28.65m-29.57m	
94					Pea Gravel 29.57m-33.83m	
96						
98						
100	30					
102						
104						
106	32					
108						
110						
112	34				Bentonite Pellets 33.83m-35.02m	
114					Pea Gravel 35.02m-42.00m	
116						
118	36					
120						
122						
124	38					
126						
128						
130						
132	40					

Drilled By: Drillwell Enterprises

Drill Method: Downhole hammer

Geologists: M. Storey

Drill Date: March 9, 2008

Hole Size: 7 in (0-4.9m), 6 in (4.9m-45.8m), 5.5 in (45.8m-EOH)

PVC Casing: Well A: 2 inch, Well B, 1-1/4 inch

Well Installation Date: April 21, 2010

Sheet: 2 of 3



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Borehole ID: QU08-08

Project #: 885-1

Project: Quinsam Coal Groundwater Monitoring

Client: Quinsam Coal/Hillsborough Resources

Location: 7 South

Northing: 5534567.64

Easting: 323940.19

Ground Elevation: 287.19m

Steel Casing: 6 inches

Depth	Symbol	Description	Depth/Elev.	Well A	Well B	Observations
134		Sandstone			Bentonite Pellets 41.15m-42.3m	GW Elevation: 244.03m Well A (April 27, 2010)
136						
138	42				Pea Gravel 42.3m-48.4m	
140						
142						
144						
146	44					
148						
150						
152	46					
154						
156						
158	48				Bentonite Pellets 48.4m-50.3	
160						
162						
164	50				10/20 Filter Sand 50.29m-57.40m	
166						
168			51.6			
170		Coal Seam 4(upper)				
172	52					
174						
176			54.2		Screen 51.82m-56.40m	
178	54	Mudstone/Siltstone				
180						
182		Coal Seam 4 (lower)				
184			56.1			
186	56	Sandstone				
188					Bentonite Chips 57.4m-60.1m	
190						
192	58					
194						
196			60.1			
198	60				EOH	

Drilled By: Drillwell Enterprises

Drill Method: Downhole hammer

Geologists: M. Storey

Drill Date: March 9, 2008

Hole Size: 7 in (0-4.9m), 6 in (4.9m-45.8m), 5.5 in (45.8m-EOH)

PVC Casing: Well A: 2 inch, Well B, 1-1/4 inch

Well Installation Date: April 21, 2010

Sheet: 3 of 3



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Borehole ID: QU08-10

Project #: 885-1

Project: Quinsam Coal Groundwater Monitoring

Client: Quinsam Coal/Hillsborough Resources

Location: 7 South

Northing: 5533856.79

Easting: 324464.06

Ground Elevation: 295.02m

Steel Casing: 6 inch

Depth	Symbol	Description	Depth/Elev.	Well	Observations
ft m		Ground Surface			
0 0		Overburden/ Glacial Till	0.0	Pea Gravel 0.0m-3.0m	
2 0					
4 0					
6 2					
8 2					
10 2					
12 4				Cement Grout 3.0m-17.37m	
14 4					
16 4					
18 6					
20 6					
22 6		Sandstone	21.3		
24 8					
26 8					
28 8					
30 10					
32 10					
34 10					
36 12					
38 12					
40 12					
42 14					
44 14					
46 14					
48 16					
50 16					
52 16					
54 16					
56 16					
58 16				Bentonite Pellets 17.37m-18.29m	

Drilled By: Drillwell

Drill Method: Downhole Hammer

Geologists: M. Storey

Drill Date: March 10, 2008

Hole Size: 7 in (0-6.5m), 6 in (6.5m-30.9m)

PVC Casing: 2 inch

Well Installation Date: April 20, 2010

Sheet: 1 of 2



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Borehole ID: QU08-10

Project #: 885-1

Project: Quinsam Coal Groundwater Monitoring

Client: Quinsam Coal/Hillsborough Resources

Location: 7 South

Northing: 5533856.79

Easting: 324464.06

Ground Elevation: 295.02m

Steel Casing: 6 inch

Depth	Symbol	Description	Depth/Elev.	Well	Observations
61		Sandstone		10/20 Filter Sand 18.29m-29.2m	GW Elevation: 273.38m (May 17, 2010)
63					
65	20	Coal Seam 4 (Upper)	65.4		
67					
69					
71	22	Sandstone	71.9		
73					
75		Coal Seam 4 (Lower)		Screen 19.51m-27.0m	
77					
79	24				
81					
83					
85	26				
87		Sandstone	86.6		
89					
91	28			Bentonite Chips	
93				10/20 Filter Sand	
95				Bentonite Chips	
97	30			29.2m-30.8m	
99					
101			101.0	EOH	
103					
105	32				
107					
109					
111	34				
113					
115					
117					

Drilled By: Drillwell

Drill Method: Downhole Hammer

Geologists: M. Storey

Drill Date: March 10, 2008

Hole Size: 7 in (0-6.5m), 6 in (6.5m-30.9m)

PVC Casing: 2 inch

Well Installation Date: April 20, 2010

Sheet: 2 of 2

Appendix A2:
Hydraulic Conductivity Calculation

Hydraulic Conductivity of Sandstone and Till

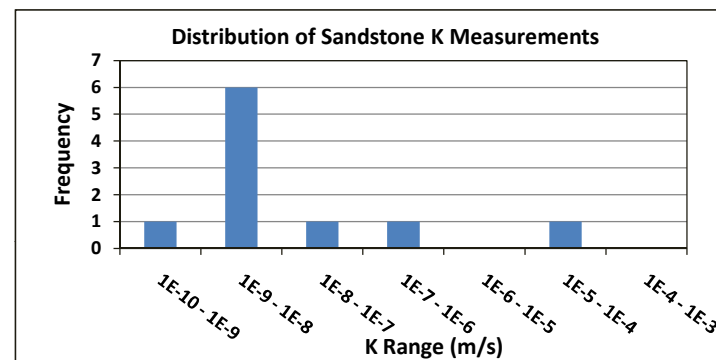
Borehole ID	Mine Area	Lithology	Interval Top (ft)	Interval Bottom (ft)	Measured K (m/s)	Assumed K (m/s)	Test Type	Analytical Method	Source
QU08-05	7 South	Sandstone	62	102	6.5E-09	6.5E-09	Slug Test	Hvorslev	Lorax May 2010 Field Investigation
QU10-07S	4 South	Sandstone	109	135	8.2E-09	8.2E-09	Slug Test	Cooper Green	Lorax Fall 2010 Field Investigation
QU10-09S	4 South	Fractured Sandstone	41	49	7.9E-05	7.9E-05	Slug Test	Hvorslev	Lorax Fall 2010 Field Investigation
QU10-07	4 South	Sandstone	234	244	9.8E-07	9.8E-07	Packer - Lugeon	Thiem	Lorax Fall 2010 Field Investigation
QU10-08	4 South	Sandstone	267	280	<7.5E-09	1.5E-09	Packer - Lugeon	Thiem	Lorax Fall 2010 Field Investigation
QU11-05	River Barrier Pillar	Sandstone	242	272	<3E-09	6.0E-10	Packer - Lugeon	Thiem	Lorax Fall 2010 Field Investigation
QU11-05	River Barrier Pillar	Sandstone	120	150	<6E-09	1.2E-09	Packer - Lugeon	Thiem	Lorax Fall 2010 Field Investigation
QU11-09	River Barrier Pillar	Sandstone	80	110	<8E-09	1.6E-09	Packer - Lugeon	Thiem	Lorax Fall 2010 Field Investigation
QU11-09	River Barrier Pillar	Sandstone	110	140	<6E-09	1.2E-09	Packer - Lugeon	Thiem	Lorax Fall 2010 Field Investigation
n/a	4-South	Sandstone	40	50	-	5.0E-08	Large scale deH20	n/a	Lorax 2011 4 South Report
P2N-09-01	2 North	Till+Sand	40	50	6.5E-06	6.5E-06	Slug Test	n/a	EGSL 2009 Field Investigation
P2N-09-02	2 North	Till	70	80	2.2E-06	2.2E-06	Slug Test	n/a	EGSL 2009 Field Investigation
QU08-13B	7 South	Till-Sandstone	77	87	5.2E-06	5.2E-06	Slug Test	Hvorslev	Lorax May 2010 Field Investigation

Notes:

n/a: Not available

Value not believed to be representative of sandstone in 7 South

Unit	Geometric Average K (m/s)	Log (Geometric Average K) (m/s)
Sandstone	5.6E-09	-8.3
Till	4.2E-06	-5.4

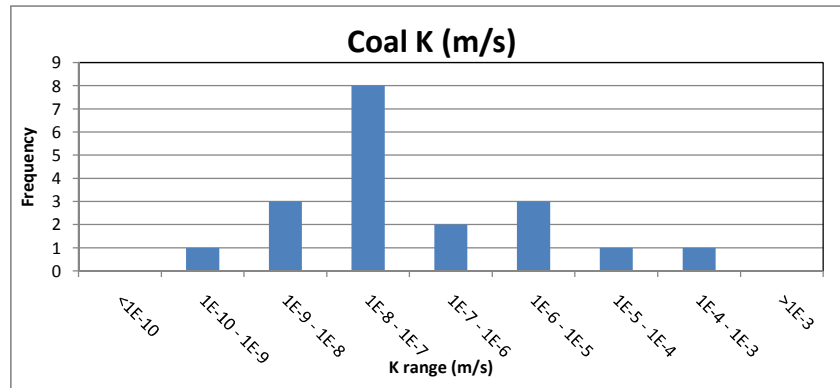


Hydraulic Conductivity of Coal

Borehole ID	Mine Area	Test Type	Lithology ¹	Interval Top (ft)	Interval Bottom (ft)	Interval Thickness (m)	T (m ² /s)	K (m/s)	Analytical Method	Source
QU08-08B	7 South	Slug Test	No. 5 + SST	26	28	0.5	2.6E-05	5.5E-05	Hvorslev	Lorax May 2010 Field Investigation
QU07-05	7 South	Bail down recovery test	No. 4+No. 5			6.1	8.0E-07	1.0E-07	Theis	Golder, 2009
QU07-07	7 South	Bail down recovery test	No. 4+No. 5			13.3	4.0E-05	3.0E-06	Theis	Golder, 2009
QU08-05	7 South	Bail down recovery test	No. 4+No. 5			5.7	1.0E-07	2.0E-08	Theis	Golder, 2009
QU08-08A	7 South	Slug Test	No. 4 + MST/SLST	52	56	1.4	4.0E-10	2.9E-10	Hvorslev	Lorax May 2010 Field Investigation
QU08-10	7 South	Slug Test	No. 4 + SST+ MST	20	27	2.3	1.1E-08	5.0E-09	Hvorslev	Lorax May 2010 Field Investigation
QU08-13A	7 South	Slug Test	No. 4 + SST+ MST	23	26	0.9	9.8E-05	1.1E-04	Hvorslev	Lorax May 2010 Field Investigation
QU10-11	2 North	Packer-Lugeon	SST + No. 4B	220	250	9.1	7.3E-08	8.0E-09	Thiem	Lorax May 2010 Field Investigation
QU10-10S	2 North	Slug Test	No. 4/SST	187	209	6.9	7.5E-06	1.1E-06	Bouwer-Rice	Lorax Fall 2010 Field Investigation
QU08-21G-S	2 North	Slug Test	No. 4/SST	242	265	7.0	1.5E-06	2.1E-07	Bouwer-Rice	Lorax Fall 2010 Field Investigation
QU07-08	7 South	Bail down recovery test	No. 4			4.8	5.0E-07	1.0E-07	Theis	Golder, 2009
QU08-07	7 South	Bail down recovery test	No. 4			3.7	2.0E-07	5.0E-08	Theis	Golder, 2009
QU09-01	7 South	Bail down recovery test	No. 4			4.4	1.0E-07	3.0E-08	Theis	Golder, 2009
QU10-07	4 South	Packer-Lugeon	No. 3 + SST	207	244	11.3	1.0E-06	2.4E-09	Thiem	Lorax Fall 2010 Field Investigation
QU10-07D	4 South	Slug Test	No. 3/MDST	205	225	6.2	6.5E-08	1.0E-08	Cooper-Green	Lorax Fall 2010 Field Investigation
QU10-08	4 South	Packer-Lugeon	SST +No. 3 + SST	210	280	21.3	2.9E-07	1.4E-08	Thiem	Lorax Fall 2010 Field Investigation
QU10-08D	4 South	Slug Test	No. 3	245	268	7.2	1.1E-06	1.6E-07	Cooper et al	Lorax Fall 2010 Field Investigation
QU10-09D	4 South	Slug Test	No. 3/SST	102	125	7.0	2.4E-05	3.4E-06	Bouwer-Rice	Lorax Fall 2010 Field Investigation
QU10-09	4 South	Packer-Lugeon	SST + No. 3 + MDST	100	140	12.2	1.0E-06	8.2E-08	Thiem	Lorax Fall 2010 Field Investigation
QU10-09	4 South	Packer-Lugeon	SST +No. 2 + SLST	140	225	25.9	3.0E-05	2.8E-06	Thiem	Lorax Fall 2010 Field Investigation
QU10-10D	2 North	Slug Test	No. 1/MDST	537	566	8.7	1.7E-07	2.0E-08	Hvorslev	Lorax Fall 2010 Field Investigation
QU10-11D	2 North	Slug Test	No. 1/MDST	491	534	13.1	1.3E-04	9.7E-06	Cooper-Green	Lorax Fall 2010 Field Investigation
QU08-21G-D	2 North	Slug Test	No. 1	536	580	13.4	2.1E-05	1.6E-06	Cooper-Green	Lorax Fall 2010 Field Investigation
P1-4-2 (P1-1C)	5 South	Pump Test	Shale+No.1					1.7E-07	Theis	Brown Erdman, 1982

1. SST= Sandstone, MDST=Mudstone, SLST=Siltstone, No. # = Coal Seam

Values are calculated from original method output



	T (m ² /s)	K (m/s)
Min	4.0E-10	2.9E-10
Max	1.3E-04	1.1E-04
Geo. Mean	1.0E-06	1.5E-07

All Coal Seams

Bin	Frequency
<1E-10	0
1E-10 - 1E-9	1
1E-9 - 1E-8	3
1E-8 - 1E-7	8
1E-7 - 1E-6	2
1E-6 - 1E-5	3
1E-5 - 1E-4	1
1E-4 - 1E-3	1
>1E-3	0

Count 19

Appendix A3:
Mass Flux Calculations

7-South Mass Flux Calculations

INPUT PARAMETERS					
Hydraulic Conductivity of Coal (K)	Units	Value	Comments		
geomean	(m/s)	1.5E-07	geometric mean of all coal seams		
Hydraulic Conductivity of SST (K)	Units	Value	Comments		
geomean	(m/s)	5.6E-09	geometric mean of all measured SST values (excluding outlier)		
Hydraulic Conductivity of SST (K)	Units	Value	Comments		
Till	m/s	4.2E-06	geometric mean of 3 tests in till		
Effective Porosity (Bedrock)	Units	Value	Comments		
log(minimum)	(-)	-5			
log(maximum)	(-)	-1			
log(average)	(-)	-3	median based on literature values		
Mean Annual Precipitation	Units	Value	Comments		
MAP	mm/yr	1034	modeled mine MAP from Lorax (2009)		
Effective Porosity (Till)	(-)	0.3			
Problem Dimensions	Units	Value	Comments		
Footprint area of 7 South Mine		422245			
Gradient in footprint		0.14	gradient at QU-08-13		
Perimeter Segment 1					
Length of workings (Segment 1)	m	2530	From 10-15 clockwise to 07-07		
Thickness of workings	m	3			
Gradient	(-)	0.11	based on pre-mine water-levels		
Perimeter Segment 2					
Length of workings (Segment 2)	m	840	From 10-15 counterclockwise to 79-14		
Thickness of workings	m	3			
Gradient	(-)	0.06	based on pre-mine water-levels		
Perimeter Segment 3					
Length of workings (Segment 3)	m	700	From 79-14 counterclockwise to 07-07		
Thickness of workings	m	3			
Gradient	(-)	0.25	based on pre-mine water-levels		
Flow Path 1 - East					
Distance travelled in Coal	m	75	Path from QU-11-10 east to Quinsam River		
Distance travelled in Till	m	325			
Gradient	(-)	0.12			
Flow Path 2 - North					
Distance travelled in Sandstone	m	190	Path from northern end of workings to Quinsam River		
Gradient	(-)	0.03			
Contaminant of Concern	Units	Scenario 1 Worst Case Concentrations	Scenario 2 Expected Concentrations		
Aluminum (Al) Dissolved	mg/L	0.024	0.0086		
Arsenic (As) Dissolved	mg/L	0.19	0.19		
Boron (B) Dissolved	mg/L	0.98	0.98		
Cadmium (Cd) Dissolved	mg/L	0.00017	0.00017		
Cobalt (Co) Dissolved	mg/L	0.063	0.062		
Copper (Cu) Dissolved	mg/L	0.056	0.001		
Fluoride (F) Dissolved	mg/L	1	0.5		
Iron (Fe) Dissolved	mg/L	257	6.7		
Manganese (Mn) Dissolved	mg/L	5.97	2.89		
Nickel (Ni) Dissolved	mg/L	0.122	0.122		
Selenium (Se) Dissolved	mg/L	0.0044	0.0044		
Sulphate (SO4) Dissolved	mg/L	2060	1260		
Zinc (Zn) Dissolved	mg/L	0.088	0.088		

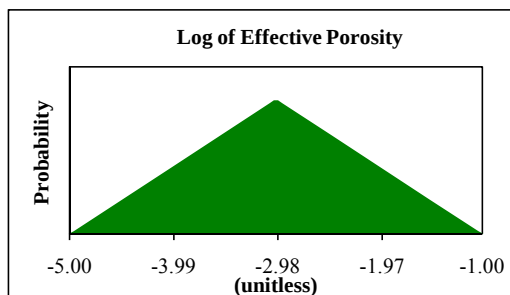
MODEL OUTPUT					
Volumetric Flux - Based on SST and Coal K-values (Geo. Avg.)					
Parameter	Unit	Excel Output	OCB Output		
Q - through perimeter of mine	m3/d	20	19.78		
Q - through footprint of mine	m3/d	29	29		
Q - total	m3/d	48	48		
Volumetric Flux - Based on Infiltration = 10% MAP					
Parameter	Unit	Excel Output			
Q - total - 10% of MAP	m3/d	120			
Travel Time Calculations	Unit	Most Likely Value	Median		
Flow Path 1 - East	days	2,287	2,289		
	years	6.3	6.3		
Flow Path 2 - North	days	13,090	13,536		
	years	35.9	37		
Mass Fluxes - Scenario 1 Flooded Workings with CCR (Worst Case)					
Contaminant of Concern	Unit	Mass Flux (Based on K)		Mass Flux (Based on MAP)	
		Excel Output	OCB Output	Excel Output	OCB Output
Aluminum (Al) Dissolved	kg/d	0.0012	0.0012	0.0029	0.0029
Arsenic (As) Dissolved	kg/d	0.0092	0.0092	0.023	0.023
Boron (B) Dissolved	kg/d	0.047	0.047	0.12	0.12
Cadmium (Cd) Dissolved	kg/d	8.2E-06	8.2E-06	2.0E-05	2.0E-05
Cobalt (Co) Dissolved	kg/d	0.0030	0.0030	0.0075	0.0075
Copper (Cu) Dissolved	kg/d	0.0027	0.0027	0.0067	0.0067
Fluoride (F) Dissolved	kg/d	0.048	0.048	0.12	0.12
Iron (Fe) Dissolved	kg/d	12	12	31	31
Manganese (Mn) Dissolved	kg/d	0.29	0.29	0.71	0.71
Nickel (Ni) Dissolved	kg/d	0.0059	0.0059	0.015	0.015
Selenium (Se) Dissolved	kg/d	2.1E-04	2.1E-04	5.3E-04	5.3E-04
Sulphate (SO4) Dissolved	kg/d	100	100	246	246
Zinc (Zn) Dissolved	kg/d	0.0043	0.0043	0.011	0.011
Mass Fluxes - Scenario 2 Flooded Workings with CCR (Expected)					
Contaminant of Concern	Unit	Mass Flux (Based on K)		Mass Flux (Based on MAP)	
		Excel Output	OCB Output	Excel Output	OCB Output
Aluminum (Al) Dissolved	kg/d	4.2E-04	4.2E-04	0.0010	0.0010
Arsenic (As) Dissolved	kg/d	0.0092	0.0092	0.023	0.023
Boron (B) Dissolved	kg/d	0.047	0.047	0.12	0.12
Cadmium (Cd) Dissolved	kg/d	8.2E-06	8.2E-06	2.0E-05	2.0E-05
Cobalt (Co) Dissolved	kg/d	0.0030	0.0030	0.0074	0.0074
Copper (Cu) Dissolved	kg/d	4.8E-05	4.8E-05	1.2E-04	1.2E-04
Fluoride (F) Dissolved	kg/d	0.024	0.024	0.060	0.060
Iron (Fe) Dissolved	kg/d	0.32	0.32	0.80	0.80
Manganese (Mn) Dissolved	kg/d	0.14	0.14	0.35	0.35
Nickel (Ni) Dissolved	kg/d	0.0059	0.0059	0.015	0.015
Selenium (Se) Dissolved	kg/d	2.1E-04	2.1E-04	5.3E-04	5.3E-04
Sulphate (SO4) Dissolved	kg/d	61	61	151	151
Zinc (Zn) Dissolved	kg/d	0.0043	0.0043	0.011	0.011

Crystal Ball Report - Assumptions

Assumption: Log of Effective Porosity

Triangular distribution with parameters:

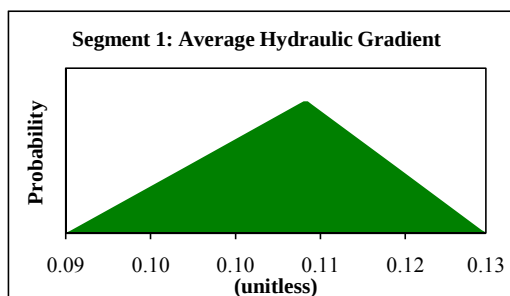
Minimum	-5.0
Likeliest	-3.0
Maximum	-1.0



Assumption: Segment 1: Average Hydraulic Gradient

Triangular distribution with parameters:

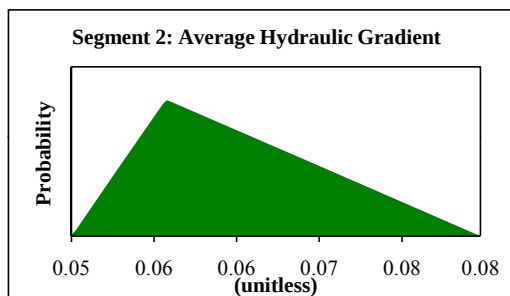
Minimum	0.09
Likeliest	0.11
Maximum	0.13



Assumption: Segment 2: Average Hydraulic Gradient

Triangular distribution with parameters:

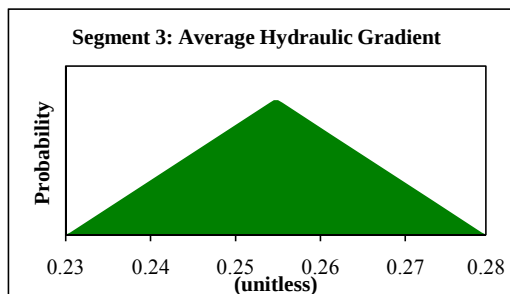
Minimum	0.05
Likeliest	0.06
Maximum	0.08



Assumption: Segment 3: Average Hydraulic Gradient

Triangular distribution with parameters:

Minimum	0.23
Likeliest	0.25
Maximum	0.28



Appendix B: Geochemical Evaluation

Appendix B1: Geochemistry of No. 4 Coal Zone Samples

*Appendix B2: Geochemistry of 7 South Hanging Wall
and Overburden Samples*

Appendix B3: Laboratory Methods

Appendix B4: Mineralogy Reports

Appendix B5: Kinetic Test Data

Appendix B6: PhreeqC Model of 4 South Mature Mine Pool



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Appendix B1:
Geochemistry of No. 4 Coal Zone Samples

Appendix B1:

Geochemistry of No. 4 Coal Zone Samples

The following appendix details the selection of the geochemical samples used for the 7 South geochemical assessment. This includes No. 4 Seam coarse reject and tailings samples manufactured at the laboratory for use in the kinetic tests as well as numerous parting and washed coal samples that were used to evaluate how the geochemical characteristics vary through the proposed 7 South Mine area. In addition, the sample selection of lithologic samples obtained stratigraphically above No. 4 Seam is discussed.

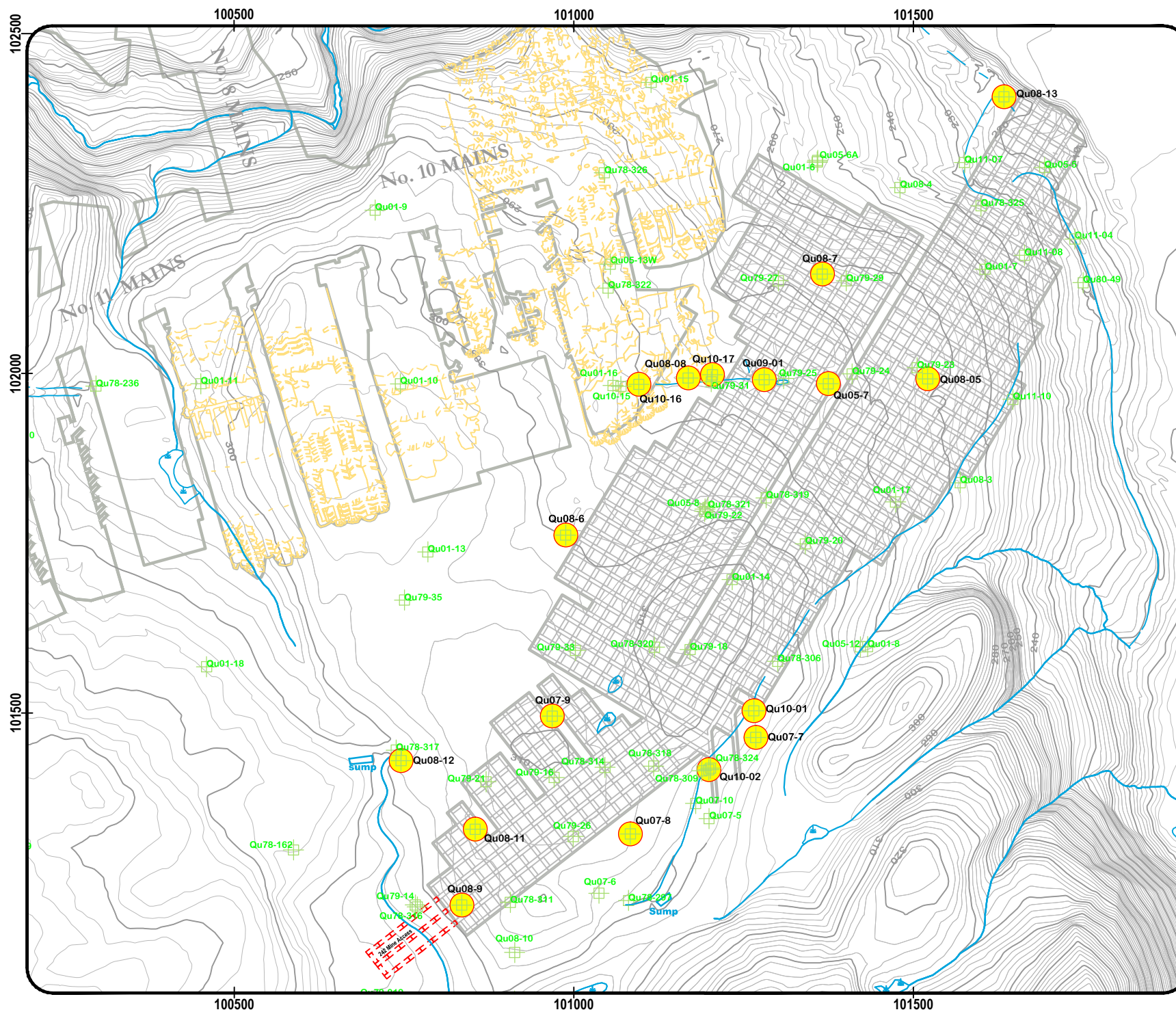
B1.1 7 South Coarse Reject and Tailings Kinetic Test Sample Selection

A large 6" diameter core was obtained from the No. 4 Coal Zone at borehole QU-09-01. This borehole is located in the central portion of the proposed mining area (Figure B1-1) and provided a bulk sample of the raw coal, which was also used for bench scale coal washing simulations to produce coarse reject and fine tailings. Raw coal samples from the core hole were placed in sealed 20 L buckets, palletized and transported to the analytical laboratory at Birtley Coal and Minerals in Calgary for coal washability testing.

The No. 4 Coal Zone includes the 4 Upper (4U) Coalbed and the 4 Lower (4L) Coalbed. The QU-09-01 core was sectioned into several different intervals extending from 0.05 m above the top of No.4 Upper Coalbed to the top of a sandstone parting midway through the No.4 Lower Coalbed. The original sample intervals and composite sample intervals are presented in Table B1-1. Two main composite samples, which correspond to the most likely mining sections identified by Quinsam Mine staff during the development and retreat of the 7 South area, were prepared to evaluate the geochemical characteristics of the raw coal and coal processing by-products from two possible mining sections:

- *No. 4 Upper Coalbed (4U)*: 0.05 m of sandstone in the roof of the No. 4 Coalbed to the top of the medial parting (Samples R1 to C2); and
- *No. 4 Lower Coalbed (4L)*: top of medial parting to parting midway through the 4 Lower Coalbed (Samples R-03 to C-07).

Coal processing byproducts were simulated by separating the raw coal samples by particle size and density. The raw composite samples were screened to obtain four size fractions, including 1) + 1/4", 2) 1/4" x 28 Mesh, 3) 28 Mesh x 100 Mesh and 4) 100 Mesh x 0. A float sink analysis was conducted on the 3 coarse size fractions at a 1.60 specific gravity. The float fraction represents the clean coal product and the sink fraction represents the coarse reject. The fine reject or tailings placed in humidity cell T1 is represented by the entire fine size fraction (100 Mesh x 0), which was not density separated.



Legend

-  Mine Workings Outline
-  GOB
-  7 South Workings
-  Boreholes
-  Swamp/Marsh
-  Holes with ABA Analyses

MINE GRID



Meters

0 100 200

Projection: Mine Grid Coordinates

Figure Title

**7 South Boreholes with
Geochemical Samples**

Figure No.

B1-1

Project No.

J885-1

Client

Hillsborough Resources

Date

Apr 7, 2011

Table B1-1:
Composite samples selected for 7 South Kinetic Tests.

Stratigraphy of QU09-01	Sample No. & Description		From (m)	To (m)	Col 1	Col 2	Col 3	HQA	HQC	T1
Sandstone (0.61 m)	R-01	roof dilution sample	45.56	46.17						
COAL (No. 4 Seam)	C-02	No. 4 Upper Coalbed	46.17							
Mudstone (0.9 m)										
COAL(No. 4 Seam)				48.71						
Sandstone (Parting)	R-03	medial parting (upper)	48.71							
Mudstone (Parting)	R-04	medial parting (lower)		48.97						
COAL (No. 4L Seam)	C-05	No. 4 Lower Coalbed	48.97							
Sandstone (parting)	R-06									
COAL (No. 4L Seam)	C-07									
Sandstone (parting)	R-08									
Coal/Mudstone	C-09									
Mudstone/Coal	R-10	Mudstone/coal								
Sandstone	R-11	floor rock samples		50.73						

Kinetic testing for the coarse reject and tailings for the 7 South Mine was undertaken using saturated and unsaturated columns (Tables B1-1 to B1-4). Unsaturated column testing is being conducted on the following 3 samples:

- Col 1: raw coal composite sample 92050 (R-01 through C-07);
- Col 2: coarse reject (+100 Mesh 1.60 Sink) 92051 from composite sample R-01 to C-02; and
- Col 3: coarse reject (+100 Mesh 1.50 Sink) 92052 from composite sample R-03 to C-07.

Saturated column testing is being conducted on 2 coarse reject samples and 1 tailings sample:

- HQA: coarse reject (+100 Mesh 1.60 Sink) 92053 from composite sample R-01 to C-07;
- HQC: coarse reject (+100 Mesh 1.60 Sink) 92054 from composite sample R-01 to C-07 (duplicate of HQA); and
- HQD: fine reject, see Table B1-2 and Figure B1-2 for composite sample details.

Humidity cell testing is being conducted on 1 tailings sample:

- T1: fine reject (-100 Mesh) 92055 from composite sample R-01 through C-07.

Kinetic testing was undertaken to evaluate the drainage chemistry and geochemical loading rates from raw coal, coarse reject and fine reject. Unsaturated trickle leach columns were constructed to simulate drainage chemistry from exposed raw coal and subaerial stockpiled coarse reject. Saturated column experiments were constructed to simulate drainage chemistry from submerged coarse reject and a standardized humidity cell test was conducted to evaluate drainage chemistry from exposed fine reject (tailings). A summary of the kinetic test set-up and operating procedures is provided in Table B1-4. For a more detailed description of the analytical techniques used in this geochemical evaluation, refer to Appendix B3.

Table B1-2:
Simplified Stratigraphy and Samples Selected for Saturated Tailings Column HQD.

Stratigraphy		Sample ID and (raw head %S)					
		Hole QU10-16	Hole QU10-17	Hole QU10-01		Hole QU10-02	
COAL (No. 5 Seam)				100114			
Siltstone/Mudstone (Parting)				100115			
*****Roof of No. 4 Coal Seam*****							
COAL (No. 4 Seam)		101601 (5.31%S)	101701	100116		100216	
Sandstone/Siltstone (Parting)			101702	100117		100217	
COAL (No. 4 Lower Seam)	Coal	101603 (1.94 %S)	101703	100118	(2.37 %S)	100218	(0.67 %S)
	Sandstone Parting		101704				
	Coal		101705				
	Sandstone Parting		101706				
	Coal		101707				
	Sandstone Parting						
	Coal						
Sandstone (Parting)							
COAL (Base of No. 4 Lower)							

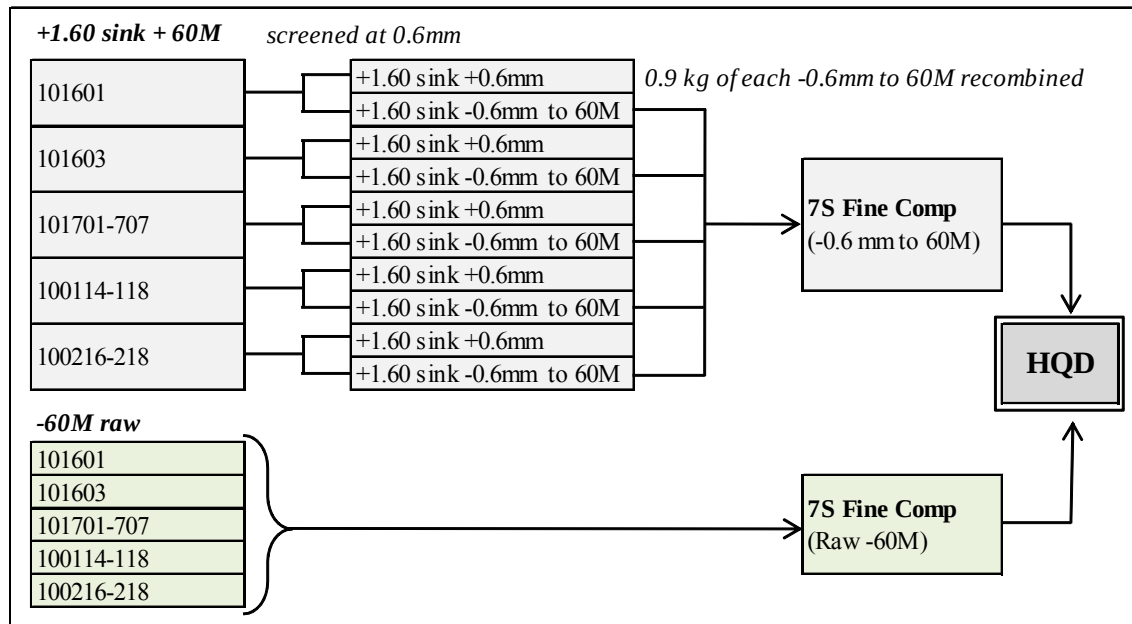


Figure B1-2: Flow sheet showing screening and washing of component samples used to develop composite tailings sample for saturated column test HQD.

Note that kinetic test HQD was initiated in February 2011; therefore leachate data is not available for presentation and discussion at this time. The saturated column was initiated to evaluate the metal leaching potential of 7 South tailings in the flooded mine workings. The tailings were produced by washing raw coal cored from four boreholes QU10-16, QU10-17, QU10-01, and QU10-02. The raw coal from these holes was screened and washed according to the flow sheet in Figure B1-2. The analyses were conducted on both the fine and coarse fractions of the sink portion of the raw coal in an attempt to evaluate how sulphur content of the original raw coal sample was portioned between the coarse reject and tailings.

**Table B1-3:
Summary of Composite Samples for 7 South Kinetic Tests**

Test	Sample	Material	Process	Stratigraphic Interval
<i>Unsaturated Columns</i>				
Col 1	92050	Raw Coal		No. 4 Upper & No. 4 Lower Coalbeds
Col 2	92051	Coarse Reject	+100 mesh 1.60 sink	No. 4 Upper Coalbed
Col 3	92052	Coarse Reject	+100 mesh 1.60 sink	No. 4 Lower Coalbed
<i>Saturated Columns</i>				
HQA	92053	Coarse Reject	+100 mesh 1.60 sink	No. 4 Upper & No. 4 Lower Coalbeds
HAC	92054	Coarse Reject	+100 mesh 1.60 sink	No. 4 Upper & No. 4 Lower
HQD	Table B1-2*	Fine Reject (tailings)	-100 mesh	No. 5, No. 4 Upper & No. 4 Lower
<i>Humidity Cell</i>				
T1	92055	Fine Reject (tailings)	-100 mesh	No. 4 Upper & No. 4 Lower

Notes: * See Table B1-2 for summary of samples used to make tailings sample HQD

Table B1-4:
Summary of 7 South Kinetic Test Set-up and Procedures.

Test	Column Dimensions		Column Packing		Volume of Initial Flushing (mL)	Current Flushing Rate / Weekly Input (mL)*	Temp (°C)	Start-Up Date	Operation Procedure	Sample Prep for Flushings
	Inner Diam. (cm)	Length (cm)	Ht. of Sample (cm)	Dry Wt. of Sample (kg)						
Unsaturated Columns										
Col 1	14.5	36	31	4.95	-	1000	20-22	27-May-09	Trickle Leach	none
Col 2	14.5	29	26	4.95	-	1000	20-22	27-May-09		none
Col 3	14.5	29	24	5	-	1000	20-22	27-May-09		none
Saturated Columns										
HQA	14	22.5	19	4.78	-	1400	20-22	3-Jul-10	Saturated, vertical flow	none
HQC	14	22.5	20	4.14	-	1400	20-22	6-May-10		none
HQD	14	20	19	3.104	-	1400	20-22	1-Feb-11		none
Humidity Cell										
T1	20	9	2	1	750	500	20-22	27-May-09	Flood Leach	stirred

Notes: * Flushing rates/weekly inputs were increased over the test period. See text in Section 3.3 for details

Subsamples of the kinetic test sample material were sent to SGS-CEMI Laboratories in Burnaby, BC for solids analyses, including acid-base accounting (ABA), solid-phase elemental determination by aqua-regia digestion and mineralogical determination, including Rietveld refined x-ray diffraction (XRD) and petrographic investigation by Scanning Electron Microscope (SEM).

Coal Wash Samples (Tailings)

In addition to the column test samples, a number of samples from the No. 4 coal zone were obtained from exploration drill core. Coal washing tests were conducted at Birtley Laboratories in Calgary to evaluate the range of chemistry that will be observed in the tailings derived from the 7 South Mine. The drill holes and stratigraphic sections from which the samples were derived are listed in Table B1-5. The location of the drill cores listed in Table B1-5 are illustrated on Figure B1-1. These samples were obtained from a number of different holes through the 7 South area and although they are not all washed to the same specifications, they do provide an estimate of the tailings characteristics from 7 South. Samples 71557 and 81520 through 81523 have been screened and washed to include the finer fractions of the coal washing by-product that will report to the tailings. The other samples include the coarser fractions up to 13 mm that will partially report to the coarse reject as well as the tailings.

**Table B1-5:
Coal Washing Tests for the 7 South Mine.**

Sample ID	Drill Hole	Zone	Head Raw	Head Raw	Sample Description
			calc ash%	calc S%	
72117	QU07-07	No. 4	20.88	1.49	13mm x 60M 1.60 sink
72118	QU07-07	ptg	51.33	0.37	raw
72119	QU07-07	No. 4L	20.93	0.62	13mm x 60M 1.60 sink
72124	QU07-08	No. 4L	27.95	0.85	13mm x 60M 1.60 sink
72128	QU07-09	No. 4	24.25	1.31	13mm x 60M 1.60 sink
72129	QU07-09	ptg	88.79	0.03	raw
72130	QU07-09	No. 4L	45.75	2.50	13mm x 60M 1.60 sink
71557	QU05-07	No. 4 & 4L	18.67	1.43	28M x 100M 1.70 sink combined with 100M x 0
81520	QU08-05	4ptg4L	21.90	1.36	28M x 100M 1.60 sink
81521	QU08-07	4ptg4L	36.81	2.66	28M x 100M 1.60 sink
81522	QU08-08	4ptg4L	32.61	2.62	28M x 100M 1.60 sink
81523	QU08-13	4ptg4L	22.68	3.70	28M x 100M 1.60 sink

Note: ptg refers to parting.

B1.2 Solid Phase Evaluation of 7 South Kinetic Test Samples

Solid phase analyses are conducted on the kinetic test samples to determine the sulphide content and neutralization potential of the tested material and to determine whether the selected samples are representative of the target stratigraphic section.

B1.2.1 Mineralogy

The results of the quantitative phase analysis for the 7 South kinetic test samples are provided in Table B1.2-1. Due to the considerable concentration of coal in the 7 South kinetic test samples, XRD results have been normalized to incorporate the organic carbon content derived during ABA analyses (Table B1.2-2) to avoid overestimating the amount of sulphide and carbonate phases identified in the 7 South samples. Also provided with the mineralogical discussion are results of the qualitative analysis of coarse reject samples 92053 (HQA) and 92054 (HQC) by SEM conducted at UNB. The complete XRD and petrographic reports are provided in Appendix B4.

Neutralizing Phases

Calcite is the primary neutralizing phase in the 7 South kinetic test samples. The raw coal from the No. 4 Coal Zone contains 3.5 wt.% calcite and < 1 wt.% dolomite. With respect to the coarse reject samples, the lowest carbonate concentrations are indicated for the No.

4 Lower Zone (Col 3) and the highest carbonate concentrations are indicated for the No. 4 Upper Zone (Col 2). The fine reject (T1) comprises notably higher concentrations of neutralizing carbonates (21 wt.%) relative to the coarse reject. Siderite is identified in both tailings samples (T1 and HQD), but in minor concentrations (<1 wt.%).

Sulphur Phases

Sulphur occurs primarily in the form of pyrite in each of the 7 South kinetic test samples (Table B1.2-1). Slightly higher concentrations of pyrite are indicated for the No. 4 Upper Zone (Col 2) compared to the No. 4 Lower Zone (Col 3). The raw coal and fine reject samples contain slightly less sulphide concentrations compared to the coarse reject.

Table B1.2-1:
Results of Semi-Quantitative Phase Analysis (wt.%) for 7 South Kinetic Test Samples (normalized to incorporate organic carbon content measured during ABA).

Mineral	Ideal formula	Col 1 4U&4L raw coal	Col 2 4U CCR	Col 3 4L CCR	HQA 4U&4L CCR	HQC 4U&4L CCR	HQD ¹ 4U&4L tailings	T1 4U&4L tailings
Quartz	SiO ₂	15.2	22.4	46.8	33.1	33.4	32.2	13.7
Kaolinite	Al ₂ Si ₂ O ₅ (OH) ₄	22.3	27.1	22.0	26.7	25.8	30.6	19.9
K-feldspar	KAlSi ₃ O ₈	-	2.8	5.0	5.8	6.2	3.2	2.0
Plagioclase	NaAlSi ₃ O ₈ – CaAl ₂ Si ₂ O ₈	-	-	2.7	2.4	1.8	0.8	-
Anatase	TiO ₂	-	-	-	-	-	0.8	-
Calcite	CaCO ₃	3.5	9.1	0.7	4.6	4.1	6.4	14.3
Dolomite	CaMg(CO ₃) ₂	0.6	0.3	2.1	1.0	0.8	1.6	2.7
Siderite	FeCO ₃	-	-	-	-	-	0.8	0.6
Pyrite	FeS ₂	2.8	7.7	4.9	5.4	6.4	3.2	3.9
Marcasite	FeS ₂	-	-	-	-	-	0.8	-
Organic Carbon ²		55.7	30.5	15.9	21.1	21.5	19.4	43.6
<i>Total</i>		<i>100.0</i>	<i>99.9</i>	<i>100.1</i>	<i>100.0</i>	<i>100.1</i>	<i>100.0</i>	<i>100.6</i>

Notes: 1. value indicated for dolomite is actually ankerite-dolomite ((Ca(Fe²⁺,Mg,Mn)(CO₃)₂ – CaMg(CO₃)₂);
2. Organic carbon from ABA results provided in Table B1-4

In addition to pyrite, petrographic observations identified minor amounts of sulphur hosted by barite (BaSO₄) and Fe-sulphate. Additionally, sulphur is hosted in coal, with contents ranging from 0.75 to 2.5 wt.% in sample 92053 (HQA) and from 0.8 to 2.3 wt.% in sample 92054 (HQC) (Appendix B4). In general, coal fragments that contain pyrite have higher sulphur contents than coal fragments that lack pyrite. In some cases, these fragments also contain fine-grained interstitial calcite, kaolinite, or more rarely Fe-sulphate.

Textured porous pyrite occurs in discrete fragments, together with equant, anhedral grains of Fe-sulphate and minor framboidal pyrite (Appendix B4). Pyrite is more abundant in sample 92054 than in sample 92053, and the relative abundance of framboidal pyrite with respect to massive pyrite is higher. The pyrite fragments may be mantled by a thin rind of Fe-sulphate, which contains minor and varied concentrations of Mg and As. Contents of As₂O₃ in the Fe-sulphate range from 0.06 to 0.80 wt.% in sample 92053 and from 0.07 to 0.87 wt.% in sample 92054. Similarly, framboidal pyrite in the 5South CCR does not contain detectable As contents. Rather the As in the 5South CCR occurs in trace quantities of the mineral safflorite [(Co,Fe)As₂]. Safflorite was not identified during petrographic evaluation of the 7 South CCR samples.

B1.2.2 Acid-Base-Accounting Analysis

Acid-base-accounting results for the 7 South kinetic test samples are presented in Table B1.1-7. The paste pH of 7 South raw coal sample is neutral; however, the coarse and fine reject samples have slightly lower pH values ranging from 6.5 to 6.7.

Table B1.2-2:
Acid Base Accounting Results for 7 South Kinetic Test Samples.

Parameter	Unit	Col 1	Col 2	Col 3	HQA	HQC	HQD	T1
		4U&4L	4U	4L	4U&4L	4U&4L	4U&4L	4U&4L
		raw coal	CCR	CCR	CCR	CCR	tailings	tailings
Paste pH		7.0	6.7	6.6	6.6	6.5	7.2	6.5
Total S	%	2.17	4.03	2.82	3.46	3.79	2.52	2.6
Sulphide S	%	1.27	2.9	2.32	2.83	3.25	2.48	1.68
Sulphate S	%	0.03	0.1	0.03	0.07	0.07	0.1	0.09
Organic S	%	0.87	1.03	0.47	0.56	0.47	0.02	0.83
SAP	%	39.7	90.6	72.5	88.4	102	77.5	78.4
Total C	%	56.1	31.6	16.3	21.9	22.2	20.5	45.3
TIC	%	0.44	1.1	0.37	0.8	0.69	1.18	1.71
TOC	%	55.7	30.5	15.9	21.1	21.5	19.4	43.6
CaNP	kg CaCO ₃ /t	36.7	91.7	30.8	66.7	57.5	97.5	143
Modified NP	kg CaCO ₃ /t	36.3	84.9	24.3	61.0	51.7	76.9	135
NPR (ModNP/SAP)		0.91	0.94	0.34	0.69	0.51	0.99	1.72

Notes: SAP = calculated from sulphide S * 31.25;
CaNP calculated from total inorganic carbon (TIC);
TOC = total organic carbon calculated from difference between Total C and TIC; and
Modified NP is corrected for siderite content.

Raw Coal (Col 1) and Coarse Reject (Col 2, Col3, HQA and HQC)

The raw coal sample selected for kinetic testing (Col 1) has a sulphur content of 2.2 %S while the sulphur content of the coarse reject samples varies with the coal interval from which it is extracted, ranging from 2.8 %S in the 4L (Col 3) to 4.0 %S in the 4U coarse reject (Col 2) (Table B1.2-2). The combined 4U and 4L products (HQA and HQC) contain an intermediate amount of approximately 3.5 %S. Based on the exploration drill core results, the sulphur content in the No. 4 Coal Zone coarse reject is expected to range from 1.0 to 5.0 %S; therefore the samples selected for kinetic testing will provide a conservative best-estimate of the leachate that can be expected from the 7 South coarse reject. When partings comprise a significant proportion of the mined coal section, the coarse reject's ABA characteristics are governed by the parting characteristics rather than the raw coal. However not all partings contain high sulphur contents. Mudstone and sandstone parting samples from drill cores QU-07-7 and QU-07-9, respectively, have total sulphur values of < 0.25 %S. Similarly, parting samples from drill cores QU-07-8, QU-08-5 through QU-08-9 and QU-08-11 also have low total S values of < 0.35 %S.

Slightly greater values of carbonate neutralization potential (CaNP) relative to modified NP values indicate that Fe-bearing carbonates may be present in the No. 4 Zone samples. Fe-bearing carbonates do not neutralize acid as efficiently as calcite and NP values corrected for Fe-carbonates (modified NP); therefore the modified NP is applied during ARD predictions in order to avoid overestimating the neutralization capacity of a sample. Similar to sulphur distribution in the No. 4 Coal Zone, the 4U coarse reject (Col 2) contains notably higher NP (85 mg CaCO₃/t) compared to the 4L coarse reject (Col 3) (< 25 mg CaCO₃/t). The combined products (HQA and HQC) contain an intermediate amount of 52 – 61 mg CaCO₃/t. The quantity of NP in the coarse reject also appears to reflect the concentrations in the partings given that the raw coal sample (Col 1) contains only 36 mg CaCO₃/t.

The net potential ratio (NPR), which compares the relative proportions of NP to AP, is used to delineate PAG from non-PAG samples using the criteria specified in the BC Ministry of Energy Mines and Petroleum Resources regulatory guidelines (Price & Errington, 1998). For the purpose of assessing the 7 South kinetic test samples, modified NP is used to estimate NP available from carbonate minerals and AP is calculated from sulphide sulphur. Samples with an NPR < 2.0 are designated as PAG, taking into account both the regulatory guidelines and the scrutiny that was undertaken to select the most appropriate and conservative measure of AP and NP. Refining the PAG criterion to NPR = 2.0 is deemed appropriate for this study due to the conservative measure of sulphur and the selection of an NP method that accounts for the mineralogy of the deposit. NPR values < 2.0 were consistently observed for the 7 South kinetic test samples from

borehole QU-09-01, indicating that raw coal and coarse reject from the No.4 Zone selected for the 7 South kinetic tests is predicted to be PAG (Table B1.2-2).

Fine Coal Reject (Tailings) (T1 and HQD)

The tailings samples (T1 and HQD) selected for kinetic testing contain ~2.5 % total sulphur, suggesting slightly lower sulphur content in the tailings compared to the coarse reject (2.8 – 4.0 %S) and slightly higher concentrations sample (Table B1.2-2). Table B1.2-3 presents the ABA results for the individual and composite samples used to generate kinetic test sample HQD. Notably high concentrations of total sulphur (6 – 8 %S) were measured in the samples 101601 (top of No. 4 Coal Seam) from drill hole QU10-16 and composite samples 100114 – 100118 (No. 5 and No. 4 upper and lower coal seams as well as mudstone and sandstone partings) from drill hole QU10-01.

The lowest total sulphur values (< 0.6 %S) were measured in composite sample 100216 – 100218 from drill core QU10-02. The total sulphur values measured in component tailings samples reflect the sulphur concentrations measured in composite raw coal (head) samples. The results presented in Table B1.2-3 indicate higher total sulphur values (> 6 %S) for samples which contain greater amounts of coal and lower total sulphur values (< 2 %S) for samples which contain greater or equal amounts of sandstone and coal. Slightly lower paste pH values of 6.4 – 7.0 are associated with the total sulphur values of > 6 %. There is no correlation between grain size and total sulphur concentrations in the samples of Table B1.2-3.

Sample T1 comprises a total carbon content of 45 % and thus contains a large fraction of coal. Tailings sample T1 also comprises a notably higher NP value of 135 mg CaCO₃/t compared to the raw coal sample (Col 1) from which the tailings sample was derived and the coarse reject samples from similar intervals (HQA and HQC), suggesting that the carbonate phases are being concentrated in the fine reject waste stream. Sample HQD has a lower NP value of 77 mg CaCO₃/t (Table B1.2-2). The highest modified NP value is derived from the composite sample with the lowest total sulphur values (sample 100216 – 100218; Table B1.2-3). Unlike the total sulphur values, NP concentrations appear to be reflective of particle size, with higher NP values concentrated in the -6 mm fraction compared to the +6 mm fraction of the same sample.

Table B1.2-3:
Acid Base Accounting Results of Component Samples Used to Develop Kinetic Test Sample HQD.

Sample ID	Paste pH	Total S %	Sulphide S %	Sulphate S %	Organic S %	SAP kg CaCO ₃ /t	Total C %	CO ₂ %	TOC	CaNP kg CaCO ₃ /t	ModNP kg CaCO ₃ /t	ModNP /SAP	Head Raw (%S)
Samples Used to Generate 7S Fine Comp -0.6 mm to 60 mesh + 1.6 sink													
101601 (+0.6mm)	6.4	8.01	7.89	0.29	<0.02	247	13.5	3.11	12.7	70.7	46.6	0.2	5.31
101601 (-0.6mm)	6.5	6.33	6.28	0.25	<0.02	196	16.2	3.26	15.3	74.1	57.3	0.3	
101603 (+0.6mm)	7.3	1.49	1.41	0.06	0.02	44.1	15.3	3.81	14.3	86.6	69.5	1.6	1.94
101603 (-0.6mm)	7.4	1.58	1.45	0.06	0.07	45.3	20.5	4.29	19.4	97.5	76.0	1.7	
101701-707 (+0.6mm)	7.3	1.61	1.67	0.07	<0.02	50.3	11.6	2.71	10.9	61.6	48.1	1.0	1.97
101701-707 (-0.6mm)	7.4	1.43	1.39	0.07	<0.02	43.4	13.8	3.31	12.9	75.2	56.7	1.3	
100114-118 (+0.6mm)	6.8	7.9	8.39	0.19	<0.02	247	21.7	3	20.9	68.2	59.6	0.2	2.37
100114-118 (-0.6mm)	7.0	6.15	6.36	0.21	<0.02	192	26.0	5.94	24.4	135.0	118.8	0.6	
100216-218 (+0.6mm)	7.5	0.28	0.24	0.02	0.02	7.5	25.6	3.78	24.5	85.9	81.5	10.9	0.67
100216-218 (-0.6mm)	7.5	0.62	0.57	0.06	<0.02	17.8	29.6	5.72	28.0	130.0	124.9	7.0	
Composites Used to Generate 7S Tailings Comp for Kinetic Test HQD													
7S Fine Comp (-0.6mm to 60 M)	7.2	2.69	2.43	0.12	0.14	75.9	18.9	3.92	17.8	89.1	74.9	1.0	
7S Fine Comp Raw (-60M)	7.3	2.48	2.3	0.11	0.07	71.9	41.6	5.1	40.2	115.9	101.4	1.4	

Notes: SAP = calculated from total S * 31.25; total S is used to calculate AP when sulphide S is higher than total S
CaNP calculated from total inorganic carbon (TIC);
TOC = total organic carbon calculated from difference between Total C and TIC; and
Modified NP is corrected for siderite content.

With the exception of composite samples 100216-100218 (-6 mm and +6 mm fractions) (Table B1.2-3) which have total sulphur values of $< 0.6\%$ and NP > 80 mg CaCO₃/t, all tailings samples from the 7 South deposit have NPR values of < 2.0 . Sample T1 has an NPR value of 1.7, which approaches the PAG cut-off value of 2 and places the T1 sample in the uncertain range for acid generating potential. Monitoring of the tailings produced during operations at the 7 South Mine will be required to confirm the range of NPR and sulphur values of the fine reject and conclusively establish the overall acid generating potential for the 7 South tailings.

Coal Washing Samples

The results of the ABA analyses for the coal wash samples are presented in Table B1.2-4. Only one sample (sample 72130) out of the 12 samples tested has an NPR value of < 2.0 , which is reflective of a relatively high total sulphur value of 2.88 % and low modified NP value of 50 mg CaCO₃/t. Although the other coal wash samples have NPR values of > 2.0 , paste pH values for half of the samples are < 7.0 . Total sulphur concentrations in the coal wash samples range from 0.12 to 4.46 %S, the majority of which is made up of sulphide and/or organic sulphur. The total sulphur values in tailings samples are reflective of the original sulphur values in the respective raw coal samples. Modified NP concentrations range from 15 to 344 mg CaCO₃/t; however the majority of the samples have concentrations of > 100 mg CaCO₃/t. Overall, the large range in sulphur species and NP values for the coal wash samples are consistent with the ranges observed in kinetic test samples (Table B1.2-3).

Table B1.2-4:
Acid Base Accounting Results for Coal Washing Samples.

Stratigraphy	Sample ID	Paste pH	Total S %	Sulphide S %	Sulphate S %	Organic S %	SAP kg CaCO ₃ /t	Total C %	CO ₂ %	TOC %	CaNP kg CaCO ₃ /t	Mod NP kg CaCO ₃ /t	NPR (Mod NP/SAP)	Head Raw (%S)
No.4 Coal Seam	72117	6	2.02	1.7	0.15	0.17	53.1	25	6.67	23.2	152	155	2.9	1.49
	72128	7.1	1.6	1.33	0.02	0.25	41.6	24.2	4.66	22.9	106	100	2.4	1.31
No.4 Lower Coal Seam	72119	7.5	0.58	0.25	0.01	0.32	7.8	35.2	6.67	33.3	152	148	18.9	0.62
	72124	7.4	0.62	0.39	<0.01	0.23	12.2	27	3.67	26	83.4	86.9	7.1	0.85
	72130	6.2	2.83	2.57	0.08	0.18	80.3	12.4	2.6	11.7	59.1	50.4	0.6	2.50
Raw Parting	72118	7	0.4	0.1	<0.01	0.3	3.1	30.7	0.71	30.5	16.1	15.4	4.9	0.37
	72129	7.9	0.12	0.05	<0.01	0.07	1.6	4.93	2.5	4.2	56.8	49.8	31.9	0.03
No.4 & 4L Seams	71557	6.6	2.1	1.56	0.31	0.23	48.8	46.9	5.9	45.3	134	145	3	1.43
	81520	6.8	1.64	1.5	0.06	0.08	46.9	16.7	20.2	11.1	458	446	9.5	1.36
No. 4 & 4L Seams (& parting)	81521	7.6	2.19	1.36	0.61	0.22	42.5	11.1	6.93	9.2	158	168	3.9	2.66
	81523	6	4.46	3.53	0.45	0.48	110.3	23	14.6	19	333	344	3.1	3.70
	81522	5.9	2.99	2.34	0.27	0.38	73.1	14.1	9.57	11.5	218	220	3	2.62

Notes: SAP = calculated from sulphide S * 31.25;
CaNP calculated from total inorganic carbon (TIC);
TOC = total organic carbon calculated from difference between Total C and TIC; and
Modified NP is corrected for siderite content.

B1.2.3 Solid-Phase Elemental Analyses

The solid phase metal concentrations measured in the 7 South kinetic test samples, HQD component samples and coal wash samples, respectively, are compared to average metal concentrations of the earth's crust in Tables B1.2-5, B1.2-6 and B1.2-7. An indicator of significant solid-phase enrichment is assigned arbitrarily herein to be values greater than or equal to three times the average abundance in the earth's crust and are shaded in the table.

Raw Coal (Col 1) and Coarse Coal Reject (Col 2, Col3, HQA and HQC)

Metalloids As, B and Se are consistently enriched in the 7 South kinetic test samples with respect to average crustal concentrations (Table B1.2-5). Arsenic is enriched by more than 10 times the crustal average, and is highest in the No. 4 upper coal seam sample (Col 2). Although Se is enriched in the No. 4 strata, the concentrations are lower than observed in the coal-bearing stratigraphy in northeast British Columbia, which consistently have average concentrations >1 ppm. Boron is also enriched in the all samples comprised of the No. 4 upper coal seam, but is below detection in the No. 4 lower seam sample (Col 3).

Fine Coal Reject (Tailings) (T1 and HQD)

The kinetic tailings samples are also enriched in As and Se with respect to average crustal concentrations (Table B1.1-5). Sample T1 is also enriched in B, which is consistent with the raw coal and coarse reject samples from the No. 4 upper and lower coal seams from the same bore hole QU-09-01. Only sample HQD is enriched in Sb, and by two orders of magnitude higher than all samples from borehole QU-09-01. The elevated Sb concentrations of the HQD and its component samples may be related to the spatial location of boreholes 10-16, -17, -01 and -02, which are located 400 to 500 m south of borehole QU-09-01 in the 7 South deposit nearer the portal pit (Figure B1.1). Concentrations of Al, As, Cd, Cr, Cu, Mn, Mo, Pb, Se, V and Zn are also higher in sample HQD relative to the other 7 South kinetic test sample.

A closer look at the component samples used to develop kinetic test sample HQD demonstrates that samples 101601 and 101603 (+0.6mm and -0.6mm fractions) contain some of the highest metal concentrations, including As, Cd, Cr, Fe, Mn, Mo, Ni, Pb, Sb, Se, Tl and Zn (Table B1.2-6). All component samples to kinetic test sample HQD are enriched As, Sb and Se. Note that Sb concentrations are particularly enriched in the -0.6 mm fraction of each component sample to HQD. The majority of the Sb is contributed by samples 101601 and 101603 from hole QU10-16.

Coal Washing Samples

Consistent with other tailings samples from the 7 South deposit, the coal washing samples are consistently enriched in As and Se (Table B1.1-7). In particular, Se is enriched in samples that contain No.4L coal seam. Antimony is also enriched, but only in two samples, one from hole QU-08-13 (sample 81523) located on the northernmost section of the deposit and the other from QU-07-09 (sample 72128) located in the southern end of the deposit.

Overall As and Se are consistently enriched in 7 South coal, coarse reject and tailings samples regardless of coal seam or spatial position within the 7 South deposit. Antimony is also enriched, but not in samples from borehole QU-09-01.

Table B1.2-5:
Elemental Concentrations for 7 South Kinetic Test Samples Compared to Average Abundance in the Earth's Crust¹.

Element	Unit	Col 1 4U&4L raw coal	Col 2 4U CCR	Col 3 4L CCR	HQA 4U&4L CCR	HQC 4U&4L CCR	T1 4U&4L tailings	HQD 4U&4L tailings	Av. Crustal ²
Ag	ppb	23	34	27	28	32	28	31	75
Al	%	0.15	0.26	0.26	0.24	0.22	0.08	0.29	8.23
As	ppm	58.6	92.2	42	59.7	68.1	86.1	117	1.8
B	ppm	145	62	<10	34	30	96	27	10
Ba	ppm	28.4	32.5	28.4	28.1	27.7	57.4	29.1	425
Bi	ppm	0.08	0.09	0.08	0.09	0.1	0.06	0.08	0.17
Ca	%	1.42	3.45	0.82	2.29	1.96	4.83	2.97	4.15
Cd	ppm	0.09	0.12	0.11	0.1	0.09	0.13	0.15	0.15
Co	ppm	7.8	5.7	15.8	10.7	11.6	7.1	13.2	25
Cr	ppm	23.3	33.6	42.1	45.1	42.7	6	74.2	102
Cu	ppm	35.9	27	33.3	30.1	29.5	32.3	39.3	60
Fe	%	1.26	3.25	2.45	2.79	3.19	1.73	2.78	5.63
Hg	ppb	98	173	152	167	167	90	121	85
Mg	%	0.08	0.12	0.17	0.14	0.15	0.22	0.24	2.33
Mn	ppm	75	163	104	148	137	224	279	950
Mo	ppm	1.21	0.9	1.06	0.99	1.15	0.94	1.61	1.5
Ni	ppm	8.3	7	21.7	13.9	14.7	9.3	19	84
Pb	ppm	3.21	4.57	3.04	3.85	4.3	4.07	5.91	14
Sb	ppm	0.27	0.41	0.21	0.29	0.31	0.3	28.9	0.2
Se	ppm	0.3	0.4	0.4	0.3	0.4	0.4	0.5	0.05
Th	ppm	0.5	1.5	0.9	1	1.1	0.5	0.9	9.6
Ti	%	0.026	0.025	0.015	0.016	0.016	0.011	0.021	0.565
Tl	ppm	<0.01	0.04	0.01	0.04	0.04	0.02	0.29	0.85
V	ppm	61	42	63	49	49	59	72	120
Zn	ppm	17.6	27.8	50.7	37.9	36	51.5	50.8	70

Notes: 1. Light shaded values exceed the average continental crust concentration by 3 x's, dark shaded values exceed by 10 x's; and
2. Average continental crustal abundances according to Price (1997). Bold values are from CCR (1985).

Table B1.2-6:
Elemental Concentrations of Component Samples Used to Develop Kinetic Test Sample HQD Compared to Average Abundance in the Earth's Crust¹.

Sample ID	Ag ppb	Al %	As ppm	Bi ppm	Cd ppm	Co ppm	Cr ppm	Cu ppm	Fe %	Hg ppb	Mn ppm	Mo ppm	Ni ppm	Pb ppm	Sb ppm	Se ppm	Tl ppm	Zn ppm
<i>Samples Used to Generate 7S Fine Comp -0.6 mm to 60 mesh + 1.6 sink</i>																		
101601 (+0.6mm)	35	0.43	310	0.12	0.44	20.1	98.7	35.3	7.12	203	460	2.45	28.2	17.6	33.3	0.6	2.61	78
101601 (-0.6mm)	31	0.53	229	0.11	0.46	17.1	133	34.1	5.98	172	460	2.63	27.7	15.1	46.6	0.4	1.39	90.9
101603 (+0.6mm)	30	0.46	78.3	0.08	0.11	16.2	109	37.5	1.94	51	246	0.65	19.2	3.23	49.2	0.2	0.3	46.3
101603 (-0.6mm)	37	0.41	77.3	0.13	0.11	16.1	127	37.9	2.15	47	272	1.52	21.4	4.03	58.8	0.2	0.3	45.1
101701-707 (+0.6mm)	27	0.47	113	0.09	0.08	11.2	114	28.4	2.06	183	232	0.61	18.8	3.82	0.16	0.6	0.07	42.2
101701-707 (-0.6mm)	28	0.51	106	0.08	0.1	11.4	152	31.3	2.04	107	256	1.45	23.1	4.05	0.66	0.3	0.08	48.5
100114-118 (+0.6mm)	82	0.7	170	0.08	0.13	25.3	37.8	100	6.31	329	136	0.78	35.6	3.73	0.13	0.9	0.08	57.4
100114-118 (-0.6mm)	59	0.67	159	0.06	0.1	20.2	51.1	69.0	5.29	499	182	1.01	26.2	4.13	0.88	0.8	0.05	39.5
100216-218 (+0.6mm)	47	0.57	33.3	0.08	0.07	5.3	22.9	66.4	0.67	37	81	0.34	7.5	2.82	0.09	0.2	<0.02	14
100216-218 (-0.6mm)	49	0.59	49.7	0.11	0.08	6.0	50.9	53.3	1.12	88	135	0.7	9.8	3.02	0.65	0.4	<0.02	15.8
<i>Composites Used to Generate 7S Tailings Comp for Kinetic Test HQD</i>																		
7S Fine Comp (-0.6mm to 60M)	37	0.4	120	0.09	0.15	13.7	91.8	39.3	2.87	118	285	1.72	21.1	6.39	24.8	0.4	0.33	48
7S Fine Comp Raw (-60M)	36	0.28	155	0.07	0.15	11	49.8	47.6	2.48	79	290	1.42	15.1	5.19	54.4	0.3	0.15	65.3
Average Crust	75	8.23	1.8	0.17	0.15	25	102	60	5.6	85	950	1.5	84	14	0.2	0.05	0.85	70

Notes: 1. Light shaded values exceed the average continental crust concentration by 3 x's, dark shaded values exceed by 10 x's; and
2. Average continental crustal abundances according to Price (1997). Bold italic values are from CRC (1985).

Table B1.2-7:
Elemental Concentrations of Coal Washing Samples Compared to Average Abundance in the Earth's Crust¹.

Element	Unit	No.4 Coal Seam		No.4 Lower Coal Seam			Raw Parting		4&4L	4prrtg4L				Av Crust
		72117	72128	72119	72124	72130	72118	72129	71557	81520	81521	81523	81522	
Ag	ppb	36	39	37	44	21	108	19	39	33	91	33	29	75
Al	%	0.37	0.33	0.26	0.37	0.28	0.37	0.34	0.16	0.26	0.26	0.24	0.22	8.23
As	ppm	108	58.4	28.9	6.4	38.4	41.7	5.4	36.6	19.4	80.9	165	146	1.8
B	ppm	35	45	55	26	<20	37	<20	82	<20	<20	<20	<20	10
Ba	ppm	22.9	23.5	26.7	28.8	22.3	24.1	25.4	71.4	41.2	34.4	23	32.8	425
Bi	ppm	0.09	0.08	0.06	0.06	0.09	0.13	0.11	0.07	0.04	0.07	0.05	0.07	0.17
Ca	%	6.29	3.63	5.44	3.14	1.54	0.38	1.41	5.59	17.4	6.89	14.1	8.56	4.15
Cd	ppm	0.03	0.09	0.05	0.06	0.11	0.07	0.1	0.12	0.07	0.12	0.09	0.08	0.15
Co	ppm	3.5	7.7	5.5	6	23.4	4.7	7.5	6.2	4.4	12.2	15.2	7.5	25
Cr	ppm	9.2	37.2	25	29.8	66.8	19.2	71.7	20	17.2	71	35.9	55.8	102
Cu	ppm	73.3	39.5	52.4	77.9	33	52.9	26.9	29.7	14.3	22.9	30.3	22.4	60
Fe	%	1.87	1.89	0.74	0.82	2.89	0.36	0.93	1.73	1.62	2.12	3.21	2.8	5.63
Hg	ppb	64	100	29	60	265	16	21	96	210	107	126	133	85
Mg	%	0.11	0.2	0.15	0.13	0.29	0.09	0.23	0.21	0.17	0.25	0.16	0.24	2.33
Mn	ppm	204	185	139	78	219	25	208	159	381	327	368	437	950
Mo	ppm	0.35	0.75	0.43	0.59	1.71	0.57	0.22	0.92	0.4	0.71	1.34	0.83	1.5
Ni	ppm	4.6	8.7	6.1	7.1	33.4	5	10.9	6.6	5.9	16.3	11.6	10.8	84
Pb	ppm	1.87	4.19	3.01	1.86	2.82	3.92	2.53	7.15	4.63	4.74	2.75	5.73	14
Sb	ppm	0.07	0.61	0.08	0.07	0.2	0.17	0.11	0.22	0.06	0.37	11.9	0.43	0.2
Se	ppm	0.4	0.3	0.3	0.3	0.6	0.2	0.2	0.5	0.5	0.5	0.7	0.7	0.05
Th	ppm	0.8	0.9	0.5	0.5	1	3.3	1.2	0.7	1	0.9	0.7	0.7	9.6
Ti	%	0.015	0.023	0.032	0.023	0.011	0.032	0.007	0.026	0.007	0.007	0.016	0.01	0.565
Tl	ppm	0.19	0.11	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.02	0.06	0.06	0.1	0.85
V	ppm	31	52	50	54	51	91	47	43	13	29	37	38	120
Zn	ppm	11.7	21.5	11.7	10.2	51.2	12.3	62.4	22.5	18.7	36.7	20.2	38.5	70

Notes: 1. Light shaded values exceed the average continental crust concentration by 3 x's, dark shaded values exceed by 10 x's; and
2. Average continental crustal abundances according to Price (1997). Bold values are from CCR (1985).

B1.3.1 Kinetic Test Leachate Chemistry

The objective of conducting the unsaturated column tests (Col 1, 2 and 3) and humidity cell test (T1) is to obtain a direct indication of expected drainage chemistry from the raw coal, coarse reject and tailings if left exposed and to provide an estimate to the timing of NP depletion and the potential onset of concomitant acidic conditions. The objective of conducting the saturated column tests (HQA and HQC) is to evaluate the potential benefit and improvement of drainage chemistry if the coal waste is placed in subaqueous storage. The leachate concentrations from the unsaturated and saturated columns are presented in comparison to British Columbia Water Quality Guidelines for freshwater aquatic life. Where guidelines are dependent on hardness, a value of 45 mg CaCO₃/L has been used in calculating the guideline, which is the average hardness of Middle Quinsam Lake. The complete leachate data from the kinetic tests are presented in Appendix B4.

To evaluate the rate of sulphide oxidation and NP depletion, the unsaturated column leaching method was changed at mid-test by increasing the volumes of water added to Col 1, 2 and 3 each cycle. The rationale in the adjustment was to increase the dilutionary capacity of the rinse water and avoid precipitation of gypsum in the column, which would remove Ca and SO₄ from the solution and potentially underestimating the sulphate mass released via sulphide oxidation. Initially, 300 ml of water were added to the unsaturated columns. After cycle 35, 600 ml of water were added each cycle to Col 1 and Col 2 and after cycle 44, 1000 mL water was added. The volume of water added each cycle to Col 3 was increased from 300 mL to 1000 mL after cycle 44. Similarly, the volume of water continually passed through the saturated columns was increased from approximately 875 mL per week for HQA to approximately 1415 mL per week. Test HQC was initiated at 1400 mL per week. Further details of the methods and test procedures for the kinetic tests are discussed in Appendix B3.

Table B1.3-1 provides a summary of the parameters which exceed guidelines in leachate from the 7 South kinetic tests. In particular, sulphate and dissolved As, B, Cd, Co, Cu, Mn, Ni, Se and Zn are indicated to be elevated with respect to BC Water Quality Guidelines for Freshwater Aquatic Life in leachate from each of the 7 South kinetic tests, including both unsaturated and saturated columns. In addition, Cl, Al, Fe and Pb are indicated to be elevated in leachate from the No. 4 Upper and No. 4 Lower coarse reject unsaturated columns (Col 2 and Col 3) and Cr is indicated to be elevated in the composite No. 4 Upper and Lower coarse reject saturated columns (HQA and HQC). The following sections provide a detailed discussion of the unsaturated and saturated leachate chemistry for the raw coal, coarse reject and tailings from the No. 4 Coal Zone.

Table B1.3-1:
Summary of Guideline Exceedences in Leachate from 7 South Kinetic Tests.

Test	pH	Alk.	SO ₄	Cl	Al	As	B	Cd	Cr	Co	Cu	Fe	Pb	Li	Mn	Ni	Se	Ag	Tl	V	Zn
<i>Unsaturated Columns</i>																					
Col 1		x	x			x	x	x		x	x			x	x	x	x	x			x
Col 2	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x			x
Col 3	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
<i>Saturated Columns</i>																					
HQA	x	x	x			x		x	x	x	x				x	x	x				
HQC	x	x	x			x	x	x	x	x	x	x			x	x	x	x			x
<i>Tailings Humidity Cell</i>																					
T1		x	x			x	x	x		x	x		x		x	x	x				x

B1.3.1.1 No. 4 Coal Zone Unsaturate Raw Coal (Col 1) and Coarse Reject (Col 2 & 3)

pH and Anions

Leachate from unsaturated raw coal of the No. 4 Coal Zone and unsaturated coarse reject of the upper portion of the No. 4 Coal Zone have slightly alkaline pH (7 – 8) for the duration of the kinetic tests. Leachate from the unsaturated coarse reject of the lower portion of the No. 4 Coal Zone has slightly alkaline pH for the first 50 cycles, but decreases to < 3 and remains acidic for the rest of the kinetic test. The decrease in pH for the unsaturated 4L coarse reject (Col 3) is consistent with a large decrease (to below detection) in alkalinity followed by a notable increase in sulphate production from ~ 1000 mg/L to > 3000 mg/L (Figure B1.3-1). Sulphate concentrations in leachate from the raw coal seem to have stabilized in the 500 mg/L range during the last 30 available test cycles while sulphate concentrations in the unsaturated 4U coarse reject seem to have stabilized in the 1000 – 1500 mg/L range. Sulphate concentrations in leachate from the unsaturated raw coal and coarse reject are greater than the acute (100 mg/L) and chronic (50 mg/L) guidelines for every cycle of the kinetic tests.

The high sulphate concentrations in the exposed raw coal and unsaturated coarse reject indicate that the pyrite contained in the No.4 coal and partings oxidizes at an accelerated rate. However, with the exception of the 4L coarse reject, the leachate has been maintained at pH > 7.5 and measured alkalinity > 40 mg CaCO₃/L. This geochemical signature indicates that the carbonate minerals are capable of buffering pH in an acceptable range despite the accelerated sulphide oxidation kinetics displayed by the reactive pyrite. However, when the carbonate minerals are depleted, acidic conditions are anticipated to prevail, as is observed for the unsaturated 4L coarse reject sample (Col 3).

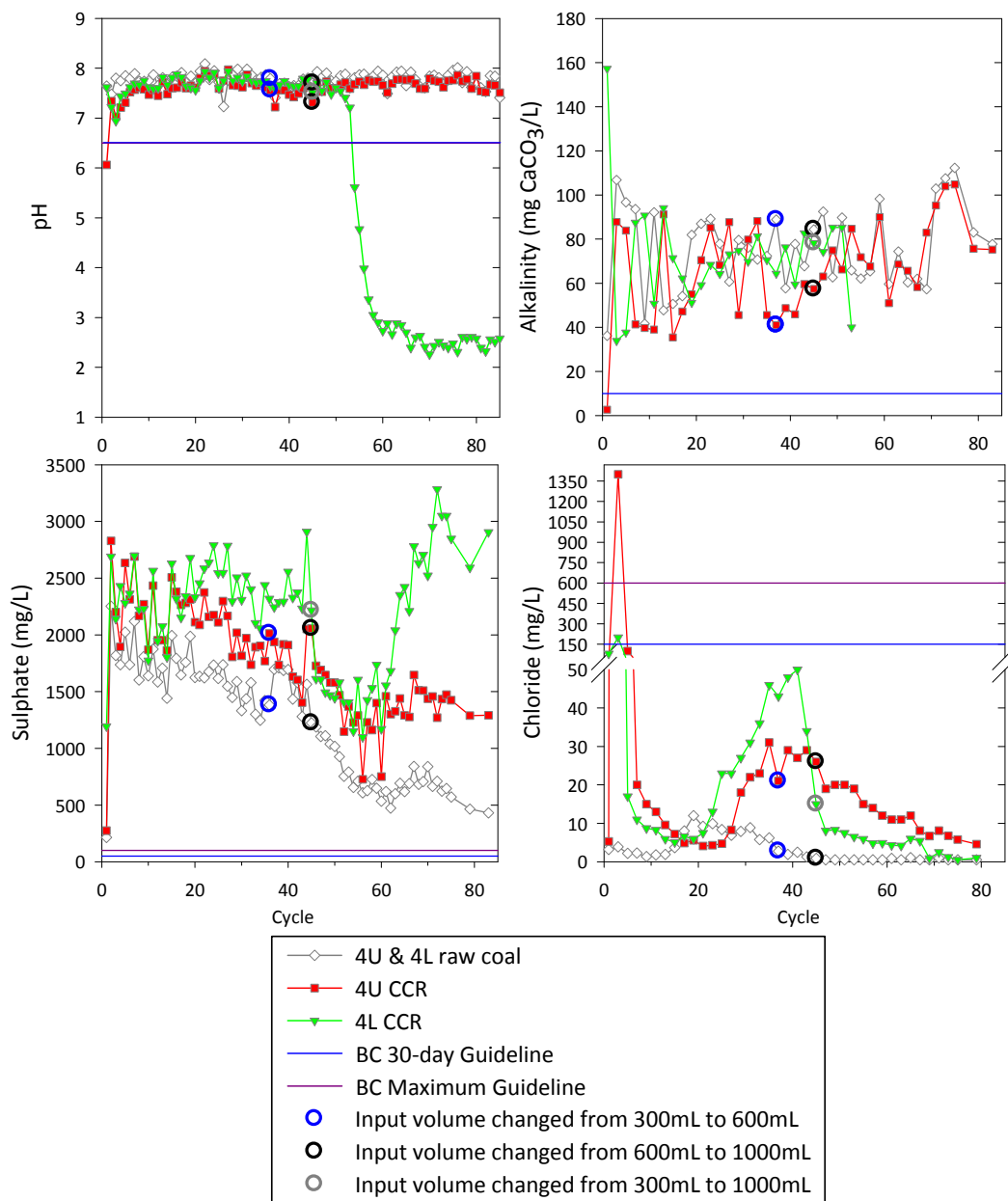


Figure B1.3-1: pH, alkalinity and sulphate and chloride concentrations in leachate from the 7 South Unsaturated Columns (raw coal and coarse reject samples).

Dissolved Metals

Metal concentrations in leachate from the raw coal and unsaturated coarse reject samples are illustrated in Figure B1.3-2 relative to the BC Water Quality Guidelines for Aquatic Life. Consistent with the initial flush of sulphate (Figure B1.3-1), concentrations of dissolved As, Co, Pb, Mn, Ni, Tl and Zn are observed in the first few leachate samples from the exposed raw coal and unsaturated coarse reject samples.

Leachate from the exposed raw coal column contains concentrations of B, Cd, Cu, Mn and Se that exceed the maximum guidelines, while Co, Ni, Ag and Zn exceed the 30-day guidelines. A general trend of decreasing concentrations was observed over the test period and concentrations of most of these elements decreased below their respective guidelines in the slightly alkaline pH leachate. However, concentrations of Cd and Se remain above guidelines during the test period.

Notable short lived increases in dissolved metal content (Al, Cd, Co, Cu, Fe, Pb, Mn, Ni, Ag, Tl and Zn) above guidelines are observed in leachate from the unsaturated 4U coarse reject, namely during cycle 27 and cycle 45. However, similar to the exposed raw coal, concentrations of metals in leachate from the unsaturated 4U coarse reject decrease during the test period below their respective guidelines in the slightly alkaline pH leachate.

During the slightly alkaline pH test period for the unsaturated 4L coarse reject sample, concentrations of metals show a general decrease consistent with the exposed raw coal and unsaturated 4U coarse reject tests. However, a notable increase in dissolved Al, As, Cd, Cr, Co, Cu, Fe, Pb, Mn, Ni, Tl, V and Zn of up to three orders of magnitude (and above the provincial guidelines) is observed in leachate from the unsaturated 4L coarse reject (Col 3), consistent with the onset of acidic pH conditions and an increase in sulphate production. It is anticipated that similar trends would be observed if or when PAG coarse reject or raw coal is exposed to the atmosphere for a sufficient period of time to allow acidic conditions to develop.

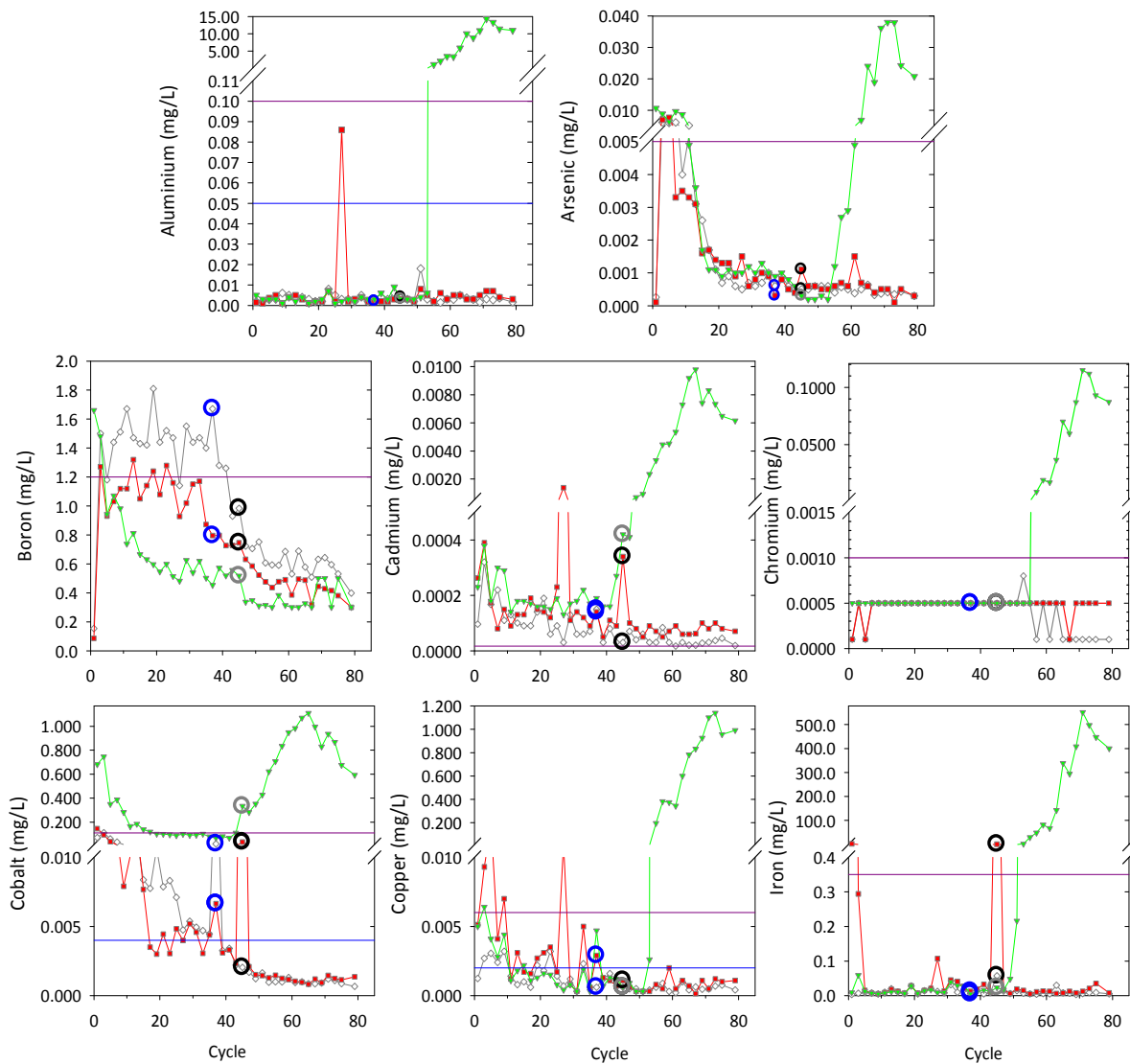


Figure B1.3-2a: Concentrations of dissolved Pb, Li, Mn, Ni, Se, Ag, Tl, V and Zn in leachate from 7 South Unsaturated Columns (raw coal and coarse reject samples).

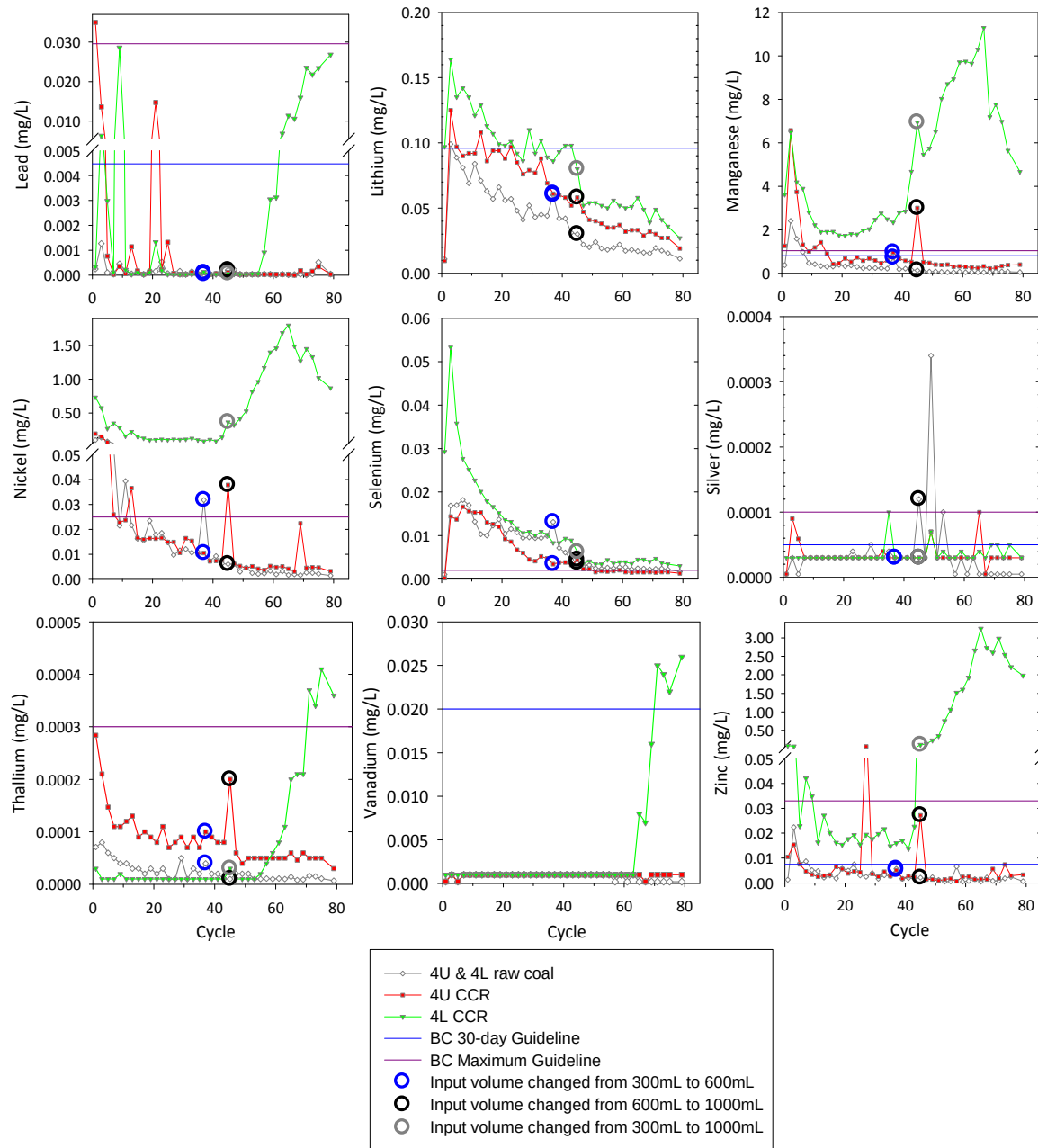


Figure B1.3-2b: Concentrations of dissolved Pb, Li, Mn, Ni, Se, Ag, Tl, V and Zn in leachate from 7 South Unsaturated Columns (raw coal and coarse reject samples).

B1.3.1.2 No. 4 Coal Zone Saturated Coarse Reject (HQA and HQC)

pH and Anions

Leachate from saturated coarse reject of the No. 4 Coal Zone was initially slightly acidic (< 6.5) but increases rapidly to slightly alkaline conditions (7 – 8) for the duration of the kinetic tests (Figure B1.3-3). Elevated concentrations of alkalinity, sulphate and chloride were measured in leachate from the first few cycles of the saturated column tests; however, concentrations decrease rapidly to stabilize at values below guidelines by cycle 20. This initial depressed pH and elevated concentration of anions in solution is likely the result of dissolution of surface oxidation products during saturation of the test samples.

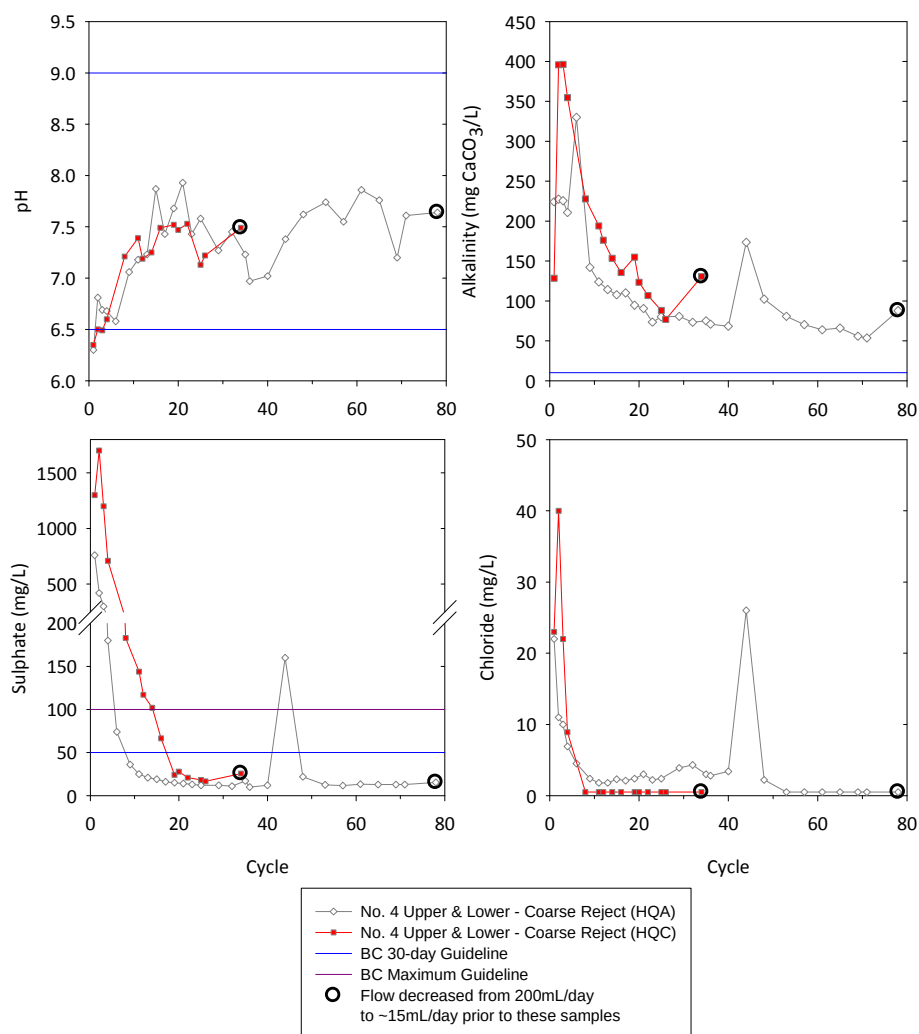


Figure B1.3-3: pH, alkalinity and sulphate and chloride concentrations in leachate from the 7 South Saturated Columns (coarse reject samples).

Dissolved Metals

Metal concentrations in leachate from the saturated coarse reject samples are illustrated in Figure B1.3-4 relative to the BC Water Quality Guidelines for Aquatic Life. Note that the second saturated column (HQC) was initiated to verify elevated dissolved metal concentrations in leachate from HQA, namely As.

Elevated concentrations of dissolved As, B, Cd, Cr, Co, Cu, Fe, Mn, Ni, Se and Zn above the maximum provincial guidelines are measured in the first few leachate samples from the saturated columns (Figure B1.3-4), consistent with the initial flush of sulphate and low pH conditions (Figure B1.3-3). However, following this initial influx, metal concentrations in leachate from the saturated columns decrease by one to two orders of magnitude and stabilize by cycle 20 at concentrations well below the maximum and 30-day guidelines. The one exception is As, which remains high and nearly two orders of magnitude above the guideline until approximately cycle 40 when concentrations temporarily decrease before gradually increasing again. As discussed in Appendix B1.2.1, As is associated with an Fe-sulphate phase rimming pyrite grains that will be susceptible to dissolution under reducing conditions.

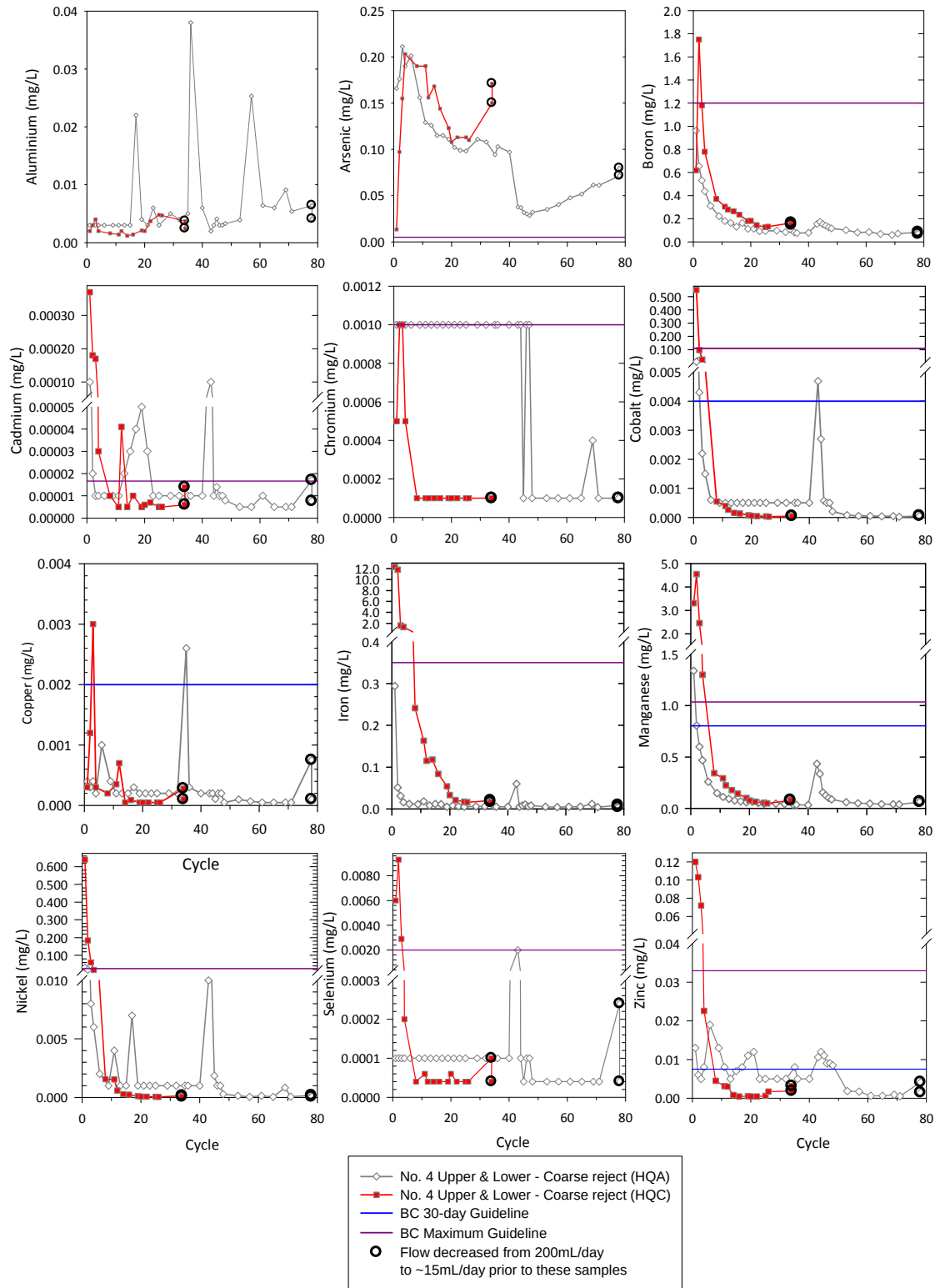


Figure B1.3-4: Dissolved metal concentrations in drainage from saturated coarse reject.

Table B1.3-2:
Column Leachate Average and 90th Percentile for 7 South Saturated Coarse Reject.

	Column Scenario	HQA 90 th Percentile	HQA Average	HQC 90 th Percentile	HQC Average	Greatest 90 th Percentile	Average Of 2 columns
<i>pH</i>		6.69	7.49	6.49	7.37	6.49	7.37
<i>Cond.</i>	<i>umhos/cm</i>	271	220	2250	235	2250	227
<i>Alkalinity</i>	<i>mgCaCO3/L</i>	224.6	82.7	379.4	105.1	379.4	93.9
<i>Sulphate</i>	<i>mg/L</i>	216	21	1260	22	1260	22
<i>Chloride</i>	<i>mg/L</i>	10.3	3.2	22.6	0.5	22.6	1.9
<i>Al</i>	<i>mg/L</i>	0.0086	0.0075	0.0044	0.0036	0.0086	0.0055
<i>Sb</i>	<i>mg/L</i>	0.00050	0.00029	0.00040	0.00002	0.00050	0.00016
<i>As</i>	<i>mg/L</i>	0.1740	0.0702	0.1900	0.1275	0.1900	0.0988
<i>Ba</i>	<i>mg/L</i>	0.110	0.082	0.141	0.113	0.141	0.098
<i>Be</i>	<i>mg/L</i>	0.00010	0.00010	0.00008	0.00001	0.00010	0.00006
<i>Bi</i>	<i>mg/L</i>	0.001000	0.000585	0.000515	0.000005	0.001000	0.000295
<i>B</i>	<i>mg/L</i>	0.41	0.10	0.98	0.15	0.98	0.13
<i>Cd</i>	<i>mg/L</i>	0.000038	0.000017	0.000175	0.000007	0.000175	0.000012
<i>Ca</i>	<i>mg/L</i>	146	38.5	490	42.2	490.0	40.3
<i>Cr</i>	<i>mg/L</i>	0.0010	0.0006	0.0008	0.0001	0.0010	0.0004
<i>Co</i>	<i>mg/L</i>	0.00260	0.00061	0.06195	0.00004	0.06195	0.00033
<i>Cu</i>	<i>mg/L</i>	0.0004	0.0003	0.0010	0.0001	0.0010	0.0002
<i>Fe</i>	<i>mg/L</i>	0.028	0.009	6.71	0.021	6.705	0.015
<i>Pb</i>	<i>mg/L</i>	0.00020	0.00016	0.00015	0.00002	0.00020	0.00009
<i>Li</i>	<i>mg/L</i>	0.017	0.008	0.041	0.014	0.041	0.011
<i>Mg</i>	<i>mg/L</i>	20.6	5.29	62.6	3.96	62.55	4.62
<i>Mn</i>	<i>mg/L</i>	0.46	0.09	2.89	0.07	2.89	0.08
<i>Hg</i>	<i>mg/L</i>	0.00007	0.00002	0.00005	0.00001	0.00007	0.00002
<i>Mo</i>	<i>mg/L</i>	0.0190	0.0107	0.0179	0.0132	0.0190	0.0120
<i>Ni</i>	<i>mg/L</i>	0.0096	0.0018	0.1220	0.0001	0.1220	0.0009
<i>K</i>	<i>mg/L</i>	3.37	0.74	7.42	0.51	7.42	0.62
<i>Se</i>	<i>mg/L</i>	0.00010	0.00016	0.00445	0.00005	0.00445	0.00011
<i>Si</i>	<i>mg/L</i>	2.312	0.966	4.735	1.170	4.735	1.068
<i>Ag</i>	<i>mg/L</i>	0.000020	0.000014	0.000035	0.000005	0.000035	0.000009
<i>Na</i>	<i>mg/L</i>	2.00	0.37	7.60	0.22	7.60	0.29
<i>Sr</i>	<i>mg/L</i>	0.85	0.21	3.07	0.24	3.07	0.22
<i>S</i>	<i>mg/L</i>	72.0	11.4	451.6	10.2	451.6	10.8
<i>Tl</i>	<i>mg/L</i>	0.000050	0.000037	0.000050	0.000002	0.000050	0.000019
<i>Sn</i>	<i>mg/L</i>	0.00500	0.00272	0.00253	0.00001	0.00500	0.00137
<i>Ti</i>	<i>mg/L</i>	0.0058	0.0040	0.0040	0.0006	0.0058	0.0023
<i>U</i>	<i>mg/L</i>	0.00066	0.00016	0.00149	0.00011	0.00149	0.00013
<i>V</i>	<i>mg/L</i>	0.0050	0.0029	0.0030	0.0002	0.0050	0.0015
<i>Zn</i>	<i>mg/L</i>	0.0120	0.0059	0.0875	0.0013	0.0875	0.0036
<i>Zr</i>	<i>mg/L</i>	0.0005	0.0003	0.0005	0.0001	0.0005	0.0002

Worst-case scenario is based on the 90th percentile of the entire record

Expected case scenario is based on the average when the release of metals has stabilized

>75% of the data is below the detection limit

B1.3.1.3 No. 4 Coal Zone Unsaturated Tailings (T1)

pH and Anions

Leachate from the unsaturated tailings from the No. 4 Coal Zone is slightly alkaline ($>7.5 - 8.0$) for the duration of the kinetic tests (Figure B1.3-5), consistent with high alkalinity levels ($120 - 160 \text{ mg CaCO}_3/\text{L}$) in leachate and relatively high concentrations of calcite and dolomite phases (Appendix B1.2.1). Following an initial influx, sulphate and chloride remain low relative to concentrations measured in leachate from the unsaturated coarse reject columns; however, sulphate concentrations generally remain above the maximum provincial guideline (100 mg/L).

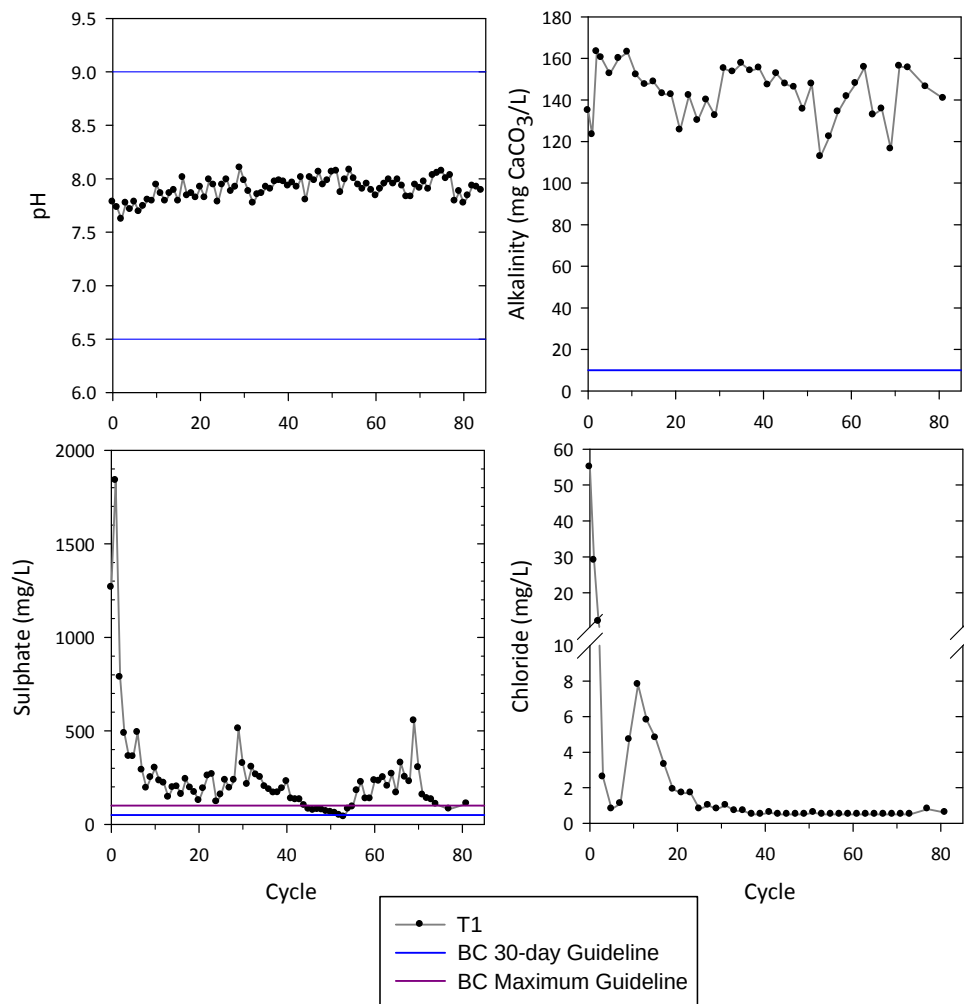


Figure B1.3-5: pH, alkalinity and sulphate and chloride concentrations in leachate from the 7 South exposed fine reject (T1).

Dissolved Metals

Metal concentrations in leachate from the tailings humidity cell are illustrated in Figure B1.3-6 relative to the BC Water Quality Guidelines for Aquatic Life. Following an initial influx of dissolved As, B, Cd, Co, Cu, Pb, Mn, Ni, Se and Zn concentrations above guidelines, concentrations of metals generally decrease and remain stable below their respective guidelines. The exceptions are concentrations of Cd and Cu, which fluctuate and repeatedly exceed the maximum and 30-day guidelines, respectively. Concentrations of dissolved Al and Fe fluctuate in leachate from the tailings, but remain up to orders of magnitude below their respective guidelines. In general, dissolved metal concentrations in leachate from the fine reject of the No. 4 Coal Zone are lower and stabilize at lower concentrations than dissolved metal concentrations in leachate from the coarse reject.

The average and 90th percentile concentrations for saturated coarse reject from the 7 South Mine are presented in Table B1.3-2. The final 90th percentile is the maximum of the two calculated 90th percentile of the entire test record. The average values are based on the average of the two tests from the latter portion of the tests when the release of metals stabilized.

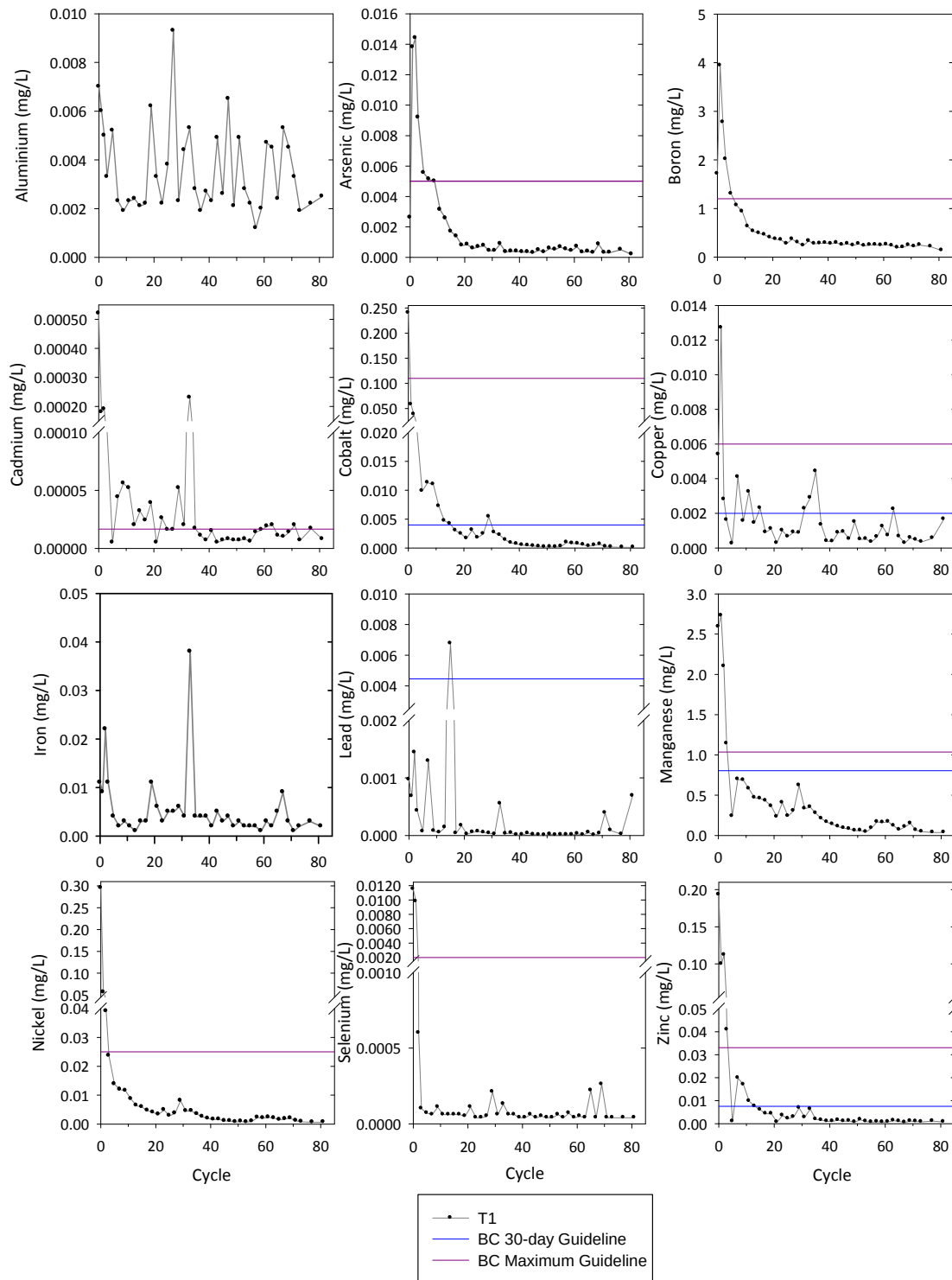


Figure B1.3-6: Dissolved metal concentrations in drainage from exposed tailings (T1).

Appendix B2:
Geochemistry of 7 South Hanging Wall and Overburden Samples

Appendix B2:

Geochemistry of 7 South Hanging Wall and Overburden Samples

The geochemical characteristics of the rock strata and overburden near the 7 South portal are of interest due to the planned mining of a small pit that will provide a stable platform and highwall to develop the 7 South portal on the No. 4 Seam. This geochemical assessment provides an updated evaluation based on samples taken from boreholes QU-10-01 and QU-10-02.

B2.1 Methodology / Sample Selection

Description of Boreholes QU-10-01 and QU-10-02 and Rationale for Sample Selection

The thickness of surficial material overlying bedrock in hole QU-10-01 is approximately 7.0 m and overlying bedrock in hole QU-10-02 is approximately 5.0 m. A total of seven samples were selected from overburden soil horizons and weathered sandstone overlying the bedrock to geochemically characterize the material which will be stored in surface dumps at the site. The sample intervals selected for analyses are presented in Tables B2.1-1 and B2.1-2.

A total of 26 samples were selected from the hanging wall strata of boreholes QU-10-01 and QU-10-02 from the 7 South area in order to determine the ARD/ML potential of the overlying lithologies. Two additional samples were also selected from partings between the No.5 and No. 4 Coal Seams and No.4 upper and lower seams of borehole QU-10-02. The sample intervals selected from stratigraphic sections of holes QU-10-01 and QU-10-02 are presented in Tables B2.1-1 and B2.1-2, respectively. Samples are predominantly from the Dunsmuir Sandstone overlying the No. 5 Coal Seam as well as from an overlying mudstone unit that contains pyrite. Boreholes QU-10-01 and QU-10-02 are located in the vicinity of 7 South portal (Figure B1.1-1).

Analysis

ABA and aqua-regia metal determination were used to assess the ARD/ML potential of the 7 South hanging wall samples. Shake flask extractions were only conducted on the QU-10-02 samples to evaluate water soluble constituents and short term drainage chemistry.

Table B2.1-1:
Stratigraphic Section for Borehole QU-10-01 showing sample locations.

Stratigraphic Unit			Static Test Sample		
From (m)	To (m)	Composition	ID	From (m)	To (m)
*****Overburden*****					
0	0.61	Loose SAND			
0.61	2.74	Dense SAND	BH10-01#1	1.22	1.98
2.74	3.96	Dense SILT and SAND	BH10-01#2	2.13	3.05
3.96	7.01	Dense SAND and SILT	BH10-01#3a	3.96	4.88
			BH10-01#3b	5.18	6.10
7.01	7.31	SANDSTONE (very weak, fresh)	BH10-01#4	7.01	7.77
7.31	7.62	SANDSTONE (very weak, slightly weathered)			
7.62	7.92	SANDSTONE (extremely weak, highly weathered)			
*****Bedrock*****					
7.92	10.29	MUDSTONE (w/ py and fine-gr sandst)	100101	8.08	9.45
			100102	9.45	10.86
10.29	26.52	SANDSTONE (med-gr)	100103	10.86	12.50
			100104	12.50	14.02
			100105	14.02	15.54
			100106	15.54	17.07
			100107	17.07	18.59
			100108	18.59	20.12
			100109	20.12	21.64
			100110	21.64	23.16
			100111	23.16	24.69
			100112	24.69	26.16
			100113	26.16	26.54
26.52	27.74	COAL (No. 5 Seam)			
27.74	28.02	SILTSTONE (Parting 5-4)			
28.02	30.54	COAL (No. 4 Seam)			
		SANDSTONE (Parting 4-4 Lower) (fine-gr)			
30.54	32.37	COAL (No. 4 Lower Seam)			
		Parting Lower Leaf			
32.37	33.22	COAL (Base of No. 4 Lower Seam)			

**Table B2.1-2:
Stratigraphic Section for Borehole QU-10-02 showing sample locations.**

Stratigraphic Unit			Static Test Sample			Kinetic Test
From (m)	To (m)	Composition	ID	From (m)	To (m)	
*****Overburden*****						
0	2.44	Dense SAND				
2.44	4.57	Dense SAND and SILT	BH10-02#2	2.44	3.05	
			BH10-02#4	3.66	4.57	
4.57	5.03	SANDSTONE (very weak, slightly weathered)				
*****Bedrock*****						
5.03	21.79	SANDSTONE medium grained	100201	5.03	6.55	Comp 2 (4.17 kg)
			100202	6.55	8.08	
			100203	8.08	9.60	
			100204	9.60	11.12	
			100205	11.12	12.65	
			100206	12.65	14.17	
			100207	14.17	15.7	
			100208	15.7	17.22	
			100209	17.22	18.75	Comp 1 (0.83 kg)
			100210	18.75	19.32	
			100211	19.32	20.27	
			100212	20.27	21.03	
			100213	21.03	21.50	
21.79	22.97	COAL (No. 5 Seam)				
22.97	23.72	MUDSTONE (Parting 5-4 Seams)	100215	23.00	23.82	
23.72	26.39	COAL (No. 4 Seam)				
		SILTSTONE (Parting 4-4 Lower)				
26.39	27.86	COAL (Base of No. 4 Lower Seam)				
		SANDSTONE (Parting)	100219	28.35	28.56	
27.86	28.7	COAL (No. 4 Lower Leaf)				
28.7	29.11	Coaly MUDSTONE				
29.11	30.52	SANDSTONE fine grained				

One unsaturated column composed of composite samples from hole QU-10-02 has been initiated to assess the long term drainage chemistry from the 7 South hanging wall stratigraphy. The column was constructed in the same manner as the other Quinsam unsaturated column tests (Appendix B1) and was packed with 0.83 kg dry wt. of Comp 1 at the bottom of the column and 4.17 kg dry wt. of Comp 2 in the upper portion of the column. The stratigraphic location of the Comp1 and Comp2 samples is illustrated in Table B2.1-1. The column test procedures are also being conducted in the same manner as the other Quinsam unsaturated columns using a trickle leach technique. Results are not yet available for this kinetic test. A summary of the solid phase geochemistry of the composite samples is discussed below.

B2.2 *Solid Phase Evaluation of Overburden Samples (QU-10-01 and QU-10-02)*

Solid phase analyses were conducted on overburden samples from holes QU-10-01 and QU-10-02 in the 7 South portal area to determine the sulphide content and neutralization potential of the material.

B2.2.1 *Acid Base Accounting Analyses*

Acid-base-accounting results for the 7 South overburden samples are presented in Table B2.2-1. The paste pH values of 7 South overburden samples are neutral to slightly alkaline (7.0 – 8.2), reflecting the generally very low total and sulphide sulphur values of the samples (< 0.05 %S). One sample (BH10-01#4) from just above the bedrock in hole QU-10-01 that is composed of weak and weathered sandstone contains 0.14 %S. Carbonate NP and modified NP values are also low (< 15.4 mg CaCO₃/t), with total organic carbon (TOC) comprising the bulk to the total carbon budget. With the exception of the weathered sandstone containing 0.14 %S, all other overburden samples from holes QU-10-01 and QU-10-02 have NPR values of > 2.0. Given the very low sulphur and NP values of the overburden samples, NPR may not be an appropriate method to evaluate the ARD potential of the overburden material. Alternatively, paste pH can be used as an indicator of ARD potential.

Table B2.2-1:
Acid Base Accounting Results for Overburden Samples from 7 South Portal Area.

Sample ID	Paste pH	Total S %	Sulphate S %	Sulphide S %	TAP kg CaCO ₃ /t	Total C %	CO ₂ %	TOC %	CaNP kg CaCO ₃ /t	Mod NP kg CaCO ₃ /t	NPR (ModNP /SAP)
QU10-01 Overburden											
BH10-01#1	7.0	<0.02	<0.01	<0.01	0.625	0.33	0.09	0.31	2.0	4.4	7.0
BH10-01#2	7.4	0.02	<0.01	0.03	0.6	0.18	0.06	0.16	1.4	6.1	9.8
BH10-01#3a	8.2	0.03	<0.01	0.04	0.9	0.18	0.25	0.11	5.7	14.6	15.6
BH10-01#3b	8.0	0.03	<0.01	0.03	0.9	0.14	0.15	0.10	3.4	11.3	12.1
BH10-01#4	7.6	0.14	<0.01	0.13	4.4	0.13	0.24	0.06	5.5	4.6	1.1
QU10-02 Overburden											
BH10-02 #2	8.0	0.04	<0.01	0.04	1.25	0.28	0.5	0.14	11.4	15.4	12.3
BH10-02 #4	8.0	0.05	<0.01	0.05	1.6	0.2	0.24	0.13	5.5	11.6	7.4

Notes: TAP = acid potential, calculated from Total S * 31.25;
Organic C calculated from Total C – total inorganic C, which was calculated from CO₂;
CaNP calculated from CO₂ originating from carbonate minerals; and
Modified NP corrected for siderite content

B2.2.2 Solid Phase Metals

Table B2.2-2 presents a summary of the solid phase metal concentrations measured in the 7 South overburden samples compared to average metal concentrations of the earth's crust. An indicator of significant solid-phase enrichment is assigned to be values greater than or equal to three times the average abundance in the earth's crust and are shaded in the table.

Metalloid As is enriched in many of the overburden samples from QU-10-01 and QU-10-02, particularly the weak and weathered sandstone overlying the bedrock in hole QU-10-02 (Table B2.2-2). Although this sample does contain elevated concentrations of metal(loid)s such as Cd, Co, Cr, Pb and Sb with respect to the other overburden samples; it does not consistently contain the most elevated concentrations of metal(loid)s.

B2.2.3 Shake Flask Extraction

Water soluble constituents of overburden samples from drill hole QU-10-01 and QU-10-02 from the 7 South portal area were determined using a SFE method (Table B2.2-3). The results of the SFE are consistent with ABA results, which indicate neutral to slightly alkaline pH values (7.1 – 8.0) and low sulphate concentrations (< 35 mg/L) in leachate from the overburden samples. Leachate from SFE also demonstrate low total acidity (< 3.0 mg CaCO₃/L) in the overburden samples and a range of low to moderate alkalinity concentrations (12.1 to 91.8 mg CaCO₃/L), with the highest alkalinity values measured in leachate from both samples of hole QU-10-02.

**Table B2.2-2:
Solid Phase Metals for Overburden Samples from 7 South Portal Area.**

Sample ID	Ag ppb	Al %	As ppm	Bi ppm	Ca %	Cd ppm	Co ppm	Cr ppm	Cu ppm	Fe %	Hg ppb	Mn ppm	Mo ppm	Ni ppm	Pb ppm	S %	Sb ppm	Se ppm	V ppm	Zn ppm
QU10-01 Overburden																				
BH10-01#1	80	2.55	13.3	0.04	1.31	0.08	15.5	50.9	70.2	3.81	24	508	1.72	28.1	2.18	<0.02	0.08	0.1	136	45
BH10-01#2	158	2.33	11	0.06	1.35	0.13	16.3	56.1	60.1	3.82	16	626	0.73	24.9	2.73	<0.02	0.07	<0.1	124	54.4
BH10-01#3a	126	2.3	4.9	0.04	1.81	0.11	18.1	55.5	70.5	4.07	10	631	0.49	30.1	2.15	0.03	0.07	<0.1	134	52
BH10-01#3b	65	2.59	4.5	0.05	1.91	0.08	19.5	57.2	71.7	4.18	17	643	0.41	32.3	2.09	<0.02	0.04	<0.1	144	50.8
BH10-01#4	61	1.54	36.3	0.06	0.91	0.4	26.6	62.5	49.9	3.43	5	627	0.77	26.5	2.86	0.15	0.2	0.4	97	51
QU10-02 Overburden																				
BH10-02#2	50	2.49	5.6	0.04	2.12	0.09	19.9	63.7	126	4.43	14	672	0.47	33.2	2.99	0.03	0.07	<0.1	151	54.2
BH10-02#4	37	2.21	6.3	0.04	1.65	0.11	17.9	60.8	70.7	3.81	11	598	0.5	28.3	2.24	0.05	0.07	<0.1	125	45.8
Av Crust	75	8.23	1.8	0.17	4.15	0.15	25	102	60	5.6	85	950	1.5	84	14	0.035	0.2	0.05	120	70

Notes: 1. Light shaded values are elevated with respect to >3x's the average continental crustal abundance; dark shaded values are elevated by > 10x's; 2. Price, 1997; bold italics are from CCR, 1985.

Table B2.2-3:
Shake Flask Extractions for Overburden Samples from 7 South Portal Area¹.

Parameter	Units	QU10-01					QU10-02		BC WQG Max
		BH10-01#1	BH10-01#2	BH10-01#3a	BH10-01#3b	BH10-01#4	BH10-02#2	BH10-02#4	
pH		7.1	7.5	7.9	7.9	7.5	8.0	8.0	
Redox	mV	277	289	297	284	296	273	276	
Conductivity	uS/cm	35	49	166	170	145	180	198	
T-Acidity ²	mg CaCO ₃ /L	2.8	2.5	2.8	2.9	2.4	2.8	3.0	
Alkalinity	mg CaCO ₃ /L	12.1	28.6	85.2	85.9	31.5	91.8	91.2	
Fluoride	mg/L	<0.06	0.10	0.08	0.10	0.14	0.07	0.09	
Sulphate	mg/L	5	4	18	13	35	16	25	100
<i>Dissolved Metals</i>									
Hardness	mg CaCO ₃ /L	14.7	19.8	68.8	69.1	53.6	84.4	89.5	
Al	mg/L	0.098	0.153	0.035	0.059	0.043	0.042	0.025	0.1
Sb	mg/L	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.02
As	mg/L	0.0005	0.0004	0.0019	0.0014	0.0010	0.0010	0.0026	0.005
Ba	mg/L	0.0030	0.0027	0.011	0.012	0.0075	0.015	0.016	5
B	mg/L	0.024	0.017	0.034	0.071	0.051	0.033	0.054	1.2
Cd	mg/L	0.000017	0.000007	0.000026	<0.000003	0.000036	<0.000003	0.000011	0.00003
Ca	mg/L	4.63	5.41	19.7	20.2	14.5	22.1	22.5	
Cr	mg/L	0.0008	0.0008	0.0006	<0.0005	0.0006	<0.0005	0.0007	0.001
Co	mg/L	0.00016	0.00012	0.00009	0.000065	0.00038	0.000092	0.000085	0.11
Cu	mg/L	0.0037	0.0098	0.0042	0.0045	0.0009	0.0026	0.0038	0.011
Fe	mg/L	0.077	0.22	0.022	0.054	0.019	0.036	0.016	0.35
Pb	mg/L	0.00015	0.00006	<0.00002	0.00004	0.00003	0.00002	0.00002	0.003
Mg	mg/L	0.76	1.53	4.77	4.53	4.25	7.11	8.13	
Mn	mg/L	0.033	0.010	0.010	0.0098	0.016	0.013	0.016	1.642
Hg	ug/L	<0.01	<0.01	<0.01	<0.01	0.04	<0.01	<0.01	
Mo	mg/L	0.00058	0.0026	0.0034	0.0032	0.0026	0.0039	0.0059	2
Ni	mg/L	0.0008	0.0007	0.0005	0.0001	0.0009	0.0002	0.0005	0.065
P	mg/L	0.010	0.047	<0.009	0.026	<0.009	0.014	<0.009	
K	mg/L	0.40	0.310	1.17	1.30	1.03	1.47	1.59	
Se	mg/L	0.00010	0.00008	0.0019	0.0017	0.0089	0.0033	0.0026	0.002
Si	mg/L	3.68	4.33	2.84	3.00	3.16	2.65	2.77	
Ag	mg/L	0.00005	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	0.0001
Na	mg/L	1.44	2.73	7.18	9.58	4.70	4.18	5.57	
Sr	mg/L	0.016	0.027	0.12	0.13	0.075	0.12	0.16	
S	mg/L	0.66	0.68	5.46	4.55	13.0	5.98	9.12	
Sn	mg/L	0.00006	<0.00001	0.00012	0.00014	0.00009	0.00003	0.00014	
Ti	mg/L	0.0054	0.0139	0.0026	0.0063	0.0027	0.0035	0.0022	
U	mg/L	0.000015	0.000008	0.000430	0.000449	0.000013	0.00030	0.00083	0.3
V	mg/L	0.001	0.002	0.014	0.016	0.0014	0.0068	0.011	0.02
Zn	mg/L	0.004	0.005	0.007	0.002	0.002	0.003	0.003	0.041

Notes: 1. Shaded values exceed the BC water quality guideline for freshwater aquatic life (BC MOE, 2006);
2. Total Acidity to pH of 8.3

Paste pH values of 7 South overburden samples are neutral to slightly alkaline (7.0 – 8.2), reflecting the generally very low total and sulphide sulphur values of the samples (< 0.05 %S). Shake flask extractions are consistent with ABA results, producing neutral to slightly alkaline pH values (7.1 – 8.0) and low sulphate concentrations (< 35 mg/L) in leachate from the soil samples. Although solid-phase arsenic is enriched in many of the overburden samples from the 7 South area, particularly in the weak and weathered sandstone strata overlying the bedrock, dissolved metal(loid) concentrations in leachate from SFE, including As, are generally low and below the maximum British Columbia water quality guideline for aquatic life. Only dissolved Se is indicated to exceed the provincial guideline in a few overburden samples.

B2.3 Solid Phase Evaluation of Hanging Wall Samples (QU-10-01 and QU-10-02)

The No. 4 Coal zone lies within the Dunsumuir sandstones of the Comox Formation. Solid phase analyses were conducted on the QU-10-01 and QU-10-02 holes samples to determine the composition of this bedrock hanging wall material.

B2.3.1 Acid Base Accounting Analyses

Acid-base-accounting results for the 7 South hanging wall samples (Holes 10-01 and 10-02) are presented in Table B2.3-1. The paste pH of 7 South hanging wall samples range from slightly alkaline to acidic depending on lithology and stratigraphic location. Based on the results for Holes 10-01 and 10-02, mudstone samples (100101, 100102 and 100215) have an acidic paste pH (4.7- 5.1). Samples from the sandstone unit of the 7 South hanging wall have paste pH values which are neutral to slightly alkaline near the top of the unit, but which decrease with depth, becoming increasingly acidic approaching the coal seams. However, the paste pH of the lower sandstone parting (sample 100219) located between the No. 4 lower and lower leaf coal seams is slightly alkaline at 7.8.

Paste pH of the 7 South hanging wall samples are reflective of total sulphur and modified NP concentrations. Mudstone samples from the hanging wall comprise 6.5 - 7 %S and sandstone samples show a general trend of increasingly higher total sulphur values with depth through the unit (Table B2.3-1). Sandstone samples directly overlying the No. 5 Coal Seam comprise 2.4 – 5 % S. Sulphide sulphur makes up the majority of the total sulphur budget, with sulphate sulphur generally comprising <0.1 %S. Conversely, modified NP concentrations decrease with depth through the sandstone and reach a low in the samples directly overlying the No. 5 Coal Seam. Mudstone samples comprise low modified NP values. The lower sandstone parting (100219) contains low total and sulphide sulphur values (< 0.07 %S) and higher concentrations of modified NP (74 mg CaCO₃/t) compared to the 10-01 and 10-02 sandstone samples in the hanging wall.

**Table B2.3-1:
Acid Base Accounting Results for 7 South Hanging Wall Samples
(Holes 10-01 and 10-02).**

Unit	Sample ID	Paste pH	Total S	Sulphide S	Sulphate S	Total C	CO ₂	TOC	AP	CaNP	ModNP	NPR
			%	%	%	%	%	%	kg CaCO ₃ /t	kg CaCO ₃ /t	kg CaCO ₃ /t	(ModNP/AP)
Hole 10-01												
MS	100101	5.0	6.76	6.89	0.09	10.1	4.69	8.83	211.3	106.6	13.5	0.06
	100102	5.1	6.96	7.12	0.05	8.98	3.53	8.01	217.5	80.2	21.4	0.10
SS	100103	7.4	0.76	0.83	0.03	0.77	2.66	0.04	23.8	60.5	46.4	1.95
	100104	7.8	0.34	0.33	0.02	0.78	2.65	0.05	10.3	60.2	48.1	4.66
	100105	7.9	0.48	0.5	0.01	1.05	3.36	0.13	15.0	76.4	63.5	4.23
	100106	7.5	1.2	1.21	0.05	1.34	4.14	0.2	37.5	94.1	82.3	2.19
	100107	7.0	1.14	1.24	0.07	0.53	1.7	0.06	35.6	38.6	27.9	0.78
	100108	7.1	1.27	1.25	0.05	0.53	1.58	0.1	39.1	35.9	27.6	0.71
	100109	7.7	0.79	0.84	0.05	1.19	4.1	0.07	24.7	93.2	84.9	3.44
	100110	7.1	1.26	1.26	0.08	0.68	2.36	0.03	39.4	53.6	41.8	1.06
	100111	5.4	1.06	0.98	0.06	0.17	0.5	0.03	30.6	11.4	6.5	0.21
	100112	3.8	1.2	1.17	0.08	0.21	0.64	0.03	36.6	14.5	4.3	0.12
	100113	3.9	5.01	5.08	0.07	1.72	0.69	1.53	156.6	15.7	4.1	0.03
Hole 10-02												
SS	100201	7.9	0.23	0.24	<0.01	0.79	2.71	0.05	7.2	61.6	51.2	7.1
	100202	7.0	0.26	0.25	0.01	0.36	1.22	0.03	7.8	27.7	17.9	2.3
	100203	6.7	0.48	0.48	0.02	0.39	1.3	0.03	15.0	29.5	18.5	1.2
	100204	7.4	0.71	0.68	0.06	0.86	2.43	0.19	21.3	55.2	41.6	2.0
	100205	6.3	1.14	1.06	0.04	0.42	1.38	0.04	33.1	31.4	19.5	0.6
	100206	6.7	0.89	0.8	0.08	0.38	1.26	0.03	25.0	28.6	16.6	0.7
	100207	5.5	1.41	1.34	0.1	0.35	1.14	0.04	41.9	25.9	14.3	0.3
	100208	6.9	1.28	1.19	0.11	0.49	1.66	0.03	37.2	37.7	26.2	0.7
	100209	6.0	1.29	1.31	0.05	0.39	1.28	0.04	40.9	29.1	17.5	0.4
	100210	5.4	1.01	0.92	0.07	0.23	0.62	0.06	28.8	14.1	9.9	0.3
	100211	5.6	1.26	1.29	0.06	0.19	0.48	0.06	39.4	10.9	6.9	0.2
	100212	3.4	2.37	2.21	0.14	0.32	0.56	0.17	69.1	12.7	4.0	0.1
	100213	4.3	2.93	2.93	0.1	1.81	0.51	1.67	91.6	11.6	5.0	0.1
No.5												
MS	100215	4.7	6.47	6.5	<0.01	17.4	2.06	16.9	202	46.8	29.1	0.1
No.4												
SiltS												
No.4L												
SS												
No.4L	100219	7.8	0.07	0.05	<0.01	2.32	3.96	1.23	1.6	90.0	73.8	47.2
MS												

Notes: AP = acid potential, calculated from Total or Sulphide S * 31.25; Total S is applied where Sulphide S values are higher than Total S;
TOC = Total Organic C calculated from Total C – total inorganic C, which was calculated from CO₂;
CaNP calculated from CO₂ originating from carbonate minerals; and
Modified NP corrected for siderite content..

In the absence of mineralogical data, higher carbonate NP values relative to modified NP values, such as is observed with the 7 South hanging wall samples (Table B2.3-1), is a strong indication that Fe-bearing carbonates, which do not neutralize acid as efficiently as calcite, are present in the sample. The method applied for the modified NP values are corrected for siderite content; thereby providing a more accurate value for carbonate phases available for neutralization. This is supported by mineralogical investigations of coal and parting samples discussed in Table B2.2.1 (tailings samples only), which identified siderite during XRD and petrographic examinations.

For the purpose of assessing the 7 South hanging wall samples, modified NP is used to estimate NP available from carbonate minerals and AP is calculated from sulphide sulphur. Where sulphide sulphur values are higher than total sulphur values, total sulphur is used to calculate AP. Samples with an NPR < 2.0 are designated as PAG, taking into account both the regulatory guidelines and the scrutiny that was undertaken to select the most appropriate and conservative measure of AP and NP. Refining the PAG criterion to NPR = 2.0 is appropriate for this study due to the conservative measure of sulphur and the selection of an NP method. With the exception of a couple of samples in the upper portion of the sandstone unit, NPR values of < 2.0 are consistently observed for the samples of boreholes 10-01 and 10-02, indicating that the 7 South hanging wall is predicted to be predominantly PAG (Table B2.3-1). The sample from the lower sandstone parting (100219) has an NPR of 34 indicating that this material is NAG.

Hanging Wall Samples from Holes QU-07-07 and QU-07-09

Stratigraphic samples from drill holes QU-07-07 and QU-07-09 were previously analyzed to assess the ARD potential of the 7 South area hanging wall. It was realized that due to the manner in which the drill core was sampled (i.e. intervals of 10 to 20 cm applied to intervals > 1m), the static test results could not be used reliably to depict the geochemistry of the 7 South hanging wall stratigraphy.

B2.3.2 Solid Phase Metals

Table B2.3-2 presents a summary of the solid phase metal concentrations measured in the 7 South hanging wall samples compared to average metal concentrations of the earth's crust. An indicator of significant solid-phase enrichment is assigned to be values greater than or equal to three times the average abundance in the earth's crust and are shaded in the table.

Only As is consistently enriched in the hanging wall strata, including the sample from the lower sandstone parting (100219), with notably higher concentrations (order of magnitude) of As indicated for the mudstone samples from both drill holes

(Table B2.3-2). In general, solid phase metal concentrations are an order of magnitude higher in the mudstone samples relative to the sandstone samples, possibly due to the presence of pyrite in the mudstone samples.

B2.3.3 Shake Flask Extraction

Results of the SFE for hanging wall samples from borehole QU-10-02 are consistent with ABA results, which indicate that the greatest metal leaching risk is posed by the PAG mudstone sample and sandstone strata near the bottom of the drill core that comprise the roof strata of the No. 5 Coal Seam. Samples from both of these stratigraphic intervals produced leachate with $\text{pH} < 4$ (high acidity) (Table B2.3-3). Under these acidic conditions, Al, As, Cd, Cr, Co, Cu, Fe, Mn, Ni, Se, Tl, V and Zn are elevated above the provincial water quality guidelines for the protection of aquatic life. All samples from the hanging wall are elevated in sulphate and all but the upper four or five sandstone samples contain elevated metal concentrations with respect to provincial guidelines.

Table B2.3-2:
Solid Phase Metal Concentrations for 7 South Hanging Wall Samples (Holes 10-01 and 10-02)¹.

Sample ID	Ag ppb	Al %	As ppm	Bi ppm	Cd ppm	Co ppm	Cr ppm	Cu ppm	Fe %	Hg ppb	Mn ppm	Mo ppm	Ni ppm	Pb ppm	Sb ppm	Se ppm	Tl ppm	U ppm	V ppm	Zn ppm
Hole 10-01																				
100101	125	0.48	210	0.09	0.16	36.7	41.3	163.9	10.3	66	510	0.75	70.8	4.96	0.28	1	0.53	0.6	125	108
100102	131	0.44	247	0.13	0.16	32.7	34.9	134.2	9.67	73	494	1.16	63.4	8.69	0.39	0.9	0.46	0.6	103	103
100103	14	0.25	26.5	0.04	0.03	6.9	74.9	11.31	1.62	<5	299	0.61	11.1	2.06	0.09	<0.1	0.07	0.2	20	28.4
100104	14	0.23	15.3	0.03	0.02	6	72.7	10.07	1.04	<5	270	0.23	10.1	2.26	0.09	<0.1	0.04	0.1	18	25.3
100105	16	0.24	18.9	0.03	<0.01	6.4	66.7	12.15	1.23	<5	370	0.4	11.2	2.22	0.09	<0.1	0.05	0.1	20	24.5
100106	15	0.25	47.2	0.03	0.02	7.5	60.5	12.14	1.79	<5	470	0.34	11.8	3.15	0.11	<0.1	0.06	0.1	22	20.1
100107	20	0.24	35.9	0.04	<0.01	7.4	64.8	11.44	1.82	6	279	0.34	11.8	3.22	0.09	<0.1	0.05	0.2	24	18.7
100108	15	0.3	88.2	0.03	0.01	8	76.6	11.85	1.78	<5	262	0.41	13	3.51	0.1	<0.1	0.15	0.2	24	16.2
100109	15	0.25	29.7	0.04	<0.01	7.1	65.3	10.17	1.37	5	387	0.22	10.9	2.78	0.08	<0.1	0.05	0.2	23	9.9
100110	13	0.25	33.3	0.04	0.03	7.5	61	11.42	1.8	<5	308	0.22	12.6	3.49	0.1	<0.1	0.12	0.2	29	23.9
100111	15	0.26	20.7	0.04	0.01	7.2	61.3	11.54	1.42	<5	176	0.2	12.3	2.84	0.1	<0.1	0.08	0.2	24	23.1
100112	14	0.25	33.2	0.04	<0.01	7.2	62.9	10.76	1.65	6	181	0.33	11.3	3.29	0.14	<0.1	0.13	0.2	23	22.3
100113	18	0.27	82.3	0.04	0.02	9.4	56.5	14.35	4.87	9	256	0.77	13.9	3.9	0.32	0.2	0.48	0.2	36	33.5
Hole 10-02																				
100201	15	0.27	14.3	0.03	0.02	5.7	68.3	9.87	1.06	<5	323	0.17	10.6	2.21	0.1	<0.1	0.02	0.2	25	20.9
100202	17	0.27	17.6	0.03	0.01	6.5	73.8	11.63	1.05	<5	194	0.19	11.9	2.55	0.11	<0.1	0.03	0.2	21	21.9
100203	14	0.24	77.2	0.04	0.03	7.1	68	11.24	1.18	<5	209	0.2	10.9	2.84	0.18	<0.1	0.09	0.2	23	22.3
100204	12	0.24	19.4	0.05	0.03	8.8	76.3	13.27	1.42	<5	357	0.27	12.9	3.24	0.12	<0.1	0.03	0.2	28	20.7
100205	16	0.23	59.3	0.05	0.07	7.6	69.7	11.92	1.76	<5	272	0.44	12	3.73	0.15	<0.1	0.07	0.2	25	44.6
100206	13	0.24	42	0.05	0.01	7.3	66.4	11.26	1.54	<5	240	0.27	11.5	3.55	0.09	<0.1	0.07	0.2	25	11.2
100207	16	0.26	51.9	0.04	0.02	7.6	71.3	12.23	1.97	<5	254	0.34	12.3	3.89	0.1	<0.1	0.09	0.2	30	12.1
100208	13	0.23	31.7	0.05	<0.01	8.1	81.3	12.39	1.74	<5	252	0.34	13.3	3.89	0.1	<0.1	0.07	0.2	30	14.6
100209	15	0.26	35.6	0.04	0.03	7.8	68.4	12.37	1.86	<5	246	0.46	12.7	3.76	0.1	<0.1	0.11	0.2	31	16.6
100210	14	0.24	40.6	0.05	0.02	7.7	72.7	12.22	1.36	<5	174	0.42	11.7	2.93	0.11	<0.1	0.11	0.2	24	11.7
100211	16	0.25	44.4	0.05	0.02	7.9	64.6	13.18	1.6	<5	148	0.49	13.2	4.17	0.15	<0.1	0.16	0.2	21	17.8
100212	18	0.24	54	0.04	0.03	8.9	67.5	15.76	2.55	<5	229	0.71	13.3	4.5	0.22	0.1	0.31	0.2	27	23.6
100213	16	0.26	68.1	0.04	0.03	8.9	64.2	13.4	2.93	<5	249	0.87	12.6	3.66	0.36	0.1	0.48	0.2	30	35.7
100215	96	0.37	129	0.06	0.09	43.6	49.8	174.1	6.33	168	164	0.58	75.2	3.5	0.08	0.7	<0.02	0.5	147	95.4
100219	23	0.4	16.5	0.1	0.01	9.6	50.8	43.37	1.46	6	241	0.07	17.6	2.97	0.03	0.1	<0.02	0.2	49	47.8
Av Crust	75	8.23	1.8	0.17	0.15	25	102	60	5.6	85	950	1.5	84	14	0.2	0.05	0.85	2.7	120	70

Notes: 1. Light shaded values are elevated with respect to >3x's the average continental crustal abundance; dark shaded values are elevated by > 10x's; 2. Price, 1997; bold italics are from CCR, 1985.

Table B2.3-3:
Shake Flask Extractions for 7 South Hanging Wall Samples (Hole 10-02)¹.

Sample	pH	T-Acidity ² mg CaCO ₃ /L	T-Alk mg CaCO ₃ /L	Sulphate mg/L	Hardness mg CaCO ₃ /L	Dissolved Metals												
						Al	As	Cd	Cr	Co	Cu	Fe	Mn	Ni	Se	Tl	V	Zn
						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
100201	7.7	4.2	64.4	104	169	0.0048	0.0016	0.000023	<0.0005	0.0052	0.0006	<0.002	0.164	0.0049	0.00024	<0.0002	0.00028	0.001
100202	7.3	3.2	25.4	188	192	0.0028	0.0005	0.000006	<0.0005	0.0077	0.0009	<0.002	0.390	0.0086	0.00044	<0.0002	0.00006	0.002
100203	7.3	3.9	23.4	260	305	0.0032	0.0015	0.000007	<0.0005	0.026	0.0020	0.004	0.783	0.0215	0.00022	<0.0002	0.00006	0.003
100204	7.5	5.2	44.4	548	687	0.0027	0.0005	<0.000003	<0.0005	0.0031	0.0007	<0.002	0.309	0.0044	0.00020	<0.0002	0.00008	0.002
100205	7.2	3.9	20.3	690	702	0.0035	0.0008	0.000026	<0.0005	0.017	0.0009	0.006	1.88	0.0263	0.00034	<0.0002	0.00007	0.004
100206	7.0	4.4	10.9	927	956	0.0015	0.0007	0.00011	<0.0005	0.017	0.0026	0.002	4.79	0.0679	0.00013	0.0006	0.00005	0.005
100207	6.8	4.7	6.4	975	1200	0.0017	0.0007	0.00022	<0.0005	0.043	0.0015	0.002	6.96	0.157	0.00039	0.0006	0.00004	0.007
100208	7.3	5.5	29.2	1353	1290	0.0017	0.0006	0.000036	<0.0005	0.0041	<0.0005	<0.002	1.24	0.0139	0.00027	0.0005	0.00007	0.005
100209	6.7	6.5	16.1	1087	1170	0.0011	0.0007	0.00010	<0.0005	0.018	0.0006	<0.002	3.35	0.0557	0.00027	0.0011	0.00005	0.004
100210	6.9	5.1	5.8	1027	1100	0.0020	0.0008	0.00027	<0.0005	0.043	0.0007	<0.002	5.96	0.170	0.00036	0.0018	0.00005	0.008
100211	3.3	296.8	#N/A	740	567	0.438	0.0102	0.002	0.0088	0.67	0.0052	102	9.36	1.01	0.00065	0.0020	0.00009	0.689
100212	2.7	1900	#N/A	1986	391	1.44	0.242	0.003	0.127	0.65	0.021	838	8.23	0.808	0.00065	0.0005	0.178	0.789
100213	2.8	2725	#N/A	2195	379	1.45	0.479	0.0026	0.113	0.60	0.035	854	8.40	0.749	0.00063	0.0007	0.157	1.51
100215	6.1	11.6	8.7	1807	2050	0.0410	0.0059	0.0011	0.0038	2.05	0.0013	0.379	4.74	2.77	0.0236	<0.0002	0.00520	0.238
100219	7.8	6.1	66.0	33	82.2	0.0331	0.0064	0.000019	0.0017	0.0010	0.0008	0.069	0.0194	0.0007	0.00885	<0.0002	0.00407	<0.001
BC WQG				100		0.1	0.005	0.00003	0.001	0.11	0.011	0.35	1.642	0.065	0.002	0.0003	0.02	0.041

Notes: 1. Shaded values exceed the BC water quality guideline for freshwater aquatic life (BC MOE, 2006);
2. Total Acidity to pH of 8.3

B2.4 Solid Phase Evaluation of Hanging Wall Kinetic Test Samples (Comp1 and 2)

Solid phase analyses were conducted on hanging wall composite samples from the 7 South portal area to determine the geochemical characteristics of the kinetic test material. ABA, solid phase and SFE results for the hanging wall kinetic test sample reflect the geochemical characteristics of the individual hanging wall samples. SFE and column tests are conducted to evaluate drainage quality from exposed bedrock material from the portal pit.

B2.4.1 Mineralogy

The results of the quantitative phase analysis for the 7 South hanging wall kinetic test composite samples (Comp1 and Comp2) are provided in Table B2.4-1. The complete XRD report is provided in Appendix B-3.

Both composite samples are predominantly composed of quartz (~70 wt. %) and kaolinite (~20 wt. %) with lesser amounts of k-feldspar, muscovite and plagioclase. Calcite, ankerite-dolomite and siderite are present in equal amounts (1 wt. %) in hanging wall kinetic sample Comp2 and siderite is the only carbonate phase in sample Comp1. Sulphur occurs primarily in the form of pyrite (1 – 3 wt. %) in each of the hanging wall composite samples, with higher concentrations of pyrite indicated for Comp1. A sulphate mineral, gypsum, is present in low concentrations (1 wt. %) in both composite samples. Trace amounts of marcasite were also identified in each sample.

**Table B2.4-1:
Results of Reitveld Refined X-Ray Diffraction for 7 South Hanging Wall Kinetic Test Composite Samples.**

Mineral	Ideal Formula	Comp 1	Comp 2
Quartz	SiO ₂	69	72
Kaolinite	Al ₂ Si ₂ O ₅ (OH) ₄	20	19
K-Feldspar	KAlSi ₃ O ₈	4	3
Muscovite	KAl ₂ AlSi ₃ O ₁₀ (OH) ₂	2	2
Plagioclase	NaAlSi ₃ O ₈ – CaAl ₂ Si ₂ O ₈	1	-
Gypsum	CaSO ₄ ·2H ₂ O	1	1
Calcite	CaCO ₃	-	1
Ankerite – Dolomite	Ca(Fe ²⁺ ,Mg,Mn)(CO ₃) ₂ – CaMg(CO ₃) ₂	-	1
Siderite	Fe ²⁺ CO ₃	1	1
Pyrite	FeS ₂	3	1
Marcasite	FeS ₂	<1	<1
<i>Total</i>		<i>100</i>	<i>100</i>

B2.4.2 Acid Base Accounting Analyses

Acid-base-accounting results for the 7 South hanging wall kinetic test samples are presented in Table B2.4-2. ABA results for the two composite samples differ. Sample Comp1 produced an acidic pH of 3.8, has a total sulphur concentration of 2.02 %S, a modified NP value of 2.9 mg CaCO₃/t and a resultant NPR value of 0.05. Sample Comp2 produced a neutral paste pH of 7.0, has a total sulphur value of 0.86 %S, a modified NP value of 24 mg CaCO₃/t and a resultant NPR value of 0.88. Due to the presence of siderite and ankerite in the composite samples, modified NP is applied in NPR calculations to estimate the ARD potential of the kinetic test sample. Acid potential is calculated from total sulphur. Both composite samples are identified as PAG and are expected to produce acidic drainage during kinetic testwork.

Table B2.4-2:
Acid Base Accounting results for 7 South Hanging Wall Kinetic Test Composite Samples.

Sample ID	Unit	Comp 1	Comp 2
Paste pH		3.8	7.1
Total C	%	0.95	0.43
CO ₂	%	0.41	1.54
Organic C	%	0.84	0.01
Total S	%	2.02	0.86
Sulphate S	%	0.19	0.14
Sulphide S	%	2.04	0.85
TAP	kg CaCO ₃ /t	63.1	26.9
CaNP	kg CaCO ₃ /t	9.3	35.0
Modified NP	kg CaCO ₃ /t	2.9	23.7
NPR (Mod NP/TAP)		0.05	0.88

Notes: TAP = acid potential, calculated from Total S * 31.25;
Organic C calculated from Total C – total inorganic C, which was calculated from CO₂;
CaNP calculated from CO₂ originating from carbonate minerals; and
Modified NP corrected for siderite content.

B2.4.3 Solid Phase Metals

Tables B2.4-3 and B2.4-4 present summaries of the solid phase metal concentrations measured in the hanging wall composite samples. The values determined by aqua regia digestion in Table B2.4-3 are compared to average metal concentrations of the earth's crust. An indicator of significant solid-phase enrichment is assigned to be values greater than or equal to three times the average abundance in the earth's crust and are shaded in the table. Only As is consistently enriched in the hanging wall composite samples. Higher concentrations of As are indicated for Comp1; however, higher metal(loid) concentrations are not consistently indicated for Comp1.

Table B2.4-3:
Solid Phase Metal Results for 7 South Hanging Wall Kinetic Test Composite Samples¹.

Sample ID	Unit	Comp 1	Comp 2	Av. Crust
Ag	ppb	16	14	75
Al	%	0.21	0.21	8.23
As	ppm	63.4	45	1.8
Ba	ppm	6.5	6.2	425
Bi	ppm	0.04	0.04	0.17
Ca	%	0.07	0.75	4.15
Cd	ppm	0.03	0.03	0.15
Co	ppm	7.3	8.4	25
Cr	ppm	65.7	76.8	102
Cu	ppm	10.8	10.26	60
Fe	%	2.27	1.62	5.6
Hg	ppb	12	<5	85
K	%	0.04	0.03	2.09
Mg	%	0.1	0.19	2.3
Mn	ppm	193	274	950
Mo	ppm	0.67	0.4	1.5
Na	%	0.002	0.003	2.36
Ni	ppm	11.1	12.1	84
P	%	0.001	<0.001	0.105
Pb	ppm	3.21	2.92	14
Sb	ppm	0.23	0.12	0.2
Se	ppm	<0.1	<0.1	0.05
Sr	ppm	4.2	8.3	370
Th	ppm	0.3	0.4	9.6
Ti	%	0.002	0.001	0.565
Tl	ppm	0.31	0.07	0.85
U	ppm	0.2	0.2	2.7
V	ppm	23	26	120
Zn	ppm	20.6	16.4	70

Notes: 1. Shaded values are elevated with respect to >10x's the average continental crustal abundance; and
2. Price, 1997; bold italics are from CCR, 1985.

Table B2.4-4:
Whole Rock Analyses Results for 7 South Hanging Wall Kinetic Test Composite Samples.

Sample ID	SiO ₂ %	Al ₂ O ₃ %	Fe ₂ O ₃ %	CaO %	MgO %	Na ₂ O %	K ₂ O %	MnO %	TiO ₂ %	P ₂ O ₅ %	Ba %	LOI %	SUM %
Comp 1	79.9	8.44	3.37	0.12	0.21	0.1	0.48	0.02	0.33	0.02	<0.01	6.24	99.2
Comp 2	80.3	8.32	2.24	1.02	0.36	0.01	0.45	0.03	0.4	0.02	<0.01	4.77	98
LOD	0.1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01		

Notes: LOD = limit of detection; LOI = loss on ignition.

B2.4.4 Shake Flask Extraction

The water soluble constituents of hanging wall composite samples were determined using a SFE method (Table B2.4-5). Consistent with ABA results, Comp 1 produced acidic leachate (pH of 3.3 and total-acidity of 902 mg CaCO₃/L) containing nearly 1500 mg/L sulphate and metal(loid)s in concentrations which exceed the provincial water quality guidelines for protection of aquatic life. Specifically, these metal(loid)s include Al, As, Cd, Cr, Co, Cu, Fe, Mn, Ni, Tl and Zn. Comp 2 produced a neutral leachate containing 700 mg/L sulphate and concentrations of Cd and Tl which exceed the provincial guidelines.

Table B2.4-5:
Shake Flask Extractions for 7 South Hanging Wall Kinetic Test Composite Samples.

Parameter	Units	Comp 1	Comp 2	Max BC WQG ¹
pH		3.3	7.3	
Redox	mV	278	71	
Conductivity	uS/cm	2270	1520	
T-Acidity (to pH 8.3)	mg CaCO ₃ /L	902	7.4	
Alkalinity	mg CaCO ₃ /L	#N/A	40.9	
Fluoride	mg/L	0.12	0.10	
Sulphate	mg/L	1496	700	100
Dissolved Metals				
Hardness	mg CaCO ₃ /L	751	829	
Al	mg/L	1.06	0.025	0.1
Sb	mg/L	0.0002	<0.0002	0.02
As	mg/L	0.015	0.0010	0.005
Ba	mg/L	0.018	0.026	5
B	mg/L	0.0062	0.015	1.2
Cd	mg/L	0.0021	0.000036	0.00003
Ca	mg/L	141	219	
Cr	mg/L	0.026	0.0006	0.001
Co	mg/L	0.53	0.0096	0.11
Cu	mg/L	0.013	0.0014	0.011
Fe	mg/L	359	0.16	0.35
Pb	mg/L	0.00068	0.0001	0.003
Li	mg/L	0.004	0.004	0.87
Mg	mg/L	87.8	68.2	
Mn	mg/L	9.02	1.38	1.64
Hg	ug/L	0.02	0.04	
Mo	mg/L	0.00018	0.00014	2
Ni	mg/L	0.74	0.023	0.065
Se	mg/L	0.00053	0.00028	0.002
Ag	mg/L	<0.00001	0.00002	0.0001
Tl	mg/L	0.0007	0.0003	0.0003
U	mg/L	0.005	0.00084	0.3
V	mg/L	0.0062	0.00021	0.02
Zn	mg/L	0.81	0.008	0.041

Notes: 1. Shaded values exceed the British Columbia Water Quality Guideline for Freshwater Aquatic Life (BC MOE, 2006).

Appendix B3:
Laboratory Methods



Canadian Environmental & Metallurgical Inc.

Test Procedures for Quinsam Coal Corp.

July 27, 2009

1.0 Sample Receiving

Samples were received, weighed and logged in.

2.0 Sample Preparation

Where necessary, samples were crushed in a jaw crusher to approximately 80% -1/4 inch. Each sample was mixed by passing through a 1/2 inch splitter box and recombining. A 200 g split was then made and pulverized in a ring pulverizer to 80% -200 mesh. Splits of the pulverized samples were then submitted for analysis.

3.0 Analysis

3.1 Paste pH

Paste pH was conducted according to the procedure by Sobek A., et. al. 1978 “Field and Laboratory Methods Applicable to Overburdens and Minesoils” (Report EPA-600/2-78-054).

3.2 Acid Base Accounting

Acid base accounting was conducted according to Method 3: Modification of Conventional EPA Neutralization Potential Determination by Addition of Hydrogen Peroxide. The procedure is outlined in MEND Project 1.16.1c, 1991.

Samples were also subjected to the modified ABA procedure outlined in MEND Project 1.16.1b, 1991.

3.3 Total Sulphur and Carbon

Total sulphur and carbon were determined by Assayers Canada Ltd. (for rush analysis) or Acme Analytical using a Leco furnace.

3.4 Sulphate-Sulphur

Acid-soluble sulphate was determined by Assayers Canada. In this procedure, the sample is digested with 20% hydrochloric acid and the sulphur content measured by ICP.

3.5 Sulphide-Sulphur

Sulphide-sulphur was determined by Assayers Canada Ltd. The procedure is based on a modified sulphide-sulphur method by Sobek, A. A., *et al.* 1978. “Field and Laboratory

Methods Applicable to Overburdens And Minesoils” Report EPA-600/2-78-054. In this procedure, acid-soluble sulphate is first removed by treatment with 20% hydrochloric acid. The sulphide-sulphur in the residue is oxidized to sulphate in a 1:7 nitric acid to water solution, and the sulphur content is then measured by ICP.

3.6 Insoluble Sulphur

Insoluble sulphur is calculated as the difference between total sulphur and the sum of sulphate-sulphur and sulphide-sulphur (Total S – Sulphate S + Sulphide S). Insoluble sulphur is acid insoluble sulphur which is attributed to refractory sulphate compounds such as barite and alunite and to organic sulphur found in coal.

3.7 Inorganic Carbon

Total inorganic carbon was determined by Assayers Canada Ltd. In this procedure, a known weight of sample is placed into a glass test tube and acidified with 25% hydrochloric acid. The sample is boiled to evolve CO₂ which is measured by coulometric titration with a UIC Carbon Dioxide Analyzer.

3.8 Total Metals

Total metals were conducted at Acme on the pulverized sample by digesting 0.500 g in aqua regia at 95°C for one hour. The extract is then diluted to 10.0 mL and analysed for metals by ICP-MS.

3.9 X-Ray Diffraction

Samples for were sent to Dr. Mati Raudsepp at the University of British Columbia for quantitative Rieveld X-ray diffraction.

3.10 Shake Flask Extraction

Shake flask extractions were conducted using a 3:1 liquid to solid ratio as described by W. A. Price “Draft Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia”; British Columbia Ministry of Employment and Investment, Energy and Minerals Division.

The leachate was filtered through 0.45µm membrane filter paper and submitted for analysis. The pH was measured using the pH meter; conductivity was measured using the conductivity meter; acidity was determined by titration with base to an end point of either pH 4.5 (free acidity) and/or pH 8.3 (total acidity); alkalinity was determined by titration with an acid to an end point of pH 4.5; sulphate was measured by the turbidimetric method. Subsamples of the leachate were sent to Maxxam Analytics Inc. for metals analysis by ICP-

MS, chloride and fluoride analysis by ion selective electrode, nitrate analysis by colourimetry, and total dissolved solids by gravimetry.

3.11 Size Fraction Analysis

Samples for kinetic testing were screened using a Ro-Tap Sieve Shaker and Tyler ASTM Certified Test Sieves. Up to 7 screens were selected with opening sizes of 0.053mm, 0.150mm, 0.425mm, 1.70mm, 6.60mm, and 9.5mm, respectively.

3.12 Tailings Humidity Cell

Tailings Humidity Cell is made from acrylic tubing with an inside diameter of eight inches and a height of four inches. The cell has a fixed base plate with a leachate drainage hole fitted with a tubing nipple. A perforated PVC support plate is placed inside the cell, one inch above the base plate and covered with a Shark Skin® filter paper and one layer of 200 mesh nylon. Inflow of humid and dry air is through an air line placed on the cell through the top cover. The cell conforms and is operated according to procedure outlined in Acid Rock Drainage Prediction Manual. March 1991. The leachate was analysed as per the parameters described in Section 3.9

3.13 Column Tests

Columns were setup using 14.6 ID acrylic tubing with a drain hole fitted in the bottom. A perforated support plate rests on the column bottom separated by 0.6 cm spacers. To prevent loss of fines one layer of 200 mesh nylon is placed on the support plate. 4.5 to 5 kg of material is placed in the column. The columns are operated on continuous humid air and sampled weekly for analysis. Prior to the sampling day a minimum amount of water is trickled onto the surface in order to obtain sufficient leachate for analysis. The leachate was analysed as per the parameters described in Section 3.10.

Appendix B3-2: **Saturated Column Methods**

B3-2.1 Column Assembly

Two CCR samples were obtained from Hillsborough Resources Ltd., samples QCM 92053 4U/4L CCR (Column HQA) and 91945 +100M/SNK 1.6 (Column HQB). Both columns were set-up using the same methodology. The following section discusses the methods used in assembling the two CCR columns.

Two clear acrylic flow through columns 20 cm in length with inner diameter of 15 cm were manufactured by Dimension 3 Plastics (Vancouver, British Columbia), Figure B3-2-1. Figure B3-2-2 shows a schematic of the column experimental set up. Note that the experiment is designed so that water enters from the bottom of the column and flows upward; discharging from the top of the columns – meaning that the bottom of the column is effectively upgradient and the top of the column is downgradient. This is a common method for simulating saturated groundwater flow in laboratory experiments (Jurjovec *et al.*, 2002; Petrunic *et al.*, 2005; Al *et al.*, 2006) and is done to ensure consistent and even flow throughout the columns, eliminating the risk of uncontrolled gravity-driven drainage and preferential flow paths.

Material was packed into the columns via initially weighing the material, then the sample was poured into a cone onto a clean piece of 61 cm by 61 cm cardboard. Sub-samples of the CCR material were taken via a typical cone and quartering method. Each sub-sample was placed in the column, until the column was filled. The remaining sample was weighed. The difference from the initial weight and the final weight of sample is the mass of material in the column.

The columns were connected to a distilled water influent solution source. Initially flow was established at a rate of 230.4 mL/d for Column HQA and 229.6 mL/d for Column 2, which provides a water velocity of 2.9 cm/d while still producing enough discharge volume to collect samples within a reasonable time frame. Based on the velocity, column dimensions and an assumed porosity of 0.45, the average residence for water in the columns was 6.9 days. Because groundwater chemistry is a function of the amount of time it is in contact with the substrate (*e.g.*, affected by the kinetics of dissolution/precipitation and microbially-mediated reactions and adsorption/desorption effects) it is important when simulating groundwater flow to keep the velocity close to what might be expected in the field in order to achieve the most representative water chemistry possible in the laboratory. Influent solution is bubbled using a standard

aquarium pump to ensure the influent solution remains oxygenated. Figure B3-2-2 provides a generalized schematic of the experimental set-up, and Figure B3-2-3 provides images of the HQA and HQB columns. A summary of the physical parameters being analyzed for is provided Table B3-2-2.

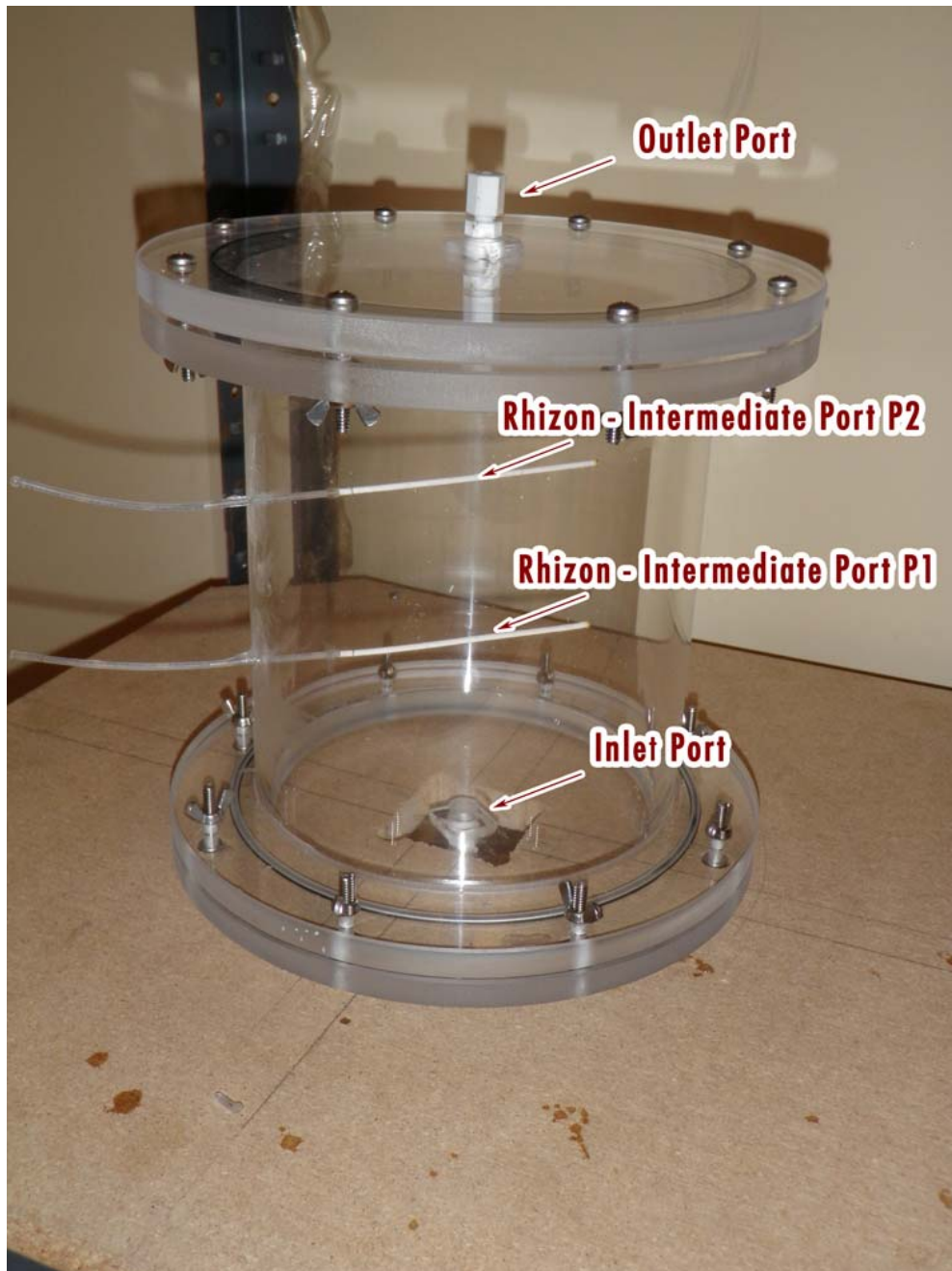


Figure B3-2-1: Acrylic column prior to packing with column material.

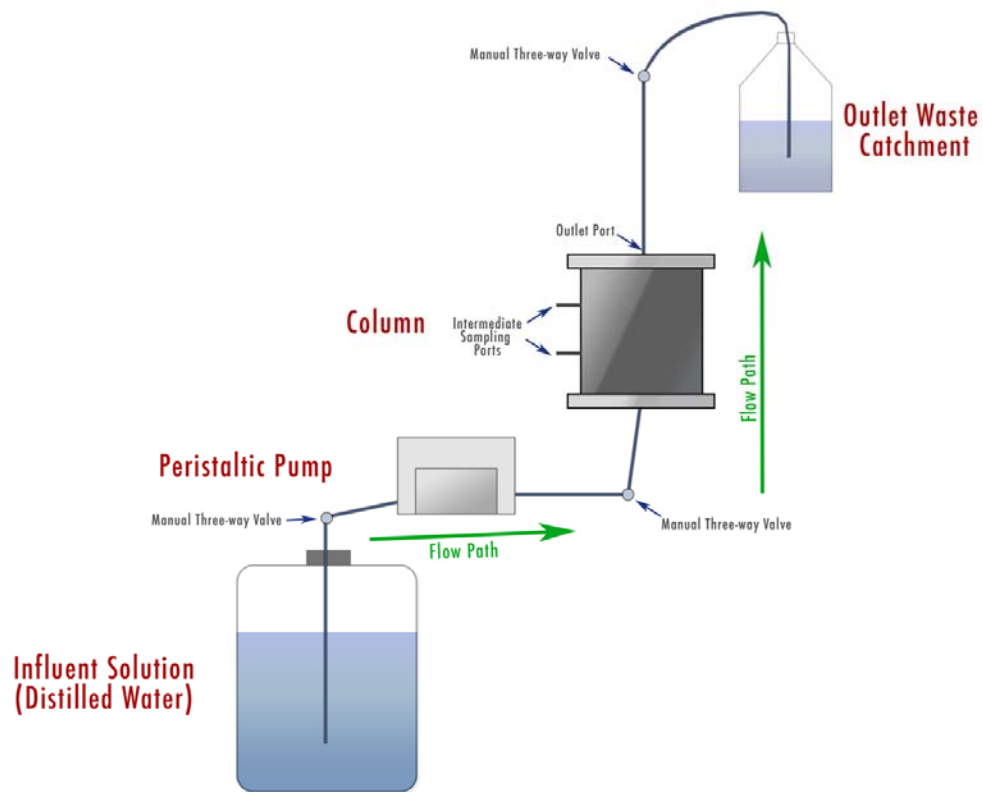


Figure B3-2-2: Schematic of Column Setup.

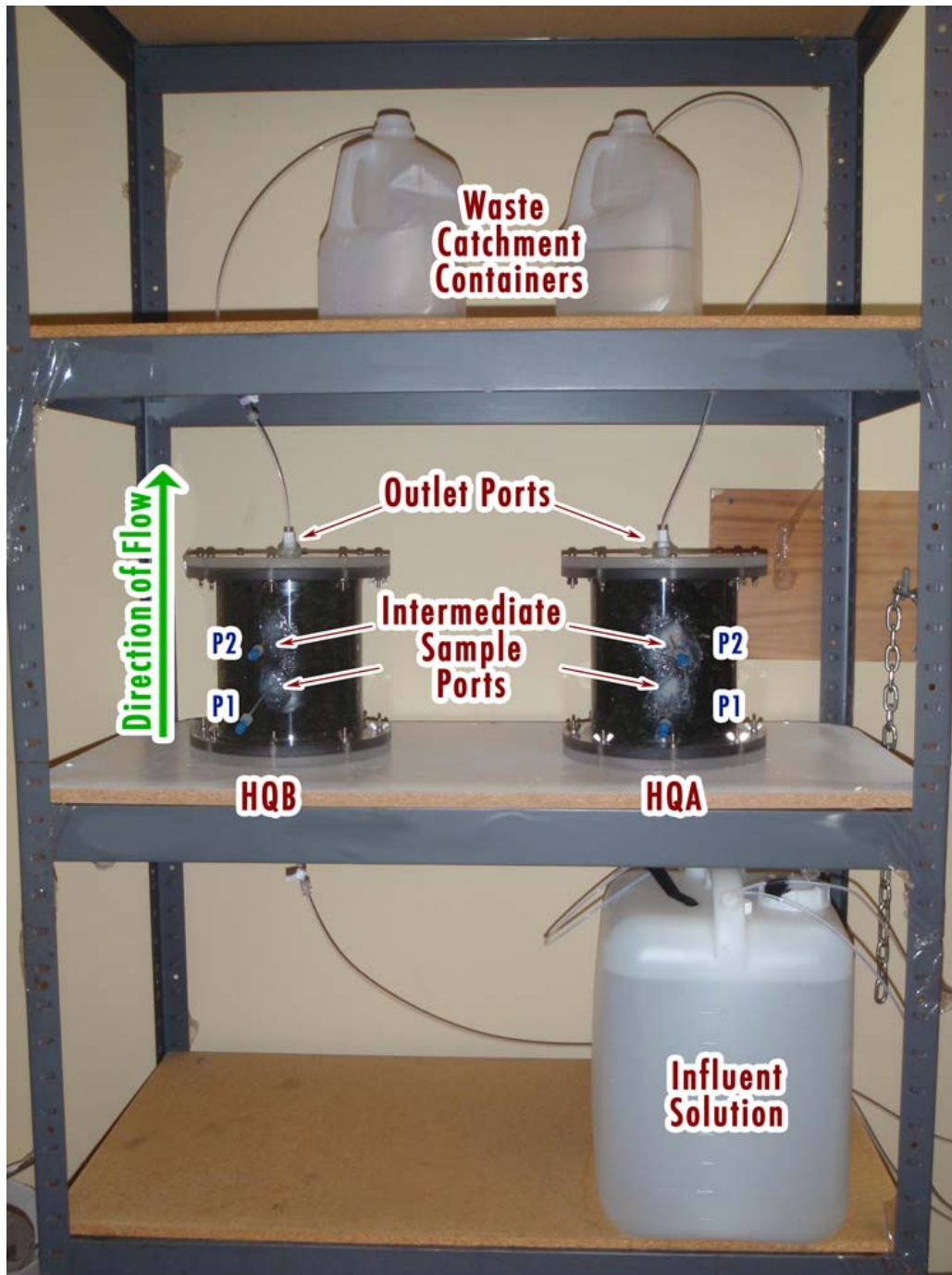


Figure B3-2-3: Columns HQA and HQB.

**Table B3-2-2:
Parameters List.**

Parameters	Units	RDL
ANIONS		
Nitrite (N)	mg/L	0.005
Calculated Parameters		
Nitrate (N)	mg/L	0.02
Misc. Inorganics		
Dissolved Hardness (CaCO ₃)	mg/L	0.5
Dissolved Organic Carbon (C)	mg/L	0.5
Anions		
Dissolved Sulphate (SO ₄)	mg/L	5
Dissolved Chloride (Cl)	mg/L	0.5
Nutrients		
Ammonia (N)	mg/L	0.01
Dissolved Phosphorus (P)	mg/L	0.005
Nitrate plus Nitrite (N)	mg/L	0.02
Dissolved Metals by ICPMS		
Dissolved Aluminum (Al)	ug/L	3
Dissolved Antimony (Sb)	ug/L	0.5
Dissolved Arsenic (As)	ug/L	0.1
Dissolved Barium (Ba)	ug/L	1
Dissolved Beryllium (Be)	ug/L	0.1
Dissolved Bismuth (Bi)	ug/L	1
Dissolved Boron (B)	ug/L	50
Dissolved Cadmium (Cd)	ug/L	0.01
Dissolved Chromium (Cr)	ug/L	1
Dissolved Cobalt (Co)	ug/L	0.5
Dissolved Copper (Cu)	ug/L	0.2
Dissolved Iron (Fe)	ug/L	5
Dissolved Lead (Pb)	ug/L	0.2
Dissolved Manganese (Mn)	ug/L	1
Dissolved Mercury (Hg)	ug/L	0.02
Dissolved Molybdenum (Mo)	ug/L	1
Dissolved Nickel (Ni)	ug/L	1
Dissolved Selenium (Se)	ug/L	0.1
Dissolved Silicon (Si)	ug/L	100
Dissolved Silver (Ag)	ug/L	0.02
Dissolved Strontium (Sr)	ug/L	1
Dissolved Thallium (Tl)	ug/L	0.05
Dissolved Tin (Sn)	ug/L	5
Dissolved Titanium (Ti)	ug/L	5
Dissolved Uranium (U)	ug/L	0.1
Dissolved Vanadium (V)	ug/L	5
Dissolved Zinc (Zn)	ug/L	5
Dissolved Zirconium (Zr)	ug/L	0.5
Dissolved Calcium (Ca)	mg/L	0.05
Dissolved Magnesium (Mg)	mg/L	0.05
Dissolved Potassium (K)	mg/L	0.05
Dissolved Sodium (Na)	mg/L	0.05
Dissolved Sulphur (S)	mg/L	3

RDL = Reported Detection Limit

Sample Collection

The sample collection for each of HQA and HQB are identical. Upon setting up the each of the columns sampling of the outlet port was done once per week for the initial 4 weeks, subsequently the outlets are sampled every second week. Influent samples are taken upon introduction of a new influent solution batch, typically once every 6 weeks. During the initial week of sampling the intermediate port, Port 1 or P1, was sampled. During the experiment these intermediate ports will be sampled occasionally.

Influent Solution

During the initial set-up of the experiment and, subsequently, upon changing the influent solutions, samples are collected from the inlets (Figure B3-2-4). During the duration of the experiment inlet samples are collected after outlet samples had been collected.

The inlet samples were collected by diverting the flow from the column at the inlet and withdrawing the solution into a syringe. The inlet samples are filtered with 0.45 µm disposable syringe filters. The pH and alkalinity are measured in-house at the time of sample collection in the same manner as the outlet samples. Flow is returned to the columns immediately after inlet sample collection.

Effluent Solution

Samples of the effluent from each column are collected on a weekly basis during the initial 4 weeks, and subsequently biweekly thereafter. An initial sampling of the intermediate port P1 was done during the initial week of sampling. When sampling of intermediate ports are taken samples collected sequentially starting from the outlet, moving up the flow gradient, toward the inlet (Figure B3-2-4).

The sampling apparatus for the aqueous geochemical samples consists of two in-line flow-through cells connected to the column outlet valves or ports with Teflon tubing (Figure B3-2-4). The first cell is a Teflon bottle used to collect water for analytical laboratory and in-house alkalinity analyses; the second cell holds a ORP probe for measurement of relative electro-conductivity and a pH probe. To prevent oxygen ingress into the sampling chamber and to preserve the redox state during sampling, the apparatus is purged with nitrogen gas (N₂). Outlet tubing from the pH flow-through cell is submersed under water that is purged with N₂. When the flow-through cell had filled, the pH and ORP probes are allowed to stabilize prior to taking a sample reading (approximately 10 minutes). A two-point calibration was carried out for the pH meter each time using pH buffer solutions that bracketed the anticipated pH of the sample,

typically pH 4.00 and 7.00 buffers. A single point calibration is used for the ORP meter each time using an ORP standard.

Subsequent to making pH measurements, N₂ is allowed to flow into the Teflon sample vessel through one of the sample vessel outlets ensuring anaerobic conditions. A poly syringe is used to withdraw a sample from the remaining outlet. The sample is passed through a 0.45 µm single use SFCA-membrane (Cole-Parmer) syringe filter. For intermediate sample port samples, given that the rhizomes have pores measuring 0.1 µm in diameter, the port samples were filtered *in situ*; therefore, they were not filtered using syringe filters.

Samples for dissolved cation analysis are acidified with concentrated, ultra-pure nitric acid after filtration. Samples for total dissolved phosphorous, dissolved organic carbon and ammonia are filtered and preserved with 1:1 sulphuric acid. Samples are refrigerated immediately after collection and shipped to Maxxam Analytics Inc. (Maxxam) in coolers with ice bricks. Total alkalinity is determined in-house by colorimetric titration with 0.01M or 0.1M hydrochloric acid. The collection time for 1 complete aqueous sample is approximately 21 hours.

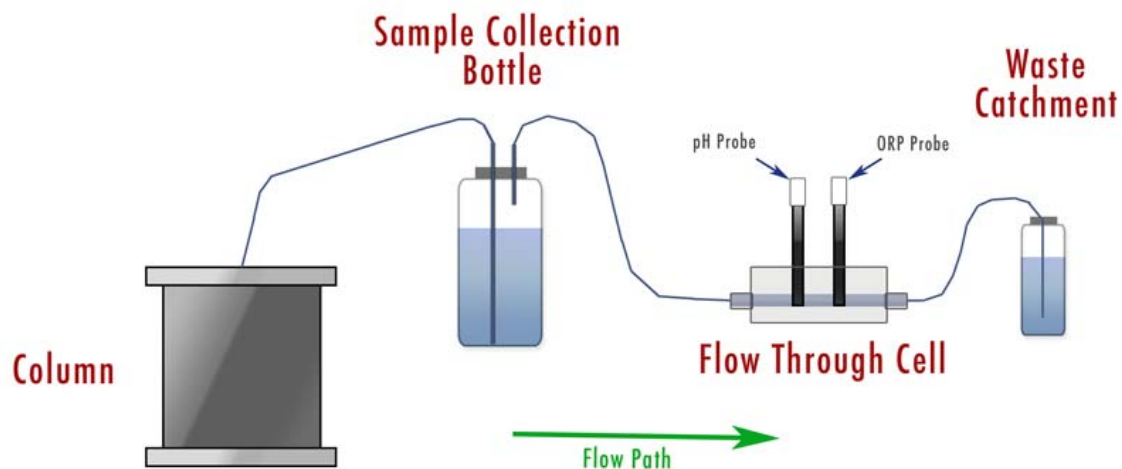


Figure B3-2-4: Schematic of sampling procedure.

***Appendix B4:
Mineralogy Reports***

**QUANTITATIVE PHASE ANALYSIS OF TWO POWDER SAMPLES USING THE
RIETVELD METHOD AND X-RAY POWDER DIFFRACTION DATA.**

(Project: 08122 Quinsam Coal – PO# 42299)

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February 3, 2011

EXPERIMENTAL METHOD

The two samples **Comp1** and **Comp2** of **Project 08122 Quinsam Coal** were reduced to the optimum grain-size range for quantitative X-ray analysis ($<10\ \mu\text{m}$) by grinding under ethanol in a vibratory McCrone Micronising Mill for 7 minutes. Step-scan X-ray powder-diffraction data were collected over a range $3\text{--}80^\circ 2\theta$ with CoK α radiation on a Bruker D8 Focus Bragg-Brentano diffractometer equipped with an Fe monochromator foil, 0.6 mm (0.3°) divergence slit, incident- and diffracted-beam Soller slits and a LynxEye detector. The long fine-focus Co X-ray tube was operated at 35 kV and 40 mA, using a take-off angle of 6° .

RESULTS

The X-ray diffractograms were analyzed using the International Centre for Diffraction Database PDF-4 and Search-Match software by Siemens (Bruker). X-ray powder-diffraction data of the samples were refined with Rietveld program Topas 4.2 (Bruker AXS). The results of semi-quantitative phase analysis by Rietveld refinements are given in Table 1. These amounts represent the relative amounts of crystalline phases normalized to 100%. The Rietveld refinement plots are shown in Figures 1 – 2.

In both samples the kaolinite exhibits a high degree of stacking disorder and the amount modeled is semi-quantitative as the crystal structure can only be approximately fitted using a modified kaolinite structure.

Table 1. Results of semi-quantitative phase analysis (wt.%)

Mineral	Ideal Formula	Comp 1	Comp 2
Quartz	SiO ₂	69	72
Muscovite	KAl ₂ AlSi ₃ O ₁₀ (OH) ₂	2	2
Kaolinite	Al ₂ Si ₂ O ₅ (OH) ₄	20	19
Gypsum	CaSO ₄ ·2H ₂ O	1	1
K-Feldspar	KAlSi ₃ O ₈	4	3
Plagioclase	NaAlSi ₃ O ₈ – CaAl ₂ Si ₂ O ₈	1	
Calcite	CaCO ₃		1
Ankerite – Dolomite	Ca(Fe ²⁺ ,Mg,Mn)(CO ₃) ₂ – CaMg(CO ₃) ₂		1
Siderite	Fe ²⁺ CO ₃	1	1
Pyrite	FeS ₂	3	1
Marcasite	FeS ₂	<1	<1
Total		100	100

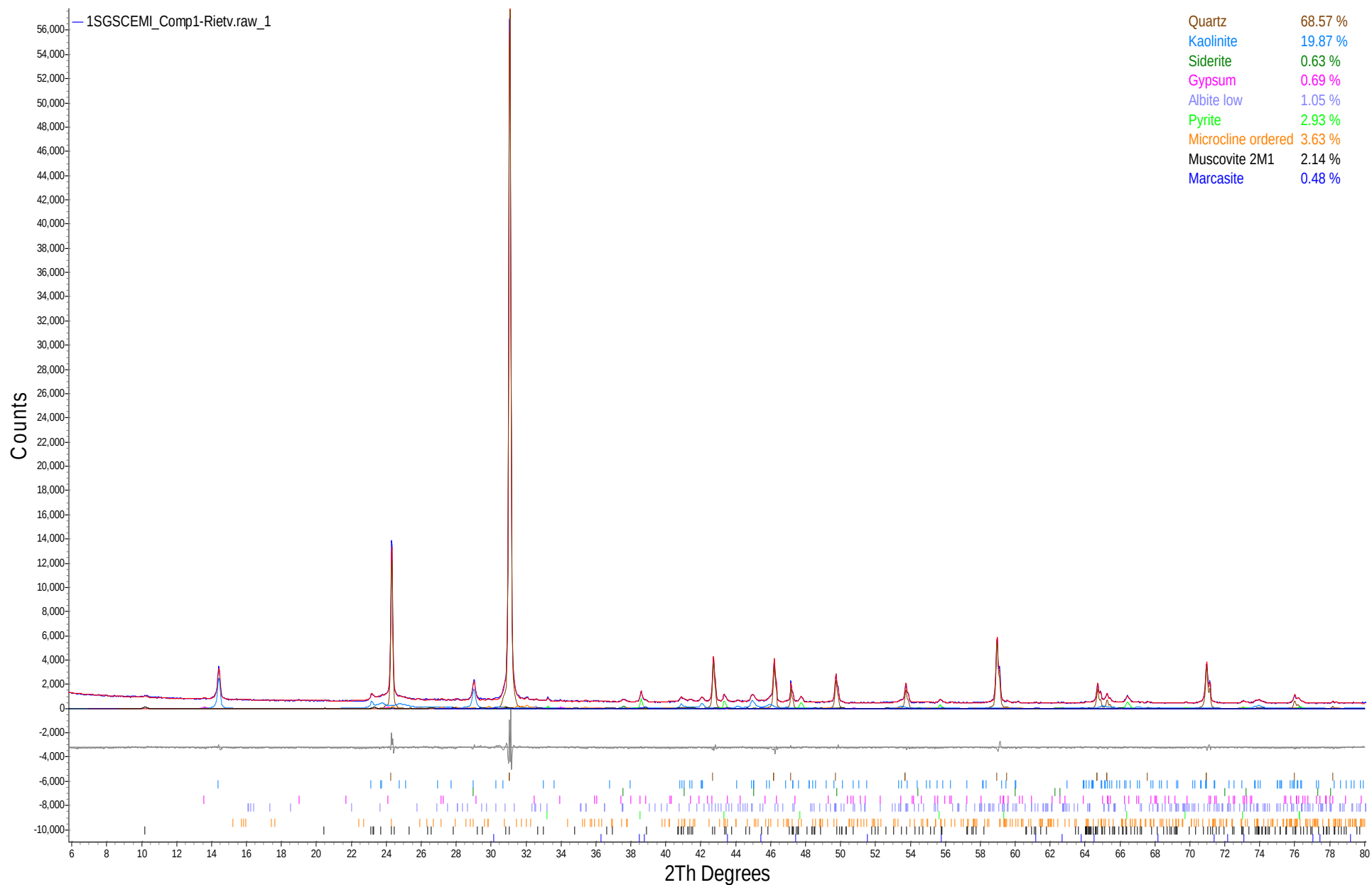


Figure 1. Rietveld refinement plot of sample **SGS CEMI “Comp 1”** (blue line - observed intensity at each step; red line - calculated pattern; solid grey line below – difference between observed and calculated intensities; vertical bars, positions of all Bragg reflections). Coloured lines are individual diffraction patterns of all phases.

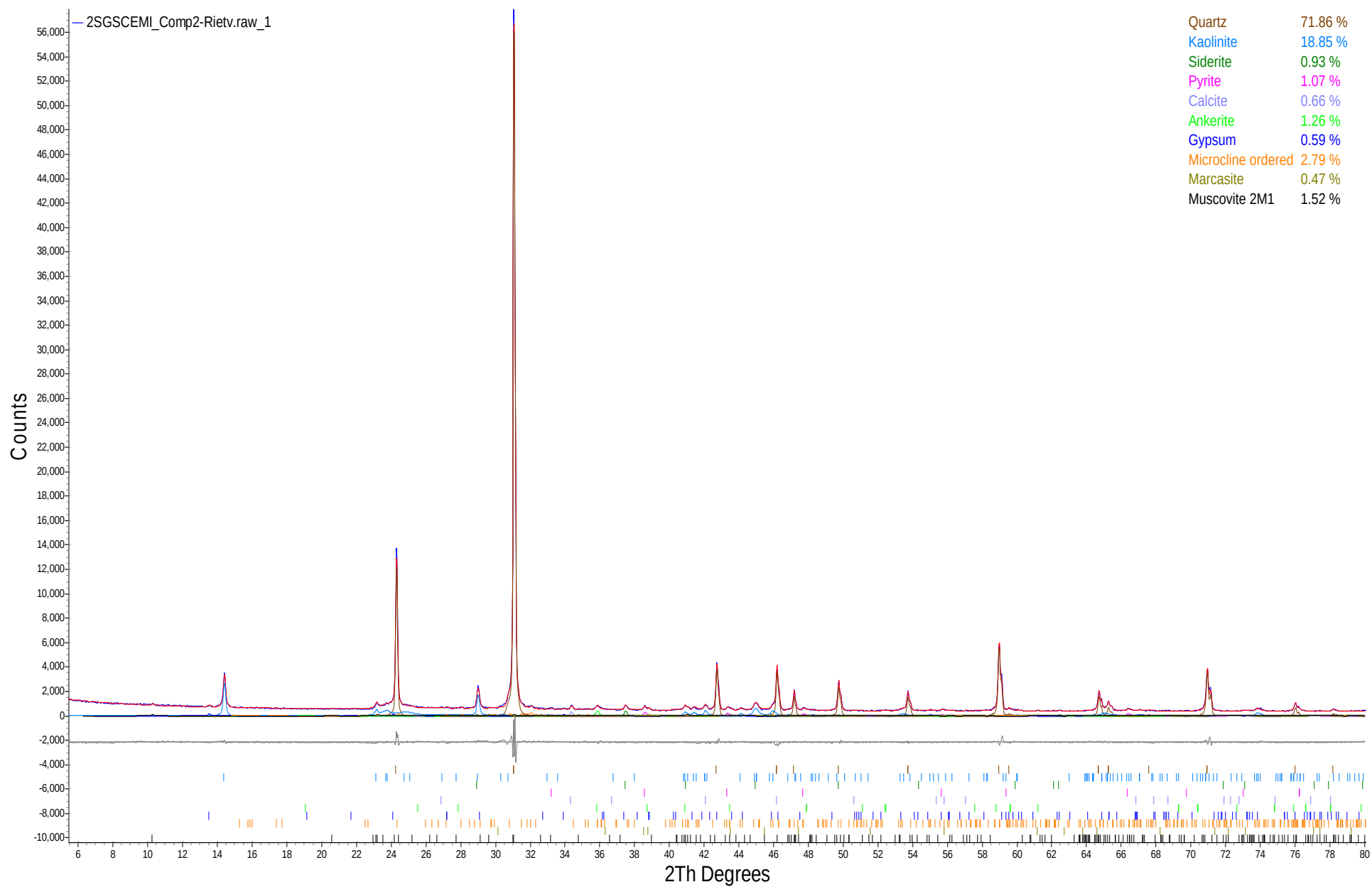


Figure 2. Rietveld refinement plot of sample **SGS CEMI “Comp 2”** (blue line - observed intensity at each step; red line - calculated pattern; solid grey line below – difference between observed and calculated intensities; vertical bars, positions of all Bragg reflections). Coloured lines are individual diffraction patterns of all phases.

**QUANTITATIVE PHASE ANALYSIS OF ONE POWDER SAMPLE USING THE
RIETVELD METHOD AND X-RAY POWDER DIFFRACTION DATA.**

(Project: 08122 Quinsam Coal – PO# 42307)

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February 9, 2011

EXPERIMENTAL METHOD

The sample “**7South Tailings Comp.**” of **Project 08122 Quinsam Coal** was reduced to the optimum grain-size range for quantitative X-ray analysis ($<10\ \mu\text{m}$) by grinding under ethanol in a vibratory McCrone Micronising Mill for 7 minutes. Step-scan X-ray powder-diffraction data were collected over a range $3\text{--}80^\circ 2\theta$ with CoK α radiation on a Bruker D8 Focus Bragg-Brentano diffractometer equipped with an Fe monochromator foil, 0.6 mm (0.3°) divergence slit, incident- and diffracted-beam Soller slits and a LynxEye detector. The long fine-focus Co X-ray tube was operated at 35 kV and 40 mA, using a take-off angle of 6° .

RESULTS

The X-ray diffractogram was analyzed using the International Centre for Diffraction Database PDF-4 and Search-Match software by Siemens (Bruker). X-ray powder-diffraction data of the sample were refined with Rietveld program Topas 4.2 (Bruker AXS). The results of quantitative phase analysis by Rietveld refinements are given in Table 1. These amounts represent the relative amounts of crystalline phases normalized to 100%. The Rietveld refinement plot is shown in Figure 1.

Note that the abundant kaolinite exhibits a high degree of stacking disorder and the amount modeled is semi-quantitative as the crystal structure can only be approximately fitted using a modified kaolinite structure.

Table 1. Results of semi-quantitative phase analysis (wt.%)

Mineral	Ideal Formula	7South Tailings Comp.
Quartz	SiO ₂	40
Kaolinite	Al ₂ Si ₂ O ₅ (OH) ₄	38
K-Feldspar	KAlSi ₃ O ₈	4
Plagioclase	NaAlSi ₃ O ₈ – CaAl ₂ Si ₂ O ₈	1
Ankerite – Dolomite	Ca(Fe ²⁺ ,Mg,Mn)(CO ₃) ₂ – CaMg(CO ₃) ₂	2
Calcite	CaCO ₃	8
Siderite	Fe ²⁺ CO ₃	1
Pyrite	FeS ₂	4
Marcasite	FeS ₂	1
Anatase	TiO ₂	1
Total		100

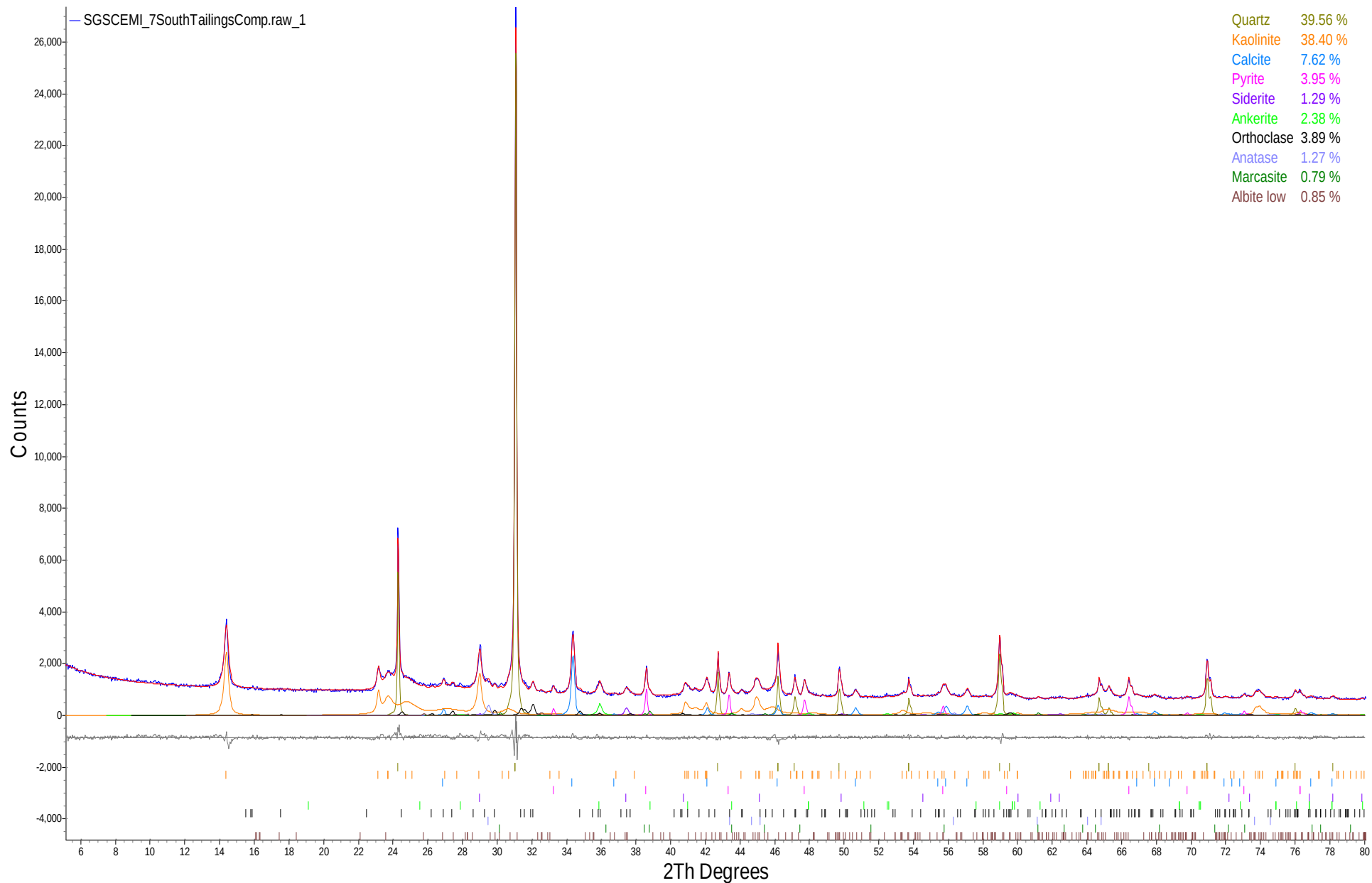


Figure 1. Rietveld refinement plot of sample **SGS CEMI “7South Tailings Comp.”** (blue line - observed intensity at each step; red line - calculated pattern; solid grey line below – difference between observed and calculated intensities; vertical bars, positions of all Bragg reflections). Coloured lines are individual diffraction patterns of all phases.

**QUANTITATIVE PHASE ANALYSIS OF 6 POWDER SAMPLES USING THE
RIETVELD METHOD AND X-RAY POWDER DIFFRACTION DATA.**

(Project: 08122 Quinsam Coal – P.O. 41887)

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May 27, 2009

EXPERIMENTAL METHOD

The six samples of **Project 08122 Quinsam Coal** were reduced into fine powder to the optimum grain-size range for X-ray analysis ($<10\mu\text{m}$) grinding under ethanol in a vibratory McCrone Micronising Mill for 7 minutes. Step-scan X-ray powder-diffraction data were collected over a range $3-80^{\circ}2\theta$ with $\text{CoK}\alpha$ radiation on a standard Siemens (Bruker) D5000 Bragg-Brentano diffractometer equipped with an Fe monochromator foil, 0.6 mm (0.3°) divergence slit, incident- and diffracted-beam Soller slits and a Vantec-1 strip detector. The long fine-focus Co X-ray tube was operated at 35 kV and 40 mA, using a take-off angle of 6° .

RESULTS AND DISCUSSION

The X-ray diffractograms were analyzed using the International Centre for Diffraction Database PDF-4 using Search-Match software by Siemens (Bruker). X-ray powder-diffraction data were refined with Rietveld program Topas 3 (Bruker AXS).

The results of quantitative phase analysis by Rietveld refinement are given in Table 1. These amounts represent the relative amounts of crystalline phases normalized to 100%. The Rietveld refinement plots for the samples are shown in Figures 1-6.

Note that in all samples the in these samples, the clay, kaolinite, exhibits structural disorder and cannot be modelled accurately. Thus the results are semi-quantitative.

Table 1. Results of *semi-quantitative* phase analysis (wt.%)

Mineral	Ideal formula	92050 sample 1	92051 sample 2	92052 sample 3	92053 sample 4	92054 sample 5	92055 sample 6
Quartz	SiO ₂	34.2	32.2	55.7	41.9	42.6	24.2
Kaolinite	Al ₂ Si ₂ O ₅ (OH) ₄	50.2	39.0	26.2	33.8	32.9	35.2
K-feldspar	KAlSi ₃ O ₈		4.0	5.9	7.3	7.9	3.5
Plagioclase	NaAlSi ₃ O ₈ – CaAl ₂ Si ₂ O ₈			3.2	3.0	2.3	
Calcite	CaCO ₃	7.8	13.1	0.8	5.8	5.2	25.4
Dolomite	CaMg(CO ₃) ₂	1.4	0.5	2.5	1.3	1.0	4.8
Pyrite	FeS ₂	6.4	11.1	5.8	6.9	8.2	6.9
Total		100.0	100.0	100.0	100.0	100.0	100.0

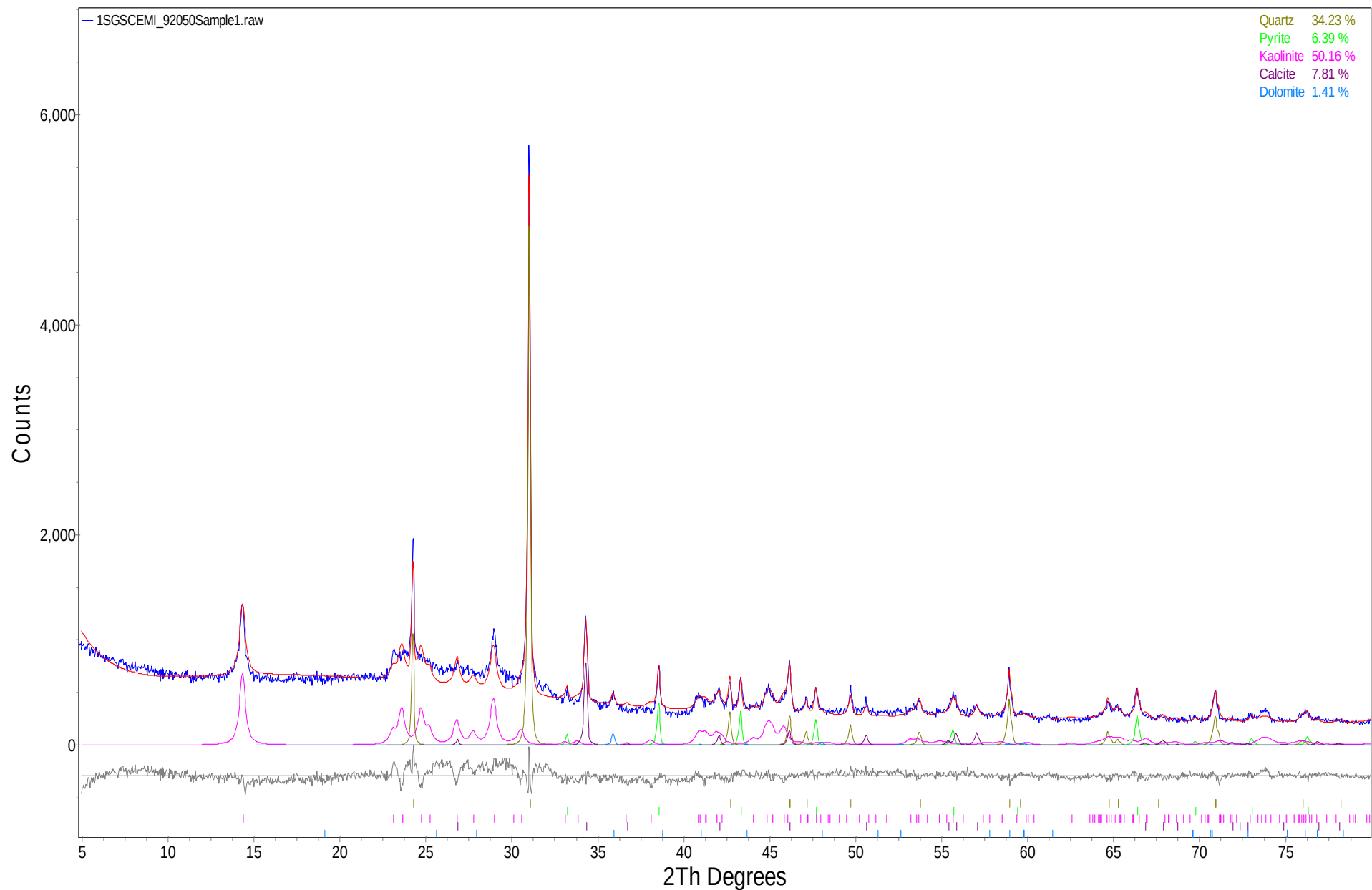


Figure 1. Rietveld refinement plot of sample **SGS CEMI “92050 sample 1”** (blue line - observed intensity at each step; red line - calculated pattern; solid grey line below – difference between observed and calculated intensities; vertical bars, positions of all Bragg reflections). Coloured lines are individual diffraction patterns of all phases.

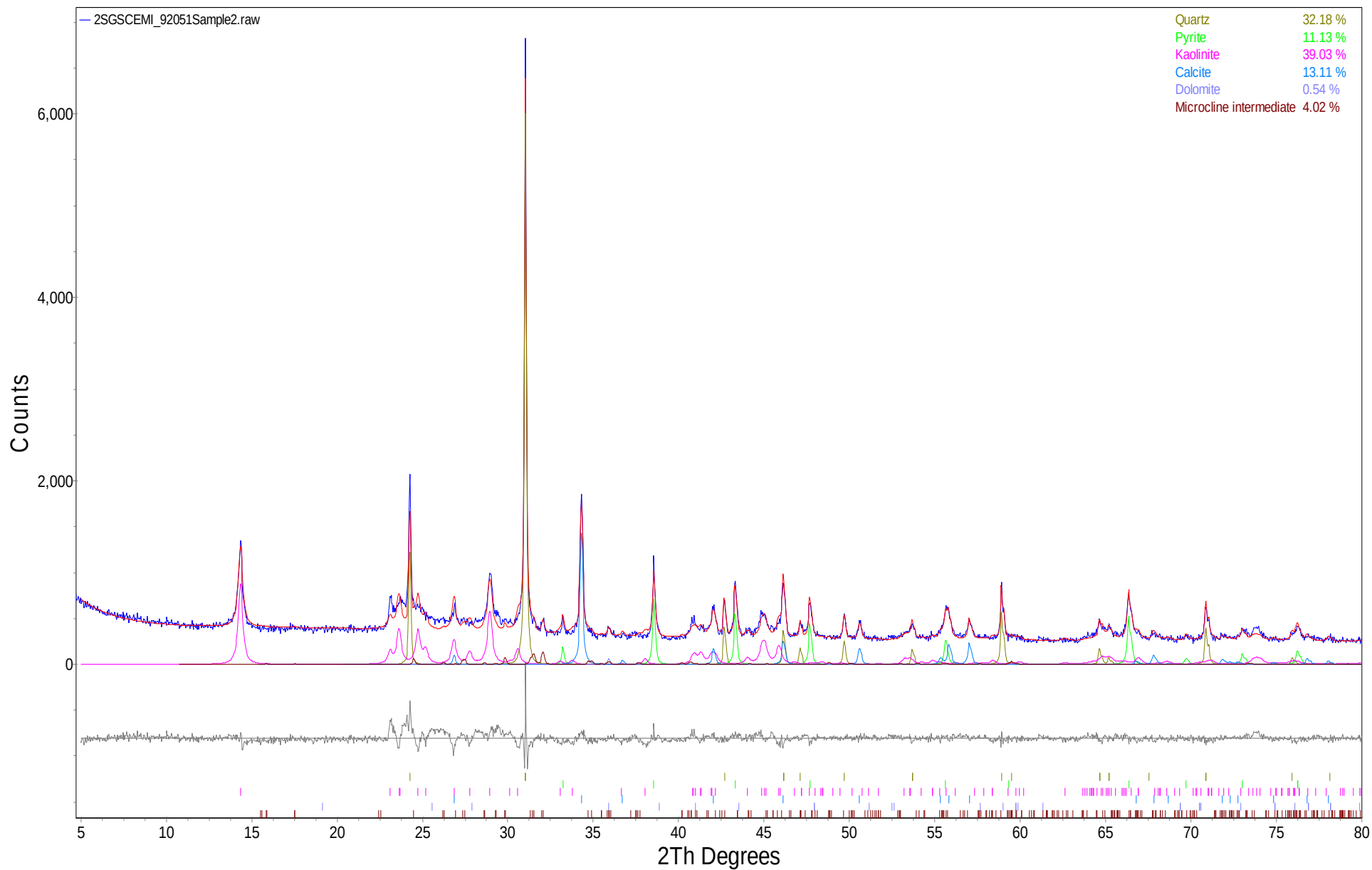


Figure 2. Rietveld refinement plot of sample **SGS CEMI “92051 sample 2”** (blue line - observed intensity at each step; red line - calculated pattern; solid grey line below – difference between observed and calculated intensities; vertical bars, positions of all Bragg reflections). Coloured lines are individual diffraction patterns of all phases.

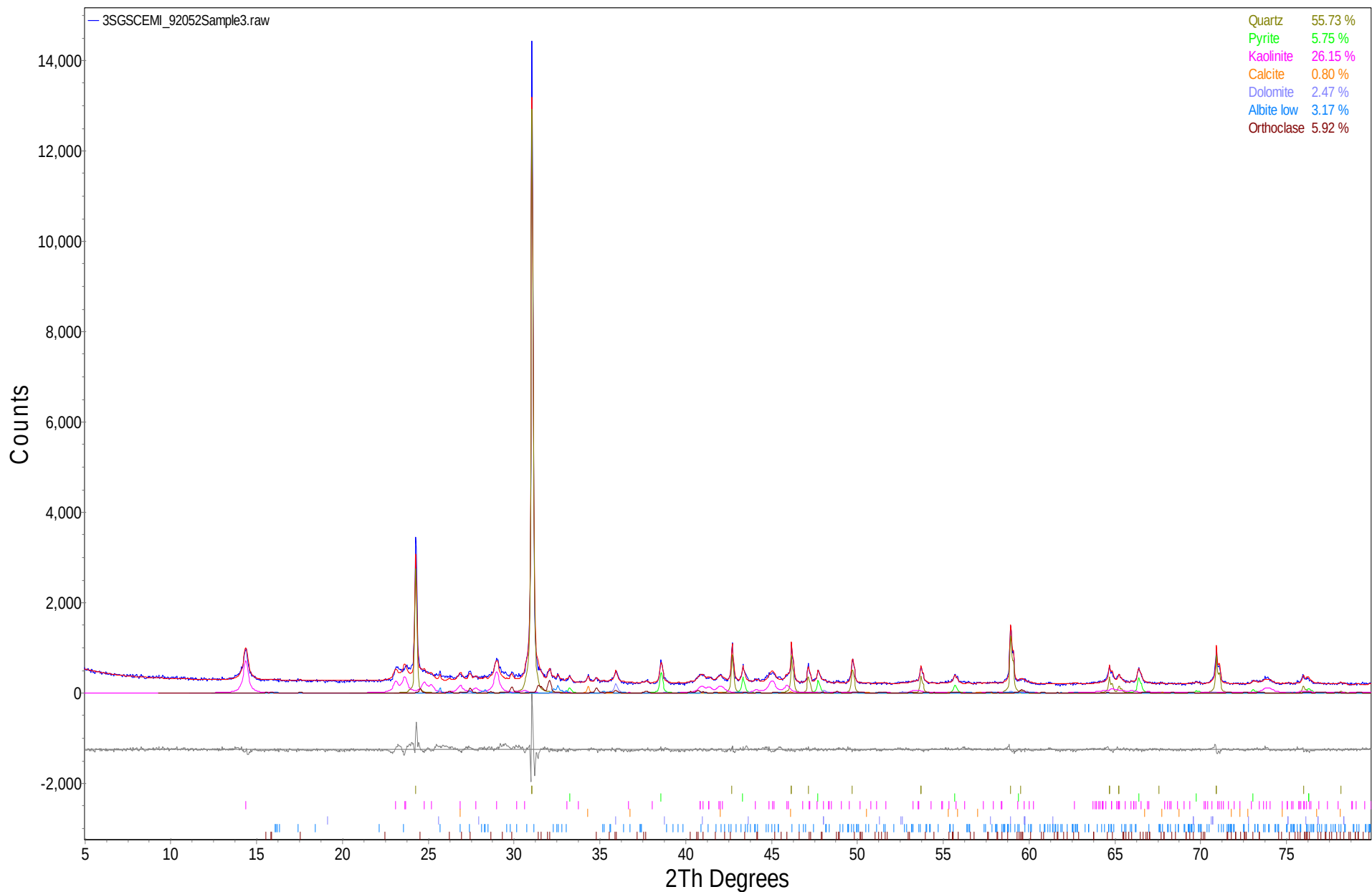


Figure 3. Rietveld refinement plot of sample **SGS CEMI “92052 sample 3”** (blue line - observed intensity at each step; red line - calculated pattern; solid grey line below – difference between observed and calculated intensities; vertical bars, positions of all Bragg reflections). Coloured lines are individual diffraction patterns of all phases.

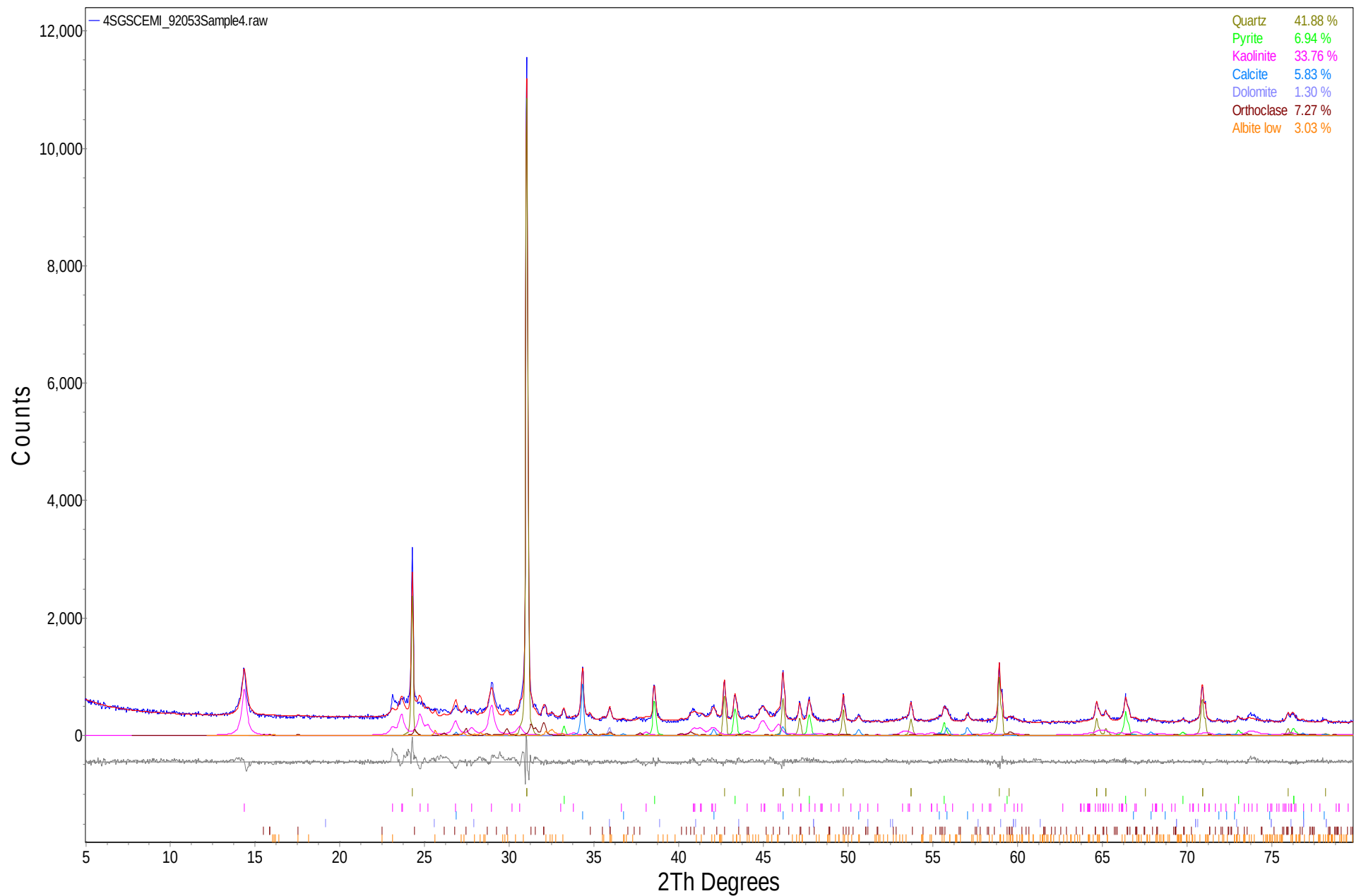


Figure 4. Rietveld refinement plot of sample **SGS CEMI “92053 sample 4”** (blue line - observed intensity at each step; red line - calculated pattern; solid grey line below – difference between observed and calculated intensities; vertical bars, positions of all Bragg reflections). Coloured lines are individual diffraction patterns of all phases.

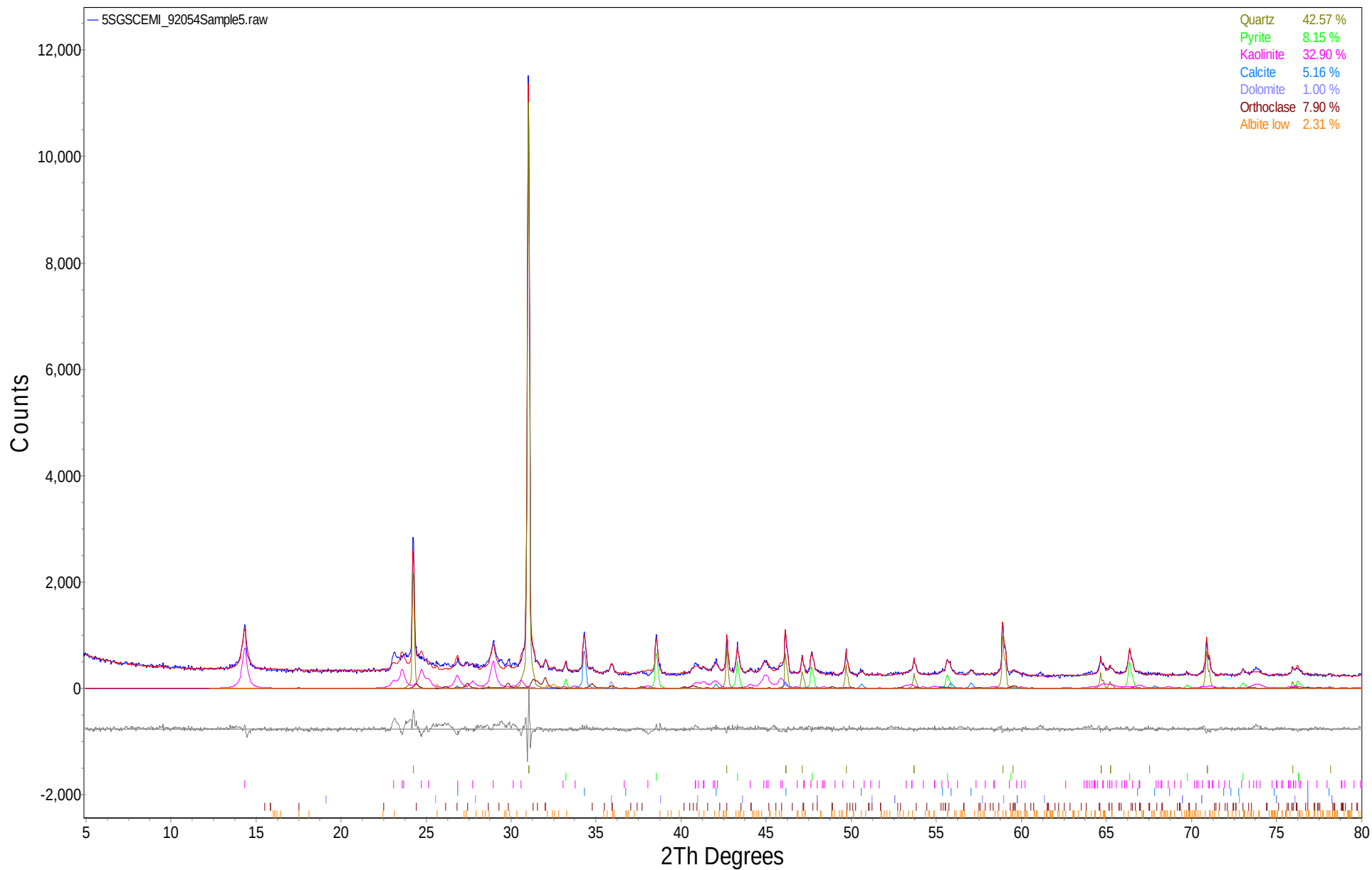


Figure 5. Rietveld refinement plot of sample **SGS CEMI “92054 sample 5”** (blue line - observed intensity at each step; red line - calculated pattern; solid grey line below – difference between observed and calculated intensities; vertical bars, positions of all Bragg reflections). Coloured lines are individual diffraction patterns of all phases.

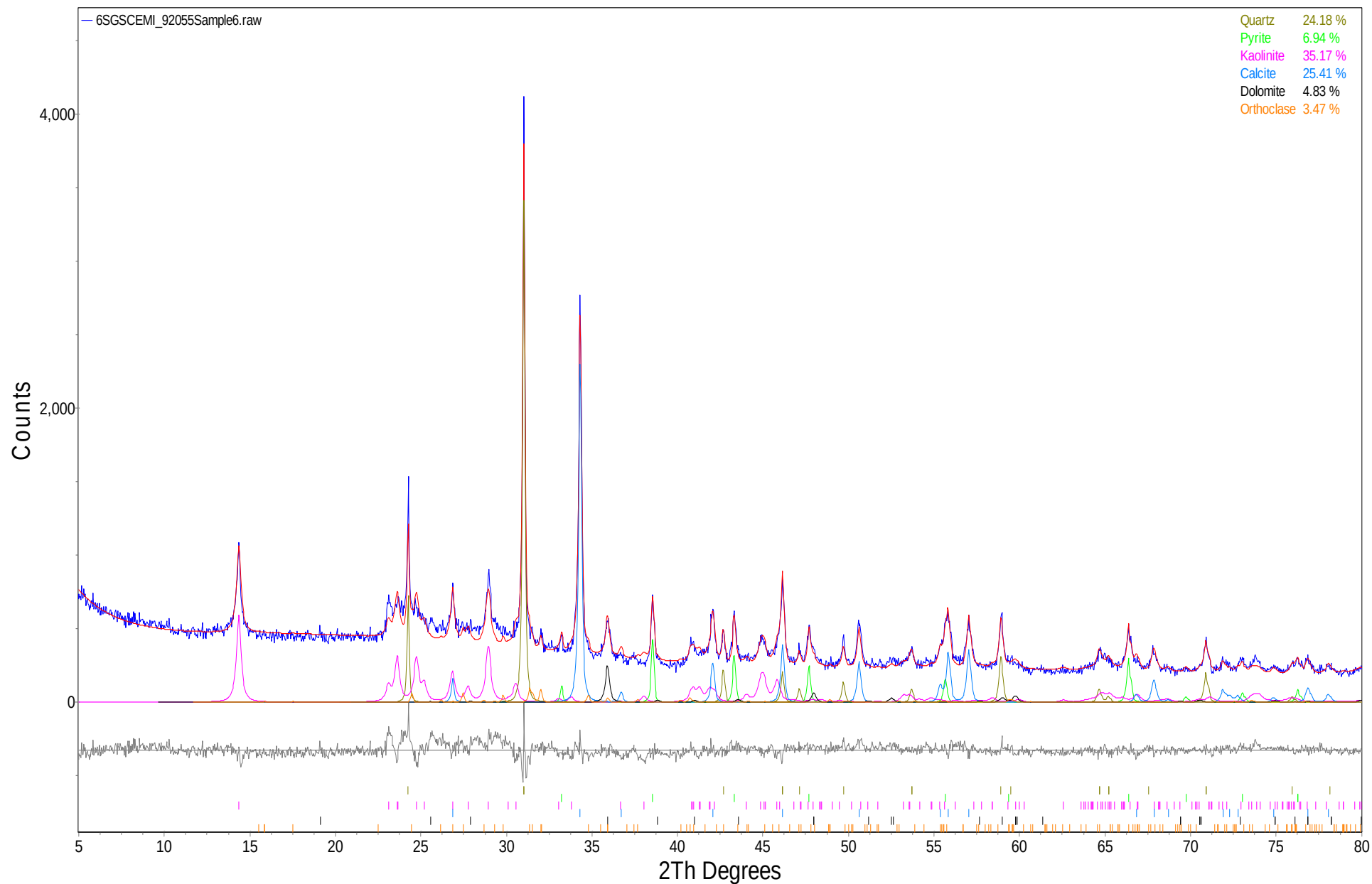


Figure 6. Rietveld refinement plot of sample **SGS CEMI “92055 sample 6”** (blue line - observed intensity at each step; red line - calculated pattern; solid grey line below – difference between observed and calculated intensities; vertical bars, positions of all Bragg reflections). Coloured lines are individual diffraction patterns of all phases.

X-RAY POWDER DIFFRACTION ANALYSIS OF TWO FRACTURE- PLANE MINERALS

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April 12, 2011

EXPERIMENTAL METHOD

The two samples were ground into fine powder with a corundum mortar and smeared on to a glass slide with ethanol. Step-scan X-ray powder-diffraction data were collected over a range 3-80°2 θ with CoK α radiation on a Bruker D8 Focus Bragg-Brentano diffractometer equipped with an Fe monochromator foil, 0.6 mm (0.3°) divergence slit, incident- and diffracted-beam Soller slits and a LynxEye detector. The long fine-focus Co X-ray tube was operated at 35 kV and 40 mA, using a take-off angle of 6°.

RESULTS

Mineral identification was done using the International Centre for Diffraction Database PDF-4 and Search-Match software by Siemens (Bruker). The results are shown in Table 1. The X-ray diffractograms are shown in Figures 1–2.

The red colour on the fracture-plane in the Dunsmuir Sandstone is the result of abundant realgar. There is no obvious red mineral on the fracture plane in the Quarry Intrusive sample, but stellerite is reported to occur with a deep salmon colour at some localities.

Table 1. Results of qualitative analysis.

Mineral	Ideal Formula	Quarry Intrusive	Dunsmuir Sandstone
Calcite	CaCO_3	X	X
Quartz low	SiO_2	X	X
Kaolinite	$\text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4$	X	
Stellerite	$\text{CaAl}_2\text{Si}_7\text{O}_{18} \cdot 7\text{H}_2\text{O}$	X	
Pargasite?	$\text{NaCa}_2\text{Mg}_4\text{Al}_3\text{Si}_6\text{O}_{22}(\text{OH})_2$	X	
Albite	$\text{NaAlSi}_3\text{O}_8$	X	
Orthoclase	$\text{NaAlSi}_3\text{O}_8$	X	
Muscovite	$\text{KnaAl}_3\text{Si}_3\text{O}_{10}(\text{OH})_2$	X	
Clinochlore	$\text{Mg}_5\text{AlSi}_3\text{AlO}_{10}(\text{OH})_8$	X	
Stilbite	$\text{NaCa}_2\text{Al}_5\text{Si}_{13}\text{O}_{36} \cdot 14\text{H}_2\text{O}$	X	
Realgar	AsS		X
Kaolinite	$\text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4$		X
pyrophyllite	$\text{Al}_2\text{Si}_4\text{O}_{10}(\text{OH})_2$		X
Rutile	TiO_2		X

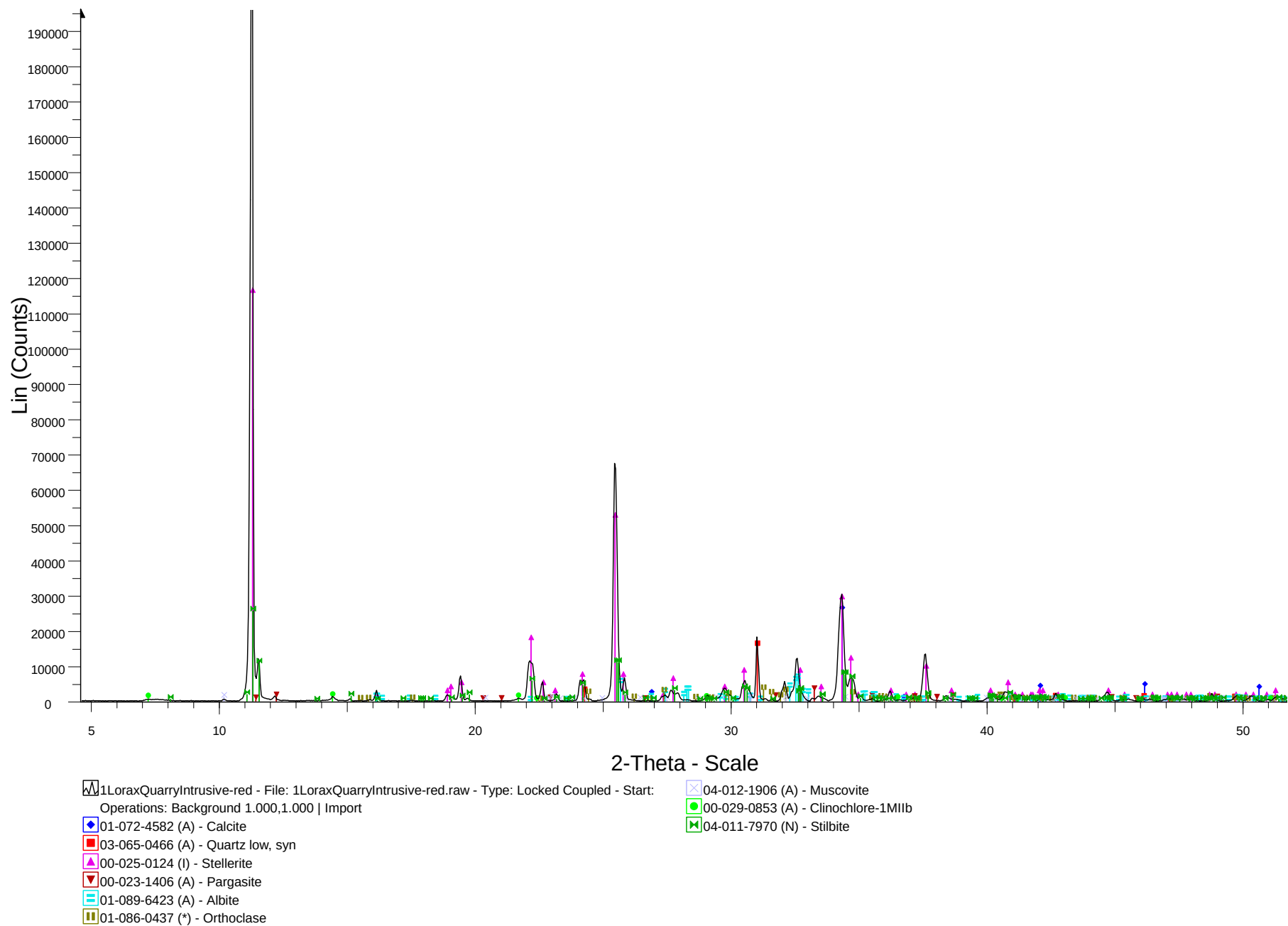


Figure 1. X-ray diffractogram of Quarry Intrusive.

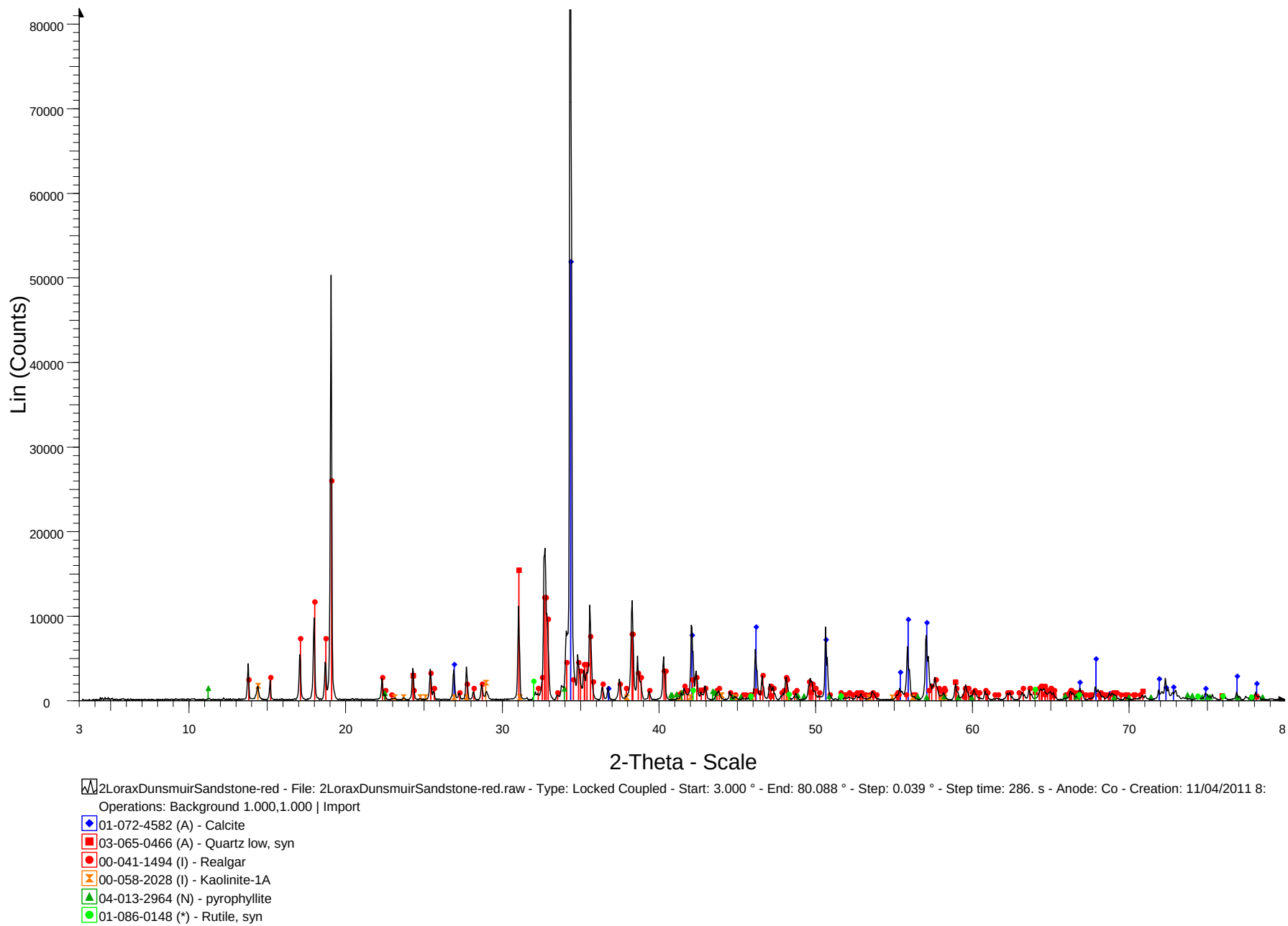


Figure 2. X-ray diffractogram of Dunsmuir Sandstone.

Appendix B5:
Kinetic Test Data

Unsaturated Column 1 (raw coal)																																														
Date	Cycle No.	Volume mL	pH	Cond. umhos/cm	Acidity (pH 4.5) mg CaCO ₃ /L	Acidity (pH 8.3) mg CaCO ₃ /L	Alkalinity mg CaCO ₃ /L	Sulphate mg/L	Chloride mg/L	Hardness mg CaCO ₃ /L	Al mg/L	Sb mg/L	As mg/L	Ba mg/L	Be mg/L	Bi mg/L	B mg/L	Cd mg/L	Ca mg/L	Cr mg/L	Co mg/L	Cu mg/L	Fe mg/L	Pb mg/L	Li mg/L	Mg mg/L	Mn mg/L	Hg ug/L	Mo mg/L	Ni mg/L	P mg/L	K mg/L	Se mg/L	Si mg/L	Ag mg/L	Na mg/L	Sr mg/L	S mg/L	Tl mg/L	Sn mg/L	Ti mg/L	U mg/L	V mg/L	Zn mg/L	Zr mg/L	
27-May-09	1	340	185	7.6	536	#N/A	4.2	36.2	214	276	0.0019	0.00008	0.00026	0.129	<0.00001	0.000006	0.154	0.000096	90.1	<0.0001	0.0714	0.00124	0.003	0.00025	0.011	12.4	0.373	0.02	0.00048	0.101	0.005	1.7	0.00104	0.389	<0.000005	1.66	0.622	79	7.1E-05	0.00006	<0.0005	0.000045	<0.0002	0.0013	<0.0001	
03-Jun-09	2	350	215	7.5	2341			2253																																						
10-Jun-09	3	315	215	7.8	2800	#N/A	10.9	106.8	1818	2100	0.002	0.0003	0.0062	0.036	<0.00005	<0.00003	1.5	0.00032	622	<0.0005	0.111	0.0027	0.007	0.00127	0.099	134	2.41	<0.05	0.0029	0.136	<0.01	5.55	0.0169	1.47	<0.00003	8.14	4.13	688	0.00008	<0.00005	<0.003	0.00058	<0.001	0.0224	<0.0005	
17-Jun-09	4	300	220	7.8	2602			1738																																						
24-Jun-09	5	300	245	7.9	2742	#N/A	10.2	96.7	2024	1980	0.0028	0.00017	0.00598	0.029	<0.00001	<0.000005	1.18	0.000167	600	<0.0001	0.0602	0.00306	0.009	0.000106	0.089	118	1.58	0.02	0.00215	0.078	0.006	4.21	0.017	1.21	<0.000005	6.39	3.53	663	0.00006	<0.00001	<0.0005	0.000402	<0.0002	0.0079	<0.0001	
01-Jul-09	6	300	305	7.8	2425			1738																																						
08-Jul-09	7	300	320	7.9	2421	#N/A	7.8	93.6	2119	1940	0.003	0.0002	0.0062	0.031	<0.00005	<0.00003	1.44	0.00022	577	<0.0005	0.0334	0.0024	0.008	0.00004	0.081	120	0.976	<0.05	0.0016	0.0545	<0.01	3.37	0.0182	1.09	<0.00003	5.25	3.24	674	0.00005	<0.00005	<0.003	0.00034	<0.001	0.0087	<0.0005	
15-Jul-09	8	300	310	7.7	2397			1602																																						
22-Jul-09	9	300	285	7.7	2369	#N/A	6.9	41.6	1809	1670	0.006	0.0001	0.004	0.028	<0.00005	<0.00003	1.51	0.00011	487	<0.0005	0.0141	0.0032	0.005	0.00046	0.069	110	0.472	<0.05	0.0023	0.0215	<0.01	2.44	0.017	0.574	<0.00003	3.75	2.88	518	0.00004	<0.00005	<0.003	0.00011	<0.001	0.0052	<0.0005	
29-Jul-09	10	300	285	7.8	2405			1639																																						
05-Aug-09	11	300	240	7.9	2508	#N/A	9.3	92.1	1874	1850	0.005	0.0004	0.0052	0.027	<0.00005	<0.00003	1.67	0.00013	533	<0.0005	0.0146	0.0014	0.01	0.00018	0.084	127	0.416	<0.05	0.0013	0.0394	<0.01	2.51	0.0132	0.967	<0.00003	3.92	2.95	617	0.00004	<0.00005	<0.003	0.0003	<0.001	0.0048	<0.0005	
12-Aug-09	12	300	335	7.7	2318			1585																																						
19-Aug-09	13	300	295	7.8	2299	#N/A	7.3	47.8	1707	1750	0.004	<0.0001	0.0031	0.026	<0.00005	<0.00003	1.47	0.0001	500	<0.0005	0.0113	0.0008	0.02	0.00005	0.071	121	0.331	<0.05	0.0015	0.0217	<0.01	2.1	0.0103	0.622	<0.00003	3.24	2.77	592	0.00003	<0.00005	<0.003	0.00017	<0.001	0.0021	<0.0005	
26-Aug-09	14	300	290	7.7	2270			1441																																						
02-Sep-09	15	300	245	7.8	2420	#N/A	10.5	50.6	1994	1820	0.004	<0.0001	0.0026	0.025	<0.00005	<0.00003	1.43	0.00009	532	<0.0005	0.0084	0.001	0.011	0.00011	0.063	120	0.299	<0.05	0.0013	0.0163	0.016	2.11	0.01	<0.5	<0.00003	3.03	2.64	636	0.00003	0.00007	<0.003	0.00013	<0.001	0.003	<0.0005	
09-Sep-09	16	300	315	7.8	2384			1793																																						
16-Sep-09	17	300	285	7.9	2349	#N/A	6.6	54.1	1647	1660	0.003	0.0001	0.0017	0.024	<0.00005	<0.00003	1.42	0.00009	480	<0.0005	0.0078	0.0006	0.006	<0.00003	0.057	112	0.304	<0.05	0.0015	0.0156	<0.01	1.71	0.0123	0.513	<0.00003	2.8	2.55	553	0.00002	0.0001	<0.003	0.00014	<0.001	0.0018	<0.0005	
23-Sep-09	18	300	305	7.7	2260			1758																																						
30-Sep-09	19	300	275	7.8	2386	#N/A	7.7	82.0	1987	1720	0.002	0.0001	0.0011	0.026	<0.00005	<0.00003	1.81	0.00014	495	<0.0005	0.0106	0.0022	0.028	0.00016	0.066	118	0.39	<0.05	0.0009	0.0235	<0.01	1.77	0.0137	0.796	<0.00003	2.6	2.71	572	0.00003	<0.00005	<0.003	0.00022	<0.001	0.0058	<0.0005	
07-Oct-09	20	300	310	7.7	2392			1624																																						
14-Oct-09	21	300	320	7.9	2219	#N/A	6.1	87.0	1635	1520	0.002	0.0001	0.0007	0.024	<0.00005	<0.00003	1.44	0.00019	453	<0.0005	0.0079	0.0018	<0.005	0.00015	0.056	95.7	0.316	<0.05	0.0006	0.0179	<0.01	1.53	0.0104	0.627	<0.00003	1.98	2.25	499	0.00002	<0.00000						

Unsaturated Column 2 (high S coarse reject)

	Cycle No.	Volume mL Input	Volume mL Output	pH	Cond. umhos/cm	Acidity (pH 4.5)	Acidity (pH 8.3)	Alkalinity	Sulphate	Chloride	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr
						mg CaCO ₃ /mg	mg CaCO ₃ /mg	mg CaCO ₃ /l	mg/L	mg/L	mg CaCO ₃ /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	ug/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
27-May-09	1	500	160	6.1	570	#N/A	7.7	2.7	274	5.3	302	0.0015	0.00002	0.00011	0.116	0.00008	0.000005	0.086	0.000263	91.9	<0.0001	0.145	0.00512	2.07	0.035	0.0094	17.5	1.26	<0.01	0.00005	0.192	0.005	1.44	0.0002	0.339	<0.000005	1.12	0.54	101	0.00028	0.00009	<0.0005	2.6E-05	<0.0002	0.0105	<0.0001
03-Jun-09	2	450	210	7.3	3334	#N/A	24.1	87.8	2829	1400	3480	0.001	0.0002	0.007	0.0434	<0.00005	<0.00003	1.27	0.00039	773	<0.0005	0.0939	0.0093	0.294	0.0136	0.125	377	6.57	<0.05	0.0019	0.148	0.012	9.32	0.0144	1.54	0.00009	16.6	5.78	2190	0.00021	<0.00005	<0.003	0.00079	<0.001	0.0154	<0.0005
10-Jun-09	3	310	245	7.0	4529				2201																																					
17-Jun-09	4	300	235	7.2	3288				1894																																					
24-Jun-09	5	300	290	7.3	3263	#N/A	15.4	83.9	2634	100	2630	0.0036	0.00018	0.00762	0.0301	<0.00001	<0.000005	0.93	0.000173	601	<0.0001	0.0369	0.0126	0.015	0.000762	0.097	275	3.74	0.05	0.00118	0.067	0.007	7.34	0.0137	1.43	0.000059	10.5	4.09	943	0.00015	<0.00001	<0.0005	0.00056	<0.0002	0.0075	<0.0001
01-Jul-09	6	220	220	7.5	2815	#N/A	6.2	41.4	2313	20	2340	0.005	0.0001	0.0033	0.03	<0.00005	<0.00003	1.03	0.00008	563	<0.0005	0.0115	0.0041	0.007	0.00004	0.09	226	1.31	<0.05	0.001	0.026	<0.01	5.86	0.0166	0.823	<0.00003	7.22	4.11	792	0.00011	<0.00005	<0.003	0.00016	<0.001	0.0047	<0.0005
08-Jul-09	7	300	285	7.6	2893				2691																																					
15-Jul-09	8	300	280	7.6	2882				2168																																					
22-Jul-09	9	300	315	7.6	2838	#N/A	7.8	39.7	2271	15	2060	<0.001	0.0001	0.0035	0.0289	<0.00005	<0.00003	1.12	0.00015	495	<0.0005	0.0079	0.007	0.005	0.00035	0.092	201	0.997	<0.05	0.0011	0.0228	<0.01	5.04	0.0156	0.686	<0.00003	5.68	3.88	675	0.00011	<0.00005	<0.003	0.00013	<0.001	0.0034	<0.0005
29-Jul-09	10	300	275	7.5	2680	#N/A	7.2	39.0	1870	13	2280	0.004	0.0002	0.0033	0.0278	<0.00005	<0.00003	1.12	0.00009	554	<0.0005	0.0101	0.0012	0.009	0.00006	0.092	217	1.18	<0.05	0.0006	0.0237	<0.01	5.02	0.0153	0.82	<0.00003	5.33	3.68	766	0.00012	<0.00005	<0.003	0.0001	<0.001	0.0025	<0.0005
05-Aug-09	11	300	290	7.6	2872				2435																																					
12-Aug-09	12	300	295	7.5	2772				1952																																					
19-Aug-09	13	300	290	7.7	2869	#N/A	10.6	91.3	1952	9.6	2340	0.005	<0.0001	0.0031	0.0271	<0.00005	<0.00003	1.32	0.00013	565	<0.0005	0.0123	0.0031	0.018	0.00114	0.108	226	1.42	<0.05	0.0004	0.0366	<0.01	5.01	0.0153	1.2	<0.00003	5.5	3.73	778	0.00013	0.00018	<0.003	0.00038	<0.001	0.0029	<0.0005
26-Aug-09	14	300	295	7.5	2745	#N/A	10.4	35.5	1863	7.2	2170	0.003	<0.0001	0.0016	0.026	<0.00005	<0.00003	1.05	0.00013	543	<0.0005	0.00767	0.0017	0.012	0.00017	0.086	199	0.904	<0.05	0.0005	0.0166	0.016	4.28	0.013	0.61	<0.00003	4.2	3.44	773	0.00009	0.00016	<0.003	0.00009	<0.001	0.0033	<0.0005
02-Sep-09	15	300	280	7.6	2898				2507																																					
09-Sep-09	16	300	280	7.6	2842				2381																																					
16-Sep-09	17	300	295	7.7	2890	#N/A	7.6	47.1	2264	4.9	2190	<0.001	0.0002	0.0017	0.0269	<0.00005	<0.00003	1.14	0.00019	541	<0.0005	0.0035	0.0016	0.007	0.00004	0.094	205	0.425	<0.05	0.0006	0.016	<0.01	3.99	0.0126	0.685	<0.00003	4.25	3.61	730	0.0001	0.00008	<0.003	0.00011	<0.001	0.0065	<0.0005
23-Sep-09	18	300	285	7.6	2688	#N/A	7.5	55.0	2282	5.6	2130	0.002	0.0001	0.0014	0.0271	<0.00005	<0.00003	1.24	0.00015	533	<0.0005	0.003	0.0027	0.028	0.00015	0.094	193	0.463	<0.05	0.0003	0.0165	<0.01	3.77	0.012	0.758	<0.00003	3.83	3.59	733	0.00009	<0.00005	<0.003	0.00017	<0.001	0.0056	<0.0005
30-Sep-09	19	300	280	7.7	2809				2312																																					
07-Oct-09	20	300	280	7.6	2894				2112																																					
14-Oct-09	21	300	285	7.8	2842	#N/A	6.5	70.5	2088	4.1	2090	0.002	0.0001	0.0013	0.0268	<0.00005	<0.00003	1.08	0.00014	568	<0.0005	0.00444	0.0031	0.007	0.0147	0.088	162	0.68	<0.05	<0.0003	0.0163	<0.01	3.38	0.0092	0.767	<0.00003	3	3.22	711	0.00008	<0.00005	<0.003	0.00022	<0.001	0.0038	<0.0005
21-Oct-09	22	300	320	7.9	2699	#N/A	8.7	85.2	2375	4.3	2060	0.007	0.0003	0.0013	0.0292	<0.00005	<0.00003	1.28	0.00012	569	<0.0005	0.00305	0.0035	0.015	0.00023	0.097	155	0.522	<0.05	<0.0003	0.0166	<0.01	3.77	0.0086	0.833	<0.00003	3.06	3.44	707	0.00011	<0.00005	<0.003	0.00024	<0.001	0.0047	<0.0005
28-Oct-09	23	300	255	7.9	2840	#N/A	14.1	68.2	2175	4.7	1920	0.002	<0.0001	0.0009	0.0239	<0.00005	<0.00003	1.16	0.00023	535	<0.0005	0.00483	0.0017	0.021	0.00132	0.085	142	0.729	<0.05	0.0004	0.015	<0.01	3.08	0.0067	0.762	<0.00003	2.58	3.03	617	0.00007	0.00006	<0.003	0.00025	<0.001	0.0043	<0.0005
04-Nov-09	24	300	295	7.9	2887				2175																																					
11-Nov-09	25	300	315	7.6	2708				2298																																					
18-Nov-09	26	300	280	7.8	2864	#N/A	7.2	87.7	2168	8.3	1890	0.086	<0.0001	0.0015	0.0239	<0.00005	<0.00003	0.927	0.00138	540	<0.0005	0.00399	0.011	0.107	0.00007	0.076	131	0.571	<0.05	0.0003	0.015	<0.01	2.83	0.006	0.734	<0.00003	2.37	2.84	613	0.00008	0.00016	<0.003	0.0003	<0.001	0.0632	<0.0005
25-Nov-09	27	300	255	8.0	2768	#N/A	7.3	45.6	1806	18	1870	0.002	<0.0001	0.0006	0.0283	<0.00005	<0.00003	1.02	0.00011	551	<0.0005	0.0052	0.0008	0.013	<0.00003	0.079	121	0.684	<0.05	0.0004	0.0106	<0.01	2.94	0.0045	0.652	<0.00003	2.07	2.99	615	0.00009	<0.00005	<0.003	0.00012	<0.001	0.0036	<0.0005
02-Dec-09	28	300	290	7.7	2670				2020																																					
09-Dec-09	29	300	295	7.7	2650				1816																																					
16-Dec-09	30	300	305	7.6	2731	#N/A	6.2	79.8	1972	22	1890	0.003	<0.0001	0.0008	0.0253	<0.00005	<0.00003	1.15	0.00014	560	<0.0005	0.00459	<0.0003	0.045	<0.00003	0.077	120	0.585	<0.05	<0.0003	0.0165	<0.01	2.79	0.0041	0.871	<0.00003	2.13	2.75	656	0.00007	<0.00005	<0.003	0.00023	<0.001	0.0025	<0.0005
23-Dec-09	31	300	310	7.9	2358	#N/A	11.0	88.2	1738	23	2050	0.004	0.0002	0.001	0.0249	<0.00005	<0.00003	1.17	0.00012	609	<0.0005	0.00306	0.005	0.041	0.00011	0.088	128	0.46	<0.05	<0.0003	0.0154	<0.01	3.19	0.0052	0.986	0.00004	2.78	2.99	713	0.00009	0.00027	0.003	0.00059	<0.001	0.0045	<0.0005
30-Dec-09	32	300	300	7.7	2634				1904																																					
06-Jan-10	33	300	280	7.7	2655				1770																																					
13-Jan-10	34	300	275	7.7	2732	#N/A	10.2	45.6	1734	31	1820	0.002	0.0001	0.0009	0.0238	<0.00005	<0.00003	0.871	0.00009	547	<0.0005	0.00438	0.0006	0.021	0.00004	0.069	110	0.585	<0.05	0.0003	0.0101	<0.01	2.47	0.0047	0.632	<0.00003	1.88	2.58	619	0.00007	0.00016	0.003	0.00016	<0.001	0.0027	<0.0005
20-Jan-10	35	300	285	7.6	2562	#N/A	7.9	41.0	2013	21	1790	0.002	<0.0001	0.0003	0.0267	<0.00005	<0.00003	0.795	0.00014	562	<0.0005	0.00664	0.0029	0.012	0.00009	0.061	93	0.955	<0.05	<0.0003	0.0105	<0.01	2.45	0.0034	0.592	<0.00003	1.51	2.34	585	0.0001	0.00009	<0.003	0.00012	<0.001	0.0052	<0.0005
27-Jan-10	36	600	570	7.6	2318				1734																																					
03-Feb-10	37	600	570	7.2	2055				1911																																					
10-Feb-10	38	600	505	7.6	2475	#N/A	7.1	48.8	1917	29	1830	0.002	<0.0001	0.0008	0.0285	<0.00005	<0.00003	0.796	0.00005	584	<0																									

Unsaturated Column 3 (moderate S coarse reject)																																																		
Date	Cycle No.	Volume mL		pH	Cond. umhos/cm	Acidity (pH 4.5)	Acidity (pH 8.3)	Alkalinity	Sulphate	Chloride	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr				
		Input	Output			mg CaCO ₃ /L	mg CaCO ₃ /L	mg CaCO ₃ /L	mg/L	mg/L	ng CaCO ₃ /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	ug/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				
27-May-09	1	0.5	600	160	7.62	2374	#N/A	14.9	157.3	1194	81	1510	0.005	0.0006	0.0107	0.128	<0.00005	<0.00003	1.66	0.0002	459	<0.0005	0.681	0.005	0.009	0.00033	0.097	89.2	3.62	0.1	0.0219	0.733	<0.01	13.9	0.0293	4.68	<0.00003	33.1	4.37	510	0.00003	0.00008	<0.003	0.00138	<0.001	0.0888	<0.0005			
03-Jun-09	2	0.5	200	180	7.22	3038				2691																																								
10-Jun-09	3	0.5	250	235	6.94	3407	#N/A	13.5	33.9	2141	200	2590	0.003	0.0003	0.0089	0.0416	<0.00005	<0.00003	1.48	0.0004	699	<0.0005	0.747	0.0064	0.059	0.00631	0.164	205	6.49	<0.05	0.0115	0.578	<0.01	13	0.0533	2.97	<0.00003	27.1	6.12	967	0.00001	<0.00005	<0.003	0.0007	<0.001	0.0676	<0.0005			
17-Jun-09	4	0.5	300	250	7.44	3067				2431																																								
24-Jun-09	5	0.5	300	305	7.49	2945	#N/A	8.6	37.7	2281	17	2210	0.003	0.0003	0.0064	0.0437	<0.00005	<0.00003	0.942	0.0002	556	<0.0005	0.35	0.0041	0.012	0.00298	0.135	200	4.19	0.06	0.006	0.267	<0.01	9.68	0.0358	1.72	<0.00003	14.7	4.87	748	0.00001	<0.00005	<0.003	0.00018	<0.001	0.0228	<0.0005			
01-Jul-09	6	0.5	300	305	7.62	2782				2363																																								
08-Jul-09	7	0.5	300	295	7.69	2839	#N/A	8.4	87.5	2697	11	2360	0.003	0.0002	0.0097	0.0382	<0.00005	<0.00003	1.07	0.0003	607	<0.0005	0.387	0.0028	0.007	0.00011	0.142	204	3.9	<0.05	0.0037	0.349	<0.01	9.02	0.0277	2.18	<0.00003	9.58	4.79	807	0.00001	<0.00005	<0.003	0.00051	<0.001	0.042	<0.0005			
15-Jul-09	8	0.5	300	290	7.67	2803				2223																																								
22-Jul-09	9	0.5	300	315	7.75	2793	#N/A	10.9	90.7	2229	8.7	2050	0.001	0.0002	0.0087	0.0359	<0.00005	<0.00003	0.982	0.0003	519	<0.0005	0.282	0.0044	<0.005	0.0286	0.135	184	2.8	<0.05	0.0039	0.283	<0.01	7.32	0.0252	1.8	<0.00003	7.01	4.2	641	0.00002	<0.00005	<0.003	0.00048	<0.001	0.0348	<0.0005			
29-Jul-09	10	0.5	300	295	7.62	2712				1774																																								
05-Aug-09	11	0.5	300	315	7.59	2828	#N/A	8.1	50.8	2565	8.3	2270	0.004	0.0003	0.0049	0.0335	<0.00005	<0.00003	0.738	0.0001	567	<0.0005	0.165	0.0011	0.008	0.00021	0.121	206	2.22	<0.05	0.0051	0.158	<0.01	6.86	0.0227	1.34	<0.00003	6.27	3.9	751	<0.00001	<0.00005	0.004	0.00023	<0.001	0.0163	<0.0005			
12-Aug-09	12	0.5	300	295	7.60	2750				1946																																								
19-Aug-09	13	0.5	300	275	7.82	2813	#N/A	9.3	94.1	2075	5.9	2270	0.002	0.0002	0.0036	0.0332	<0.00005	<0.00003	0.811	0.0002	558	<0.0005	0.184	0.0018	0.011	0.00004	0.129	214	1.9	<0.05	0.0031	0.224	0.04	6.39	0.0201	1.96	<0.00003	5.72	3.83	755	<0.00001	<0.00005	<0.003	0.00054	<0.001	0.0271	<0.0005			
26-Aug-09	14	0.5	300	315	7.67	2756				1803																																								
02-Sep-09	15	0.5	300	275	7.81	2963	#N/A	11.0	71.4	2629	5.1	2290	0.004	0.0002	0.0017	0.0313	<0.00005	<0.00003	0.666	0.0002	555	<0.0005	0.139	0.0022	0.011	0.00011	0.113	220	1.91	<0.05	0.0033	0.153	0.011	6.13	0.0179	1.25	<0.00003	5.11	3.63	809	<0.00001	0.00011	<0.003	0.00034	<0.001	0.0201	<0.0005			
09-Sep-09	16	0.5	300	270	7.88	2862				2319																																								
16-Sep-09	17	0.5	300	305	7.82	2912	#N/A	7.5	62.2	2151	6.6	2250	0.001	0.0002	0.0011	0.0322	<0.00005	<0.00003	0.63	0.0002	521	<0.0005	0.12	0.0011	0.006	<0.00003	0.107	230	1.92	<0.05	0.0033	0.124	<0.01	5.26	0.0166	1.22	<0.00003	4.54	3.51	741	0.00001	0.00006	<0.003	0.00024	<0.001	0.0162	<0.0005			
23-Sep-09	18	0.5	300	280	7.64	2776				2341																																								
30-Sep-09	19	0.5	300	295	7.61	3004	#N/A	7.5	51.2	2678	5.9	2350	0.002	0.0002	0.0011	0.0324	<0.00005	<0.00003	0.596	0.0002	533	<0.0005	0.101	0.0013	0.028	0.00011	0.099	247	1.75	<0.05	0.0026	0.101	<0.01	4.93	0.0152	1.18	<0.00003	4.17	3.61	807	0.00001	<0.00005	<0.003	0.0002	<0.001	0.0154	<0.0005			
07-Oct-09	20	0.5	300	300	7.56	3116				2331																																								

Humidity Cell T1

Date	Cycle No.	Volume mL Input	Volume mL Output	pH	Cond. umhos/cm	Acidity (pH 4.5) mg CaCO ₃ /L	Acidity (pH 8.3) mg CaCO ₃ /L	Alkalinity mg CaCO ₃ /L	Sulphate mg/L	Chloride mg/L	Hardness mg CaCO ₃ /L	Al mg/L	Sb mg/L	As mg/L	Ba mg/L	Be mg/L	Bi mg/L	B mg/L	Cd mg/L	Ca mg/L	Cr mg/L	Co mg/L	Cu mg/L	Fe mg/L	Pb mg/L	Li mg/L	Mg mg/L	Mn mg/L	Hg ug/L	Mo mg/L	Ni mg/L	P mg/L	K mg/L	Se mg/L	Si mg/L	Ag mg/L	Na mg/L	Sr mg/L	S mg/L	Tl mg/L	Sn mg/L	Ti mg/L	U mg/L	V mg/L	Zn mg/L	Zr mg/L	
27-May-09	0	750	195	7.8	2479	#N/A	13.7	134.8	1266	55	1760	0.007	0.001	0.0026	0.0906	<0.00005	<0.00003	1.71	0.00052	582	<0.0005	0.24	0.0054	0.011	0.00097	0.062	73.9	2.59	<0.05	0.0097	0.295	0.013	9.37	0.0115	3.02	<0.00003	18.8	3.43	572	0.00009	<0.00005	<0.003	0.00146	<0.001	0.193	<0.0005	
03-Jun-09	1	500	460	7.7	2226	#N/A	16.6	123.3	1838	29	1690	0.006	0.0012	0.0138	0.0267	<0.00005	<0.00003	3.94	0.00018	564	<0.0005	0.0578	0.0127	0.009	0.00068	0.053	69	2.73	<0.05	0.0112	0.0559	<0.01	4.96	0.0098	4.02	0.00003	11.1	3.04	514	0.00003	<0.00005	<0.003	0.00125	<0.001	0.0996	<0.0005	
10-Jun-09	2	500	500	7.6	1659	#N/A	17.0	163.2	785	12	1100	0.005	0.0012	0.0144	0.0252	<0.00005	<0.00003	2.77	0.00019	373	<0.0005	0.0382	0.0028	0.022	0.00144	0.035	41.8	2.1	<0.05	0.0084	0.039	<0.01	3.22	0.0006	3.83	<0.00003	5.57	1.98	334	0.00002	<0.00005	<0.003	0.001	<0.001	0.112	<0.0005	
17-Jun-09	3	500	465	7.8	1024	#N/A	14.3	160.3	486	2.6	618	0.0033	0.00089	0.00918	0.0233	<0.00001	<0.000005	2.01	0.000105	209	<0.0001	0.0211	0.00161	0.011	0.00043	0.0247	23.4	1.14	<0.01	0.00865	0.0236	0.004	1.87	0.0001	2.51	<0.000005	2.64	1.11	157	0.00003	0.00002	<0.0005	0.00058	0.0003	0.0408	<0.0001	
24-Jun-09	4	500	475	7.7	903				362																																						
01-Jul-09	5	500	430	7.8	852	#N/A	11.8	152.5	361	0.8	465	0.0052	0.0006	0.00554	0.0189	<0.00001	<0.000005	1.3	<0.000005	152	<0.0001	0.00987	0.00026	0.004	6.7E-05	0.018	20.7	0.238	<0.01	0.00733	0.0138	0.005	1.21	0.00007	1.79	<0.000005	1.45	0.801	121	0.000008	0.00001	<0.0005	0.0004	0.0003	0.0009	<0.0001	
08-Jul-09	6	500	475	7.7	856				491																																						
15-Jul-09	7	500	475	7.7	743	#N/A	13.0	159.9	289	1.1	412	0.0023	0.00047	0.00512	0.0196	<0.00001	<0.000005	1.06	0.000044	133	<0.0001	0.0113	0.00409	0.002	0.00129	0.0165	19.5	0.697	<0.01	0.00694	0.0119	0.003	1.01	0.00006	1.68	<0.000005	1.04	0.671	88	0.000008	0.00001	<0.0005	0.00032	0.0003	0.0198	<0.0001	
22-Jul-09	8	500	425	7.8	606				193																																						
29-Jul-09	9	500	490	7.8	715	#N/A	14.7	163.0	249	4.7	450	0.0019	0.00029	0.00498	0.0266	<0.00001	<0.000005	0.94	0.000056	143	<0.0001	0.011	0.00156	0.003	7.4E-05	0.0177	22.5	0.686	0.03	0.00659	0.0115	0.002	1.1	0.00011	1.91	<0.000005	1.08	0.688	106	0.000012	<0.00001	<0.0005	0.00031	<0.0002	0.0169	<0.0001	
05-Aug-09	10	500	495	7.9	723				300																																						
12-Aug-09	11	500	450	7.9	672	#N/A	11.7	152.0	232	7.8	393	0.0023	0.00021	0.00312	0.0237	<0.00001	<0.000005	0.63	0.000052	123	<0.0001	0.00721	0.00324	0.002	0.00005	0.0148	20.9	0.58	<0.01	0.00496	0.0087	<0.002	0.88	0.00006	1.52	<0.000005	0.83	0.566	87	0.000006	0.00012	<0.0005	0.00026	<0.0002	0.0098	<0.0001	
19-Aug-09	12	500	480	7.8	615				220																																						
26-Aug-09	13	500	480	7.9	581	#N/A	9.3	147.4	144	5.8	336	0.0024	0.00016	0.00256	0.024	<0.00001	<0.000005	0.53	0.00002	105	<0.0001	0.00471	0.00144	0.001	0.00014	0.0128	17.6	0.468	<0.01	0.00433	0.0064	<0.002	0.74	0.00006	1.38	<0.000005	0.71	0.473	70	0.000007	<0.00001	<0.0005	0.00022	<0.0002	0.0075	<0.0001	
02-Sep-09	14	500	465	7.9	634				196																																						
09-Sep-09	15	500	515	7.8	601	#N/A	10.0	148.6	200	4.8	346	0.0021	0.00011	0.00169	0.0255	<0.00001	<0.000005	0.49	0.000032	110	<0.0001	0.0042	0.0023	0.003	0.00676	0.0123	17.5	0.459	<0.01	0.00395	0.0059	0.003	0.71	0.00006	1.41	<0.000005	0.62	0.467	69	0.000006	0.00001	<0.0005	0.0002	<0.0002	0.006	<0.0001	
16-Sep-09	16	500	480	8.0	543				160																																						
23-Sep-09	17	500	505	7.8	614	#N/A	9.8	142.9	240	3.3	345	0.0022	0.00009	0.00137	0.0279	0.00001	<0.000005	0.46	0.000024	109	<0.0001	0.00301	0.0009	0.003	3.3E-05	0.0129	18	0.429	<0.01	0.00369	0.0047	0.003	0.65	0.00006	1.23	<0.000005	0.57	0.458	75	0.000005	<0.00001	<0.0005	0.00021	<0.0002	0.0043	<0.0001	
30-Sep-09	18	500	515	7.9	535				194																																						
07-Oct-09	19	500	495	7.8	546	#N/A	11.1	142.5	170	1.9	299	0.0062	0.0001	0.00078	0.0298	<0.00001	<0.000005	0.4	0.000039	94.1	<0.0001	0.00243	0.0011	0.011	0.00017	0.011	15.6	0.362	<0.01	0.00368	0.004	0.006	0.57	0.00005	1.19	<0.000005	0.5	0.388	59	0.000004	0.00001	<0.0005	0.00017	<0.0002	0.0043	<0.0001	
14-Oct-09	20	500	440	7.9	389				127																																						
21-Oct-09	21	500	495	7.8	513	#N/A	7.1	125.5	190	1.7	283	0.0033	0.00009	0.00084	0.0332	<0.00001	<0.000005	0.37	<0.000005	87.6	<0.0001	0.00166	0.00028	0.006	1.9E-05	0.0096	15.6	0.23	<0.01	0.00338	0.0033	<0.002	0.5	0.00011	1.02	<0.000005	0.49	0.344	60	0.000003	0.00002	<0.0005	0.00018	<0.0002	0.0006	<0.0001	
28-Oct-09	22	500	485	8.0	641				258																																						
04-Nov-09	23	500	480	7.9	652	#N/A	8.8	142.1	266	1.7	370	0.0022	0.00012	0.00058	0.0262	<0.00001	<0.000005	0.35	0.000026	114	<0.0001	0.00309	0.001	0.003	5.5E-05	0.0121	20.6	0.405	0.02	0.00255	0.0049	<0.002	0.58	0.00004	1	<0.000005	0.5	0.423	84	0.000004	<0.00001	<0.0005	0.00018	<0.0002	0.0035	<0.0001	
11-Nov-09	24	500	410	7.8	442				120																																						
18-Nov-09	25	500	495	7.9	487	#N/A	10.0	130.0	157	0.8	260	0.0038	0.00012	0.00068	0.0285	<0.00001	<0.000005	0.28	0.000016	79.9	<0.0001	0.00178	0.00065	0.005	6.6E-05	0.0088	14.8	0.24	<0.01	0.00272	0.0029	0.002	0.44	<0.00004	0.84	0.000011	0.43	0.289	50	0.00001	<0.00001	<0.0005	0.00015	<0.0002	0.0021	<0.0001	
25-Nov-09	26	500	500	8.0	590				235																																						
02-Dec-09	27	500	490	7.9	545	#N/A	8.6	140.0	193	1	326	0.0093	0.00013	0.00076	0.032	<0.00001	<0.000005	0.37	0.000016	100	<0.0001	0.00242	0.0009	0.005	4.9E-05	0.0114	18.5	0.305	0.01	0.00242	0.0037	<0.002	0.58	0.00005	0.99	<0.000005	0.48	0.35	68	0.000005	0.00001	<0.0005	0.00015	<0.0002	0.0028	<0.0001	
09-Dec-09	28	500	480	7.9	604				235																																						
16-Dec-09	29	500	395	8.1	983	#N/A	3.4	132.4	510	0.8	626	0.0023	0.00017	0.00043	0.0205	<0.00001	<0.000005	0.3	0.000052	197	<0.0001	0.0054	0.00087	0.006	3.6E-05	0.0127	32.9	0.62	<0.01	0.00147	0.008	<0.002	0.6	0.00021	1.17	<0.000005	0.54	0.596	173	0.000004	<0.00001	<0.0005	0.00027	<0.0002	0.0068	<0.0001	
23-Dec-09	30	500	460	8.0	680				325																																						
30-Dec-09	31	500	450	7.9	586	#N/A	7.7	155.0	213	1	329	0.0044	0.00012	0.00043	0.0217	<0.00001	<0.000005	0.24	0.00002	101	<0.0001	0.00268	0.00226	0.004	1.8E-05	0.0097	18.8	0.332	<0.01	0.00132	0.0045	<0.002	0.46	0.00006	0.88	<0.0											

Notes: Oct 27/10. Change in analytical schedule.

Values in red are below the detection limit. For calculation purposes, values below detection were set at half the value of the analytical limit.

Saturated Column HQA (coarse reject)

Date	Cycle No.	Volume mL Input	Volume mL Output	pH	Cond. umhos/cm	Alkalinity mg CaCO ₃ /l	Sulphate mg/L	Chloride mg/L	Hardness ng CaCO ₃ /l	Al mg/L	Sb mg/L	As mg/L	Ba mg/L	Be mg/L	Bi mg/L	B mg/L	Cd mg/L	Ca mg/L	Cr mg/L	Co mg/L	Cu mg/L	Fe mg/L	Pb mg/L	Li mg/L	Mg mg/L	Mn mg/L	Hg ug/L	Mo mg/L	Ni mg/L	P mg/L	K mg/L	Se mg/L	Si mg/L	Ag mg/L	Na mg/L	Sr mg/L	S mg/L	Tl mg/L	Sn mg/L	Ti mg/L	U mg/L	V mg/L	Zn mg/L	Zr mg/L
3-Jul-09	0	1250	1250	6.3		224.2	760	22	998	<0.003	0.0008	0.166	0.061	<0.0001	<0.001	0.962	0.0001	322	<0.001	0.009	0.0004	0.294	<0.0002		47.1	1.34	0.0001	0.017	0.03	0.055	5.82	0.0001	4.11	<0.00002	5.52	2.16	259	<0.00005	<0.005	<0.005	0.0015	<0.005	0.013	<0.0005
10-Jul-09	1	1400	1400	6.8		227.6	420	11	662	<0.003	0.0006	0.176	0.061	<0.0001	<0.001	0.655	0.00002	216	<0.001	0.004	0.0003	0.051	<0.0002		29.5	0.806	0.00002	0.018	0.019	0.02	4.21	<0.0001	3.07	<0.00002	3.13	1.41	158	<0.00005	<0.005	<0.005	0.001	<0.005	0.006	<0.0005
17-Jul-09	2	1400	1400	6.7		225.5	300	10	517	<0.003	<0.0005	0.211	0.058	<0.0001	<0.001	0.531	<0.00001	172	<0.001	0.002	0.0004	0.031	<0.0002		21.3	0.599	0.0001	0.016	0.008	0.009	3.48	0.0001	2.92	<0.00002	2.1	1.1	103	<0.00005	<0.005	<0.005	0.0007	<0.005	<0.005	<0.0005
24-Jul-09	3	1400	1400	6.7		210.9	180	6.9	411	<0.003	<0.0005	0.19	0.066	<0.0001	<0.001	0.437	<0.00001	137	<0.001	0.002	0.0002	0.016	<0.0002		16.4	0.468	0.00009	0.017	0.006	0.009	2.94	0.0001	2.47	<0.00002	1.59	0.898	72	<0.00005	<0.005	0.006	0.0005	<0.005	0.008	<0.0005
31-Jul-09	4	1400	1400																																									
7-Aug-09	5	1400	1400	6.6		330.0	74	4.5	258	<0.003	<0.0005	0.201	0.091	<0.0001	<0.001	0.312	<0.00001	88.7	<0.001	6E-04	0.001	0.012	<0.0002	0.031	8.85	0.259	0.00005	0.018	0.002	0.009	2.13	<0.0001	1.68	<0.00002	0.99	0.591	25	<0.00005	<0.005	<0.005	0.0003	<0.005	0.019	<0.0005
14-Aug-09	6	1400	1400																																									
21-Aug-09	7	1400	1400																																									
28-Aug-09	8	1400	1400	7.1		142.1	36	2.4	170	<0.003	<0.0005	0.156	0.111	<0.0001	<0.001	0.221	<0.00001	58.4	<0.001	<0.0005	0.0004	0.011	<0.0002		5.84	0.148	0.00007	0.019	<0.001	<0.005	1.39	<0.0001	1.46	<0.00002	0.63	0.393	15	<0.00005	<0.005	0.011	0.0002	<0.005	0.013	<0.0005
4-Sep-09	9	1400	1400																																									
11-Sep-09	10	1400	1400	7.2		123.8	25	1.8	137	<0.003	<0.0005	0.129	0.106	<0.0001	<0.001	0.18	<0.00001	46.7	<0.001	<0.0005	<0.0002	0.018	<0.0002		4.94	0.111	<0.00002	0.019	0.004	<0.005	1.15	<0.0001	1.28	<0.00002	0.66	0.322	7	<0.00005	<0.005	<0.005	0.0001	<0.005	0.008	<0.0005
18-Sep-09	11	1400	1400																																									
25-Sep-09	12	1400	1400	7.2		114.2	21	1.8	122	<0.003	<0.0005	0.126	0.094	<0.0001	<0.001	0.164	0.00002	41.8	<0.001	<0.0005	<0.0002	0.008	<0.0002	0.017	4.4	0.093	0.00003	0.02	<0.001	<0.005	1.01	<0.0001	1.15	<0.00002	0.31	0.275	8	<0.00005	<0.005	<0.005	0.0001	<0.005	0.005	<0.0005
2-Oct-09	13	1400	1400																																									
10-Oct-09	14	1400	1400	7.9		107.7	19	2.3	108	<0.003	<0.0005	0.115	0.081	<0.0001	<0.001	0.131	0.00003	36.7	<0.001	<0.0005	<0.0002	0.012	<0.0002		4.1	0.077	<0.00002	0.019	<0.001	0.018	0.86	<0.0001	1.08	<0.00002	0.27	0.237	8	<0.00005	<0.005	<0.005	0.0001	<0.005	0.007	<0.0005
17-Oct-09	15	1400	1400																																									
23-Oct-09	16	1400	1400	7.4		110.0	16	2.1	100	0.022	<0.0005	0.115	0.08	<0.0001	<0.001	0.163	0.00004	34.1	<0.001	<0.0005	0.0003	0.011	<0.0002	0.014	3.72	0.068	<0.00002	0.019	0.007	<0.005	0.86	<0.0001	1	<0.00002	0.4	0.219	14	<0.00005	<0.005	0.01	<0.0001	<0.005	0.008	<0.0005
30-Oct-09	17	1400	1400																																									
6-Nov-09	18	1400	1400	7.7		94.6	15	2.4	96.1	0.004	<0.0005	0.111	0.071	<0.0001	<0.001	0.113	0.00005	32.6	<0.001	<0.0005	<0.0002	0.005	<0.0002		3.59	0.058	<0.00002	0.017	<0.001	<0.005	0.72	<0.0001	0.934	<0.00002	0.28	0.186	8	<0.00005	<0.005	<0.005	<0.0001	<0.005	0.011	<0.0005
13-Nov-09	19	1400	1400																																									
20-Nov-09	20	1400	1400	7.9		90.6	14	3	97.2	<0.003	<0.0005	0.102	0.079	<0.0001	<0.001	0.114	0.00003	32.9	<0.001	<0.0005	<0.0002	0.008	<0.0002		3.68	0.064	<0.00002	0.018	<0.001	<0.005	0.68	<0.0001	0.95	<0.00002	0.2	0.199	7	<0.00005	<0.005	<0.005	0.0001	<0.005	0.012	<0.0005
27-Nov-09	21	1400	1400																																									
4-Dec-09	22	1400	1400	7.4		73.4	13	2.2	89.7	0.006	<0.0005	0.0989	0.067	<0.0001	<0.001	0.092	<0.00001	30.3	<0.001	<0.0005	<0.0002	0.006	<0.0002		3.44	0.053	<0.00002	0.016	<0.001	<0.005	0.64	<0.0001	0.811	<0.00002	0.19	0.173	5	<0.00005	<0.005	<0.005	<0.0001	<0.005	<0.005	<0.0005
11-Dec-09	23	1400	1400																																									
18-Dec-09	24	1400	1400	7.6		80.1	12	2.4	81.4	<0.003	<0.0005	0.0981	0.065	<0.0001	<0.001	0.095	<0.00001	27.7	<0.001	<0.0005	<0.0002	<0.005	<0.0002		2.97	0.045	<0.00002	0.015	<0.001	<0.005	0.58	<0.0001	0.797	<0.00002	0.17	0.166	5	<0.00005	<0.005	<0.005	<0.0001	<0.005	<0.005	<0.0005
25-Dec-09	25	1400	1400																																									
1-Jan-10	26	1400	1400																																									
8-Jan-10	27	1400	1400																																									
15-Jan-10	28	1400	1400	7.3		80.7	12	3.9	86	0.005	<0.0005	0.111	0.072	<0.0001	<0.001	0.097	<0.00001	28.9	<0.001	<0.0005	<0.0002	0.006	<0.0002		3.35	0.046	0.00004	0.015	<0.001	<0.005	0.57	<0.0001	0.805	<0.00002	0.16	0.17	5	<0.00005	<0.005	<0.005	<0.0001	<0.005	<0.005	<0.0005
22-Jan-10	29	1400	1400																																									
2-Feb-10	30	2200	2200	7.5		73.3	11	4.3	77.6	0.004	<0.0005	0.108	0.063	<0.0001	<0.001	0.085	<0.00001	25.8	<0.001	<0.0005	<0.0002	0.006	<0.0002		3.2	0.042	0.00006	0.013	<0.001	<0.005	0.51	<0.0001	0.798	<0.00002	0.17	0.153	6	<0.00005	<0.005	<0.005	<0.0001	<0.005	<0.005	<0.0005
9-Feb-10	31	1400	1400																																									
16-Feb-10	32	1400	1400																																									
23-Feb-10	33	1400	1400	7.2		75.1	17	3	73.2	0.005	<0.0005	0.0944	0.062	<0.0001	<0.001	0.083	0.00001	24	<0.001	<0.0005	0.0026	0.007	<0.0002		3.22	0.035	0.00003	0.011	<0.001	<0.005	0.46	<0.0001	0.757	<0.00002	0.12	0.134	5	<0.00005	<0.005	<0.005	<0.0001	<0.005	0.008	<0.0005
3-Mar-10	34	1600	1600	7.0		70.9	10	2.8	69.6	0.038	<0.0005	0.103	0.058	<0.0001	<0.001	0.076	<0.00001	23	<0.001	<0.0005	0.0003	<0.005	<0.0002	0.009	2.94	0.035	0.00007	0.01	<0.001	<0.005	0.44	<0.0001	0.754	<0.00002	0.12	0.127	5	<0.00005	<0.005	<0.005				

Saturated Column HQC (coarse reject)

Date	Cycle No.	Volume mL		pH	Alkalinity	Sulphate	Chloride	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr	
		Input	Output		mg CaCO ₃ /l	mg/L	mg/L	mg CaCO ₃ /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	ug/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
8-May-10	0	1415	1415	6.4	128.4	1300	23	1370	0.002	<0.0001	0.013	0.145	<0.0001	<0.00003	0.619	0.00037	446	<0.0005	0.551	<0.0003	12.3	0.0001	0.052	62.7	3.31	<0.00005	<0.0003	0.64	0.006	8.3	0.006	1.68	<0.00003	10.7	2.85	468	0.00006	<0.00005	<0.003	0.0004	<0.001	0.12	<0.0005	
13-May-10	1	960	1350	6.5	395.8	1700	40	2210	0.003	<0.0005	0.097	0.061	<0.0001	<0.001	1.75	0.00018	702	<0.001	0.0975	0.0012	11.8	<0.0002	0	110	4.55	0.0001	0.003	0.184	<0.005	9.08	0.0093	6.43	0.00005	11.2	4.86	629	<0.00005	<0.005	<0.005	0.0023	<0.005	0.103	<0.0005	
19-May-10	2	1160	1350	6.5	396.6	1200	22	1590	0.004	<0.0005	0.155	0.062	<0.0001	<0.001	1.18	0.00017	534	<0.001	0.0264	0.003	1.61	0.0004	0	62.4	2.46	<0.00002	0.007	0.06	0.006	6.53	0.0029	5.01	<0.00002	4.49	3.29	427	<0.00005	<0.005	<0.005	0.0018	<0.005	0.072	<0.0005	
27-May-10	3	1540	1350	6.6	354.8	710	8.9	1010	0.002	0.0003	0.203	0.0621	<0.0001	<0.00003	0.779	<0.00003	352	<0.0005	0.00524	<0.0003	1.33	<0.00003	0.065	32.3	1.3	<0.00002	0.0092	0.0172	<0.005	4.3	<0.0002	4.46	0.00004	1.8	2.04	243	<0.00001	<0.00005	<0.003	0.0012	<0.001	0.0226	<0.0005	
3-Jun-10	4	1350	1350																																									
10-Jun-10	5	1350	1350																																									
17-Jun-10	6	1405	1405																																									
29-Jun-10	7	2405	1405	7.2	228.0	183	<0.50	415	0.0016	0.00003	0.19	0.0613	<0.0001	<0.000005	0.372	0.00001	153	<0.0001	0.00055	0.0002	0.241	0.000024	0.0308	8.41	0.343	<0.00001	0.0152	0.00156		1.77	<0.00004	2.62	<0.000005	0.58	0.816	65	<0.000002	0.00002	<0.0005	0.0004	<0.0002	0.0045	<0.0001	
6-Jul-10	8	1405	1405																																									
14-Jul-10	9	1670	1460	7.4	193.9	144	<0.50	347	0.0014	<0.00002	0.19	0.063	<0.0001	<0.000005	0.304	5E-06	125	<0.0001	0.00039	0.00035	0.163	0.000005	0.03	8.44	0.293	0.00001	0.0157	0.00153		1.7	0.00006	2.35	<0.000005	0.53	0.713	61	<0.000002	<0.00001	<0.0005	0.0003	<0.0002	0.0031	<0.0001	
21-Jul-10	10	1460	1460																																									
27-Jul-10	11	1250	1460	7.2	176.1	117	<0.50	279	0.002	0.00003	0.156	0.0642	<0.0001	<0.000005	0.28	4.1E-05	100	<0.0001	0.00026	0.0007	0.115	0.000085	0.0265	7.1	0.224	<0.00001	0.0164	0.00059		1.37	<0.00004	1.89	<0.000005	0.42	0.584	44	<0.000002	<0.00001	0.001	0.0003	<0.0002	0.003	<0.0001	
3-Aug-10	12	1460	1460																																									
10-Aug-10	13	1460	1460	7.3	153.5	102	<0.50	257	0.0012	<0.00002	0.168	0.0659	<0.0001	<0.000005	0.265	5E-06	92	<0.0001	0.00016	<0.00005	0.118	<0.000005	0.0246	6.67	0.178	0.00002	0.0171	0.00027		1.2	<0.00004	2.03	<0.000005	0.38	0.494	38	<0.000002	<0.00001	<0.0005	0.0003	<0.0002	0.0008	<0.0001	
17-Aug-10	14	1460	1460																																									
24-Aug-10	15	1460	1460	7.5	135.7	66.5	<0.50	197	0.0014	<0.00002	0.144	0.075	<0.0001	<0.000005	0.235	0.00001	70.5	<0.0001	0.00014	0.00009	0.084	0.000025	0.022	5.08	0.143	<0.00001	0.0184	0.00023		0.9	<0.00004	1.64	<0.000005	0.28	0.415	25	<0.000002	<0.00001	<0.0005	0.0002	<0.0002	0.0004	<0.0001	
31-Aug-10	16	1460	1460																																									
8-Sep-10	17	1685	1475	7.5	154.9	24.1	<0.50	164	0.0021	<0.00002	0.123	0.0938	<0.0001	<0.000005	0.181	<0.000005	58.5	<0.0001	7.8E-05	<0.00005	0.054	<0.000005	0.0174	4.27	0.102	<0.00001	0.0195	0.0001		0.73	<0.00004	1.49	<0.000005	0.22	0.324	15	<0.000002	<0.00001	<0.0005	0.0001	<0.0002	0.0005	<0.0001	
15-Sep-10	18	1475	1475																																									
21-Sep-10	19	1475	1475	7.5	123.3	27.8	<0.50	128	0.002	<0.00002	0.108	0.0968	<0.0001	<0.000005	0.182	6E-06	45.3	<0.0001	0.00006	<0.00005	0.033	<0.000005	0.015	3.62	0.077	<0.00001	0.0174	0.00007		0.59	0.00006	1.2	<0.000005	0.19	0.256	11	<0.000002	<0.00001	<0.0005	0.0001	<0.0002	0.0004	<0.0001	
28-Sep-10	20	1475	1475																																									
5-Oct-10	21	1475	1475	7.5	106.8	20.9	<0.50	117	0.0037	<0.00002	0.113	0.105	<0.0001	<0.000005	0.145	7E-06	41.1	<0.0001	4.5E-05	<0.00005	0.021	<0.000005	0.0135	3.54	0.0643	0.00001	0.0157	0.00006		0.55	<0.00004	1.15	<0.000005	0.25	0.237	<10	<0.000002	<0.00001	<0.0005	0.0001	<0.0002	0.0004	<0.0001	
12-Oct-10	22	1475	1475																																									
21-Oct-10	23	1475	1475	7.1	88.1	18.2	<0.50																																					

Notes: Values in red are below the detection limit. For calculation purposes, values below detection were set at half the value of the analytical limit.

Appendix B6:
PhreeqC Model of 4 South Mature Mine Pool

Appendix B6: PhreeqC Model of 4 South Mature Mine Pool

B6-1 Water chemistry of PHREEQC inputs

The speciation of two separate water samples (*i.e.*, QU-78-161_72m and QU-11-01) from the Quinsam Mine in Campbell River, B.C. was calculated using PHREEQC to provide an estimate of the water quality, and the candidate minerals that would control the water quality by exceeding saturation limits. The water quality inputs for the models are displayed in Table B6-1 according to measurements collected in the field (pH and alkalinity) and laboratory analysis (metals and anions). Assumed values for temperature, *pe*, and density were applied, and the sulfate/sulfide redox couple (S(6)/S(-2)) was selected since the mine water is anoxic (not in equilibrium with the atmosphere) and dominated by sulfate.

Table B6-1:
Water quality inputs

Site	QU-78-161_72m	QU-11-01
Temperature (°C)	10	10
pH (pH units)	6.51	5.8
pe (pe units)	-4	-4
Redox couple	S(6)/S(-2)	S(6)/S(-2)
Density (g/mL)	1	1
Alkalinity as CaCO ₃	192 ¹	121 ¹
N(-3)	0.191	0.275
Br	1.25*	2.5*
Cl	12.5*	25*
F	0.06	0.086
N(5)	0.125*	0.25*
N(3)	0.025	0.05*
P	0.0051	0.0059
S(6)	1720	2060
S(-2)	0.065 [#]	0.0035 [#]
Dom_a	6.81	1.85
Al	0.024	0.0196
Sb	0.00025*	0.0001*
As	0.0924	0.0432
Ba	0.0278	0.0216
Be	0.00125*	0.0005*
Bi	0.00125*	0.0005*
B	0.637	0.488
Cd	0.0000425*	0.00001*
Ca	380	376
Cr	0.00125*	0.0002
Co	0.0634	0.0203
Cu	0.00125*	0.0564
Fe	194	257
Pb	0.000125*	0.0248
Li	0.051	0.029
Mg	56	86
Mn	3.69	5.96
Mo	0.00181	0.00018
Ni	0.113	0.0548
K	4.3	5.77
Se	0.0002*	0.0001*
Si	5.53	4.69
Ag	0.000025*	0.00001*
Na	96.5	77.6
Sr	1.35	2.09
Tl	0.00025*	0.0001*
Sn	0.00025*	0.0001*
Ti	0.005*	0.01*
U	0.00007	0.00007
V	0.0025*	0.001*
Zn	0.0075*	0.0709

¹ All units in mg/L unless stated otherwise

Updated with field measurements

*Values represent one half the detection limit

[#]Original value

B6-2 Description of solution and saturation indices

The outputs of the PHREEQC speciation calculations for QU-78-161_72m and QU-11-01 are presented below. Included in the outputs are the solution composition, a description of the solution, the available redox couples, and the saturation indices. Minerals above the saturation limits are highlighted in yellow. Minerals that are close to reaching their saturation limits should also be recognized for potentially controlling the water quality of each solution, *e.g.*, anhydrite, celestite, gypsum, *etc.* Given the suboxic to anoxic conditions of the mine waters, and the abundance of sulfate, the precipitation of numerous sulfide minerals are super saturated.

QU-78-161_72m

Solution composition		
Elements	Molality	Moles
Ag	2.32E-10	2.32E-10
Al	8.92E-07	8.92E-07
Alkalinity	3.16E-03	3.16E-03
As	1.24E-06	1.24E-06
B	5.91E-05	5.91E-05
Ba	2.03E-07	2.03E-07
Be	1.39E-07	1.39E-07
Br	1.57E-05	1.57E-05
Ca	9.51E-03	9.51E-03
Cd	3.79E-10	3.79E-10
Cl	3.54E-04	3.54E-04
Co	1.08E-06	1.08E-06
Cr	2.41E-08	2.41E-08
Cu	1.97E-08	1.97E-08
Dom_a	5.69E-04	5.69E-04
F	3.17E-06	3.17E-06
Fe	3.48E-03	3.48E-03
K	1.10E-04	1.10E-04
Li	7.37E-06	7.37E-06
Mg	2.31E-03	2.31E-03
Mn	6.74E-05	6.74E-05
Mo	1.89E-08	1.89E-08
N(-3)	1.37E-05	1.37E-05
N(3)	1.79E-06	1.79E-06
N(5)	8.95E-06	8.95E-06
Na	4.21E-03	4.21E-03
Ni	1.93E-06	1.93E-06
P	1.65E-07	1.65E-07
Pb	6.05E-10	6.05E-10
S(-2)	2.03E-06	2.03E-06
S(6)	1.80E-02	1.80E-02
Sb	2.06E-09	2.06E-09

Solution composition			
Elements	Molality	Moles	
Se	2.54E-09	2.54E-09	
Si	9.23E-05	9.23E-05	
Sn	2.11E-09	2.11E-09	
Sr	1.55E-05	1.55E-05	
Tl	1.23E-09	1.23E-09	
U	2.95E-10	2.95E-10	
V	4.92E-08	4.92E-08	
Zn	1.15E-07	1.15E-07	
Description of solution			
pH	6.51		
pe	-4		
Activity of water	0.999		
Ionic strength	4.97E-02		
Mass of water (kg)	1.00E+00		
Total carbon (mol/kg)	5.26E-03		
Total CO2 (mol/kg)	5.26E-03		
Temperature (deg C)	10		
Electrical balance (eq)	-4.33E-03		
Percent error, 100*			
(Cat- An)/(Cat+ An)	-8.06		
Iterations	23		
Total H	1.11E+02		
Total O	5.56E+01		
Redox couples			
Redox couple	pe	Eh (volts)	
N(-3)/N(3)	7.1899	0.4039	
N(-3)/N(5)	7.6364	0.429	
N(3)/N(5)	8.9758	0.5043	
S(-2)/S(6)	-2.5046	-0.1407	
Saturation indices			
Phase	SI	log IAP	log KT
(Co(NH3)5Cl)(NO3)2	-53.89	-47.66	6.23 (Co(NH3)5Cl)(NO3)2
(Co(NH3)5Cl)Br2	-52.25	-47.16	5.09 (Co(NH3)5Cl)Br2
(Co(NH3)5Cl)Cl2	-49.07	-44.46	4.61 (Co(NH3)5Cl)Cl2
(Co(NH3)5OH2)Cl3	-56.43	-44.46	11.97 (Co(NH3)5OH2)Cl3
(Co(NH3)6)(NO3)3	-65.66	-47.74	17.92 (Co(NH3)6)(NO3)3
(Co(NH3)6)Br3	-65.5	-46.99	18.51 (Co(NH3)6)Br3
(Co(NH3)6)Cl3	-63.27	-42.93	20.34 (Co(NH3)6)Cl3
(NH4)2CrO4	-55.43	-55.11	0.32 (NH4)2CrO4
(NH4)2SeO4	-63.63	-63.18	0.45 (NH4)2SeO4
(UO2)3(PO4)2	-27.4	-80.49	-53.08 (UO2)3(PO4)2
(VO)3(PO4)2	-59.6	-84.7	-25.1 (VO)3(PO4)2
Acanthite	-4.35	-42.68	-38.33 Ag2S
Ag2CO3	-37.71	-49.19	-11.48 Ag2CO3
Ag2CrO4	-75.61	-87.77	-12.17 Ag2CrO4
Ag2HVO4	-51.04	-49.56	1.48 Ag2HVO4
Ag2MoO4	-38.65	-50.69	-12.04 Ag2MoO4

Solution composition				
Elements	Molality	Moles		
Ag2O	-42.61	-29.61	13	Ag2O
Ag2Se	6.32	-44.85	-51.16	Ag2Se
Ag2SeO3	-58.16	-65.67	-7.52	Ag2SeO3
Ag2SeO4	-87.33	-95.84	-8.51	Ag2SeO4
Ag2SO4	-39.88	-44.86	-4.98	Ag2SO4
Ag3AsO3	-52.48	-50.32	2.16	Ag3AsO3
Ag3AsO4	-59.59	-62.37	-2.79	Ag3AsO4
Ag3H2VO5	-69.54	-64.36	5.18	Ag3H2VO5
Ag3PO4	-60.3	-77.89	-17.59	Ag3PO4
AgF·4H2O	-27.85	-26.94	0.91	AgF·4H2O
Agmetal	-4.32	-18.81	-14.49	Ag
AgVO3	-35.52	-34.75	0.77	AgVO3
Al(OH)3(am)	-1.6	10.23	11.83	Al(OH)3
Al2(MoO4)3	-47.55	-42.76	4.79	Al2(MoO4)3
Al2O3	-1.58	20.47	22.05	Al2O3
Al4(OH)10SO4	2.99	25.69	22.7	Al4(OH)10SO4
AlAsO4·2H2O	-12.53	-7.73	4.8	AlAsO4·2H2O
AlOHSO4	-1.78	-5.01	-3.23	AlOHSO4
AlSb	-90.69	-25.07	65.62	AlSb
Alunite	2.11	2.66	0.55	KAl3(SO4)2(OH)6
Anglesite	-5.72	-13.62	-7.9	PbSO4
Anhydrite	-0.48	-4.78	-4.29	CaSO4
Anilite	12.22	-21.35	-33.57	Cu0.25Cu1.5S
Antlerite	-34.68	-25.89	8.79	Cu3(OH)4SO4
Aragonite	-0.92	-9.11	-8.19	CaCO3
Arsenolite	-20.32	-23.63	-3.32	As4O6
Artinite	-10.52	0.2	10.72	MgCO3·Mg(OH)2·3H2O
As2O5	-42.84	-35.92	6.92	As2O5
Atacamite	-25.4	-17.14	8.26	Cu2(OH)3Cl
Autunite	-22.14	-65.51	-43.37	Ca(UO2)2(PO4)2
Avicennite	-67.22	-80.22	-13	Tl2O3
Azurite	-33.78	-49.8	-16.02	Cu3(OH)2(CO3)2
Ba(OH)2·8H2O	-18.91	5.99	24.9	Ba(OH)2·8H2O
Ba2V2O7·2H2O	-43.79	-27.92	15.87	Ba2V2O7·2H2O
Ba3(AsO4)2	-8.94	-17.95	-9.01	Ba3(AsO4)2
Ba3(VO4)2·4H2O	-54.87	-21.93	32.94	Ba3(VO4)2·4H2O
BaCrO4	-42.2	-52.17	-9.98	BaCrO4
BaF2	-12.42	-18.28	-5.86	BaF2
BaHPO4	-7.71	-27.49	-19.77	BaHPO4
BaMoO4	-8.02	-15.09	-7.06	BaMoO4
Barite	0.94	-9.26	-10.19	BaSO4
BaS	-23.26	-7.08	16.18	BaS
BaSeO3	-31.79	-30.08	1.72	BaSeO3
BaSeO4	-52.58	-60.24	-7.66	BaSeO4
Bassetite	-22.31	-66.02	-43.71	Fe(UO2)2(PO4)2
Be(OH)2(alpha)	-2.02	4.87	6.89	Be(OH)2
Be(OH)2(am)	-2.32	4.87	7.19	Be(OH)2

Solution composition				
Elements	Molality	Moles		
Be(OH)2(beta)	-1.62	4.87	6.49	Be(OH)2
BeMoO4	-14.94	-16.2	-1.26	BeMoO4
BeS	-27.58	-8.2	19.38	BeS
BeSeO4:4H2O	-58.42	-61.36	-2.94	BeSeO4:4H2O
Bianchite	-8.2	-9.95	-1.76	ZnSO4:6H2O
Birnessite	-28.15	-10.06	18.09	MnO2
Bixbyite	-28.64	-28.13	0.51	Mn2O3
BlaubleiI	6.91	-17.25	-24.16	Cu0.9Cu0.2S
BlaubleiII	8.14	-19.14	-27.28	Cu0.6Cu0.8S
Boehmite	0.56	10.23	9.67	AlOOH
Breithauptite	-5.12	-24.54	-19.41	NiSb
Brochantite	-46.55	-29.44	17.1	Cu4(OH)6SO4
Bromyrite	-13.12	-26.2	-13.08	AgBr
Brucite	-8.01	9.89	17.9	Mg(OH)2
Bunsenite	-6.61	6.76	13.37	NiO
Ca(VO3)2	-35.88	-29.43	6.45	Ca(VO3)2
Ca2V2O7	-37.94	-18.96	18.98	Ca2V2O7
Ca2V2O7:2H2O	-40.51	-18.96	21.55	Ca2V2O7:2H2O
Ca3(AsO4)2:4H2O	-26.81	-4.51	22.3	Ca3(AsO4)2:4H2O
Ca3(PO4)2(beta)	-6.12	-35.54	-29.42	Ca3(PO4)2
Ca3(VO4)2	-50.17	-8.48	41.68	Ca3(VO4)2
Ca3(VO4)2:4H2O	-48.35	-8.49	39.86	Ca3(VO4)2:4H2O
Ca3Sb2	-188.96	-39.19	149.77	Ca3Sb2
Ca4H(PO4)3:3H2O	-11.47	-58.55	-47.08	Ca4H(PO4)3:3H2O
CaCrO4	-45.67	-47.69	-2.02	CaCrO4
CaHPO4	-3.45	-23.01	-19.56	CaHPO4
CaHPO4:2H2O	-3.8	-23.01	-19.21	CaHPO4:2H2O
Calcite	-0.7	-9.11	-8.41	CaCO3
CaMoO4	-2.67	-10.6	-7.93	CaMoO4
Carnotite	-22.58	-22.01	0.57	KUO2VO4
CaSeO3:2H2O	-28.59	-25.59	2.99	CaSeO3:2H2O
CaSeO4:2H2O	-52.82	-55.76	-2.94	CaSeO4:2H2O
Cd(BO2)2	-16.9	-7.06	9.84	Cd(BO2)2
Cd(OH)2	-13.13	1.39	14.52	Cd(OH)2
Cd(OH)2(am)	-13.15	1.39	14.54	Cd(OH)2
Cd3(OH)2(SO4)2	-33.04	-26.33	6.71	Cd3(OH)2(SO4)2
Cd3(OH)4SO4	-33.64	-11.08	22.56	Cd3(OH)4SO4
Cd3(PO4)2	-30.2	-62.8	-32.6	Cd3(PO4)2
Cd4(OH)6SO4	-38.1	-9.7	28.4	Cd4(OH)6SO4
CdBr2:4H2O	-18.7	-21.41	-2.71	CdBr2:4H2O
CdCl2	-18.22	-18.7	-0.49	CdCl2
CdCl2:1H2O	-17.08	-18.7	-1.62	CdCl2:1H2O
CdCl2:2.5H2O	-16.72	-18.7	-1.98	CdCl2:2.5H2O
CdF2	-22.1	-22.88	-0.78	CdF2
Cdmetal(alpha)	-20.84	-6.62	14.21	Cd
Cdmetal(gamma)	-20.95	-6.62	14.32	Cd
CdMoO4	-5.36	-19.69	-14.33	CdMoO4

Solution composition				
Elements	Molality	Moles		
CdOHCl	-12.48	-8.66	3.82	CdOHCl
CdSb	-29.35	-29.91	-0.56	CdSb
CdSe	7.06	-13.85	-20.91	CdSe
CdSeO4:2H2O	-62.99	-64.84	-1.85	CdSeO4:2H2O
CdSO4	-14.17	-13.86	0.31	CdSO4
CdSO4:1H2O	-12.43	-13.86	-1.43	CdSO4:1H2O
CdSO4:2.67H2O	-12.15	-13.86	-1.71	CdSO4:2.67H2O
Celestite	-0.9	-7.54	-6.64	SrSO4
Cerargyrite	-14.49	-24.85	-10.36	AgCl
Cerrusite	-4.59	-17.95	-13.36	PbCO3
CH4(g)	-8.19	-51.62	-43.43	CH4
Chalcanthite	-16.1	-18.8	-2.7	CuSO4:5H2O
Chalcedony	-0.3	-4.03	-3.73	SiO2
Chalcocite	13.55	-22.93	-36.48	Cu2S
Chalcopyrite	16.91	-19.74	-36.65	CuFeS2
Chrysotile	-12.42	21.6	34.02	Mg3Si2O5(OH)4
Claudetite	-20.05	-23.63	-3.58	As4O6
Clausthalite	14.6	-13.61	-28.21	PbSe
Co(BO2)2	-29.07	-2	27.07	Co(BO2)2
Co(OH)2	-6.64	6.45	13.09	Co(OH)2
Co(OH)3	-20.49	-21.94	-1.45	Co(OH)3
CO2(g)	-1.39	-19.58	-18.18	CO2
Co3(AsO4)2	-29.61	-16.57	13.03	Co3(AsO4)2
Co3(PO4)2	-12.92	-47.61	-34.69	Co3(PO4)2
Co3O4	-27.94	-37.44	-9.5	Co3O4
CoCl2	-22.65	-13.64	9.01	CoCl2
CoCl2:6H2O	-16.1	-13.64	2.46	CoCl2:6H2O
CoCO3	-3.27	-13.13	-9.86	CoCO3
CoF2	-16.76	-17.82	-1.06	CoF2
CoF3	-58.04	-58.35	-0.31	CoF3
CoFe2O4	9.57	7.52	-2.05	CoFe2O4
CoHPO4	-7.97	-27.03	-19.06	CoHPO4
CoMoO4	-7.08	-14.63	-7.54	CoMoO4
CoO	-8.12	6.45	14.57	CoO
CoS(alpha)	0.82	-6.62	-7.44	CoS
CoS(beta)	4.45	-6.62	-11.07	CoS
CoSe	7.41	-8.79	-16.2	CoSe
CoSeO3	-30.94	-29.62	1.32	CoSeO3
CoSeO4:6H2O	-58.25	-59.78	-1.53	CoSeO4:6H2O
CoSO4	-12.34	-8.8	3.54	CoSO4
CoSO4:6H2O	-6.32	-8.8	-2.48	CoSO4:6H2O
Cotunnite	-13.44	-18.46	-5.02	PbCl2
Covellite	6.58	-16.62	-23.2	CuS
Cr(OH)2	-14.11	-2.96	11.15	Cr(OH)2
Cr(OH)3	-3.46	-1.85	1.61	Cr(OH)3
Cr(OH)3(am)	-1.1	-1.85	-0.75	Cr(OH)3
Cr2O3	-1.81	-3.69	-1.89	Cr2O3

Solution composition				
Elements	Molality	Moles		
CrBr3	-57.26	-36.04	21.22	CrBr3
CrCl2	-38.17	-23.05	15.12	CrCl2
CrCl3	-48.22	-31.98	16.24	CrCl3
CrF3	-27.13	-38.25	-11.12	CrF3
Cristobalite	-0.49	-4.03	-3.54	SiO2
Crmetal	-43.05	-10.97	32.08	Cr
CrO3	-55	-58.16	-3.16	CrO3
Cryolite	-16.28	-50.47	-34.19	Na3AlF6
Cu(OH)2	-12.75	-3.55	9.2	Cu(OH)2
Cu(SbO3)2	-55.28	-10.07	45.21	Cu(SbO3)2
Cu2(OH)3Br	-27.27	-18.5	8.78	Cu2(OH)3Br
Cu2(OH)3NO3	-28.67	-18.74	9.92	Cu2(OH)3NO3
Cu2Sb:3H2O	-6.73	-43.78	-37.05	Cu2Sb:3H2O
Cu2Se(alpha)	22.7	-25.09	-47.79	Cu2Se
Cu2SO4	-23.33	-25.1	-1.77	Cu2SO4
Cu3(AsO4)2:2H2O	-52.67	-46.57	6.1	Cu3(AsO4)2:2H2O
Cu3(PO4)2	-40.76	-77.61	-36.85	Cu3(PO4)2
Cu3(PO4)2:3H2O	-42.49	-77.61	-35.12	Cu3(PO4)2:3H2O
Cu3Sb	-4.63	-50.09	-45.45	Cu3Sb
Cu3Se2	22.77	-43.88	-66.65	Cu3Se2
CuBr	-7.52	-16.33	-8.81	CuBr
CuCO3	-11.63	-23.13	-11.5	CuCO3
CuCrO4	-56.27	-61.71	-5.44	CuCrO4
CuF	-12	-17.06	-5.06	CuF
CuF2	-29.56	-27.82	1.74	CuF2
CuF2:2H2O	-23.41	-27.82	-4.41	CuF2:2H2O
Cumetal	0.49	-8.93	-9.42	Cu
CuMoO4	-11.44	-24.63	-13.19	CuMoO4
CuOCuSO4	-33.93	-22.35	11.58	CuOCuSO4
Cupricferrite	-10.42	-2.48	7.94	CuFe2O4
Cuprite	-9.6	-9.86	-0.26	Cu2O
Cuprousferrite	4.37	-4.39	-8.77	CuFeO2
CuSe	15.44	-18.79	-34.22	CuSe
CuSe2	8.66	-26.01	-34.67	CuSe2
CuSeO3:2H2O	-40.47	-39.61	0.85	CuSeO3:2H2O
CuSeO4:5H2O	-67.34	-69.78	-2.44	CuSeO4:5H2O
CuSO4	-22.41	-18.8	3.62	CuSO4
Diaspore	2.41	10.23	7.83	AlOOH
Djurleite	13.27	-22.51	-35.78	Cu0.066Cu1.868S
Dolomite(disordered)	-2.69	-18.8	-16.11	CaMg(CO3)2
Dolomite(ordered)	-2.07	-18.8	-16.72	CaMg(CO3)2
Epsomite	-3.13	-5.36	-2.23	MgSO4:7H2O
FCO3Apatite	2.07	-113.86	-115.93	Ca9.316Na0.36Mg0.144(PO4)4.8(CO3)1.2F2.48
Fe(OH)2	-3.61	9.96	13.56	Fe(OH)2
Fe(OH)2:7Cl.3	0.56	-2.48	-3.04	Fe(OH)2:7Cl.3
Fe(VO3)2	-26.8	-29.94	-3.15	Fe(VO3)2

Solution composition				
Elements	Molality	Moles		
Fe ₂ (OH) ₄ SeO ₃	-36.55	-35	1.55	Fe ₂ (OH) ₄ SeO ₃
Fe ₂ (SeO ₃) ₃ ·2H ₂ O	-86.5	-107.13	-20.63	Fe ₂ (SeO ₃) ₃ ·2H ₂ O
Fe ₂ (SO ₄) ₃	-43.19	-44.68	-1.49	Fe ₂ (SO ₄) ₃
Fe ₃ (OH) ₈	-9.2	11.02	20.22	Fe ₃ (OH) ₈
FeAsO ₄ ·2H ₂ O	-17.83	-17.43	0.4	FeAsO ₄ ·2H ₂ O
FeCr ₂ O ₄	-2.24	6.26	8.5	FeCr ₂ O ₄
FeMoO ₄	-1.13	-11.12	-9.99	FeMoO ₄
Ferrihydrite	-3.34	0.53	3.87	Fe(OH) ₃
Ferroselite	6.53	-12.51	-19.03	FeSe ₂
FeS(ppt)	-0.27	-3.12	-2.85	FeS
FeSe	5.74	-5.28	-11.02	FeSe
Fluorite	-3.23	-13.8	-10.57	CaF ₂
Galena	3.27	-11.44	-14.71	PbS
Gibbsite	1.06	10.23	9.18	Al(OH) ₃
Goethite	-0.52	0.53	1.05	FeOOH
Goslarite	-7.81	-9.95	-2.14	ZnSO ₄ ·7H ₂ O
Greenalite	1	21.81	20.81	Fe ₃ Si ₂ O ₅ (OH) ₄
Greenockite	3.19	-11.68	-14.87	CdS
Greigite	3.77	-41.26	-45.03	Fe ₃ S ₄
Gummite	-12.93	-4.51	8.42	UO ₃
Gypsum	-0.16	-4.78	-4.62	CaSO ₄ ·2H ₂ O
H-Autunite	-28.19	-75.98	-47.79	H ₂ (UO ₂) ₂ (PO ₄) ₂
H-Jarosite	-18.94	-28.9	-9.96	(H ₃ O)Fe ₃ (SO ₄) ₂ (OH) ₆
H ₂ MoO ₄	-7.75	-21.08	-13.33	H ₂ MoO ₄
H ₂ S(g)	-5.06	-13.07	-8.01	H ₂ S
H ₂ Se(g)	-10.42	-15.24	-4.82	H ₂ Se
H ₂ Sn(OH) ₆	1.49	-22.03	-23.53	H ₂ Sn(OH) ₆
Halite	-7.58	-6.01	1.57	NaCl
Halloysite	1.15	12.41	11.26	Al ₂ Si ₂ O ₅ (OH) ₄
Hausmannite	-32.09	32.85	64.94	Mn ₃ O ₄
Hematite	1.29	1.07	-0.22	Fe ₂ O ₃
Hercynite	4.62	30.43	25.81	FeAl ₂ O ₄
Hinsdalite	-13.89	-16.39	-2.5	PbAl ₃ PO ₄ SO ₄ (OH) ₆
Huntite	-9.21	-38.18	-28.97	CaMg ₃ (CO ₃) ₄
Hydrocerrusite	-15.49	-34.26	-18.77	Pb ₃ (OH) ₂ (CO ₃) ₂
Hydromagnesite	-22.14	-28.88	-6.74	Mg ₅ (CO ₃) ₄ (OH) ₂ ·4H ₂ O
Hydroxylapatite	-3.75	-48.08	-44.33	Ca ₅ (PO ₄) ₃ OH
Hydroxylpyromorphite	-29.5	-92.29	-62.79	Pb ₅ (PO ₄) ₃ OH
K-Alum	-12.36	-17.81	-5.45	KAl(SO ₄) ₂ ·12H ₂ O
K-Autunite	-22.6	-71.07	-48.47	K ₂ (UO ₂) ₂ (PO ₄) ₂
K-Jarosite	-12.86	-26.44	-13.59	KFe ₃ (SO ₄) ₂ (OH) ₆
K ₂ Cr ₂ O ₇	-93.43	-111.42	-17.99	K ₂ Cr ₂ O ₇
K ₂ CrO ₄	-52.57	-53.26	-0.68	K ₂ CrO ₄
K ₂ MoO ₄	-19.46	-16.17	3.29	K ₂ MoO ₄
K ₂ SeO ₄	-60.59	-61.32	-0.73	K ₂ SeO ₄
Kaolinite	3.6	12.41	8.81	Al ₂ Si ₂ O ₅ (OH) ₄
Langite	-48.47	-29.44	19.03	Cu ₄ (OH) ₆ SO ₄ ·H ₂ O

Solution composition				
Elements	Molality	Moles		
Larnakite	-11.75	-11.99	-0.23	PbO:PbSO4
Laurionite	-9.04	-8.41	0.62	PbOHCl
Lepidocrocite	-0.84	0.53	1.37	FeOOH
Li2CrO4	-60.87	-55.6	5.28	Li2CrO4
Li2MoO4	-21.27	-18.51	2.76	Li2MoO4
Lime	-24.03	10.47	34.5	CaO
Litharge	-11.67	1.63	13.3	PbO
Mackinawite	0.48	-3.12	-3.6	FeS
Maghemite	-5.32	1.07	6.39	Fe2O3
Magnesioferrite	-8.49	10.95	19.45	Fe2MgO4
Magnesite	-2.04	-9.69	-7.65	MgCO3
Magnetite	5.68	11.02	5.34	Fe3O4
Malachite	-20.66	-26.68	-6.01	Cu2(OH)2CO3
Manganite	-13.06	12.28	25.34	MnOOH
Massicot	-11.88	1.63	13.51	PbO
Matlockite	-11.27	-20.55	-9.28	PbClF
Melanothallite	-30.48	-23.64	6.85	CuCl2
Melanterite	-2.89	-5.29	-2.4	FeSO4:7H2O
Mg(OH)2(active)	-8.91	9.89	18.79	Mg(OH)2
Mg(VO3)2	-42.56	-30.01	12.55	Mg(VO3)2
Mg2Sb3	-140.79	-66.11	74.68	Mg2Sb3
Mg2V2O7	-48.85	-20.13	28.73	Mg2V2O7
Mg3(PO4)2	-14.02	-37.3	-23.28	Mg3(PO4)2
MgCr2O4	-11.67	6.2	17.87	MgCr2O4
MgCrO4	-54.48	-48.27	6.21	MgCrO4
MgF2	-6.33	-14.38	-8.06	MgF2
MgHPO4:3H2O	-5.42	-23.59	-18.18	MgHPO4:3H2O
MgMoO4	-9.34	-11.19	-1.85	MgMoO4
MgSeO3:6H2O	-29.19	-26.18	3.01	MgSeO3:6H2O
MgSeO4:6H2O	-55.14	-56.34	-1.2	MgSeO4:6H2O
Minium	-64.53	12.9	77.44	Pb3O4
Mirabilite	-5.33	-7.18	-1.85	Na2SO4:10H2O
Mn(VO3)2	-37.38	-31.62	5.76	Mn(VO3)2
Mn2(SO4)3	-69.68	-73.88	-4.19	Mn2(SO4)3
Mn2Sb	-83.83	-22.75	61.08	Mn2Sb
Mn3(AsO4)2:8H2O	-23.59	-11.09	12.5	Mn3(AsO4)2:8H2O
Mn3(PO4)2	-18.21	-42.12	-23.91	Mn3(PO4)2
MnCl2:4H2O	-14.63	-11.81	2.82	MnCl2:4H2O
MnHPO4	0.2	-25.2	-25.4	MnHPO4
MnS(grn)	-5.26	-4.79	0.47	MnS
MnS(pnk)	-8.13	-4.79	3.34	MnS
MnSb	-46.26	-49.37	-3.11	MnSb
MnSe	-11.37	-6.96	4.41	MnSe
MnSeO3	-28.92	-27.79	1.13	MnSeO3
MnSeO3:2H2O	-28.69	-27.79	0.9	MnSeO3:2H2O
MnSeO4:5H2O	-55.9	-57.95	-2.05	MnSeO4:5H2O
MnSO4	-10.15	-6.97	3.18	MnSO4

Solution composition				
Elements	Molality	Moles		
Monteponite	-14.68	1.39	16.06	CdO
MoO3	-13.08	-21.08	-8	MoO3
Morenosite	-6.23	-8.49	-2.26	NiSO4:7H2O
MoS2	18.64	-55.23	-73.87	MoS2
Na-Autunite	-20.51	-67.91	-47.39	Na2(UO2)2(PO4)2
Na-Jarosite	-15.06	-24.86	-9.8	NaFe3(SO4)2(OH)6
Na2Cr2O7	-98.15	-108.25	-10.1	Na2Cr2O7
Na2CrO4	-53.2	-50.09	3.11	Na2CrO4
Na2Mo2O7	-16.96	-34.08	-17.12	Na2Mo2O7
Na2MoO4	-14.59	-13	1.58	Na2MoO4
Na2MoO4:2H2O	-14.23	-13	1.22	Na2MoO4:2H2O
Na2SeO3:5H2O	-38.29	-27.99	10.3	Na2SeO3:5H2O
Na2SeO4	-59.44	-58.16	1.28	Na2SeO4
Na3Sb	-121.65	-23.19	98.46	Na3Sb
Na3VO4	-46.23	-7.84	38.39	Na3VO4
Na4V2O7	-63.02	-23.75	39.27	Na4V2O7
Nantokite	-7.85	-14.97	-7.13	CuCl
NaSb	-47.29	-23.26	24.03	NaSb
Natron	-9.58	-11.51	-1.92	Na2CO3:10H2O
NaVO3	-20.05	-15.91	4.14	NaVO3
Nesquehonite	-5.25	-9.69	-4.45	MgCO3:3H2O
Ni(OH)2	-6.92	6.76	13.68	Ni(OH)2
Ni3(AsO4)2:8H2O	-31.34	-15.64	15.7	Ni3(AsO4)2:8H2O
Ni3(PO4)2	-15.38	-46.68	-31.3	Ni3(PO4)2
Ni4(OH)6SO4	-20.2	11.8	32	Ni4(OH)6SO4
NiCO3	-6.33	-12.82	-6.48	NiCO3
NiMoO4	-3.16	-14.32	-11.15	NiMoO4
Ningyoite	-4.64	-58.45	-53.82	CaU(PO4)2:2H2O
NiS(alpha)	-0.71	-6.31	-5.6	NiS
NiS(beta)	4.79	-6.31	-11.1	NiS
NiS(gamma)	6.49	-6.31	-12.8	NiS
NiSe	9.22	-8.48	-17.7	NiSe
NiSeO3:2H2O	-32.41	-29.3	3.1	NiSeO3:2H2O
NiSeO4:6H2O	-57.95	-59.47	-1.52	NiSeO4:6H2O
Nsutite	-27.57	-10.06	17.5	MnO2
O2(g)	-71.67	-74.44	-2.77	O2
Orpiment	13.29	-51.03	-64.32	As2S3
Otavite	-6.19	-18.19	-11.99	CdCO3
Pb(BO2)2	-13.48	-6.82	6.66	Pb(BO2)2
Pb(OH)2	-7.06	1.63	8.69	Pb(OH)2
Pb10(OH)6O(CO3)6	-92.4	-101.16	-8.76	Pb10(OH)6O(CO3)6
Pb2(OH)3Cl	-15.58	-6.78	8.79	Pb2(OH)3Cl
Pb2O(OH)2	-22.93	3.26	26.19	Pb2O(OH)2
Pb2O3	-49.77	11.27	61.04	Pb2O3
Pb2OCO3	-16.14	-16.32	-0.18	Pb2OCO3
Pb2V2O7	-34.99	-36.64	-1.65	Pb2V2O7
Pb3(AsO4)2	-36.83	-31.03	5.8	Pb3(AsO4)2

Solution composition				
Elements	Molality	Moles		
Pb3(PO4)2	-18.54	-62.07	-43.53	Pb3(PO4)2
Pb3(VO4)2	-41.82	-35.01	6.81	Pb3(VO4)2
Pb3O2CO3	-26.73	-14.69	12.05	Pb3O2CO3
Pb3O2SO4	-21.78	-10.36	11.42	Pb3O2SO4
Pb4(OH)6SO4	-29.83	-8.73	21.1	Pb4(OH)6SO4
Pb4O3SO4	-31.87	-8.73	23.14	Pb4O3SO4
PbBr2	-15.54	-21.16	-5.63	PbBr2
PbBrF	-13.41	-21.9	-8.49	PbBrF
PbCrO4	-43.52	-56.53	-13.01	PbCrO4
PbF2	-15.02	-22.64	-7.63	PbF2
PbHPO4	-8.04	-31.85	-23.81	PbHPO4
Pbmetal	-10.62	-6.38	4.24	Pb
PbMoO4	-3.33	-19.45	-16.12	PbMoO4
PbO:0.3H2O	-11.35	1.63	12.98	PbO:0.33H2O
PbSeO4	-57.62	-64.6	-6.98	PbSeO4
Periclase	-13.1	9.89	22.99	MgO
Phosgenite	-16.6	-36.41	-19.81	PbCl2:PbCO3
Plattnerite	-42.71	9.64	52.35	PbO2
Plumbgummit	-1.83	-34.62	-32.79	PbAl3(PO4)2(OH)5:H2O
Portlandite	-13.53	10.47	24	Ca(OH)2
Przhevalskite	-30.41	-74.35	-43.94	Pb(UO2)2(PO4)2
Pyrith	10.79	-8.18	-18.97	FeS2
Pyrochroite	-7.82	8.28	16.09	Mn(OH)2
Pyrolusite	-27.61	16.29	43.9	MnO2
Pyromorphite	-17.9	-102.33	-84.43	Pb5(PO4)3Cl
Quartz	0.18	-4.03	-4.21	SiO2
Realgar	-2.05	-22.98	-20.93	AsS
Retgersite	-6.41	-8.49	-2.08	NiSO4:6H2O
Rhodochrosite	-0.74	-11.3	-10.56	MnCO3
Rutherfordine	-9.62	-24.09	-14.47	UO2CO3
Saleeite	-23.23	-66.09	-42.86	Mg(UO2)2(PO4)2
Sb(OH)3	-3.88	-11.27	-7.39	Sb(OH)3
Sb2O4	-18.57	-14.53	4.03	Sb2O4
Sb2O5	-45.47	-55.14	-9.67	Sb2O5
Sb2Se3	2.69	-68.25	-70.94	Sb2Se3
Sb4O6(cubic)	-26.26	-45.08	-18.83	Sb4O6
Sb4O6(orth)	-26.83	-45.08	-18.25	Sb4O6
SbBr3	-46.63	-45.46	1.16	SbBr3
SbCl3	-42.3	-41.41	0.9	SbCl3
SbF3	-37.52	-47.68	-10.16	SbF3
Sbmetal	-10.82	-23.29	-12.47	Sb
SbO2	-3.75	-31.58	-27.82	SbO2
Schoepite	-10.97	-4.51	6.46	UO2(OH)2:H2O
Semetal(am)	-0.02	-7.23	-7.21	Se
Semetal(hex)	0.63	-7.23	-7.86	Se
Senarmontite	-9.89	-22.54	-12.65	Sb2O3
SeO2	-36.18	-36.07	0.11	SeO2

Solution composition				
Elements	Molality	Moles		
SeO3	-88.63	-66.23	22.4	SeO3
Sepiolite	-9.13	7.69	16.82	Mg2Si3O7.5OH:3H2O
Sepiolite(A)	-11.09	7.69	18.78	Mg2Si3O7.5OH:3H2O
Siderite	0.47	-9.62	-10.09	FeCO3
SiO2(am-gel)	-1.19	-4.03	-2.84	SiO2
SiO2(am-ppt)	-1.15	-4.03	-2.88	SiO2
Smithsonite	-4.43	-14.28	-9.85	ZnCO3
Sn(OH)2	-5.41	-10.84	-5.43	Sn(OH)2
Sn(OH)4	0.25	-22.03	-22.28	Sn(OH)4
Sn(SO4)2	-37.32	-52.53	-15.21	Sn(SO4)2
SnBr2	-24.1	-33.64	-9.54	SnBr2
SnBr4	-38.78	-67.62	-28.85	SnBr4
SnCl2	-21.66	-30.93	-9.28	SnCl2
Snmetal(wht)	-16.53	-18.85	-2.33	Sn
SnO	-5.93	-10.84	-4.91	SnO
SnO2	6.94	-22.03	-28.97	SnO2
SnS	-4.8	-23.92	-19.11	SnS
SnS2	9.28	-48.18	-57.45	SnS2
SnSe	4.41	-26.08	-30.49	SnSe
SnSe2	12.61	-52.51	-65.12	SnSe2
SnSO4	30.88	-26.09	-56.97	SnSO4
Sphalerite	3.95	-7.78	-11.73	ZnS
Spinel	-10.09	30.36	40.45	MgAl2O4
Sr-Autunite	-24.32	-68.27	-43.95	Sr(UO2)2(PO4)2
SrCrO4	-45.9	-50.46	-4.56	SrCrO4
SrF2	-7.95	-16.57	-8.62	SrF2
SrHPO4	-6.48	-25.77	-19.3	SrHPO4
SrSeO3	-30.66	-28.36	2.3	SrSeO3
SrSeO4	-54.12	-58.52	-4.4	SrSeO4
Stibnite	-8.57	-61.76	-53.19	Sb2S3
Strengite	-6.63	-32.95	-26.31	FePO4:2H2O
Strontianite	-2.6	-11.87	-9.27	SrCO3
Sulfur	-3.07	-5.06	-1.99	S
Tenorite	-11.79	-3.55	8.25	CuO
Thenardite	-7.58	-7.17	0.41	Na2SO4
Thermonatrite	-12.24	-11.5	0.73	Na2CO3:H2O
Tl(OH)3	-34.67	-40.11	-5.44	Tl(OH)3
Tl2CO3	-20.55	-24.72	-4.17	Tl2CO3
Tl2CrO4	-50.6	-63.3	-12.7	Tl2CrO4
Tl2MoO4	-18.23	-26.22	-7.99	Tl2MoO4
Tl2O	-33.13	-5.14	27.99	Tl2O
Tl2S	-10.17	-18.21	-8.04	Tl2S
Tl2Se	-1.48	-20.38	-18.89	Tl2Se
Tl2SeO4	-66.87	-71.37	-4.5	Tl2SeO4
Tl2SO4	-16.29	-20.39	-4.09	Tl2SO4
TlBr	-8.03	-13.97	-5.94	TlBr
TlCl	-8.49	-12.61	-4.12	TlCl

Solution composition				
Elements	Molality	Moles		
Tlmetal	-12.2	-6.58	5.63	Tl
TiNO3	-12.21	-14.22	-2.01	TiNO3
TiOH	-15.87	-2.57	13.3	TiOH
Torbernite	-34.87	-79.53	-44.66	Cu(UO2)2(PO4)2
Tsumebite	-23.98	-33.77	-9.79	Pb2CuPO4(OH)3:3H2O
Tyuyamunite	-43.95	-38.45	5.5	Ca(UO2)2(VO4)2
U(HPO4)2:4H2O	-17.19	-68.93	-51.73	U(HPO4)2:4H2O
U3O8	-15.47	10.12	25.59	U3O8
U3Sb4	-308.65	-147.11	161.53	U3Sb4
U4O9	-0.8	0.14	0.94	U4O9
UF4	-21.71	-50.51	-28.8	UF4
UF4:2.5H2O	-17.57	-50.51	-32.94	UF4:2.5H2O
UO2(am)	-3.92	-1.97	1.95	UO2
UO2(NO3)2	-40.72	-27.8	12.92	UO2(NO3)2
UO2(NO3)2:2H2O	-32.89	-27.8	5.09	UO2(NO3)2:2H2O
UO2(NO3)2:3H2O	-31.28	-27.8	3.48	UO2(NO3)2:3H2O
UO2(NO3)2:6H2O	-29.66	-27.8	1.85	UO2(NO3)2:6H2O
UO2(OH)2(beta)	-10.65	-4.51	6.14	UO2(OH)2
UO2HPO4	-13.76	-37.99	-24.23	UO2HPO4
UO2SeO4:4H2O	-68.49	-70.74	-2.25	UO2SeO4:4H2O
UO3	-12.96	-4.51	8.45	UO3
Uramphite	-20.81	-72.93	-52.13	(NH4)2(UO2)2(PO4)2
Uraninite	1.98	-1.97	-3.95	UO2
Uranocircite	-25.75	-69.99	-44.24	Ba(UO2)2(PO4)2
USb2	-105.65	-75.11	30.54	USb2
V(OH)3	-11.81	-4.22	7.59	V(OH)3
V2O5	-38.23	-39.9	-1.68	V2O5
V3O5	-28.5	-25.75	2.75	V3O5
V4O7	-40.37	-31.67	8.71	V4O7
V6O13	-72.34	-135.72	-63.38	V6O13
Valentinite	-13.89	-22.54	-8.66	Sb2O3
VCl2	-48.5	-28.32	20.18	VCl2
VCl3	-59.46	-34.36	25.1	VCl3
VF4	-71.24	-54.46	16.78	VF4
Vivianite	-1.09	-37.09	-36	Fe3(PO4)2:8H2O
Vmetal	-62.67	-16.24	46.43	V
VO	-24.03	-8.23	15.81	VO
VO(OH)2	-11.06	-5.91	5.15	VO(OH)2
VO2Cl	-33.21	-30	3.22	VO2Cl
VOC1	-26.39	-14.27	12.13	VOC1
VOC12	-39.86	-26	13.85	VOC12
VOSO4	-25.58	-21.16	4.41	VOSO4
Witherite	-4.98	-13.59	-8.61	BaCO3
Wurtzite	1.37	-7.78	-9.15	ZnS
Zincite	-6.87	5.3	12.17	ZnO
Zincosite	-14.65	-9.95	4.7	ZnSO4
Zn(BO2)2	-11.44	-3.15	8.29	Zn(BO2)2

Solution composition				
Elements	Molality	Moles		
Zn(NO3)2:6H2O	-21.09	-18	3.09	Zn(NO3)2:6H2O
Zn(OH)2	-6.9	5.3	12.2	Zn(OH)2
Zn(OH)2(am)	-7.93	5.3	13.22	Zn(OH)2
Zn(OH)2(beta)	-7.23	5.3	12.53	Zn(OH)2
Zn(OH)2(epsilon)	-7	5.3	12.29	Zn(OH)2
Zn(OH)2(gamma)	-6.44	5.3	11.73	Zn(OH)2
Zn2(OH)2SO4	-12.16	-4.66	7.5	Zn2(OH)2SO4
Zn2(OH)3Cl	-14.64	0.55	15.19	Zn2(OH)3Cl
Zn3(AsO4)2:2.5H2O	-33.69	-20.04	13.65	Zn3(AsO4)2:2.5H2O
Zn3(PO4)2:4H2O	-15.65	-51.07	-35.42	Zn3(PO4)2:4H2O
Zn3O(SO4)2	-35.92	-14.61	21.31	Zn3O(SO4)2
Zn4(OH)6SO4	-22.47	5.93	28.4	Zn4(OH)6SO4
Zn5(OH)8Cl2	-32.11	6.39	38.5	Zn5(OH)8Cl2
ZnBr2:2H2O	-22.99	-17.5	5.49	ZnBr2:2H2O
ZnCl2	-22.52	-14.79	7.72	ZnCl2
ZnCO3:1H2O	-4.02	-14.28	-10.26	ZnCO3:1H2O
ZnF2	-19	-18.98	0.02	ZnF2
Znmetal	-29.93	-2.71	27.21	Zn
ZnMoO4	-5.76	-15.78	-10.03	ZnMoO4
ZnO(active)	-6.72	5.3	12.01	ZnO
ZnS(am)	1.42	-7.78	-9.19	ZnS
ZnSb	-37.52	-26	11.52	ZnSb
ZnSe	4.7	-9.94	-14.64	ZnSe
ZnSeO4:6H2O	-59.42	-60.94	-1.52	ZnSeO4:6H2O
ZnSO4:1H2O	-9.72	-9.95	-0.23	ZnSO4:1H2O

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Solution composition		
Elements	Molality	Moles
Ag	9.30E-11	9.30E-11
Al	7.29E-07	7.29E-07
Alkalinity	1.99E-03	1.99E-03
As	5.78E-07	5.78E-07
B	4.53E-05	4.53E-05
Ba	1.58E-07	1.58E-07
Be	5.57E-08	5.57E-08
Br	3.14E-05	3.14E-05
Ca	9.41E-03	9.41E-03
Cd	8.92E-11	8.92E-11
Cl	7.07E-04	7.07E-04
Co	3.46E-07	3.46E-07
Cr	3.86E-09	3.86E-09
Cu	8.90E-07	8.90E-07
Dom_a	1.55E-04	1.55E-04
F	4.54E-06	4.54E-06
Fe	4.62E-03	4.62E-03
Hg	2.50E-11	2.50E-11
K	1.48E-04	1.48E-04
Li	4.19E-06	4.19E-06
Mg	3.55E-03	3.55E-03
Mn	1.09E-04	1.09E-04
Mo	1.88E-09	1.88E-09
N(-3)	1.97E-05	1.97E-05
N(3)	3.58E-06	3.58E-06
N(5)	1.79E-05	1.79E-05
Na	3.39E-03	3.39E-03
Ni	9.37E-07	9.37E-07
P	1.91E-07	1.91E-07
Pb	1.20E-07	1.20E-07
S(-2)	1.10E-07	1.10E-07
S(6)	2.15E-02	2.15E-02
Sb	8.24E-10	8.24E-10
Se	1.27E-09	1.27E-09
Si	7.83E-05	7.83E-05
Sn	8.45E-10	8.45E-10
Sr	2.39E-05	2.39E-05
Tl	4.91E-10	4.91E-10
U	2.95E-10	2.95E-10
V	1.97E-08	1.97E-08
Zn	1.09E-06	1.09E-06

Solution composition				
Elements	Molality	Moles		
Description of solution				
pH	5.8			
pe	-4			
Activity of water	0.999			
Ionic strength	5.64E-02			
Mass of water (kg)	1.00E+00			
Total carbon (mol/kg)	8.75E-03			
Total CO2 (mol/kg)	8.75E-03			
Temperature (deg C)	10			
Electrical balance (eq)	-6.79E-03			
Percent error, 100*				
(Cat- An)/(Cat+ An)	-11.4			
Iterations	13			
Total H	1.11E+02			
Total O	5.56E+01			
Redox couples				
Redox couple	pe	Eh (volts)		
N(-3)/N(3)	8.1608	0.4585		
N(-3)/N(5)	8.5422	0.4799		
N(3)/N(5)	9.6865	0.5442		
S(-2)/S(6)	-1.4549	-0.0817		
Saturation indices				
Phase	SI	log IAP	log KT	
(Co(NH3)5Cl)(NO3)2	-55.27	-49.04	6.23	(Co(NH3)5Cl)(NO3)2
(Co(NH3)5Cl)Br2	-53.63	-48.54	5.09	(Co(NH3)5Cl)Br2
(Co(NH3)5Cl)Cl2	-50.44	-45.83	4.61	(Co(NH3)5Cl)Cl2
(Co(NH3)5OH2)Cl3	-57.81	-45.83	11.97	(Co(NH3)5OH2)Cl3
(Co(NH3)6)(NO3)3	-67.59	-49.67	17.92	(Co(NH3)6)(NO3)3
(Co(NH3)6)Br3	-67.44	-48.93	18.51	(Co(NH3)6)Br3
(Co(NH3)6)Cl3	-65.21	-44.87	20.34	(Co(NH3)6)Cl3
(NH4)2CrO4	-57.73	-57.41	0.32	(NH4)2CrO4
(NH4)2SeO4	-61.63	-61.18	0.45	(NH4)2SeO4
(UO2)3(PO4)2	-21.7	-74.79	-53.08	(UO2)3(PO4)2
(VO)3(PO4)2	-57.93	-83.03	-25.1	(VO)3(PO4)2
Acanthite	-6.39	-44.72	-38.33	Ag2S
Ag2CO3	-38	-49.48	-11.48	Ag2CO3
Ag2CrO4	-77.59	-89.75	-12.17	Ag2CrO4
Ag2HVO4	-51.56	-50.08	1.48	Ag2HVO4
Ag2MoO4	-39.05	-51.09	-12.04	Ag2MoO4
Ag2O	-43.41	-30.41	13	Ag2O
Ag2Se	5.92	-45.24	-51.16	Ag2Se
Ag2SeO3	-56.52	-64.03	-7.52	Ag2SeO3
Ag2SeO4	-85.01	-93.52	-8.51	Ag2SeO4
Ag2SO4	-39.2	-44.18	-4.98	Ag2SO4
Ag3AsO3	-54.01	-51.85	2.16	Ag3AsO3
Ag3AsO4	-60.44	-63.23	-2.79	Ag3AsO4
Ag3H2VO5	-70.46	-65.28	5.18	Ag3H2VO5

Solution composition				
Elements	Molality	Moles		
Ag3PO4	-60.58	-78.17	-17.59	Ag3PO4
AgF:4H2O	-27.44	-26.54	0.91	AgF:4H2O
Agmetal	-5.06	-19.55	-14.49	Ag
AgVO3	-35.64	-34.87	0.77	AgVO3
Al(OH)3(am)	-2.84	8.99	11.83	Al(OH)3
Al2(MoO4)3	-48.84	-44.06	4.79	Al2(MoO4)3
Al2O3	-4.07	17.98	22.05	Al2O3
Al4(OH)10SO4	-0.51	22.19	22.7	Al4(OH)10SO4
AlAsO4:2H2O	-13.42	-8.62	4.8	AlAsO4:2H2O
AlOHSO4	-1.55	-4.78	-3.23	AlOHSO4
AlSb	-92.09	-26.46	65.62	AlSb
Alunite	0.75	1.3	0.55	KAl3(SO4)2(OH)6
Anglesite	-2.05	-9.95	-7.9	PbSO4
Anhydrite	-0.46	-4.75	-4.29	CaSO4
Anilite	18.66	-14.91	-33.57	Cu0.25Cu1.5S
Antlerite	-19.17	-10.38	8.79	Cu3(OH)4SO4
Aragonite	-1.86	-10.05	-8.19	CaCO3
Arsenolite	-21.63	-24.95	-3.32	As4O6
Artinite	-12.54	-1.82	10.72	MgCO3:Mg(OH)2:3H2O
As2O5	-42.14	-35.22	6.92	As2O5
Atacamite	-15.04	-6.78	8.26	Cu2(OH)3Cl
Autunite	-19.18	-62.55	-43.37	Ca(UO2)2(PO4)2
Avicennite	-68.11	-81.11	-13	Tl2O3
Azurite	-18.73	-34.75	-16.02	Cu3(OH)2(CO3)2
Ba(OH)2:8H2O	-20.45	4.44	24.9	Ba(OH)2:8H2O
Ba2V2O7:2H2O	-46.32	-30.44	15.87	Ba2V2O7:2H2O
Ba3(AsO4)2	-12.87	-21.88	-9.01	Ba3(AsO4)2
Ba3(VO4)2:4H2O	-58.94	-26	32.94	Ba3(VO4)2:4H2O
BaCrO4	-44.92	-54.9	-9.98	BaCrO4
BaF2	-12.35	-18.21	-5.86	BaF2
BaHPO4	-8.34	-28.11	-19.77	BaHPO4
BaMoO4	-9.17	-16.23	-7.06	BaMoO4
Barite	0.87	-9.32	-10.19	BaSO4
BaS	-26.04	-9.86	16.18	BaS
BaSeO3	-30.9	-29.18	1.72	BaSeO3
BaSeO4	-51	-58.66	-7.66	BaSeO4
Bassetite	-19.23	-62.94	-43.71	Fe(UO2)2(PO4)2
Be(OH)2(alpha)	-3.37	3.52	6.89	Be(OH)2
Be(OH)2(am)	-3.67	3.52	7.19	Be(OH)2
Be(OH)2(beta)	-2.97	3.52	6.49	Be(OH)2
BeMoO4	-15.9	-17.16	-1.26	BeMoO4
BeS	-30.17	-10.79	19.38	BeS
BeSeO4:4H2O	-56.65	-59.59	-2.94	BeSeO4:4H2O
Bianchite	-6.96	-8.72	-1.76	ZnSO4:6H2O
Birnessite	-28.72	-10.63	18.09	MnO2
Bixbyite	-30.46	-29.94	0.51	Mn2O3

Solution composition

Elements	Molality	Moles		
BlaubleiI	10.75	-13.41	-24.16	Cu0.9Cu0.2S
BlaubleiII	13.18	-14.1	-27.28	Cu0.6Cu0.8S
Boehmite	-0.68	8.99	9.67	AlOOH
Breithauptite	-6.68	-26.1	-19.41	NiSb
Brochantite	-26.35	-9.25	17.1	Cu4(OH)6SO4
Bromyrite	-12.51	-25.6	-13.08	AgBr
Brucite	-9.28	8.63	17.9	Mg(OH)2
Bunsenite	-8.36	5.01	13.37	NiO
Ca(VO3)2	-36.77	-30.32	6.45	Ca(VO3)2
Ca2V2O7	-40.28	-21.3	18.98	Ca2V2O7
Ca2V2O7:2H2O	-42.85	-21.3	21.55	Ca2V2O7:2H2O
Ca3(AsO4)2:4H2O	-30.47	-8.17	22.3	Ca3(AsO4)2:4H2O
Ca3(PO4)2(beta)	-8.64	-38.07	-29.42	Ca3(PO4)2
Ca3(VO4)2	-53.97	-12.28	41.68	Ca3(VO4)2
Ca3(VO4)2:4H2O	-52.15	-12.29	39.86	Ca3(VO4)2:4H2O
Ca3Sb2	-193.63	-43.85	149.77	Ca3Sb2
Ca4H(PO4)3:3H2O	-14.53	-61.61	-47.08	Ca4H(PO4)3:3H2O
CaCrO4	-48.31	-50.33	-2.02	CaCrO4
CaHPO4	-3.98	-23.54	-19.56	CaHPO4
CaHPO4:2H2O	-4.33	-23.54	-19.21	CaHPO4:2H2O
Calcite	-1.65	-10.05	-8.41	CaCO3
Calomel	-25.81	-44.57	-18.76	Hg2Cl2
CaMoO4	-3.73	-11.66	-7.93	CaMoO4
Carnotite	-21.59	-21.03	0.57	KUO2VO4
CaSeO3:2H2O	-27.6	-24.61	2.99	CaSeO3:2H2O
CaSeO4:2H2O	-51.15	-54.09	-2.94	CaSeO4:2H2O
Cd(BO2)2	-17.62	-7.78	9.84	Cd(BO2)2
Cd(OH)2	-13.63	0.9	14.52	Cd(OH)2
Cd(OH)2(am)	-13.64	0.9	14.54	Cd(OH)2
Cd3(OH)2(SO4)2	-31.55	-24.84	6.71	Cd3(OH)2(SO4)2
Cd3(OH)4SO4	-33.64	-11.08	22.56	Cd3(OH)4SO4
Cd3(PO4)2	-29.83	-62.43	-32.6	Cd3(PO4)2
Cd4(OH)6SO4	-38.58	-10.18	28.4	Cd4(OH)6SO4
CdBr2:4H2O	-17.18	-19.89	-2.71	CdBr2:4H2O
CdCl2	-16.69	-17.18	-0.49	CdCl2
CdCl2:1H2O	-15.55	-17.18	-1.62	CdCl2:1H2O
CdCl2:2.5H2O	-15.2	-17.18	-1.98	CdCl2:2.5H2O
CdF2	-20.98	-21.76	-0.78	CdF2
Cdmetal(alpha)	-22.01	-7.79	14.21	Cd
Cdmetal(gamma)	-22.12	-7.79	14.32	Cd
CdMoO4	-5.45	-19.78	-14.33	CdMoO4
CdOHCl	-11.97	-8.14	3.82	CdOHCl
CdSb	-29.65	-30.21	-0.56	CdSb
CdSe	6.97	-13.94	-20.91	CdSe
CdSeO4:2H2O	-60.36	-62.21	-1.85	CdSeO4:2H2O
CdSO4	-13.18	-12.87	0.31	CdSO4

Solution composition

Elements	Molality	Moles		
CdSO4:1H2O	-11.44	-12.87	-1.43	CdSO4:1H2O
CdSO4:2.67H2O	-11.16	-12.87	-1.71	CdSO4:2.67H2O
Celestite	-0.68	-7.32	-6.64	SrSO4
Cerargyrite	-13.89	-24.24	-10.36	AgCl
Cerrusite	-1.89	-15.25	-13.36	PbCO3
CH4(g)	-10.4	-53.83	-43.43	CH4
Chalcanthite	-9.94	-12.64	-2.7	CuSO4:5H2O
Chalcedony	-0.37	-4.1	-3.73	SiO2
Chalcocite	20.99	-15.49	-36.48	Cu2S
Chalcopyrite	17.78	-18.86	-36.65	CuFeS2
Chrysotile	-16.34	17.68	34.02	Mg3Si2O5(OH)4
Cinnabar	2.95	-45.1	-48.05	HgS
Claudetite	-21.37	-24.95	-3.58	As4O6
Clausthalite	17.2	-11.02	-28.21	PbSe
Co(BO2)2	-31.24	-4.17	27.07	Co(BO2)2
Co(OH)2	-8.59	4.51	13.09	Co(OH)2
Co(OH)3	-22.1	-23.55	-1.45	Co(OH)3
CO2(g)	-0.89	-19.07	-18.18	CO2
Co3(AsO4)2	-34.74	-21.7	13.03	Co3(AsO4)2
Co3(PO4)2	-16.91	-51.6	-34.69	Co3(PO4)2
Co3O4	-33.09	-42.59	-9.5	Co3O4
CoCl2	-22.58	-13.57	9.01	CoCl2
CoCl2:6H2O	-16.03	-13.57	2.46	CoCl2:6H2O
CoCO3	-4.7	-14.56	-9.86	CoCO3
CoF2	-17.09	-18.15	-1.06	CoF2
CoF3	-57.23	-57.54	-0.31	CoF3
CoFe2O4	5.64	3.58	-2.05	CoFe2O4
CoHPO4	-8.99	-28.05	-19.06	CoHPO4
CoMoO4	-8.63	-16.17	-7.54	CoMoO4
CoO	-10.07	4.51	14.57	CoO
CoS(alpha)	-2.36	-9.8	-7.44	CoS
CoS(beta)	1.27	-9.8	-11.07	CoS
CoSe	5.87	-10.33	-16.2	CoSe
CoSeO3	-30.44	-29.12	1.32	CoSeO3
CoSeO4:6H2O	-57.08	-58.61	-1.53	CoSeO4:6H2O
CoSO4	-12.8	-9.26	3.54	CoSO4
CoSO4:6H2O	-6.78	-9.26	-2.48	CoSO4:6H2O
Cotunnite	-9.23	-14.26	-5.02	PbCl2
Covellite	10.02	-13.18	-23.2	CuS
Cr(OH)2	-16.65	-5.5	11.15	Cr(OH)2
Cr(OH)3	-5.66	-4.05	1.61	Cr(OH)3
Cr(OH)3(am)	-3.3	-4.05	-0.75	Cr(OH)3
Cr2O3	-6.21	-8.09	-1.89	Cr2O3
CrBr3	-56.44	-35.22	21.22	CrBr3
CrCl2	-38.7	-23.58	15.12	CrCl2
CrCl3	-47.4	-31.16	16.24	CrCl3

Solution composition				
Elements	Molality	Moles		
CrF3	-26.92	-38.04	-11.12	CrF3
Cristobalite	-0.56	-4.1	-3.54	SiO2
Crmetal	-46.27	-14.19	32.08	Cr
CrO3	-56.18	-59.34	-3.16	CrO3
Cryolite	-15.11	-49.31	-34.19	Na3AlF6
Cu(OH)2	-8.07	1.13	9.2	Cu(OH)2
Cu(SbO3)2	-45.47	-0.26	45.21	Cu(SbO3)2
Cu2(OH)3Br	-16.91	-8.13	8.78	Cu2(OH)3Br
Cu2(OH)3NO3	-18.3	-8.38	9.92	Cu2(OH)3NO3
Cu2Sb.3H2O	2.13	-34.91	-37.05	Cu2Sb.3H2O
Cu2Se(alpha)	31.78	-16.01	-47.79	Cu2Se
Cu2SO4	-13.17	-14.94	-1.77	Cu2SO4
Cu3(AsO4)2.2H2O	-37.93	-31.83	6.1	Cu3(AsO4)2.2H2O
Cu3(PO4)2	-24.88	-61.73	-36.85	Cu3(PO4)2
Cu3(PO4)2.3H2O	-26.61	-61.73	-35.12	Cu3(PO4)2.3H2O
Cu3Sb	8.23	-37.22	-45.45	Cu3Sb
Cu3Se2	36.93	-29.72	-66.65	Cu3Se2
CuBr	-2.17	-10.98	-8.81	CuBr
CuCO3	-6.44	-17.94	-11.5	CuCO3
CuCrO4	-52.77	-58.21	-5.44	CuCrO4
CuF	-6.86	-11.92	-5.06	CuF
CuF2	-23.27	-21.53	1.74	CuF2
CuF2.2H2O	-17.12	-21.53	-4.41	CuF2.2H2O
Cumetal	4.49	-4.93	-9.42	Cu
CuMoO4	-6.36	-19.55	-13.19	CuMoO4
CuOCuSO4	-23.09	-11.51	11.58	CuOCuSO4
Cupricferrite	-7.73	0.2	7.94	CuFe2O4
Cuprite	-0.92	-1.18	-0.26	Cu2O
Cuprousferrite	7.72	-1.05	-8.77	CuFeO2
CuSe	20.52	-13.7	-34.22	CuSe
CuSe2	14.82	-19.85	-34.67	CuSe2
CuSeO3.2H2O	-33.35	-32.5	0.85	CuSeO3.2H2O
CuSeO4.5H2O	-59.54	-61.98	-2.44	CuSeO4.5H2O
CuSO4	-16.25	-12.64	3.62	CuSO4
Diaspore	1.16	8.99	7.83	AlOOH
Djurleite	20.45	-15.33	-35.78	Cu0.066Cu1.868S
Dolomite(disordered)	-4.39	-20.5	-16.11	CaMg(CO3)2
Dolomite(ordered)	-3.78	-20.5	-16.72	CaMg(CO3)2
Epsomite	-2.91	-5.14	-2.23	MgSO4.7H2O
FCO3Apatite	-4.92	-120.85	115.93	4.8(CO3)1.2F2.48
Fe(OH)2	-4.94	8.62	13.56	Fe(OH)2
Fe(OH)2.7Cl.3	-0.13	-3.17	-3.04	Fe(OH)2.7Cl.3
Fe(VO3)2	-27.57	-30.72	-3.15	Fe(VO3)2
Fe2(OH)4SeO3	-36.1	-34.55	1.55	Fe2(OH)4SeO3
Fe2(SeO3)3.2H2O	-81.17	-101.8	-20.63	Fe2(SeO3)3.2H2O

Solution composition

Elements	Molality	Moles		
Fe2(SO4)3	-40.74	-42.22	-1.49	Fe2(SO4)3
Fe3(OH)8	-12.53	7.69	20.22	Fe3(OH)8
FeAsO4:2H2O	-18.47	-18.07	0.4	FeAsO4:2H2O
FeCr2O4	-7.98	0.53	8.5	FeCr2O4
FeMoO4	-2.07	-12.06	-9.99	FeMoO4
Ferrihydrite	-4.33	-0.46	3.87	Fe(OH)3
Ferroselite	6.68	-12.36	-19.03	FeSe2
FeS(ppt)	-2.84	-5.69	-2.85	FeS
FeSe	4.81	-6.21	-11.02	FeSe
Fluorite	-3.07	-13.64	-10.57	CaF2
Galena	4.22	-10.49	-14.71	PbS
Gibbsite	-0.19	8.99	9.18	Al(OH)3
Goethite	-1.52	-0.46	1.05	FeOOH
Goslarite	-6.57	-8.72	-2.14	ZnSO4:7H2O
Greenalite	-3.15	17.66	20.81	Fe3Si2O5(OH)4
Greenockite	1.46	-13.41	-14.87	CdS
Greigite	-4.5	-49.53	-45.03	Fe3S4
Gummite	-11.65	-3.22	8.42	UO3
Gypsum	-0.13	-4.75	-4.62	CaSO4:2H2O
H-Autunite	-23.77	-71.56	-47.79	H2(UO2)2(PO4)2
H-Jarosite	-18.96	-28.92	-9.96	(H3O)Fe3(SO4)2(OH)6
H2MoO4	-7.35	-20.68	-13.33	H2MoO4
H2S(g)	-6.3	-14.31	-8.01	H2S
H2Se(g)	-10.02	-14.83	-4.82	H2Se
H2Sn(OH)6	2.49	-21.04	-23.53	H2Sn(OH)6
Halite	-7.38	-5.81	1.57	NaCl
Halloysite	-1.48	9.78	11.26	Al2Si2O5(OH)4
Hausmannite	-35.15	29.79	64.94	Mn3O4
Hematite	-0.7	-0.93	-0.22	Fe2O3
Hercynite	0.79	26.6	25.81	FeAl2O4
Hg(CH3)2(g)	-60.27	-138.45	-78.18	Hg(CH3)2
Hg(g)	-9.52	-17.59	-8.08	Hg
Hg(OH)2	-27.3	-30.79	-3.5	Hg(OH)2
Hg2(g)	-19.69	-35.19	-15.49	Hg2
Hg2(OH)2	-31.76	-26.5	5.26	Hg2(OH)2
Hg2Br2	-23.79	-47.28	-23.48	Hg2Br2
Hg2CO3	-29.1	-45.57	-16.47	Hg2CO3
Hg2CrO4	-77.14	-85.84	-8.7	Hg2CrO4
Hg2F2	-38.96	-49.16	-10.19	Hg2F2
Hg2HPO4	-34.28	-59.06	-24.77	Hg2HPO4
Hg2S	-28.48	-40.8	-12.32	Hg2S
Hg2SeO3	-55.46	-60.12	-4.66	Hg2SeO3
Hg2SO4	-34.08	-40.26	-6.18	Hg2SO4
Hg3O2CO3	-81.76	-111.44	-29.68	Hg3O2CO3
HgBr(g)	-41.71	-23.64	18.08	HgBr
HgBr2	-25.01	-51.57	-26.56	HgBr2
HgBr2(g)	-32.68	-51.57	-18.89	HgBr2

Solution composition				
Elements	Molality	Moles		
HgCl(g)	-43.29	-22.29	21	HgCl
HgCl2	-26.6	-48.87	-22.26	HgCl2
HgF(g)	-59.62	-24.58	35.04	HgF
HgF2(g)	-67.55	-53.45	14.1	HgF2
Hgmetal(l)	-3.37	-17.59	-14.23	Hg
HgSe	10.07	-45.62	-55.69	HgSe
HgSeO3	-51.99	-64.42	-12.43	HgSeO3
HgSO4	-35	-44.56	-9.56	HgSO4
Hinsdalite	-13.04	-15.54	-2.5	PbAl3PO4SO4(OH)6
Huntite	-12.42	-41.39	-28.97	CaMg3(CO3)4
Hydrocerrusite	-7.92	-26.69	-18.77	Pb3(OH)2(CO3)2
Hydromagnesite	-26.42	-33.16	-6.74	Mg5(CO3)4(OH)2·4H2O
Hydroxylapatite	-8.26	-52.59	-44.33	Ca5(PO4)3OH
Hydroxylpyromorphite	-15.79	-78.58	-62.79	Pb5(PO4)3OH
K-Alum	-11.23	-16.68	-5.45	KAl(SO4)2·12H2O
K-Autunite	-19.36	-67.83	-48.47	K2(UO2)2(PO4)2
K-Jarosite	-13.47	-27.06	-13.59	KFe3(SO4)2(OH)6
K2Cr2O7	-96.97	-114.96	-17.99	K2Cr2O7
K2CrO4	-54.93	-55.61	-0.68	K2CrO4
K2MoO4	-20.24	-16.95	3.29	K2MoO4
K2SeO4	-58.65	-59.38	-0.73	K2SeO4
Kaolinite	0.97	9.78	8.81	Al2Si2O5(OH)4
Langite	-28.27	-9.25	19.03	Cu4(OH)6SO4·H2O
Larnakite	-5.9	-6.13	-0.23	PbO:PbSO4
Laurionite	-5.84	-5.22	0.62	PbOHCl
Lepidocrocite	-1.83	-0.46	1.37	FeOOH
Li2CrO4	-63.98	-58.7	5.28	Li2CrO4
Li2MoO4	-22.79	-20.03	2.76	Li2MoO4
Lime	-25.48	9.02	34.5	CaO
Litharge	-9.48	3.82	13.3	PbO
Mackinawite	-2.09	-5.69	-3.6	FeS
Maghemite	-7.31	-0.93	6.39	Fe2O3
Magnesioferrite	-11.75	7.7	19.45	Fe2MgO4
Magnesite	-2.8	-10.45	-7.65	MgCO3
Magnetite	2.36	7.7	5.34	Fe3O4
Malachite	-10.8	-16.81	-6.01	Cu2(OH)2CO3
Manganite	-13.96	11.38	25.34	MnOOH
Massicot	-9.7	3.82	13.51	PbO
Matlockite	-7.27	-16.55	-9.28	PbClF
Melanothallite	-23.79	-16.95	6.85	CuCl2
Melanterite	-2.75	-5.15	-2.4	FeSO4·7H2O
Metacinnabar	2.35	-45.1	-47.45	HgS
Mg(OH)2(active)	-10.17	8.63	18.79	Mg(OH)2
Mg(VO3)2	-43.26	-30.71	12.55	Mg(VO3)2
Mg2Sb3	-142.07	-67.38	74.68	Mg2Sb3
Mg2V2O7	-50.82	-22.09	28.73	Mg2V2O7

Solution composition				
Elements	Molality	Moles		
Mg3(PO4)2	-15.96	-39.24	-23.28	Mg3(PO4)2
MgCr2O4	-17.33	0.53	17.87	MgCr2O4
MgCrO4	-56.92	-50.72	6.21	MgCrO4
MgF2	-5.98	-14.03	-8.06	MgF2
MgHPO4:3H2O	-5.76	-23.93	-18.18	MgHPO4:3H2O
MgMoO4	-10.2	-12.05	-1.85	MgMoO4
MgSeO3:6H2O	-28.01	-25	3.01	MgSeO3:6H2O
MgSeO4:6H2O	-53.29	-54.49	-1.2	MgSeO4:6H2O
Minium	-57.29	20.15	77.44	Pb3O4
Mirabilite	-5.46	-7.32	-1.85	Na2SO4:10H2O
Mn(VO3)2	-38.06	-32.3	5.76	Mn(VO3)2
Mn2(SO4)3	-67.05	-71.24	-4.19	Mn2(SO4)3
Mn2Sb	-86.81	-25.73	61.08	Mn2Sb
Mn3(AsO4)2:8H2O	-26.63	-14.13	12.5	Mn3(AsO4)2:8H2O
Mn3(PO4)2	-20.11	-44.02	-23.91	Mn3(PO4)2
MnCl2:4H2O	-13.86	-11.04	2.82	MnCl2:4H2O
MnHPO4	-0.13	-25.53	-25.4	MnHPO4
MnS(grn)	-7.74	-7.27	0.47	MnS
MnS(pnk)	-10.61	-7.27	3.34	MnS
MnSb	-47.32	-50.43	-3.11	MnSb
MnSe	-12.21	-7.8	4.41	MnSe
MnSeO3	-27.72	-26.59	1.13	MnSeO3
MnSeO3:2H2O	-27.5	-26.59	0.9	MnSeO3:2H2O
MnSeO4:5H2O	-54.03	-56.08	-2.05	MnSeO4:5H2O
MnSO4	-9.92	-6.73	3.18	MnSO4
Monteponite	-15.17	0.9	16.06	CdO
Montroydite	-27.51	-30.79	-3.28	HgO
MoO3	-12.68	-20.68	-8	MoO3
Morenosite	-6.5	-8.76	-2.26	NiSO4:7H2O
MoS2	15.89	-57.98	-73.87	MoS2
Na-Autunite	-17.72	-65.11	-47.39	Na2(UO2)2(PO4)2
Na-Jarosite	-15.9	-25.69	-9.8	NaFe3(SO4)2(OH)6
Na2Cr2O7	-102.13	-112.23	-10.1	Na2Cr2O7
Na2CrO4	-56	-52.89	3.11	Na2CrO4
Na2Mo2O7	-17.78	-34.9	-17.12	Na2Mo2O7
Na2MoO4	-15.81	-14.22	1.58	Na2MoO4
Na2MoO4:2H2O	-15.45	-14.23	1.22	Na2MoO4:2H2O
Na2SeO3:5H2O	-37.47	-27.17	10.3	Na2SeO3:5H2O
Na2SeO4	-57.94	-56.66	1.28	Na2SeO4
Na3Sb	-124.23	-25.77	98.46	Na3Sb
Na3VO4	-48.38	-9.99	38.39	Na3VO4
Na4V2O7	-65.7	-26.43	39.27	Na4V2O7
Nantokite	-2.5	-9.63	-7.13	CuCl
NaSb	-47.57	-23.54	24.03	NaSb
Natron	-10.7	-12.62	-1.92	Na2CO3:10H2O
NaVO3	-20.58	-16.44	4.14	NaVO3

Solution composition				
Elements	Molality	Moles		
Nesquehonite	-6	-10.45	-4.45	MgCO3:3H2O
Ni(OH)2	-8.67	5.01	13.68	Ni(OH)2
Ni3(AsO4)2:8H2O	-35.89	-20.19	15.7	Ni3(AsO4)2:8H2O
Ni3(PO4)2	-18.78	-50.08	-31.3	Ni3(PO4)2
Ni4(OH)6SO4	-25.72	6.28	32	Ni4(OH)6SO4
NiCO3	-7.57	-14.06	-6.48	NiCO3
NiMoO4	-4.51	-15.67	-11.15	NiMoO4
Ningyoite	-3.64	-57.46	-53.82	CaU(PO4)2:2H2O
NiS(alpha)	-3.69	-9.29	-5.6	NiS
NiS(beta)	1.81	-9.29	-11.1	NiS
NiS(gamma)	3.51	-9.29	-12.8	NiS
NiSe	7.88	-9.82	-17.7	NiSe
NiSeO3:2H2O	-31.72	-28.61	3.1	NiSeO3:2H2O
NiSeO4:6H2O	-56.58	-58.1	-1.52	NiSeO4:6H2O
Nsutite	-28.13	-10.63	17.5	MnO2
O2(g)	-70.31	-73.08	-2.77	O2
Orpiment	8.92	-55.4	-64.32	As2S3
Otavite	-6.18	-18.17	-11.99	CdCO3
Pb(BO2)2	-11.52	-4.86	6.66	Pb(BO2)2
Pb(OH)2	-4.87	3.82	8.69	Pb(OH)2
Pb10(OH)6O(CO3)6	-67.48	-76.24	-8.76	Pb10(OH)6O(CO3)6
Pb2(OH)3Cl	-10.19	-1.4	8.79	Pb2(OH)3Cl
Pb2O(OH)2	-18.55	7.64	26.19	Pb2O(OH)2
Pb2O3	-44.71	16.33	61.04	Pb2O3
Pb2OCO3	-11.26	-11.43	-0.18	Pb2OCO3
Pb2V2O7	-30.05	-31.7	-1.65	Pb2V2O7
Pb3(AsO4)2	-29.57	-23.77	5.8	Pb3(AsO4)2
Pb3(PO4)2	-10.13	-53.66	-43.53	Pb3(PO4)2
Pb3(VO4)2	-34.7	-27.88	6.81	Pb3(VO4)2
Pb3O2CO3	-19.66	-7.62	12.05	Pb3O2CO3
Pb3O2SO4	-13.73	-2.31	11.42	Pb3O2SO4
Pb4(OH)6SO4	-19.59	1.51	21.1	Pb4(OH)6SO4
Pb4O3SO4	-21.64	1.51	23.14	Pb4O3SO4
PbBr2	-11.33	-16.96	-5.63	PbBr2
PbBrF	-9.41	-17.9	-8.49	PbBrF
PbCrO4	-42.52	-55.53	-13.01	PbCrO4
PbF2	-11.21	-18.84	-7.63	PbF2
PbHPO4	-4.94	-28.74	-23.81	PbHPO4
Pbmetal	-9.11	-4.87	4.24	Pb
PbMoO4	-0.74	-16.86	-16.12	PbMoO4
PbO:0.3H2O	-9.16	3.82	12.98	PbO:0.33H2O
PbSeO4	-52.31	-59.29	-6.98	PbSeO4
Periclase	-14.36	8.63	22.99	MgO
Phosgenite	-9.7	-29.51	-19.81	PbCl2:PbCO3
Plattnerite	-39.84	12.51	52.35	PbO2
Plumbgummite	-1.54	-34.33	-32.79	PbAl3(PO4)2(OH)5:H2O

Solution composition

Elements	Molality	Moles		
Portlandite	-14.98	9.02	24	Ca(OH)2
Przhevalskite	-23.81	-67.75	-43.94	Pb(UO2)2(PO4)2
Pyrite	7.67	-11.3	-18.97	FeS2
Pyrochroite	-9.06	7.03	16.09	Mn(OH)2
Pyrolusite	-28.18	15.72	43.9	MnO2
Pyromorphite	-3.19	-87.62	-84.43	Pb5(PO4)3Cl
Quartz	0.11	-4.1	-4.21	SiO2
Realgar	-3.96	-24.89	-20.93	AsS
Retgersite	-6.67	-8.76	-2.08	NiSO4·6H2O
Rhodochrosite	-1.48	-12.04	-10.56	MnCO3
Rutherfordine	-7.82	-22.29	-14.47	UO2CO3
Saleeite	-20.08	-62.94	-42.86	Mg(UO2)2(PO4)2
Sb(OH)3	-1.99	-9.38	-7.39	Sb(OH)3
Sb2O4	-14.11	-10.08	4.03	Sb2O4
Sb2O5	-40.34	-50.01	-9.67	Sb2O5
Sb2Se3	7.67	-63.27	-70.94	Sb2Se3
Sb4O6(cubic)	-18.7	-37.53	-18.83	Sb4O6
Sb4O6(orth)	-19.28	-37.53	-18.25	Sb4O6
SbBr3	-41.72	-40.55	1.16	SbBr3
SbCl3	-37.39	-36.5	0.9	SbCl3
SbF3	-33.21	-43.37	-10.16	SbF3
Sbmetal	-9.95	-22.42	-12.47	Sb
SbO2	-1.52	-29.35	-27.82	SbO2
Schoepite	-9.68	-3.22	6.46	UO2(OH)2·H2O
Semetal(am)	1.07	-6.14	-7.21	Se
Semetal(hex)	1.71	-6.14	-7.86	Se
Senarmontite	-6.12	-18.77	-12.65	Sb2O3
SeO2	-33.74	-33.62	0.11	SeO2
SeO3	-85.51	-63.11	22.4	SeO3
Sepiolite	-11.87	4.95	16.82	Mg2Si3O7·5OH·3H2O
Sepiolite(A)	-13.83	4.95	18.78	Mg2Si3O7·5OH·3H2O
Siderite	-0.36	-10.45	-10.09	FeCO3
SiO2(am-gel)	-1.26	-4.1	-2.84	SiO2
SiO2(am-ppt)	-1.22	-4.1	-2.88	SiO2
Smithsonite	-4.17	-14.02	-9.85	ZnCO3
Sn(OH)2	-5.1	-10.53	-5.43	Sn(OH)2
Sn(OH)4	1.24	-21.04	-22.28	Sn(OH)4
Sn(SO4)2	-33.36	-48.57	-15.21	Sn(SO4)2
SnBr2	-21.77	-31.31	-9.54	SnBr2
SnBr4	-33.75	-62.6	-28.85	SnBr4
SnCl2	-19.33	-28.6	-9.28	SnCl2
Snmetal(wht)	-16.89	-19.22	-2.33	Sn
SnO	-5.61	-10.53	-4.91	SnO
SnO2	7.94	-21.04	-28.97	SnO2
SnS	-5.72	-24.84	-19.11	SnS
SnS2	7.8	-49.65	-57.45	SnS2

Solution composition

Elements	Molality	Moles		
SnSe	5.13	-25.36	-30.49	SnSe
SnSe2	14.41	-50.71	-65.12	SnSe2
SnSO4	32.68	-24.3	-56.97	SnSO4
Sphalerite	2.47	-9.26	-11.73	ZnS
Spinel	-13.84	26.61	40.45	MgAl2O4
Sr-Autunite	-21.17	-65.12	-43.95	Sr(UO2)2(PO4)2
SrCrO4	-48.34	-52.9	-4.56	SrCrO4
SrF2	-7.59	-16.21	-8.62	SrF2
SrHPO4	-6.82	-26.11	-19.3	SrHPO4
SrSeO3	-29.48	-27.18	2.3	SrSeO3
SrSeO4	-52.26	-56.66	-4.4	SrSeO4
Stibnite	-8.5	-61.69	-53.19	Sb2S3
Strengite	-6.71	-33.02	-26.31	FePO4·2H2O
Strontianite	-3.35	-12.62	-9.27	SrCO3
Sulfur	-3.62	-5.62	-1.99	S
Tenorite	-7.12	1.13	8.25	CuO
Thenardite	-7.72	-7.31	0.41	Na2SO4
Thermonatrite	-13.35	-12.62	0.73	Na2CO3·H2O
Tl(OH)3	-35.11	-40.55	-5.44	Tl(OH)3
Tl2CO3	-22.29	-26.46	-4.17	Tl2CO3
Tl2CrO4	-54.03	-66.73	-12.7	Tl2CrO4
Tl2MoO4	-20.08	-28.07	-7.99	Tl2MoO4
Tl2O	-35.37	-7.39	27.99	Tl2O
Tl2S	-13.66	-21.69	-8.04	Tl2S
Tl2Se	-3.33	-22.22	-18.89	Tl2Se
Tl2SeO4	-66	-70.5	-4.5	Tl2SeO4
Tl2SO4	-17.06	-21.15	-4.09	Tl2SO4
TlBr	-8.14	-14.08	-5.94	TlBr
TlCl	-8.61	-12.73	-4.12	TlCl
Tlmetal	-13.66	-8.04	5.63	Tl
TlNO3	-12.33	-14.33	-2.01	TlNO3
TlOH	-17	-3.69	13.3	TlOH
Torbernite	-25.77	-70.43	-44.66	Cu(UO2)2(PO4)2
Tsumebite	-14	-23.79	-9.79	Pb2CuPO4(OH)3·3H2O
Tyuyamunite	-42.27	-36.77	5.5	Ca(UO2)2(VO4)2
U(HPO4)2·4H2O	-14.75	-66.48	-51.73	U(HPO4)2·4H2O
U3O8	-12.29	13.3	25.59	U3O8
U3Sb4	-307.42	-145.89	161.53	U3Sb4
U4O9	2.31	3.25	0.94	U4O9
UF4	-17.87	-46.68	-28.8	UF4
UF4·2.5H2O	-13.73	-46.68	-32.94	UF4·2.5H2O
UO2(am)	-3.31	-1.36	1.95	UO2
UO2(NO3)2	-37.42	-24.5	12.92	UO2(NO3)2
UO2(NO3)2·2H2O	-29.59	-24.5	5.09	UO2(NO3)2·2H2O
UO2(NO3)2·3H2O	-27.98	-24.5	3.48	UO2(NO3)2·3H2O
UO2(NO3)2·6H2O	-26.35	-24.5	1.85	UO2(NO3)2·6H2O

Solution composition				
Elements	Molality	Moles		
UO ₂ (OH) ₂ (beta)	-9.36	-3.22	6.14	UO ₂ (OH) ₂
UO ₂ HPO ₄	-11.56	-35.78	-24.23	UO ₂ HPO ₄
UO ₂ SeO ₄ :4H ₂ O	-64.08	-66.33	-2.25	UO ₂ SeO ₄ :4H ₂ O
UO ₃	-11.67	-3.22	8.45	UO ₃
Uramphite	-17.51	-69.63	-52.13	(NH ₄) ₂ (UO ₂) ₂ (PO ₄) ₂
Uraninite	2.59	-1.36	-3.95	UO ₂
Uranocircite	-22.88	-67.12	-44.24	Ba(UO ₂) ₂ (PO ₄) ₂
USb ₂	-104.67	-74.13	30.54	USb ₂
V(OH) ₃	-12.21	-4.62	7.59	V(OH) ₃
V ₂ O ₅	-37.66	-39.34	-1.68	V ₂ O ₅
V ₃ O ₅	-29.36	-26.61	2.75	V ₃ O ₅
V ₄ O ₇	-41.29	-32.58	8.71	V ₄ O ₇
V ₆ O ₁₃	-72.01	-135.39	-63.38	V ₆ O ₁₃
Valentinite	-10.11	-18.77	-8.66	Sb ₂ O ₃
VCl ₂	-47.23	-27.04	20.18	VCl ₂
VCl ₃	-56.83	-31.73	25.1	VCl ₃
VF ₄	-68.07	-51.29	16.78	VF ₄
Vivianite	-3.26	-39.26	-36	Fe ₃ (PO ₄) ₂ :8H ₂ O
Vmetal	-64.08	-17.66	46.43	V
VO	-24.77	-8.97	15.81	VO
VO(OH) ₂	-11.12	-5.97	5.15	VO(OH) ₂
VO ₂ Cl	-31.92	-28.71	3.22	VO ₂ Cl
VOCl	-25.78	-13.66	12.13	VOCl
VOCl ₂	-37.9	-24.05	13.85	VOCl ₂
VOSO ₄	-24.15	-19.74	4.41	VOSO ₄
Witherite	-6.02	-14.62	-8.61	BaCO ₃
Wurtzite	-0.11	-9.26	-9.15	ZnS
Zincite	-7.12	5.05	12.17	ZnO
Zincosite	-13.41	-8.72	4.7	ZnSO ₄
Zn(BO ₂) ₂	-11.92	-3.63	8.29	Zn(BO ₂) ₂
Zn(NO ₃) ₂ :6H ₂ O	-19.32	-16.23	3.09	Zn(NO ₃) ₂ :6H ₂ O
Zn(OH) ₂	-7.15	5.05	12.2	Zn(OH) ₂
Zn(OH) ₂ (am)	-8.17	5.05	13.22	Zn(OH) ₂
Zn(OH) ₂ (beta)	-7.48	5.05	12.53	Zn(OH) ₂
Zn(OH) ₂ (epsilon)	-7.24	5.05	12.29	Zn(OH) ₂
Zn(OH) ₂ (gamma)	-6.68	5.05	11.73	Zn(OH) ₂
Zn ₂ (OH) ₂ SO ₄	-11.17	-3.67	7.5	Zn ₂ (OH) ₂ SO ₄
Zn ₂ (OH) ₃ Cl	-14.13	1.06	15.19	Zn ₂ (OH) ₃ Cl
Zn ₃ (AsO ₄) ₂ :2.5H ₂ O	-33.72	-20.07	13.65	Zn ₃ (AsO ₄) ₂ :2.5H ₂ O
Zn ₃ (PO ₄) ₂ :4H ₂ O	-14.55	-49.97	-35.42	Zn ₃ (PO ₄) ₂ :4H ₂ O
Zn ₃ O(SO ₄) ₂	-33.69	-12.38	21.31	Zn ₃ O(SO ₄) ₂
Zn ₄ (OH) ₆ SO ₄	-21.96	6.44	28.4	Zn ₄ (OH) ₆ SO ₄
Zn ₅ (OH) ₈ Cl ₂	-31.32	7.18	38.5	Zn ₅ (OH) ₈ Cl ₂
ZnBr ₂ :2H ₂ O	-21.22	-15.73	5.49	ZnBr ₂ :2H ₂ O
ZnCl ₂	-20.75	-13.02	7.72	ZnCl ₂
ZnCO ₃ :1H ₂ O	-3.76	-14.02	-10.26	ZnCO ₃ :1H ₂ O

Solution composition

Elements	Molality	Moles		
ZnF2	-17.63	-17.61	0.02	ZnF2
Znmetal	-30.85	-3.64	27.21	Zn
ZnMoO4	-5.6	-15.63	-10.03	ZnMoO4
ZnO(active)	-6.96	5.05	12.01	ZnO
ZnS(am)	-0.06	-9.26	-9.19	ZnS
ZnSb	-37.58	-26.06	11.52	ZnSb
ZnSe	4.85	-9.78	-14.64	ZnSe
ZnSeO4:6H2O	-56.54	-58.06	-1.52	ZnSeO4:6H2O
ZnSO4:1H2O	-8.49	-8.72	-0.23	ZnSO4:1H2O

Appendix C: Groundwater Quality

Appendix C1: Groundwater Sampling

Appendix C2: Groundwater Quality Data Evaluation

Appendix C3: Groundwater Quality Data and Guidelines



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***Appendix C1:
Groundwater Sampling***

Appendix C1: Groundwater Sampling

Table C1-1 summarizes the sampling dates and collection methods for the 7 South groundwater monitoring locations. The routine groundwater monitoring samples were collected by Golder Associates of Victoria, BC (Golder) or by Quinsam personnel. Samples specific to the Lorax hydrogeological field investigation were collected by Lorax personnel.

**Table C1-1:
Timing and methods of groundwater sample collection in the 7 South area.**

Location ID	Type ¹	2009 March/April	2009 November	2010 April	2010 May	2010 July	2010 November/December	2011 January
Qu-01-07	B		H ³					
Qu-07-07	B		H ³			H ³	G ²	G ²
Qu-08-05	B	G ²	H ³					
Qu-08-05	W				H+P			H+P
Qu-08-07	B	G ²	H ³			G ²	G ²	G ²
Qu-08-08	B	G ²	H ³					
Qu-08-08A	W			H	H+P	G ²	G ²	G ²
Qu-08-08B	W			H	H+P			H
Qu-08-10	W				H+P			
Qu-08-13A	W			H	H+P		G	
Qu-08-13B	W			H	H+P			
Qu-09-01	B	G ²	H ³			G ²	G ²	G ²

Shading indicates a water quality sample was collected during that time period using the indicated method:

H=Hydrolift, H+P=Hydrolift in combination with peristaltic pump, G=Grundfos submersible pump.

Water quality samples were collected by Lorax unless otherwise indicated.

¹ B=borehole; W=well with screened PVC casing installed into borehole.

² Water quality samples collected by Golder.

³ Water quality samples collected by Quinsam.

³ Samples collected by Quinsam personnel.

As indicated in Table C1-1 several methods were employed to collect water quality samples from the groundwater monitoring wells. One method consisted of Waterra tubing terminating in a one-way foot valve and actuated by a Hydrolift. Alternately, the Waterra tubing and Hydrolift was used in combination with a peristaltic pump; this involved threading ¼ inch tubing coupled to the peristaltic pump into the larger diameter Waterra tubing. The peristaltic pump smooths the strongly pulsed flow of the Hydrolift, and aids with the pumping of wells at the limits of Hydrolift head pressure range. The third method involved the use of a Grundfos submersible pump attached to the submerged end of Waterra tubing.

All boreholes and wells were purged prior to sampling. In general a minimum of three well volumes was removed prior to sampling. During sampling the pump discharge line was coupled to a flow cell housing a multi-parameter probe (*e.g.*, YSI model 600XL or similar device). Field parameters (*i.e.*, pH, conductivity, temperature and oxidation reduction potential) were monitored at regular intervals until stabilized, at which point the flow cell was disconnected. Separate subsamples were then collected for general chemistry/anions, nutrients, sulphide, total metals, dissolved metals, total organic carbon (TOC), dissolved organic carbon (DOC) and iron species. A 0.45 micron filter was used to collect dissolved metals and DOC samples, except for the samples collected by Lorax in January 2011 when a 0.2 micron filter was used (to enhance the removal of colloidal particles by filtration). All subsamples (save general chemistry/anions) were preserved in the field and submitted to ALS Environmental in Burnaby, BC, for analysis.

Appendix C2:
Groundwater Quality Data Evaluation

Appendix C2: ***Groundwater Quality Data Evaluation***

An extensive quality assurance program was implemented for the groundwater quality monitoring program. Samples were collected, preserved, stored, transported and tested in accordance with the requirements in the British Columbia Lab Manual (BC, 2009). Laboratory quality control included the preparation and analysis of blanks, sample duplicates and reference samples. Field quality control included the monitoring of indicator parameters during sampling and the preparation of field blanks and field replicates. The quality assurance program indicates good overall sample data quality, although dissolved organic carbon, total nitrogen and total metals should be evaluated considering the observations outlined in the following paragraphs. Several samples have been flagged as outliers and are excluded from the 7 South water quality data set, specifically QU-08-05 (May 2010 sample) and QU-08-08B (all samples).

Laboratory quality control data indicate good precision, accuracy and contamination control in the laboratory test procedures. The field blank data (Table C2-1) indicates good contamination control with the exception of Field Blank 1 total nitrogen (0.385 mg/L) and dissolved organic carbon (4.19 mg/L). The field replicates indicate good precision and sample homogeneity with the exception of QU-08-08B with relative percent differences that range from 0% to 106%. The total suspended solids in QU-08-08B is elevated, ranging from 1620 mg/L to 1870 mg/L in the replicate samples, and is the likely cause of the poor precision observed in this field replicate. Samples from all other locations have significantly lower levels of suspended solids (ranging from 4.5 mg/L to 224 mg/L) therefore the QU-08-08B replicate pair is not considered to be representative of 7 South groundwater water quality.

The water quality consistency was evaluated for boreholes and wells with multiple samples by deriving the relative standard deviation (RSD) of water quality parameters at locations with three or more samples, or the relative percent difference (RPD) of water quality parameters at locations with only two samples (Table C2-2). Two or more samples were collected at boreholes QU-07-07, QU-08-05, QU-08-07, QU-08-08, QU-09-01, and wells QU-08-05, QU-08-08A, QU-08-08B, QU-08-13A, QU-08-13B. The most consistent groundwater water quality was observed at boreholes QU-07-07, QU-08-07 and QU-09-01 with most parameters at these locations below 50% RSD. The highest variability was observed locations where wells were installed with a significant number of parameters exceeding 50% RSD or 50% RPD at QU-08-05, QU-08-08A, QU-08-08B, and QU-08-13B. The variability observed in the well samples is attributed

to artefacts of well installation that may have influenced dissolved and total parameter concentrations, and is further discussed in the following paragraphs.

It should be noted that replicate samples with variations in total suspended solids tend to have a significant number of total metals and non-metal parameters that exceed 50% RSD or 50% RPD. Total suspended solids were observed to vary significantly at QU-08-08A (ranging from 5 mg/L to 111 mg/L), QU-08-08B (ranging from 1620 mg/L to 6470 mg/L), QU-08-13B (ranging from 18 mg/L to 104 mg/L), and QU-08-05 well (ranging from 10 mg/L to 54.5 mg/L). Total suspended solids data is not available for the borehole samples, therefore comparisons on this basis cannot be made between wells and boreholes.

Groundwater collected at QU-08-05 appears to be influenced by artefacts of the April 2010 well installation. This is a slowly recharging well; as a consequence it was only possible to purge the well by 1.4 well volumes prior to the May 2010 sample collection (Lorax, 2010). Figure C2-1 illustrates the elevated field conductivity and field pH values (860 $\mu\text{S}/\text{cm}$ and 10.68 respectively) of the collected sample. Other parameters that are significantly elevated relative to other QU-08-05 samples include chloride (24.7 mg/L), sulphate (255 mg/L), and sodium (107 mg/L). The elevated parameter concentrations relative to other QU-08-05 and 7 South water quality samples strongly suggest the May 2010 sample is well installation influenced. The QU-08-05 well sample collected in January 2011 is generally comparable to the QU-08-05 borehole samples. Water quality data for the QU-08-05 May 2010 sample is considered suspect and is excluded from the 7 South groundwater water quality characterization.

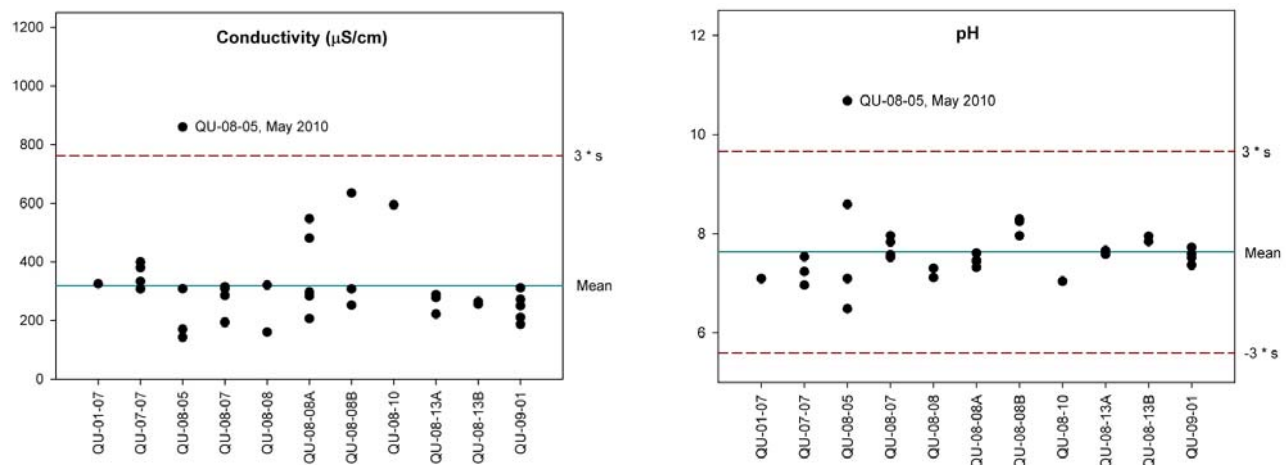


Figure C2-1: Field conductivity and pH readings of 7 South groundwater showing the conductivity and pH outliers of the May 2010 QU-08-05 sample. The data set mean is shown as a solid line and the dashed line equals three standard deviations from the mean.

Similarly QU-08-08A is a slowly recharging well, and the samples collected in April 2010 and May 2010 were elevated relative to other 7 South samples for field conductivity (546 $\mu\text{S}/\text{cm}$ and 480 $\mu\text{S}/\text{cm}$ respectively), total suspended solids (111 mg/L and 20.0 mg/L respectively), chloride (9.35 mg/L and 3.24 mg/L respectively), sulphate (136 mg/L and 99.5 mg/L respectively) and total sodium (39.1 mg/L and 285.5 mg/L respectively), note that a dissolved metal sample was not collected in April 2010 as a consequence of the slow recharge at this well (Lorax, 2010). It is possible the water quality of the April and May 2010 QU-08-08A sample was influenced by well installation artefacts; this should be considered when reviewing the water quality of this well.

Well QU-08-08B is significantly grout affected as demonstrated by the elevated total suspended solids in all samples (ranging from 1620 mg/L to 6470 mg/L), elevated total aluminum (ranging from 34.5 mg/L to 106 mg/L), elevated dissolved sodium (ranging from 40.1 mg/L to 142 mg/L) and field observations of the groundwater appearance (opaque milky-grey). Aluminum and sodium are principal components of bentonite minerals (WHO, 2005). The milky grey appearance, high levels of suspended solids and elevated total aluminum and dissolved sodium levels strongly suggest the water quality of this well is bentonite grout influenced. Water quality data for QU-08-08B is considered suspect and is excluded from the 7 South groundwater water quality characterization.

QU-08-10 was also noted to be a slowly recharging well; it was only possible to purge one well volume after well installation in April 2010 and prior to sampling in May 2010 (Lorax, 2010). Only one sample was collected at this well. Several parameters at this well were elevated relative to other 7 South water quality samples including field conductivity (590 $\mu\text{S}/\text{cm}$) as shown in Figure C2-1, total suspended solids (224 mg/L), chloride (5.28 mg/L), sulphate (112 mg/L) and dissolved sodium (40.2 mg/L). It is possible the water quality of the May 2010 QU-08-10 sample was influenced by well installation artefacts; this should be considered when reviewing the water quality of this well.

At QU-08-13B a significant number of total metal RPDs exceed 50% (ranging from 54% to 151%). The total suspended solids at this location range from 18 mg/L (April 2010) to 104 mg/L (May 2010). In general, the total metals are elevated in the May 2010 sample suggesting the total suspended solids are contributing to the elevated RPDs observed for the total metals. The dissolved metals and non-metal parameters are generally in good agreement for QU-08-13B.

Overall, the water quality data from the boreholes and wells are considered to be representative of the groundwater water quality in the 7 South area, with the exception of

the data for QU-08-05 (May, 2010) and QU-08-08B (all samples). There is insufficient data to determine if the observed variation in the repeat well samples is due to artefacts of well installation or natural variations in groundwater in the target zones at these locations.

Table C2-1: Groundwater Quality Data Evaluation
7 South Mine Groundwater Evaluation - Quinsam Mine

Field Quality Control

Sample ID		Field Blank 1	Field Blank 2	Field Replicate (QU-01-07)			Field Replicate (QU-08-07)			Field Replicate (QU-08-08)			Field Replicate (QU-08-08B)			Field Replicate (QU-08-13A)		
Date Sampled		29-OCT-10	19-JAN-11	24-Nov-09	24-Nov-09	RPD ¹	25-JAN-11	25-JAN-11	RPD ¹	31-Mar-09	31-Mar-09	RPD ¹	26-Apr-10	26-Apr-10	RPD ¹	27-May-10	27-May-10	RPD ¹
Field Physical Tests																		
Field Conductivity	uS/cm	-	-	-	324	-	194	-	-	320	320	0.0	251	240	4.5	288	288	0.0
Field Eh	mV	-	-	-	103.0	-	-80.4	-	-	130.0	130.0	0.0	70.5	59.7	16.6	-103.9	-102.1	1.7
Field pH	pH	-	-	-	7.09	-	7.96	-	-	7.3	7.3	0.0	8.25	8.32	0.8	7.58	7.57	0.1
Field Temperature	C	-	-	-	7.93	-	8.45	-	-	8.64	8.64	0.0	8.79	8.89	1.1	9.12	9.15	0.3
Field Dissolved Oxygen %	%	-	-	-	-	-	-	-	-	-	-	-	23.7	19.1	21.4	1.8	1.8	0.0
Physical Tests																		
Colour, True	CU	-	-	-	-	-	-	-	-	-	-	-	5	5	0.0	5	5	0.0
Conductivity	uS/cm	2	2	-	-	-	-	-	-	-	-	-	243	243	0.0	283	284	0.4
Hardness (as CaCO3)	mg/L	0.5	0.5	148	148	0.0	142	143	0.7	166	166	0.0	36.6	37.2	1.6	119	119	0.0
pH	pH	5.69	6.28	-	-	-	-	-	-	-	-	-	8.22	8.21	0.1	7.74	8.00	3.3
Total Suspended Solids	mg/L	-	3	-	-	-	-	-	-	-	-	-	1620	1870	14.3	4.5	4.0	11.8
Total Dissolved Solids	mg/L	-	10	-	-	-	-	-	-	-	-	-	220	222	0.9	164	164	0.0
Turbidity	NTU	-	0.1	-	-	-	-	-	-	-	-	-	936	946	1.1	7.97	7.26	9.3
Anions and Nutrients																		
Acidity (as CaCO3) (pH 8.3)	mg/L	-	3.0	3.8	3.9	2.6	-	-	-	-	-	-	-	-	-	-	-	-
Alkalinity, Total (as CaCO3)	mg/L	2	2	133	143	7.2	122	122	0.0	163	162	0.6	77.4	75.1	3.0	146	145	0.7
Ammonia as N	mg/L	0.005	0.005	-	-	-	-	-	-	-	-	-	0.045	0.035	25.0	0.120	0.126	4.9
Bromide (Br)	mg/L	0.05	0.05	0.05	0.05	0.0	0.05	0.05	0.0	0.05	0.05	0.0	0.05	0.05	0.0	0.05	0.05	0.0
Chloride (Cl)	mg/L	0.5	0.5	0.5	0.5	0.0	0.31	0.31	0.0	0.59	0.59	0.0	1.14	1.17	2.6	0.62	0.62	0.0
Fluoride (F)	mg/L	0.02	0.02	0.337	0.337	0.0	0.507	0.510	0.6	0.478	0.495	3.5	0.167	0.165	1.2	0.584	0.584	0.0
Nitrate (as N)	mg/L	0.005	0.005	-	-	-	0.0160	0.0162	1.2	0.005	0.005	0.0	0.0156	0.0111	33.7	0.005	0.005	0.0
Nitrite (as N)	mg/L	0.001	0.001	-	-	-	0.0012	0.0012	0.0	0.001	0.001	0.0	0.0012	0.0012	0.0	0.001	0.001	0.0
Total Nitrogen	mg/L	0.385	0.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ortho Phosphate as P	mg/L	0.001	-	-	-	-	-	-	-	-	-	-	0.0055	0.0017	105.6	0.0272	0.0279	2.5
Total Dissolved Phosphate As P	mg/L	-	0.002	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Phosphate as P	mg/L	0.002	0.002	-	-	-	-	-	-	-	-	-	0.119	0.242	68.1	0.0361	0.0386	6.7
Sulfate (SO4)	mg/L	0.5	0.5	9.39	9.37	0.2	31.9	31.9	0.0	12.4	12.3	0.8	47.0	47.4	0.8	10.8	10.9	0.9
Sulphide as S	mg/L	0.02	0.002	-	-	-	-	-	-	-	-	-	0.02	0.02	0.0	0.036	0.038	5.4
Organic / Inorganic Carbon																		
Dissolved Organic Carbon	mg/L	4.19	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Organic Carbon	mg/L	0.5	0.5	-	-	-	-	-	-	-	-	-	2.68	2.75	2.6	0.81	0.89	9.4
Total Metals																		
Aluminum (Al)-Total	mg/L	0.003	0.003	-	-	-	-	-	-	-	-	-	34.5	36.7	6.2	0.0839	0.0924	9.6
Antimony (Sb)-Total	mg/L	0.0001	0.0001	-	-	-	-	-	-	-	-	-	0.00079	0.00069	13.5	0.0001	0.0001	0.0
Arsenic (As)-Total	mg/L	0.0001	0.0001	-	-	-	-	-	-	-	-	-	0.00985	0.00982	0.3	0.433	0.434	0.2
Barium (Ba)-Total	mg/L	0.00005	0.00005	-	-	-	-	-	-	-	-	-	0.0978	0.0944	3.5	0.112	0.113	0.9
Beryllium (Be)-Total	mg/L	0.0005	0.0005	-	-	-	-	-	-	-	-	-	0.0054	0.0046	16.0	0.0005	0.0005	0.0
Bismuth (Bi)-Total	mg/L	0.0005	0.0005	-	-	-	-	-	-	-	-	-	0.0025	0.0025	0.0	0.0005	0.0005	0.0
Boron (B)-Total	mg/L	0.01	0.01	-	-	-	-	-	-	-	-	-	0.109	0.107	1.9	0.340	0.357	4.9
Cadmium (Cd)-Total	mg/L	0.000017	0.00001	-	-	-	-	-	-	-	-	-	0.000091	0.000189	70.0	0.000017	0.000017	0.0
Calcium (Ca)-Total	mg/L	0.05	0.02	-	-	-	-	-	-	-	-	-	48.0	48.8	1.7	33.5	33.6	0.3
Chromium (Cr)-Total	mg/L	0.0005	0.0001	-	-	-	-	-	-	-	-	-	0.0045	0.0051	12.5	0.0005	0.0005	0.0
Cobalt (Co)-Total	mg/L	0.0001	0.0001	-	-	-	-	-	-	-	-	-	0.00407	0.00426	4.6	0.00036	0.00038	5.4
Copper (Cu)-Total	mg/L	0.0005	0.0005	-	-	-	-	-	-	-	-	-	0.0124	0.0123	0.8	0.00037	0.00081	74.6
Iron (Fe)-Total	mg/L	0.03	0.01	-	-	-	-	-	-	-	-	-	8.97	9.82	9.0	0.266	0.275	3.3
Lead (Pb)-Total	mg/L	0.00005	0.00005	-	-	-	-	-	-	-	-	-	0.0268	0.0276	2.9	0.000087	0.000078	10.9
Lithium (Li)-Total	mg/L	0.005	0.005	-	-	-	-	-	-	-	-	-	0.025	0.025	0.0	0.0368	0.0390	5.8
Magnesium (Mg)-Total	mg/L	0.1	0.005	-	-	-	-	-	-	-	-	-	9.89	10.5	6.0	7.65	7.70	0.7
Manganese (Mn)-Total	mg/L	0.00005	0.00005	-	-	-	-	-	-	-	-	-	0.184	0.183	0.5	0.129	0.130	0.8
Mercury (Hg)-Total	mg/L	-	0.00001	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Molybdenum (Mo)-Total	mg/L	0.00005	0.00005	-	-	-	-	-	-	-	-	-	0.00077	0.00063	20.0	0.00130	0.00134	3.0
Nickel (Ni)-Total	mg/L	0.0005	0.0005	-	-	-	-	-	-	-	-	-	0.0058	0.0060	3.4	0.00071	0.00072	1.4

Table C2-1: Groundwater Quality Data Evaluation
7 South Mine Groundwater Evaluation - Quinsam Mine

Field Quality Control

Sample ID		Field Blank 1	Field Blank 2	Field Replicate (QU-01-07)			Field Replicate (QU-08-07)			Field Replicate (QU-08-08)			Field Replicate (QU-08-08B)			Field Replicate (QU-08-13A)		
Date Sampled		29-OCT-10	19-JAN-11	24-Nov-09	24-Nov-09	RPD ¹	25-JAN-11	25-JAN-11	RPD ¹	31-Mar-09	31-Mar-09	RPD ¹	26-Apr-10	26-Apr-10	RPD ¹	27-May-10	27-May-10	RPD ¹
Phosphorus (P)-Total	mg/L	0.3	0.3	-	-	-	-	-	-	-	-	-	0.3	0.3	0.0	0.3	0.3	0.0
Potassium (K)-Total	mg/L	2	0.05	-	-	-	-	-	-	-	-	-	3.6	3.9	8.0	2.2	2.2	0.0
Selenium (Se)-Total	mg/L	0.0004	0.0001	-	-	-	-	-	-	-	-	-	0.0005	0.0005	0.0	0.0005	0.0005	0.0
Silicon (Si)-Total	mg/L	0.05	0.05	-	-	-	-	-	-	-	-	-	75.6	81.7	7.8	3.83	3.82	0.3
Silver (Ag)-Total	mg/L	0.00001	0.00001	-	-	-	-	-	-	-	-	-	0.00005	0.00005	0.0	0.00001	0.000079	155.1
Sodium (Na)-Total	mg/L	2	0.05	-	-	-	-	-	-	-	-	-	38.7	40.3	4.1	20.9	21.0	0.5
Strontium (Sr)-Total	mg/L	0.0001	0.0001	-	-	-	-	-	-	-	-	-	0.348	0.343	1.4	0.401	0.407	1.5
Thallium (Tl)-Total	mg/L	0.0001	0.0001	-	-	-	-	-	-	-	-	-	0.0005	0.0005	0.0	0.0001	0.0001	0.0
Tin (Sn)-Total	mg/L	0.0001	0.0001	-	-	-	-	-	-	-	-	-	0.0005	0.0005	0.0	0.0001	0.00011	9.5
Titanium (Ti)-Total	mg/L	0.01	0.01	-	-	-	-	-	-	-	-	-	0.070	0.051	31.4	0.01	0.01	0.0
Uranium (U)-Total	mg/L	0.00001	0.00001	-	-	-	-	-	-	-	-	-	0.0105	0.0105	0.0	0.000341	0.000319	6.7
Vanadium (V)-Total	mg/L	0.001	0.001	-	-	-	-	-	-	-	-	-	0.0190	0.0200	5.1	0.001	0.001	0.0
Zinc (Zn)-Total	mg/L	0.003	0.003	-	-	-	-	-	-	-	-	-	0.0462	0.0518	11.4	0.0024	0.0026	8.0
Dissolved Metals																		
Aluminum (Al)-Dissolved	mg/L	0.003	0.003	0.01	0.01	0.0	0.005	0.005	0.0	0.005	0.005	0.0	0.005	0.005	0.0	0.0038	0.0037	2.7
Antimony (Sb)-Dissolved	mg/L	0.0001	0.0001	0.00086	0.00082	4.8	0.0005	0.0005	0.0	0.0005	0.0005	0.0	0.00176	0.00179	1.7	0.0001	0.0001	0.0
Arsenic (As)-Dissolved	mg/L	0.0001	0.0001	0.127	0.128	0.8	0.311	0.306	1.6	0.400	0.402	0.5	0.00596	0.00588	1.4	0.468	0.468	0.0
Barium (Ba)-Dissolved	mg/L	0.00005	0.00005	0.192	0.189	1.6	0.139	0.141	1.4	0.133	0.131	1.5	0.00675	0.00698	3.4	0.103	0.105	1.9
Beryllium (Be)-Dissolved	mg/L	0.0005	0.0005	0.005	0.005	0.0	0.001	0.001	0.0	0.001	0.001	0.0	0.0025	0.0025	0.0	0.0005	0.0005	0.0
Bismuth (Bi)-Dissolved	mg/L	0.0005	0.0005	0.2	0.2	0.0	0.2	0.2	0.0	0.2	0.2	0.0	0.0025	0.0025	0.0	0.0005	0.0005	0.0
Boron (B)-Dissolved	mg/L	0.01	0.01	0.29	0.29	0.0	0.50	0.49	2.0	0.41	0.40	2.5	0.082	0.080	2.5	0.310	0.323	4.1
Cadmium (Cd)-Dissolved	mg/L	0.000017	0.00001	0.00005	0.00005	0.0	0.000017	0.000017	0.0	0.000017	0.000017	0.0	0.000085	0.000085	0.0	0.000017	0.000017	0.0
Calcium (Ca)-Dissolved	mg/L	0.05	0.02	46.3	46.2	0.2	41.1	41.2	0.2	49.6	49.8	0.4	12.1	12.3	1.6	35.0	34.8	0.6
Chromium (Cr)-Dissolved	mg/L	0.0005	0.0001	0.0005	0.0005	0.0	0.001	0.001	0.0	0.002	0.0017	16.2	0.0025	0.0025	0.0	0.0005	0.0005	0.0
Cobalt (Co)-Dissolved	mg/L	0.0001	0.0001	0.0005	0.0005	0.0	0.00063	0.00062	1.6	0.00115	0.00112	2.6	0.0005	0.0005	0.0	0.00031	0.00030	3.3
Copper (Cu)-Dissolved	mg/L	0.0005	0.0005	0.001	0.001	0.0	0.001	0.001	0.0	0.001	0.001	0.0	0.00100	0.00099	1.0	0.0001	0.00012	18.2
Iron (Fe)-Dissolved	mg/L	0.03	0.01	0.081	0.083	2.4	0.111	0.113	1.8	0.084	0.071	16.8	0.03	0.03	0.0	0.117	0.136	15.0
Lead (Pb)-Dissolved	mg/L	0.00005	0.00005	0.001	0.001	0.0	0.0005	0.0005	0.0	0.0005	0.0005	0.0	0.00025	0.00025	0.0	0.00005	0.00005	0.0
Lithium (Li)-Dissolved	mg/L	0.005	0.005	0.05	0.05	0.0	0.0444	0.0455	2.4	0.0408	0.0403	1.2	0.025	0.025	0.0	0.0336	0.0365	8.3
Magnesium (Mg)-Dissolved	mg/L	0.1	0.005	7.97	7.91	0.8	9.55	9.66	1.1	10.2	10.1	1.0	1.55	1.56	0.6	7.79	7.79	0.0
Manganese (Mn)-Dissolved	mg/L	0.00005	0.00005	0.041	0.042	2.4	0.0419	0.0415	1.0	0.0446	0.0445	0.2	0.00648	0.00618	4.7	0.129	0.127	1.6
Mercury (Hg)-Dissolved	mg/L	-	0.00001	0.0002	0.0002	0.0	0.00001	0.00001	0.0	0.00002	0.00002	0.0	-	-	-	-	-	-
Molybdenum (Mo)-Dissolved	mg/L	0.00005	0.00005	0.0016	0.0015	6.5	0.001	0.001	0.0	0.0012	0.0013	8.0	0.00087	0.00094	7.7	0.00127	0.00125	1.6
Nickel (Ni)-Dissolved	mg/L	0.0005	0.0005	0.005	0.005	0.0	0.0012	0.0012	0.0	0.0029	0.0029	0.0	0.0025	0.0025	0.0	0.00056	0.00055	1.8
Phosphorus (P)-Dissolved	mg/L	0.3	0.3	0.3	0.3	0.0	0.03	0.03	0.0	0.3	0.3	0.0	0.3	0.3	0.0	0.3	0.3	0.0
Potassium (K)-Dissolved	mg/L	2	0.05	2	2	0.0	2.3	2.3	0.0	2.0	2	0.0	2	2	0.0	2.3	2.3	0.0
Selenium (Se)-Dissolved	mg/L	0.0004	0.0001	0.001	0.001	0.0	0.001	0.001	0.0	0.001	0.001	0.0	0.0005	0.0005	0.0	0.0005	0.0005	0.0
Silicon (Si)-Dissolved	mg/L	0.05	0.05	4.24	4.23	0.2	3.49	3.51	0.6	3.66	3.64	0.5	5.35	5.40	0.9	3.79	3.78	0.3
Silver (Ag)-Dissolved	mg/L	0.00001	0.00001	0.00005	0.00005	0.0	0.00002	0.00002	0.0	0.00002	0.00002	0.0	0.00005	0.00005	0.0	0.00001	0.00001	0.0
Sodium (Na)-Dissolved	mg/L	2	0.05	8.5	8.4	1.2	7.3	7.4	1.4	7.1	7.0	1.4	40.1	40.4	0.7	20.7	21.7	4.7
Strontium (Sr)-Dissolved	mg/L	0.0001	0.0001	0.270	0.267	1.1	0.686	0.693	1.0	0.587	0.585	0.3	0.114	0.115	0.9	0.378	0.381	0.8
Thallium (Tl)-Dissolved	mg/L	0.0001	0.0001	0.0002	0.0002	0.0	0.0002	0.0002	0.0	0.0002	0.0002	0.0	0.0005	0.0005	0.0	0.0001	0.0001	0.0
Tin (Sn)-Dissolved	mg/L	0.0001	0.0001	0.03	0.03	0.0	0.0005	0.0005	0.0	0.0005	0.0005	0.0	0.0005	0.0005	0.0	0.0001	0.0001	0.0
Titanium (Ti)-Dissolved	mg/L	0.01	0.01	0.05	0.05	0.0	0.01	0.01	0.0	0.01	0.01	0.0	0.01	0.01	0.0	0.01	0.01	0.0
Uranium (U)-Dissolved	mg/L	0.00001	0.00001	0.0002	0.0002	0.0	0.0002	0.0002	0.0	0.0002	0.0002	0.0	0.00231	0.00244	5.5	0.000312	0.000311	0.3
Vanadium (V)-Dissolved	mg/L	0.001	0.001	0.03	0.03	0.0	0.001	0.001	0.0	0.001	0.001	0.0	0.005	0.005	0.0	0.001	0.001	0.0
Zinc (Zn)-Dissolved	mg/L	0.003	0.003	0.0062	0.0066	6.3	0.005	0.005	0.0	0.005	0.005	0.0	0.005	0.005	0.0	0.001	0.001	0.0

Results in *blue italics* are below the detection limit indicated.

¹RPD = Relative Percent Difference = 100 * | (result 1 - result 2) / average (result 1, result 2) |

Table C2-2: Groundwater Quality Data Evaluation
7 South Mine Goundwater Evaluation - Quinsam Mine

Well Evaluation

Sample ID		QU-07-07										QU-08-05				QU-08-05				QU-08-07						
Type		borehole										borehole				well				borehole						
Date Sampled	Units	19-Nov-09	21-Jul-10	03-Nov-10	27-Jan-11	n	Max	Min	Mean	s	RSD ¹	30-Mar-09	19-Nov-09	Mean	RPD ²	25-May-10	24-Jan-11	Mean	RPD ²	30-Mar-09	18-Nov-09	14-Jul-10	02-Nov-10	25-Jan-11	n	Max
Field Physical Tests																										
Field Conductivity	uS/cm	379	399	307	333	4	399	307	354.5	42.0	11.9	142	169	155.5	17.4	860	308	584.0	94.5	309	285	192	315	194	5	315
Field Eh	mV	-66.0	-67.9	-31.6	-33.1	4	-31.6	-67.9	-49.65	-	-	212.4	96.0	154.20	-	-61.0	-60.5	-60.8	-	-70.0	-105	-37.9	-58.0	-80.4	5	-38
Field pH	pH	7.53	-	7.23	6.96	3	7.53	6.96	7.24	0.3	3.9	6.48	7.09	6.785	9.0	10.68	8.59	9.635	21.7	7.55	7.57	7.83	7.52	7.96	5	8
Field Temperature	C	7.42	8.92	8.15	7.93	4	8.92	7.42	8.105	0.6	7.7	8.33	7.46	7.895	11.0	10.270	7.09	8.680	36.6	9.05	8.44	9.24	9.11	8.45	5	9
Physical Tests																										
Conductivity	uS/cm	-	-	-	-	0	-	-	-	-	-	-	-	-	-	794	326	560.0	83.6	-	-	-	-	-	0	-
Hardness (as CaCO3)	mg/L	195	302	227	287	4	302	195	252.8	50.3	19.9	69.6	119	94.3	52.4	187	122	154.5	42.1	150	178	140	217	142	5	217
pH	pH	-	8.10	-	-	1	-	-	-	-	-	-	-	-	-	9.67	9.27	9.470	4.2	-	-	-	-	-	0	-
Total Suspended Solids	mg/L	-	-	-	-	0	-	-	-	-	-	-	-	-	-	10.0	54.5	32.25	138.0	-	-	-	-	-	0	-
Total Dissolved Solids	mg/L	-	-	-	-	0	-	-	-	-	-	-	-	-	-	572	223	397.5	87.8	-	-	-	-	-	0	-
Turbidity	NTU	-	-	-	-	0	-	-	-	-	-	-	-	-	-	13.3	62.3	37.80	129.6	-	-	-	-	-	0	-
Anions and Nutrients																										
Acidity (as CaCO3) (pH 8.3)	mg/L	4.0	2.2	-	-	2	-	-	-	-	-	-	5.8	-	-	-	1	-	-	-	3.7	-	-	-	1	-
Alkalinity, Total (as CaCO3)	mg/L	145	134	133	135	4	145	133	136.8	5.6	4.1	73.3	128	100.7	54.3	120	135	127.5	11.8	163	172	138	127	122	5	172
Ammonia as N	mg/L	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0.062	0.0257	0.04385	82.8	-	-	-	-	-	0	-
Bromide (Br)	mg/L	0.05	0.05	0.05	0.05	4	-	-	-	-	-	0.05	0.05	-	-	0.5	0.05	-	-	0.05	0.05	0.05	0.05	0.05	5	-
Chloride (Cl)	mg/L	0.5	0.51	0.50	0.53	4	0.53	0.5	0.510	0.014	2.8	0.79	0.5	0.65	45.0	24.7	7.58	16.14	106.1	0.87	0.5	0.36	0.46	0.31	5	1
Fluoride (F)	mg/L	0.062	0.054	0.066	0.053	4	0.066	0.053	0.0588	0.0063	10.7	0.068	0.098	0.0830	36.1	0.41	0.247	0.3285	49.6	0.563	0.466	0.493	0.468	0.507	5	1
Nitrate (as N)	mg/L	-	0.005	0.005	0.005	3	-	-	-	-	-	0.005	-	-	-	0.05	0.005	-	-	0.0467	-	0.0155	0.0181	0.0160	4	0
Nitrite (as N)	mg/L	-	0.001	0.001	0.001	3	-	-	-	-	-	0.001	-	-	-	0.01	0.001	-	-	0.001	-	0.0112	0.001	0.0012	4	0
Total Nitrogen	mg/L	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	0.180	-	-	-	-	-	-	-	0	-
Ortho Phosphate as P	mg/L	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0.0323	-	-	-	-	-	-	-	-	0	-
Total Phosphate as P	mg/L	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0.093	0.358	0.2255	117.5	-	-	-	-	-	0	-
Sulfate (SO4)	mg/L	79.1	162	104	162	4	162	79.1	126.8	41.9	33.1	3.33	7.03	5.180	71.4	255	31.4	143.20	156.1	6.39	38.2	15.8	95.8	31.9	5	96
Sulphide as S	mg/L	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0.02	0.0028	0.01140	150.9	-	-	-	-	-	0	-
Organic / Inorganic Carbon																										
Total Organic Carbon	mg/L	-	-	-	-	0	-	-	-	-	-	-	-	-	-	1.89	14.8	8.345	154.7	-	-	-	-	-	0	-
Total Metals																										
Aluminum (Al)-Total	mg/L	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0.499	1.41	0.9545	95.4	-	-	-	-	-	0	-
Antimony (Sb)-Total	mg/L	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0.00121	0.00120	0.001205	0.8	-	-	-	-	-	0	-
Arsenic (As)-Total	mg/L	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0.0350	0.0277	0.03135	23.3	-	-	-	-	-	0	-
Barium (Ba)-Total	mg/L	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0.0236	0.0400	0.03180	51.6	-	-	-	-	-	0	-
Beryllium (Be)-Total	mg/L	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0.001	0.0005	-	-	-	-	-	-	-	0	-
Bismuth (Bi)-Total	mg/L	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0.001	0.0005	-	-	-	-	-	-	-	0	-
Boron (B)-Total	mg/L	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0.047	0.045	0.0460	4.3	-	-	-	-	-	0	-
Cadmium (Cd)-Total	mg/L	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0.000034	0.000153	0.0000935	127.3	-	-	-	-	-	0	-
Calcium (Ca)-Total	mg/L	-	-	-	-	0	-	-	-	-	-	-	-	-	-	73.5	46.2	59.85	45.6	-	-	-	-	-	0	-
Chromium (Cr)-Total	mg/L	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0.0473	0.00257	0.02494	179.4	-	-	-	-	-	0	-
Cobalt (Co)-Total	mg/L	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0.00070	0.00208	0.001390	99.3	-	-	-	-	-	0	-
Copper (Cu)-Total	mg/L	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0.00924	0.00970	0.009470	4.9	-	-	-	-	-	0	-
Iron (Fe)-Total	mg/L	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0.412	2.87	1.641	149.8	-	-	-	-	-	0	-
Lead (Pb)-Total	mg/L	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0.00027	0.00186	0.001065	149.3	-	-	-	-	-	0	-
Lithium (Li)-Total	mg/L	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0.01	0.0056	0.00780	56.4	-	-	-	-	-	0	-
Magnesium (Mg)-Total	mg/L	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0.34	2.31	1.325	148.7	-	-	-	-	-	0	-
Manganese (Mn)-Total	mg/L	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0.0182	0.121	0.0696	147.7	-	-	-	-	-	0	-
Mercury (Hg)-Total	mg/L	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	0.000018	-	-	-	-	-	-	-	0	-
Molybdenum (Mo)-Total	mg/L	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0.0213	0.00456	0.012930	129.5	-	-	-	-	-	0	-
Nickel (Ni)-Total	mg/L	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0.0038	0.00607	0.00494	46.0	-	-	-	-	-	0	-
Phosphorus (P)-Total	mg/L	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0.3	0.34	0.320	12.5	-	-	-	-	-	0	-
Potassium (K)-Total	mg/L	-	-	-	-	0	-	-	-	-	-	-	-	-	-	8.0	3.2	5.60	85.7	-	-	-	-	-	0	-
Selenium (Se)-Total	mg/L	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0.00412	0.00055	0.002335	152.9	-	-	-	-	-	0	-
Silicon (Si)-Total	mg/L	-	-	-	-	0	-	-	-	-	-	-	-	-	-	5.99	5.69	5.840	5.1	-	-	-	-	-	0	-
Silver (Ag)-Total	mg/L	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0.00002	0.000058	0.0000390	97.4	-	-	-	-	-	0	-
Sodium (Na)-Total	mg/L	-	-	-	-	0	-	-	-	-	-	-	-	-	-	107	28.8	67.90	115.2	-	-	-	-	-	0	-
Strontium (Sr)-Total	mg/L	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0.250	0.147	0.1985	51.9	-	-	-	-	-	0	-
Thallium (Tl)-Total	mg/L	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0.0002	0.00013	0.000165	42.4	-	-	-	-	-	0	-
Tin (Sn)-Total	mg/L	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0.00040	0.00058	0.000490	36.7	-	-	-	-	-	0	-

Table C2-2: Groundwater Quality Data Evaluation
7 South Mine Goundwater Evaluation - Quinsam Mine

Well Evaluation

Sample ID		QU-07-07										QU-08-05				QU-08-05				QU-08-07						
Type		borehole										borehole				well				borehole						
Date Sampled	Units	19-Nov-09	21-Jul-10	03-Nov-10	27-Jan-11	n	Max	Min	Mean	s	RSD ¹	30-Mar-09	19-Nov-09	Mean	RPD ²	25-May-10	24-Jan-11	Mean	RPD ²	30-Mar-09	18-Nov-09	14-Jul-10	02-Nov-10	25-Jan-11	n	Max
Titanium (Ti)-Total	mg/L	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0.020	0.060	0.0400	100.0	-	-	-	-	-	0	-
Uranium (U)-Total	mg/L	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0.00124	0.00911	0.005175	152.1	-	-	-	-	-	0	-
Vanadium (V)-Total	mg/L	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0.0223	0.0063	0.01430	111.9	-	-	-	-	-	0	-
Zinc (Zn)-Total	mg/L	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0.0058	0.0177	0.01175	101.3	-	-	-	-	-	0	-
Dissolved Metals																										
Aluminum (Al)-Dissolved	mg/L	0.01	0.005	0.005	0.005	4	-	-	-	-	-	0.005	0.01	-	-	0.322	0.0492	0.18560	147.0	0.005	0.01	0.005	0.005	0.005	5	-
Antimony (Sb)-Dissolved	mg/L	0.0005	0.0005	0.0005	0.0005	4	-	-	-	-	-	0.0005	0.0005	-	-	0.00114	0.00069	0.000915	49.2	0.0005	0.0005	0.0005	0.0005	0.0005	5	-
Arsenic (As)-Dissolved	mg/L	0.0205	0.0187	0.0195	0.0210	4	0.021	0.019	0.01993	0.00103	5.2	0.00396	0.0092	0.00658	79.6	0.0342	0.0285	0.03135	18.2	0.369	0.366	0.361	0.387	0.311	5	0
Barium (Ba)-Dissolved	mg/L	0.078	0.100	0.078	0.095	4	0.1	0.078	0.0878	0.0114	13.0	0.241	0.259	0.2500	7.2	0.0195	0.0187	0.01910	4.2	0.210	0.245	0.195	0.157	0.139	5	0
Beryllium (Be)-Dissolved	mg/L	0.005	0.001	0.001	0.001	4	-	-	-	-	-	0.001	0.005	-	-	0.001	0.0005	-	-	0.001	0.005	0.001	0.001	0.001	5	-
Bismuth (Bi)-Dissolved	mg/L	0.2	-	0.2	0.2	3	-	-	-	-	-	0.2	0.2	-	-	0.001	0.0005	-	-	0.2	0.2	0.2	0.2	0.2	5	-
Boron (B)-Dissolved	mg/L	0.1	0.1	0.1	0.1	4	-	-	-	-	-	0.1	0.14	0.120	33.3	0.041	0.043	0.0420	4.8	0.64	0.60	0.57	0.58	0.50	5	1
Cadmium (Cd)-Dissolved	mg/L	0.00005	0.000017	0.000017	0.000017	4	-	-	-	-	-	0.000017	0.00005	-	-	0.000034	0.00001	0.000022	109.1	0.000017	0.00005	0.000017	0.000017	0.000017	5	-
Calcium (Ca)-Dissolved	mg/L	54.5	82.9	62.4	78.6	4	82.9	54.5	69.60	13.39	19.2	22.8	40.4	31.60	55.7	74.6	45.2	59.90	49.1	43.0	51.3	39.4	63.0	41.1	5	63
Chromium (Cr)-Dissolved	mg/L	0.0005	0.001	0.001	0.001	4	-	-	-	-	-	0.001	0.0005	-	-	0.0455	0.00018	0.02284	198.4	0.001	0.0005	0.001	0.001	0.001	5	-
Cobalt (Co)-Dissolved	mg/L	0.0005	0.0003	0.0003	0.0003	4	-	-	-	-	-	0.0003	0.0005	-	-	0.00034	0.00022	0.000280	42.9	0.0007	0.00078	0.00089	0.00058	0.00063	5	0
Copper (Cu)-Dissolved	mg/L	0.001	0.001	0.001	0.001	4	-	-	-	-	-	0.001	0.001	-	-	0.00729	0.0005	0.00390	174.3	0.001	0.001	0.001	0.001	0.001	5	-
Iron (Fe)-Dissolved	mg/L	0.144	0.250	0.236	0.200	4	0.25	0.144	0.2075	0.0473	22.8	0.03	0.03	-	-	0.03	0.03	-	-	0.108	0.109	0.139	0.245	0.111	5	0
Lead (Pb)-Dissolved	mg/L	0.001	0.0005	0.0005	0.0005	4	-	-	-	-	-	0.0005	0.001	-	-	0.0001	0.00005	-	-	0.0005	0.001	0.0005	0.0005	0.0005	5	-
Lithium (Li)-Dissolved	mg/L	0.05	0.005	0.0062	0.005	4	0.05	0.005	0.0166	0.0223	134.8	0.0258	0.05	0.0379	63.9	0.01	0.0055	0.00775	58.1	0.0551	0.064	0.0526	0.0509	0.0444	5	0
Magnesium (Mg)-Dissolved	mg/L	14.4	23.0	17.4	22.0	4	23	14.4	19.20	4.02	21.0	3.07	4.38	3.725	35.2	0.28	2.19	1.235	154.7	10.4	12.1	10.0	14.6	9.55	5	15
Manganese (Mn)-Dissolved	mg/L	0.086	0.134	0.110	0.112	4	0.134	0.086	0.1105	0.0196	17.8	0.00483	0.01	0.00742	69.7	0.00088	0.0326	0.01674	189.5	0.0237	0.027	0.0306	0.0533	0.0419	5	0
Mercury (Hg)-Dissolved	mg/L	0.0002	0.00001	0.00001	0.00001	4	-	-	-	-	-	0.00002	0.0002	-	-	-	0.00001	-	-	0.00002	0.0002	0.00001	0.00001	0.00001	5	-
Molybdenum (Mo)-Dissolved	mg/L	0.001	0.001	0.001	0.001	4	-	-	-	-	-	0.001	0.001	-	-	0.0214	0.00440	0.012900	131.8	0.001	0.001	0.001	0.001	0.001	5	-
Nickel (Ni)-Dissolved	mg/L	0.005	0.001	0.0011	0.001	4	0.005	0.001	0.00203	0.00198	98.0	0.0025	0.005	0.003750	66.7	0.0032	0.00281	0.003005	13.0	0.001	0.005	0.001	0.0016	0.0012	5	0
Phosphorus (P)-Dissolved	mg/L	0.3	-	0.3	0.03	3	-	-	-	-	-	0.3	0.3	-	-	0.3	0.3	-	-	0.3	0.3	0.3	0.3	0.3	5	-
Potassium (K)-Dissolved	mg/L	2	2	2	2	4	-	-	-	-	-	2	2	-	-	8.0	3.1	5.55	88.3	2.6	2.8	2.6	2.8	2.3	5	3
Selenium (Se)-Dissolved	mg/L	0.001	0.001	0.001	0.001	4	-	-	-	-	-	0.001	0.001	-	-	0.00431	0.00034	0.00233	170.8	0.001	0.001	0.001	0.001	0.001	5	-
Silicon (Si)-Dissolved	mg/L	5.58	-	6.02	5.81	3	6.02	5.58	5.803	0.220	3.8	6.63	6.00	6.315	10.0	5.51	3.32	4.415	49.6	3.46	3.73	3.86	3.78	3.49	5	4
Silver (Ag)-Dissolved	mg/L	0.00005	0.00002	0.00002	0.00002	4	-	-	-	-	-	0.00002	0.00005	-	-	0.00002	0.00001	-	-	0.00002	0.00005	0.00002	0.00002	0.00002	5	-
Sodium (Na)-Dissolved	mg/L	11.4	13.1	11.5	12.9	4	13.1	11.4	12.23	0.90	7.4	2.7	3.4	3.05	23.0	106	29.2	67.60	113.6	10.2	9.5	8.8	9.3	7.3	5	10
Strontium (Sr)-Dissolved	mg/L	0.231	-	0.292	0.347	3	0.347	0.231	0.2900	0.0580	20.0	0.172	0.230	0.2010	28.9	0.247	0.144	0.1955	52.7	0.763	0.832	0.704	1.04	0.686	5	1
Thallium (Tl)-Dissolved	mg/L	0.0002	0.0002	0.0002	0.0002	4	-	-	-	-	-	0.0002	0.0002	-	-	0.0002	0.0001	-	-	0.0002	0.0002	0.0002	0.0002	0.0002	5	-
Tin (Sn)-Dissolved	mg/L	0.03	0.0005	0.0005	0.0005	4	-	-	-	-	-	0.0005	0.03	-	-	0.0002	0.0001	-	-	0.001	0.03	0.0005	0.0005	0.0005	5	0
Titanium (Ti)-Dissolved	mg/L	0.05	0.01	0.01	0.01	4	-	-	-	-	-	0.01	0.05	-	-	0.012	0.01	0.0110	18.2	0.01	0.05	0.01	0.01	0.01	5	-
Uranium (U)-Dissolved	mg/L	0.0002	0.0002	0.0002	0.0002	4	-	-	-	-	-	0.0002	0.0002	-	-	0.00109	0.00836	0.004725	153.9	0.0002	0.0002	0.0002	0.0002	0.0002	5	-
Vanadium (V)-Dissolved	mg/L	0.03	0.001	0.001	0.001	4	-	-	-	-	-	0.001	0.03	-	-	0.0217	0.0034	0.01255	145.8	0.001	0.03	0.001	0.001	0.001	5	-
Zinc (Zn)-Dissolved	mg/L	0.005	0.005	0.005	0.005	4	-	-	-	-	-	0.0092	0.005	0.00710	59.2	0.002	0.003	-	-	0.005	0.005	0.005	0.005	0.005	5	-

Results in *blue italics* are below the detection limit indicated.

¹ RSD = Percent Relative Standard Deviation = 100 * | s / mean |

² RPD = Relative Percent Difference = 100 * | (result 1 - result 2) / average (result 1, result 2) |

Well Evaluation

Sample ID		QU-08-07				QU-08-08				QU-08-08A											QU-08-08B					
Type		borehole				borehole				well											well					
Date Sampled	Units	Min	Mean	s	RSD ¹	31-Mar-09	18-Nov-09	Mean	RPD ²	28-Apr-10	27-May-10	15-Jul-10	03-Nov-10	27-Jan-11	n	Max	Min	Mean	s	RSD ¹	26-Apr-10	27-May-10	24-JAN-11	n	Max	Min
Field Physical Tests																										
Field Conductivity	uS/cm	192	259.0	61.3	23.7	320	160	240.0	66.7	546	480	283	296	206	5	546	206	362.2	143.8	39.7	251	635	307	3	635	251
Field Eh	mV	-105	-70.3	-	-	130.0	17.2	73.60	-	76.3	-64.2	21.4	-81.8	-44.1	5	76	-82	-18.5	-	-	70.5	-55.2	8	3	70.5	-55.2
Field pH	pH	8	7.686	0.197	2.6	7.3	7.11	7.205	2.6	7.32	7.46	7.61	7.44	7.32	5	8	7	7.4	0.1	1.6	8.25	8.29	7.96	3	8.29	7.96
Field Temperature	C	8	8.858	0.383	4.3	8.64	8.21	8.425	5.1	8.05	13.36	8.99	7.84	8.19	5	13	8	9.3	2.3	25.0	8.79	8.54	5.76	3	8.79	5.76
Physical Tests																										
Conductivity	uS/cm	-	-	-	-	-	-	-	-	541	462	-	-	330	3	541	330	444.3	106.6	24.0	243	648	305	3	648	243
Hardness (as CaCO3)	mg/L	140	165.4	32.6	19.7	166	73.3	119.65	77.5	215	207	177	179	174	5	215	174	190.4	19.1	10.0	36.6	31.8	14.2	3	36.6	14.2
pH	pH	-	-	-	-	-	-	-	-	8.02	6.92	-	-	7.95	3	8	7	7.630	0.616	8.1	8.22	7.41	8.44	3	8.44	7.41
Total Suspended Solids	mg/L	-	-	-	-	-	-	-	-	111	20.0	-	-	5.00	3	111	5	45.33	57.36	126.5	1620	6470	5460	3	6470	1620
Total Dissolved Solids	mg/L	-	-	-	-	-	-	-	-	378	307	-	-	205	3	378	205	296.7	87.0	29.3	220	626	248	3	626	220
Turbidity	NTU	-	-	-	-	-	-	-	-	113	24.0	-	-	6.19	3	113	6	47.73	57.22	119.9	936	>4000	>4000	1	-	-
Anions and Nutrients																										
Acidity (as CaCO3) (pH 8.3)	mg/L	-	-	-	-	-	4.2	-	-	-	-	-	-	3.4	1	-	-	-	-	-	-	-	1.00	1	-	-
Alkalinity, Total (as CaCO3)	mg/L	122	144.4	22.1	15.3	163	77.8	120.4	70.8	136	156	144	158	152	5	158	136	149.2	9.1	6.1	77.4	161	147	3	161	77.4
Ammonia as N	mg/L	-	-	-	-	-	-	-	-	0.026	0.039	-	-	0.0949	3	0	0	0.05330	0.03661	68.7	0.045	0.01	0.02	3	0.045	0.01
Bromide (Br)	mg/L	-	-	-	-	0.05	0.05	-	-	0.05	0.05	0.05	0.05	0.05	5	-	-	-	-	-	0.05	0.5	0.05	3	0.5	0.05
Chloride (Cl)	mg/L	0	0.500	0.220	44.1	0.59	0.5	0.545	16.5	9.35	3.24	0.84	1.35	0.62	5	9	1	3.080	3.654	118.6	1.14	5	0.52	3	5	0.52
Fluoride (F)	mg/L	0	0.4994	0.0395	7.9	0.478	0.101	0.2895	130.2	0.154	0.227	0.289	0.375	0.417	5	0	0	0.2924	0.1070	36.6	0.167	0.43	0.659	3	0.659	0.167
Nitrate (as N)	mg/L	0	0.02408	0.01513	62.8	0.005	-	-	-	0.005	0.005	0.005	0.0095	0.0152	5	0	0	0.00794	0.00450	56.7	0.0156	0.05	0.005	3	0.05	0.005
Nitrite (as N)	mg/L	0	0.00360	0.00507	140.8	0.001	-	-	-	0.001	0.001	0.001	0.001	0.001	5	-	-	-	-	-	0.0012	0.01	0.001	3	0.01	0.001
Total Nitrogen	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	0.15	1	-	-	-	-	-	-	0.5	1	-	-	
Ortho Phosphate as P	mg/L	-	-	-	-	-	-	-	-	0.0168	0.0179	-	-	-	2	-	-	-	-	-	0.0055	0.0456	-	2	0.0456	0.0055
Total Phosphate as P	mg/L	-	-	-	-	-	-	-	-	0.084	0.0507	-	-	0.0272	3	0	0	0.05397	0.02854	52.9	0.119	0.85	0.34	3	0.85	0.119
Sulfate (SO4)	mg/L	6	37.62	34.89	92.7	12.4	27.1	19.75	74.4	136	99.5	47.1	42.7	25.9	5	136	26	70.24	45.94	65.4	47.0	162	22.1	3	162	22.1
Sulphide as S	mg/L	-	-	-	-	-	-	-	-	0.02	0.02	-	-	0.02	3	-	-	-	-	-	0.02	0.02	0.0053	3	0.02	0.0053
Organic / Inorganic Carbon																										
Total Organic Carbon	mg/L	-	-	-	-	-	-	-	-	14.8	5.44	-	-	1.8	3	15	2	7.347	6.706	91.3	2.68	17.0	13.1	3	17	2.68
Total Metals																										
Aluminum (Al)-Total	mg/L	-	-	-	-	-	-	-	-	3.14	0.882	-	-	0.201	3	3	0	1.4077	1.5384	109.3	34.5	106	84.6	3	106	34.5
Antimony (Sb)-Total	mg/L	-	-	-	-	-	-	-	-	0.00037	0.00017	-	-	0.0005	3	0	0	0.000347	0.000166	48.0	0.00079	0.001	0.0002	3	0.001	0.0002
Arsenic (As)-Total	mg/L	-	-	-	-	-	-	-	-	0.0464	0.118	-	-	0.201	3	0	0	0.1218	0.0774	63.5	0.00985	0.0663	0.2050	3	0.205	0.00985
Barium (Ba)-Total	mg/L	-	-	-	-	-	-	-	-	0.147	0.109	-	-	0.115	3	0	0	0.1237	0.0204	16.5	0.0978	0.463	0.493	3	0.493	0.0978
Beryllium (Be)-Total	mg/L	-	-	-	-	-	-	-	-	0.0005	0.0005	-	-	0.001	3	-	-	-	-	-	0.0054	0.0155	0.0135	3	0.0155	0.0054
Bismuth (Bi)-Total	mg/L	-	-	-	-	-	-	-	-	0.0005	0.0005	-	-	0.2	3	-	-	-	-	-	0.0025	0.005	0.0031	3	0.005	0.0025
Boron (B)-Total	mg/L	-	-	-	-	-	-	-	-	0.153	0.229	-	-	0.36	3	0	0	0.2473	0.1047	42.3	0.109	0.25	0.291	3	0.291	0.109
Cadmium (Cd)-Total	mg/L	-	-	-	-	-	-	-	-	0.000067	0.000099	-	-	0.000045	3	0	0	0.0000703	0.0000272	38.6	0.000091	0.00052	0.00056	3	0.00056	0.000091
Calcium (Ca)-Total	mg/L	-	-	-	-	-	-	-	-	66.5	60.9	-	-	50.3	3	67	50	59.23	8.23	13.9	48.0	123	146	3	146	48
Chromium (Cr)-Total	mg/L	-	-	-	-	-	-	-	-	0.00190	0.00061	-	-	0.0038	3	0	0	0.002103	0.001605	76.3	0.0045	0.0167	0.0148	3	0.0167	0.0045
Cobalt (Co)-Total	mg/L	-	-	-	-	-	-	-	-	0.00321	0.00201	-	-	0.00183	3	0	0	0.002350	0.000750	31.9	0.00407	0.0239	0.0141	3	0.0239	0.00407
Copper (Cu)-Total	mg/L	-	-	-	-	-	-	-	-	0.00291	0.00142	-	-	0.001	3	0	0	0.001777	0.001004	56.5	0.0124	0.0490	0.0352	3	0.049	0.0124
Iron (Fe)-Total	mg/L	-	-	-	-	-	-	-	-	3.14	0.861	-	-	0.19	3	3	0	1.3970	1.5463	110.7	8.97	34.7	28.7	3	34.7	8.97
Lead (Pb)-Total	mg/L	-	-	-	-	-	-	-	-	0.00139	0.000425	-	-	0.0005	3	0	0	0.000772	0.000537	69.6	0.0268	0.0905	0.0910	3	0.091	0.0268
Lithium (Li)-Total	mg/L	-	-	-	-	-	-	-	-	0.0129	0.0191	-	-	0.0361	3	0	0	0.02270	0.01201	52.9	0.025	0.05	0.044	3	0.05	0.025
Magnesium (Mg)-Total	mg/L	-	-	-	-	-	-	-	-	12.0	11.1	-	-	9.97	3	12	10	11.02	1.02	9.2	9.89	28.8	22.5	3	28.8	9.89
Manganese (Mn)-Total	mg/L	-	-	-	-	-	-	-	-	0.259	0.572	-	-	0.0938	3	1	0	0.3083	0.2429	78.8	0.184	1.50	1.45	3	1.5	0.184
Mercury (Hg)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	0.00001	1	-	-	-	-	-	-	-	0.00001	1	-	-
Molybdenum (Mo)-Total	mg/L	-	-	-	-	-	-	-	-	0.00210	0.00205	-	-	0.0012	3	0	0	0.001783	0.000506	28.4	0.00077	0.00221	0.00083	3	0.00221	0.00077
Nickel (Ni)-Total	mg/L	-	-	-	-	-	-	-	-	0.00563	0.00323	-	-	0.0031	3	0	0	0.003987	0.001425	35.7	0.0058	0.0267	0.0189	3	0.0267	0.0058
Phosphorus (P)-Total	mg/L	-	-	-	-	-	-	-	-	0.3	0.3	-	-	0.03	3	-	-	-	-	-	0.3	0.66	0.81	3	0.81	0.3
Potassium (K)-Total	mg/L	-	-	-	-	-	-	-	-	2.5	2	-	-	0.2	3	3	2	2.17	0.29	13.3	3.6	9.2	8.9	3	9.2	3.6
Selenium (Se)-Total	mg/L	-	-	-	-	-	-	-	-	0.00053	0.0005	-	-	0.001	3	0	0	0.000677	0.000280	41.4	0.0005	0.00057	0.00020	3	0.00057	0.0002
Silicon (Si)-Total	mg/L	-	-	-	-	-	-	-	-	15.0	7.00	-	-	4.54	3	15	5	8.847	5.469	61.8	75.6	203	144	3	203	75.6
Silver (Ag)-Total	mg/L	-	-	-	-	-	-	-	-	0.000023	0.000015	-	-	0.00002	3	0	0	0.0000193	0.0000040	20.9	0.00005	0.0001	0.000049	3	0.0001	0.000049
Sodium (Na)-Total	mg/L	-	-	-	-	-	-	-	-	39.1	28.5	-	-	8.9	3	39	9	25.50	15.32	60.1	38.7	135	72.4	3	135	38.7
Strontium (Sr)-Total	mg/L	-	-	-	-	-	-	-	-	0.337	0.425	-	-	0.543	3	1	0	0.4350	0.1034	23.8	0.348	1.02	1.33	3	1.33	0.348
Thallium (Tl)-Total	mg/L	-	-	-	-	-	-	-	-	0.0001	0.0001	-	-	0.0002	3	-	-	-	-	-	0.0005	0.0011	0.0012	3	0.00115	0.0005
Tin (Sn)-Total	mg/L	-	-	-	-	-	-	-	-	0.00493	0.00031	-	-	0.0005	3	0	0	0.001913	0.002614	136.6	0.0005	0.001	0.0002	3	-	-

Table C2-2: Groundwater Quality Data Evaluation
7 South Mine Goundwater Evaluation - Quinsam Mine

Well Evaluation

Sample ID		QU-08-07				QU-08-08				QU-08-08A										QU-08-08B						
Type		borehole				borehole				well										well						
Date Sampled	Units	Min	Mean	s	RSD ¹	31-Mar-09	18-Nov-09	Mean	RPD ²	28-Apr-10	27-May-10	15-Jul-10	03-Nov-10	27-Jan-11	n	Max	Min	Mean	s	RSD ¹	26-Apr-10	27-May-10	24-JAN-11	n	Max	Min
Titanium (Ti)-Total	mg/L	-	-	-	-	-	-	-	-	0.222	0.076	-	-	0.016	3	0	0	0.1047	0.1059	101.2	0.070	0.099	0.095	3	0.099	0.07
Uranium (U)-Total	mg/L	-	-	-	-	-	-	-	-	0.00361	0.00237	-	-	0.00034	3	0	0	0.002107	0.001651	78.4	0.0105	0.0337	0.0257	3	0.0337	0.0105
Vanadium (V)-Total	mg/L	-	-	-	-	-	-	-	-	0.0068	0.0021	-	-	0.0017	3	0	0	0.00353	0.00284	80.3	0.0190	0.065	0.052	3	0.065	0.019
Zinc (Zn)-Total	mg/L	-	-	-	-	-	-	-	-	0.0266	0.0323	-	-	0.005	3	0	0	0.02130	0.01440	67.6	0.0462	0.153	0.115	3	0.153	0.0462
Dissolved Metals																										
Aluminum (Al)-Dissolved	mg/L	-	-	-	-	0.005	0.015	0.0100	100.0	-	0.0048	0.0091	0.005	0.0073	4	0	0	0.00655	0.00204	31.2	0.005	0.291	0.540	3	0.54	0.005
Antimony (Sb)-Dissolved	mg/L	-	-	-	-	0.0005	0.0005	-	-	-	0.00010	0.0005	0.0005	0.0005	4	0	0	0.00040	0.00020	50.0	0.00176	0.0018	0.0002	3	0.0018	0.00024
Arsenic (As)-Dissolved	mg/L	0	0.3588	0.0285	7.9	0.400	0.0045	0.20225	195.6	-	0.126	0.145	0.222	0.241	4	0	0	0.1835	0.0565	30.8	0.00596	0.0134	0.1430	3	0.143	0.00596
Barium (Ba)-Dissolved	mg/L	0	0.1892	0.0422	22.3	0.133	0.152	0.1425	13.3	-	0.0687	0.079	0.110	0.108	4	0	0	0.0914	0.0207	22.7	0.00675	0.0185	0.0078	3	0.0185	0.00675
Beryllium (Be)-Dissolved	mg/L	-	-	-	-	0.001	0.005	-	-	-	0.0005	0.001	0.001	0.001	4	-	-	-	-	-	0.0025	0.005	0.001	3	-	-
Bismuth (Bi)-Dissolved	mg/L	-	-	-	-	0.2	0.2	0.20	0.0	-	0.0005	0.2	0.2	0.2	4	-	-	-	-	-	0.0025	0.005	0.001	3	-	-
Boron (B)-Dissolved	mg/L	1	0.578	0.051	8.9	0.41	0.18	0.295	78.0	-	0.227	0.28	0.35	0.36	4	0	0	0.304	0.063	20.6	0.082	0.17	0.20	3	0.2	0.082
Cadmium (Cd)-Dissolved	mg/L	-	-	-	-	0.000017	0.00005	-	-	-	0.000021	0.000030	0.000026	0.000029	4	0	0	0.0000265	0.0000040	15.3	0.000085	0.00017	0.00002	3	0.00017	0.00002
Calcium (Ca)-Dissolved	mg/L	39	47.56	9.77	20.5	49.6	21.5	35.55	79.0	-	63.7	53.1	54.6	52.8	4	64	53	56.05	5.16	9.2	12.1	10.8	4.1	3	12.1	4.1
Chromium (Cr)-Dissolved	mg/L	-	-	-	-	0.002	0.0005	-	-	-	0.0005	0.001	0.001	0.001	4	-	-	-	-	-	0.0025	0.005	0.0002	3	0.005	0.0002
Cobalt (Co)-Dissolved	mg/L	0	0.000716	0.000123	17.2	0.00115	0.00103	0.00109	11.0	-	0.00159	0.00067	0.00043	0.00073	4	0	0	0.000855	0.000507	59.3	0.0005	0.001	0.0002	3	-	-
Copper (Cu)-Dissolved	mg/L	-	-	-	-	0.001	0.001	0.00100	0.0	-	0.00033	0.001	0.001	0.001	4	0	0	0.000833	0.000335	40.2	0.00100	0.0015	0.0010	3	0.0015	0.001
Iron (Fe)-Dissolved	mg/L	0	0.1424	0.0588	41.3	0.084	0.140	0.1120	50.0	-	0.109	0.03	0.109	0.030	4	0	0	0.0695	0.0456	65.6	0.03	0.180	0.674	3	0.674	0.03
Lead (Pb)-Dissolved	mg/L	-	-	-	-	0.0005	0.001	0.00075	66.7	-	0.00005	0.0005	0.0005	0.0005	4	0	0	0.00039	0.00023	58.1	0.00025	0.00153	0.00033	3	0.00153	0.00025
Lithium (Li)-Dissolved	mg/L	0	0.05340	0.00713	13.3	0.0408	0.05	0.04540	20.3	-	0.0179	0.0259	0.0303	0.0328	4	0	0	0.02673	0.00654	24.5	0.025	0.05	0.012	3	0.05	0.012
Magnesium (Mg)-Dissolved	mg/L	10	11.330	2.067	18.2	10.2	4.74	7.470	73.1	-	11.7	10.8	10.3	10.2	4	12	10	10.75	0.69	6.4	1.55	1.17	0.95	3	1.55	0.95
Manganese (Mn)-Dissolved	mg/L	0	0.03530	0.01218	34.5	0.0446	0.038	0.04130	16.0	-	0.537	0.234	0.155	0.086	4	1	0	0.2530	0.1987	78.5	0.00648	0.125	0.040	3	0.125	0.00648
Mercury (Hg)-Dissolved	mg/L	-	-	-	-	0.00002	0.0002	-	-	-	-	0.00001	0.00001	0.00001	3	-	-	-	-	-	-	-	0.00001	1	-	-
Molybdenum (Mo)-Dissolved	mg/L	-	-	-	-	0.0012	0.0011	0.00115	8.7	-	0.00203	0.0011	0.001	0.0011	4	0	0	0.00131	0.00048	37.0	0.00087	0.00285	0.00109	3	0.00285	0.00087
Nickel (Ni)-Dissolved	mg/L	0	0.00196	0.00172	87.6	0.0029	0.005	0.00395	53.2	-	0.00257	0.0012	0.001	0.0028	4	0	0	0.00189	0.00092	48.8	0.0025	0.005	0.001	3	0.005	0.001
Phosphorus (P)-Dissolved	mg/L	-	-	-	-	0.3	0.3	-	-	-	0.3	0.3	0.3	0.3	4	-	-	-	-	-	0.3	0.3	0.3	3	-	-
Potassium (K)-Dissolved	mg/L	2	2.62	0.20	7.8	2.0	2	2.00	0.0	-	2	2	2	2	4	-	-	-	-	-	2	2	2	3	-	-
Selenium (Se)-Dissolved	mg/L	-	-	-	-	0.001	0.001	-	-	-	0.0005	0.001	0.001	0.001	4	-	-	-	-	-	0.0005	0.0005	0.0002	3	-	-
Silicon (Si)-Dissolved	mg/L	3	3.664	0.179	4.9	3.66	5.98	4.820	48.1	-	5.82	5.26	4.69	4.33	4	6	4	5.025	0.654	13.0	5.35	6.05	10.80	3	10.8	5.35
Silver (Ag)-Dissolved	mg/L	-	-	-	-	0.00002	0.00005	-	-	-	0.00001	0.00002	0.00002	0.00002	4	-	-	-	-	-	0.00005	0.0001	0.00002	3	-	-
Sodium (Na)-Dissolved	mg/L	7	9.02	1.08	12.0	7.1	8.0	7.55	11.9	-	30.8	10.3	18.2	9.0	4	31	9	17.08	10.01	58.6	40.1	142	68.3	3	142	40.1
Strontium (Sr)-Dissolved	mg/L	1	0.8050	0.1432	17.8	0.587	0.291	0.4390	67.4	-	0.414	0.479	0.546	0.543	4	1	0	0.4955	0.0625	12.6	0.114	0.110	0.060	3	0.114	0.0599
Thallium (Tl)-Dissolved	mg/L	-	-	-	-	0.0002	0.0002	-	-	-	0.0001	0.0002	0.0002	0.0002	4	-	-	-	-	-	0.0005	0.001	0.0002	3	-	-
Tin (Sn)-Dissolved	mg/L	0	0.00650	0.01314	202.1	0.0005	0.03	-	-	-	0.0001	0.0005	0.0005	0.0005	4	-	-	-	-	-	0.0005	0.001	0.0002	3	-	-
Titanium (Ti)-Dissolved	mg/L	-	-	-	-	0.01	0.05	-	-	-	0.010	0.01	0.01	0.01	4	-	-	-	-	-	0.01	0.01	0.049	3	0.049	0.01
Uranium (U)-Dissolved	mg/L	-	-	-	-	0.0002	0.0002	-	-	-	0.00226	0.00075	0.00077	0.00030	4	0	0	0.001020	0.000855	83.8	0.00231	0.00880	0.00304	3	0.0088	0.00231
Vanadium (V)-Dissolved	mg/L	-	-	-	-	0.001	0.03	-	-	-	0.001	0.001	0.0010	0.0011	4	0	0	0.00103	0.00005	4.9	0.005	0.01	0.0051	3	0.01	0.005
Zinc (Zn)-Dissolved	mg/L	-	-	-	-	0.005	0.005	-	-	-	0.0623	0.005	0.005	0.005	4	0	0	0.01933	0.02865	148.3	0.005	0.01	0.006	3	-	-

Results in *blue italics* are below the detection limit indic
¹ RSD = Percent Relative Standard Deviation = 100 * | s
² RPD = Relative Percent Difference = 100 * | (result 1 - result 2) / average (result 1, result 2) |

Table C2-2: Groundwater Quality Data Evaluation
7 South Mine Goundwater Evaluation - Quinsam Mine

Well Evaluation

Sample ID		QU-08-08B			QU-08-13A									QU-08-13B				QU-09-01										
Type		well			well									well				borehole										
Date Sampled	Units	Mean	s	RSD ¹	25-Apr-10	27-May-10	10-DEC-10	n	Max	Min	Mean	s	RSD ¹	25-Apr-10	28-May-10	Mean	RPD ²	08-Apr-09	18-Nov-09	15-Jul-10	03-Nov-10	27-JAN-11	n	Max	Min	Mean	s	RSD ¹
Field Physical Tests																												
Field Conductivity	uS/cm	397.7	207.4	52.2	277	288	221	3	288	221	262.00	35.93	13.7	255	264	259.5	3.5	271	311	186	249	210	5	311	186	245.4	49.4	20.1
Field Eh	mV	7.8	62.9	809.2	-74.9	-103.9	62.0	3	62	-103.9	-38.9	-	-	-62.4	-128.2	-95.3	-	-96.0	-21.4	-17.8	-106.4	-137.2	5	-18	-137	-75.8	-	-
Field pH	pH	8.2	0.2	2.2	7.66	7.58	7.64	3	7.66	7.58	7.627	0.042	0.5	7.84	7.95	7.895	1.4	7.72	7.51	7.59	7.37	7.36	5	8	7	7.5	0.2	2.0
Field Temperature	C	7.7	1.7	21.9	8.32	9.12	8.11	3	9.12	8.11	8.517	0.533	6.3	8.55	8.73	8.640	2.1	8.52	8.20	9.41	9.62	8.37	5	10	8	8.8	0.6	7.3
Physical Tests																												
Conductivity	uS/cm	398.7	218.1	54.7	273	283	309	3	309	273	288.3	18.6	6.4	248	262	255.0	5.5	-	-	-	-	-	0	-	-	-	-	-
Hardness (as CaCO3)	mg/L	27.53	11.79	42.8	19.2	119	125	3	125	19.2	87.73	59.43	67.7	70.1	78.0	74.1	10.7	157	184	135	173	155	5	184	135	160.8	18.7	11.6
pH	pH	8.023	0.542	6.8	8.19	7.74	8.25	3	8.25	7.74	8.060	0.279	3.5	8.24	7.53	7.885	9.0	-	-	-	-	-	0	-	-	-	-	-
Total Suspended Solids	mg/L	4516.7	2558.9	56.7	5.5	4.5	4.9	3	5.5	4.5	4.97	0.50	10.1	18.0	104	61.0	141.0	-	-	-	-	-	0	-	-	-	-	-
Total Dissolved Solids	mg/L	364.7	226.8	62.2	164	164	179	3	179	164	169.0	8.7	5.1	156	193	174.5	21.2	-	-	-	-	-	0	-	-	-	-	-
Turbidity	NTU	-	-	-	22.0	7.97	6.90	3	22	6.9	12.29	8.43	68.6	21.3	230	125.7	166.1	-	-	-	-	-	0	-	-	-	-	-
Anions and Nutrients																												
Acidity (as CaCO3) (pH 8.3)	mg/L	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	4.7	-	-	-	1	-	-	-	-	-
Alkalinity, Total (as CaCO3)	mg/L	128.5	44.8	34.9	143	146	151	3	151	143	146.7	4.0	2.8	131	155	143.0	16.8	158	180	134	160	142	5	180	134	154.8	17.8	11.5
Ammonia as N	mg/L	0.0250	0.0180	72.1	0.154	0.120	0.151	3	0.154	0.12	0.142	0.019	13.3	0.129	0.088	0.1085	37.8	-	-	-	-	-	0	-	-	-	-	-
Bromide (Br)	mg/L	0.200	0.260	129.9	0.05	0.05	0.05	3	-	-	-	-	-	0.05	0.05	-	-	0.05	0.05	0.05	0.05	0.05	5	-	-	-	-	-
Chloride (Cl)	mg/L	2.220	2.427	109.3	0.63	0.62	4.10	3	4.1	0.62	1.783	2.006	112.5	0.56	0.70	0.630	22.2	0.67	0.5	0.45	0.55	0.51	5	1	0	0.536	0.083	15.5
Fluoride (F)	mg/L	0.4187	0.2462	58.8	0.483	0.584	0.569	3	0.584	0.483	0.5453	0.0545	10.0	0.34	0.363	0.3515	6.5	0.542	0.494	0.543	0.552	0.621	5	1	0	0.5504	0.0455	8.3
Nitrate (as N)	mg/L	0.02353	0.02353	100.0	0.005	0.005	0.005	3	-	-	-	-	-	0.005	0.005	-	-	0.005	-	0.0814	0.0538	0.005	4	0	0	0.0363	0.0379	104.3
Nitrite (as N)	mg/L	0.00407	0.00514	126.4	0.001	0.001	0.001	3	-	-	-	-	-	0.001	0.001	-	-	0.0018	-	0.0219	0.0060	0.001	4	0	0	0.0077	0.0097	126.8
Total Nitrogen	mg/L	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-
Ortho Phosphate as P	mg/L	0.02555	0.02835	111.0	0.0210	0.0272	0.0083	3	0.0272	0.0083	0.01883	0.00963	51.2	0.0215	0.0304	0.0260	34.3	-	-	-	-	-	0	-	-	-	-	-
Total Phosphate as P	mg/L	0.435	0.375	86.2	0.0362	0.0361	0.0337	3	0.0362	0.0337	0.0353	0.0014	4.0	0.0479	0.132	0.0900	93.5	-	-	-	-	-	0	-	-	-	-	-
Sulfate (SO4)	mg/L	77.03	74.63	96.9	9.55	10.8	10.3	3	10.8	9.55	10.217	0.629	6.2	8.39	9.76	9.08	15.1	13.0	36.0	9.84	25.8	37.2	5	37	10	24.37	12.67	52.0
Sulphide as S	mg/L	0.0151	0.0085	56.2	0.02	0.036	0.151	3	0.151	0.02	0.069	0.071	103.6	0.02	0.02	-	-	-	-	-	-	-	0	-	-	-	-	-
Organic / Inorganic Carbon																												
Total Organic Carbon	mg/L	10.93	7.40	67.8	0.66	0.81	3.34	3	3.34	0.66	1.603	1.506	93.9	0.53	1.16	0.845	74.6	-	-	-	-	-	0	-	-	-	-	-
Total Metals																												
Aluminum (Al)-Total	mg/L	75.03	36.70	48.9	0.916	0.0839	0.0463	3	0.916	0.0463	0.3487	0.4916	141.0	2.22	6.19	4.205	94.4	0.272	-	-	-	-	1	-	-	-	-	-
Antimony (Sb)-Total	mg/L	0.000663	0.000415	62.5	0.00044	0.0001	0.0001	3	0.00044	0.0001	0.00021	0.00020	92.0	0.00015	0.00068	0.000415	127.7	0.00162	-	-	-	-	1	-	-	-	-	-
Arsenic (As)-Total	mg/L	0.0937	0.1004	107.2	0.412	0.433	0.524	3	0.524	0.412	0.4563	0.0595	13.0	0.387	0.448	0.4175	14.6	0.333	-	-	-	-	1	-	-	-	-	-
Barium (Ba)-Total	mg/L	0.3513	0.2200	62.6	0.0890	0.112	0.138	3	0.138	0.089	0.1130	0.0245	21.7	0.0412	0.0747	0.05795	57.8	0.146	-	-	-	-	1	-	-	-	-	-
Beryllium (Be)-Total	mg/L	0.01147	0.00535	46.6	0.0005	0.0005	0.0005	3	-	-	-	-	-	0.0005	0.0005	-	-	0.001	-	-	-	-	1	-	-	-	-	-
Bismuth (Bi)-Total	mg/L	0.00353	0.00131	36.9	0.0005	0.0005	0.0005	3	-	-	-	-	-	0.0005	0.0005	-	-	0.2	-	-	-	-	1	-	-	-	-	-
Boron (B)-Total	mg/L	0.2167	0.0955	44.1	0.311	0.340	0.377	3	0.377	0.311	0.3427	0.0331	9.7	0.354	0.257	0.3055	31.8	0.48	-	-	-	-	1	-	-	-	-	-
Cadmium (Cd)-Total	mg/L	0.000390	0.000260	66.6	0.000022	0.000017	0.000017	3	#####	0.000017	0.0000187	0.0000029	15.5	0.000021	0.000042	0.0000315	66.7	0.000026	-	-	-	-	1	-	-	-	-	-
Calcium (Ca)-Total	mg/L	105.7	51.2	48.5	26.6	33.5	37.4	3	37.4	26.6	32.50	5.47	16.8	22.0	26.9	24.45	20.0	45.1	-	-	-	-	1	-	-	-	-	-
Chromium (Cr)-Total	mg/L	0.01200	0.00656	54.7	0.00135	0.0005	0.00228	3	0.00228	0.0005	0.00138	0.00089	64.7	0.00244	0.0114	0.00692	129.5	0.0137	-	-	-	-	1	-	-	-	-	-
Cobalt (Co)-Total	mg/L	0.014023	0.009915	70.7	0.00082	0.00036	0.00012	3	0.00082	0.00012	0.000433	0.000356	82.1	0.00146	0.00581	0.003635	119.7	0.00616	-	-	-	-	1	-	-	-	-	-
Copper (Cu)-Total	mg/L	0.03220	0.01848	57.4	0.00186	0.00037	0.0005	3	0.00186	0.00037	0.000910	0.000825	90.7	0.00396	0.0181	0.011030	128.2	0.0267	-	-	-	-	1	-	-	-	-	-
Iron (Fe)-Total	mg/L	24.12	13.46	55.8	0.886	0.266	0.374	3	0.886	0.266	0.5087	0.3312	65.1	1.75	9.91	5.830	140.0	4.55	-	-	-	-	1	-	-	-	-	-
Lead (Pb)-Total	mg/L	0.06943	0.03692	53.2	0.000145	0.000087	0.00005	3	0.00015	0.00005	0.0000940	0.0000479	50.9	0.000396	0.000835	0.000616	71.3	0.0005	-	-	-	-	1</					

Table C2-2: Groundwater Quality Data Evaluation
7 South Mine Goundwater Evaluation - Quinsam Mine

Well Evaluation

Sample ID		QU-08-08B			QU-08-13A									QU-08-13B				QU-09-01										
Type		well			well									well				borehole										
Date Sampled	Units	Mean	s	RSD ¹	25-Apr-10	27-May-10	10-DEC-10	n	Max	Min	Mean	s	RSD ¹	25-Apr-10	28-May-10	Mean	RPD ²	08-Apr-09	18-Nov-09	15-Jul-10	03-Nov-10	27-JAN-11	n	Max	Min	Mean	s	RSD ¹
Titanium (Ti)-Total	mg/L	0.0880	0.0157	17.9	0.049	0.01	0.01	3	0.049	0.01	0.023	0.023	97.9	0.084	0.607	0.3455	151.4	0.016	-	-	-	-	1	-	-	-	-	-
Uranium (U)-Total	mg/L	0.02330	0.01178	50.6	0.000330	0.000341	0.000033	3	0.00034	3.3E-05	0.000235	0.000175	74.5	0.000489	0.000235	0.000362	70.2	0.0002	-	-	-	-	1	-	-	-	-	-
Vanadium (V)-Total	mg/L	0.0455	0.0238	52.3	0.0026	0.001	0.001	3	0.0026	0.001	0.0015	0.0009	60.2	0.0049	0.0243	0.01460	132.9	0.0063	-	-	-	-	1	-	-	-	-	-
Zinc (Zn)-Total	mg/L	0.1047	0.0541	51.7	0.0025	0.0024	0.003	3	0.003	0.0024	0.0026	0.0003	12.2	0.0046	0.0176	0.01110	117.1	0.0123	-	-	-	-	1	-	-	-	-	-
Dissolved Metals																												
Aluminum (Al)-Dissolved	mg/L	0.2787	0.2677	96.1	0.0085	0.0038	0.003	3	0.0085	0.003	0.00510	0.00297	58.3	0.0112	0.0097	0.0105	14.4	0.005	0.01	0.005	0.005	0.005	5	-	-	-	-	-
Antimony (Sb)-Dissolved	mg/L	0.00127	0.00089	70.2	0.00025	0.0001	0.0001	3	0.00025	0.0001	0.00015	0.00009	57.7	0.0001	0.00016	0.000130	46.2	0.00159	0.0005	0.00077	0.0005	0.0005	5	0	0	0.00077	0.00047	61.1
Arsenic (As)-Dissolved	mg/L	0.0541	0.0771	142.4	0.426	0.468	0.544	3	0.544	0.426	0.4793	0.0598	12.5	0.419	0.475	0.4470	12.5	0.314	0.324	0.197	0.243	0.316	5	0	0	0.2788	0.0562	20.2
Barium (Ba)-Dissolved	mg/L	0.01102	0.00650	58.9	0.0814	0.103	0.133	3	0.133	0.0814	0.1058	0.0259	24.5	0.0317	0.0311	0.03140	1.9	0.138	0.183	0.356	0.305	0.217	5	0	0	0.2398	0.0893	37.2
Beryllium (Be)-Dissolved	mg/L	-	-	-	0.0005	0.0005	0.0005	3	-	-	-	-	-	0.0005	0.0005	-	-	0.001	0.005	0.001	0.001	0.001	5	-	-	-	-	-
Bismuth (Bi)-Dissolved	mg/L	-	-	-	0.0005	0.0005	0.0005	3	-	-	-	-	-	0.0005	0.0005	-	-	0.2	0.2	0.2	0.2	0.2	5	-	-	-	-	-
Boron (B)-Dissolved	mg/L	0.151	0.061	40.7	0.299	0.310	0.361	3	0.361	0.299	0.3233	0.0331	10.2	0.328	0.242	0.2850	30.2	0.51	0.57	0.62	0.70	0.68	5	1	1	0.616	0.078	12.7
Cadmium (Cd)-Dissolved	mg/L	0.0000917	0.0000752	82.1	0.000017	0.000017	0.000017	3	-	-	-	-	-	0.000017	0.000017	-	-	0.000017	0.00005	0.000017	0.000017	0.000019	5	0	0	0.000024	0.000015	60.7
Calcium (Ca)-Dissolved	mg/L	9.00	4.29	47.7	29.4	35.0	37.4	3	37.4	29.4	33.93	4.11	12.1	22.2	24.8	23.50	11.1	45.6	53.3	37.2	48.7	43.0	5	53	37	45.56	6.05	13.3
Chromium (Cr)-Dissolved	mg/L	0.00257	0.00240	93.5	0.0005	0.0005	0.0005	3	-	-	-	-	-	0.0005	0.0005	-	-	0.001	0.0005	0.001	0.001	0.001	5	-	-	-	-	-
Cobalt (Co)-Dissolved	mg/L	-	-	-	0.00033	0.00031	0.0001	3	0.00033	0.0001	0.00025	0.00013	51.7	0.00038	0.00022	0.00030	53.3	0.00453	0.00118	0.00301	0.00275	0.00519	5	0	0	0.003332	0.001578	47.4
Copper (Cu)-Dissolved	mg/L	0.00117	0.00029	24.7	0.00045	0.0001	0.0005	3	0.0005	0.0001	0.00035	0.00022	62.3	0.0001	0.0001	-	-	0.001	0.001	0.001	0.001	0.001	5	-	-	-	-	-
Iron (Fe)-Dissolved	mg/L	0.2947	0.3370	114.4	0.03	0.117	0.294	3	0.294	0.03	0.1470	0.1345	91.5	0.03	0.039	0.03450	26.1	0.158	0.086	0.097	0.126	0.403	5	0	0	0.1740	0.1310	75.3
Lead (Pb)-Dissolved	mg/L	0.00070	0.00072	101.9	0.00005	0.00005	0.00005	3	-	-	-	-	-	0.00005	0.00005	-	-	0.0005	0.001	0.0005	0.0005	0.0005	5	-	-	-	-	-
Lithium (Li)-Dissolved	mg/L	0.0290	0.0193	66.6	0.0314	0.0336	0.0351	3	0.0351	0.0314	0.03337	0.00186	5.6	0.0164	0.0168	0.01660	2.4	0.0504	0.062	0.0623	0.0577	0.0503	5	0	0	0.0565	0.0059	10.5
Magnesium (Mg)-Dissolved	mg/L	1.223	0.304	24.8	5.80	7.79	7.64	3	7.79	5.8	7.077	1.108	15.7	3.56	3.89	3.725	8.9	10.4	12.3	10.2	12.4	11.5	5	12	10	11.36	1.03	9.1
Manganese (Mn)-Dissolved	mg/L	0.05729	0.06104	106.5	0.0931	0.129	0.0531	3	0.129	0.0531	0.09173	0.03797	41.4	0.0886	0.0796	0.08410	10.7	0.0386	0.029	0.0220	0.0414	0.0519	5	0	0	0.03658	0.01153	31.5
Mercury (Hg)-Dissolved	mg/L	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0.00002	0.0002	0.00001	0.00001	0.00001	5	-	-	-	-	-
Molybdenum (Mo)-Dissolved	mg/L	0.001603	0.001085	67.7	0.00203	0.00127	0.00106	3	0.00203	0.00106	0.001453	0.000510	35.1	0.00340	0.00327	0.003335	3.9	0.0039	0.001	0.001	0.001	0.001	5	0	0	0.0016	0.0013	82.1
Nickel (Ni)-Dissolved	mg/L	0.00283	0.00202	71.3	0.00071	0.00056	0.0005	3	0.00071	0.0005	0.000590	0.000108	18.3	0.00076	0.0005	0.000630	41.3	0.0066	0.005	0.0073	0.0038	0.0027	5	0	0	0.00508	0.00191	37.5
Phosphorus (P)-Dissolved	mg/L	-	-	-	0.3	0.3	0.3	3	-	-	-	-	-	0.3	0.3	-	-	0.3	0.3	0.3	0.3	0.3	5	-	-	-	-	-
Potassium (K)-Dissolved	mg/L	-	-	-	2	2.3	2	3	2.3	2	2.10	0.17	8.2	2	2	-	-	2.5	2.8	3.4	3.2	2.9	5	3	3	2.96	0.35	11.8
Selenium (Se)-Dissolved	mg/L	-	-	-	0.0005	0.0005	0.0004	3	-	-	-	-	-	0.0005	0.0005	-	-	0.001	0.001	0.001	0.001	0.001	5	-	-	-	-	-
Silicon (Si)-Dissolved	mg/L	7.400	2.965	40.1	3.34	3.79	3.72	3	3.79	3.34	3.617	0.242	6.7	4.06	4.21	4.135	3.6	3.94	4.02	3.89	3.47	3.43	5	4	3	3.750	0.278	7.4
Silver (Ag)-Dissolved	mg/L	-	-	-	0.00001	0.00001	0.00001	3	-	-	-	-	-	0.00001	0.00001	-	-	0.00002	0.00005	0.00002	0.00002	0.00002	5	-	-	-	-	-
Sodium (Na)-Dissolved	mg/L	83.47	52.62	63.0	20.9	20.7	21.6	3	21.6	20.7	21.07	0.47	2.2	31.4	31.4	31.40	0.0	8.4	10.6	9.3	9.8	10.5	5	11	8	9.72	0.91	9.4
Strontium (Sr)-Dissolved	mg/L	0.0946	0.0301	31.9	0.330	0.378	0.392	3	0.392	0.33	0.3667	0.0325	8.9	0.141	0.144	0.1425	2.1	0.742	0.860	0.841	1.03	0.934	5	1	1	0.881	0.108	12.2
Thallium (Tl)-Dissolved	mg/L	-	-	-	0.0001	0.0001	0.0001	3	-	-	-	-	-	0.0001	0.0001	-	-	0.0002	0.0002	0.0002	0.0002	0.0002	5	-	-	-	-	-
Tin (Sn)-Dissolved	mg/L	-	-	-	0.0001	0.0001	0.0001	3	-	-	-	-	-	0.0001	0.0001	-	-	0.0005	0.03	0.0005	0.0005	0.0005	5	-	-	-	-	-
Titanium (Ti)-Dissolved	mg/L	0.0230	0.0225	97.9	0.01	0.01	0.01	3	-	-	-	-	-	0.01	0.01	-	-	0.01	0.05	0.01	0.01	0.01	5	-	-	-	-	-
Uranium (U)-Dissolved	mg/L	0.004717	0.003555	75.4	0.000288	0.000312	0.000028	3	0.00031	2.8E-05	0.000209	0.000157	75.2	0.000324	0.000117	0.000221	93.9	0.0002	0.0002	0.0002	0.0002	0.0002	5	-	-	-	-	-
Vanadium (V)-Dissolved	mg/L	0.00670	0.00286	42.7	0.001	0.001	0.001	3	-	-	-	-	-	0.001	0.001	-	-	0.001	0.03	0.001	0.001	0.001	5	-	-	-	-	-
Zinc (Zn)-Dissolved	mg/L	-	-	-	0.001	0.001	0.0046	3	0.0046	0.001	0.0022	0.0021	94.5	0.001	0.001	-	-	0.005	0.0841	0.005	0.005	0.0055	5	0	0	0.0209	0.0353	168.8

Results in *blue italics* are below the detection limit indic

¹ RSD = Percent Relative Standard Deviation = 100 * |s

² RPD = Relative Percent Diffrence = 100 * | (result 1 - result 2) / average (result 1, result 2) |

Appendix C3:
Groundwater Quality Data and Guidelines

Table C3: Groundwater Quality Data and Guidelines
7 South Mine Goundwater Evaluation - Quinsam Mine

Sample ID	Units	QU-01-07	QU-07-07				QU-08-05		QU-08-05		QU-08-07					QU-08-08		QU08-08A				
Type		borehole	borehole				borehole		well		borehole					borehole		well				
Date Sampled		QU-01-009	19/11/2009	21/07/2010	03/11/2010	27/01/2011	30/03/2009	19/11/2009	25/05/2010	24/01/2011	30/03/2009	18/11/2009	14/07/2010	02/11/2010	25/01/2011	31/03/2009	18/11/2009	28/04/2010	27/05/2010	15/07/2010	03/11/2010	27/01/2011
Field Physical Tests		QU-01-07	QU-07-07	QU-07-07	QU-07-07	QU-07-07	QU-08-05	MW 08-05	QU08-05	QU-08-05	QU-08-07	MW 08-07	QU-08-07	QU-08-07		QU-08-08	QU-08-08	QU08-08A	QU08-08A	QU08-08A	QU08-08A	QU08-08A
Field Alkalinity, Total (as CaCO3)	mg/L	-	-	-	-	-	-	-	-	159	-	-	-	-	-	-	-	-	-	-	-	-
Field Conductivity	uS/cm	324	379	399	307	333	142	169	860	308	309	285	192	315	194	320	160	546	480	283	296	206
Field Eh	mV	103.0	-66.0	-67.9	-31.6	-33.1	212.4	96.0	-61.0	-60.5	-70.0	-105	-37.9	-58.0	-80.4	130.0	17.2	76.3	-64.2	21.4	-81.8	-44.1
Field pH	pH	7.09	7.53	-	7.23	6.96	6.48	7.09	10.68	8.59	7.55	7.57	7.83	7.52	7.96	7.3	7.11	7.32	7.46	7.61	7.44	7.32
Field Temperature	C	7.93	7.42	8.92	8.15	7.93	8.33	7.46	10.27	7.09	9.05	8.44	9.24	9.11	8.45	8.64	8.21	8.05	13.36	8.99	7.84	8.19
Field Dissolved Oxygen (% Saturation)	%	-	-	-	-	-	-	-	5.5	12.7	-	-	-	-	-	-	-	40.8	4.7	-	-	-
Field Iron Species Tests																						
Field Dissolved Iron, Ferrous	mg/L	-	-	-	-	-	-	-	-	<0.020	-	-	-	-	-	-	-	-	-	-	-	-
Field Dissolved Iron, Total	mg/L	-	-	-	-	-	-	-	-	<0.030	-	-	-	-	-	-	-	-	-	-	-	-
Field Dissolved Iron, Ferric (calculated)	mg/L	-	-	-	-	-	-	-	-	<0.050	-	-	-	-	-	-	-	-	-	-	-	-
Physical Tests																						
Colour, True	CU	-	-	-	-	-	-	-	49.1		-	-	-	-	-	-	-	8.1	<5	-	-	
Conductivity	uS/cm	-	-	-	-	-	-	-	794	326	-	-	-	-	-	-	-	541	462	-	-	330
Hardness (as CaCO3)	mg/L	148	195	302	227	287	69.6	119	187	122	150	178	140	217	142	166	73.3	215	207	177	179	174
pH	pH	-	-	8.10	-	-	-	-	9.67	9.27	-	-	-	-	-	-	-	8.02	6.92	-	-	7.95
Total Suspended Solids	mg/L	-	-	-	-	-	-	-	10.0	54.5	-	-	-	-	-	-	-	111	20.0	-	-	5.00
Total Dissolved Solids	mg/L	-	-	-	-	-	-	-	572	223	-	-	-	-	-	-	-	378	307	-	-	205
TDS, Conductivity to TDS factor	-	0.647	0.647	0.647	0.647	0.647	0.647	0.647	0.720	0.684	0.647	0.647	0.647	0.647	0.647	0.647	0.647	0.699	0.665	0.647	0.647	0.621
TDS, Calculated from conductivity	mg/L	210	245	258	199	215	92	109	620	211	200	184	124	204	126	207	104	381	319	183	192	128
Turbidity	NTU	-	-	-	-	-	-	-	13.3	62.3	-	-	-	-	-	-	-	113	24.0	-	-	6.19
Anions and Nutrients																						
Acidity (as CaCO3) (pH 8.3)	mg/L	3.9	4.0	2.2	-		-	5.8	-	<1.0	-	3.7	-	-		-	4.2	-	-	-	-	3.4
Alkalinity, Total (as CaCO3)	mg/L	143	145	134	133	135	73.3	128	120	135	163	172	138	127	122	163	77.8	136	156	144	158	152
Ammonia as N	mg/L	-	-	-	-	-	-	-	0.062	0.0257	-	-	-	-	-	-	-	0.026	0.039	-	-	0.0949
Bromide (Br)	mg/L	<0.05	<0.05	<0.050	<0.050	<0.050	<0.050	<0.05	<0.50	<0.050	<0.050	<0.05	<0.050	<0.050	<0.050	<0.050	<0.05	<0.05	<0.05	<0.050	<0.050	<0.050
Chloride (Cl)	mg/L	<0.5	<0.5	0.51	0.50	0.53	0.79	<0.5	24.7	7.58	0.87	<0.5	0.36	0.46	0.31	0.59	<0.5	9.35	3.24	0.84	1.35	0.62
Fluoride (F)	mg/L	0.337	0.062	0.054	0.066	0.053	0.068	0.098	0.41	0.247	0.563	0.466	0.493	0.468	0.507	0.478	0.101	0.154	0.227	0.289	0.375	0.417
Nitrate (as N)	mg/L	-	-	<0.0050	<0.0050	<0.0050	<0.0050	-	<0.050	<0.0050	0.0467	-	0.0155	0.0181	0.0160	<0.0050	-	<0.005	<0.005	<0.0050	0.0095	0.0152
Nitrite (as N)	mg/L	-	-	<0.0010	<0.0010	<0.0010	<0.0010	-	<0.010	<0.0010	<0.0010	-	0.0112	<0.0010	0.0012	<0.0010	-	<0.001	<0.001	<0.0010	<0.0010	<0.0010
Total Kjeldahl Nitrogen	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Nitrogen	mg/L	-	-	-	-	-	-	-	-	0.180	-	-	-	-	-	-	-	-	-	-	-	0.15
Ortho Phosphate as P	mg/L	-	-	-	-	-	-	-	0.0323	-	-	-	-	-	-	-	-	0.0168	0.0179	-	-	-
Total Dissolved Phosphate As P	mg/L	-	-	-	-	-	-	-	-	0.246	-	-	-	-	-	-	-	-	-	-	-	0.0141
Total Phosphate as P	mg/L	-	-	-	-	-	-	-	0.093	0.358	-	-	-	-	-	-	-	0.084	0.0507	-	-	0.0272
Sulfate (SO4)	mg/L	9.37	79.1	162	104	162	3.33	7.03	255	31.4	6.39	38.2	15.8	95.8	31.9	12.4	27.1	136	99.5	47.1	42.7	25.9
Sulphide as S	mg/L	-	-	-	-	-	-	-	<0.02	0.0028	-	-	-	-	-	-	-	<0.020	<0.020	-	-	<0.020
Organic / Inorganic Carbon																						
Dissolved Organic Carbon	mg/L	-	-	-	-	-	-	-	-	11.0	-	-	-	-	-	-	-	-	-	-	-	1.69
Total Organic Carbon	mg/L	-	-	-	-	-	-	-	1.89	14.8	-	-	-	-	-	-	-	14.8	5.44	-	-	1.8
Total Metals																						
Aluminum (Al)-Total	mg/L	-	-	-	-	-	-	-	0.499	1.41	-	-	-	-	-	-	-	3.14	0.882	-	-	0.201
Antimony (Sb)-Total	mg/L	-	-	-	-	-	-	-	0.00121	0.00120	-	-	-	-	-	-	-	0.00037	0.00017	-	-	<0.00050
Arsenic (As)-Total	mg/L	-	-	-	-	-	-	-	0.0350	0.0277	-	-	-	-	-	-	-	0.0464	0.118	-	-	0.201
Barium (Ba)-Total	mg/L	-	-	-	-	-	-	-	0.0236	0.0400	-	-	-	-	-	-	-	0.147	0.109	-	-	0.115
Beryllium (Be)-Total	mg/L	-	-	-	-	-	-	-	<0.001	<0.00050	-	-	-	-	-	-	-	<0.0005	<0.0005	-	-	<0.0010
Bismuth (Bi)-Total	mg/L	-	-	-	-	-	-	-	<0.001	<0.00050	-	-	-	-	-	-	-	<0.0005	<0.0005	-	-	<0.20
Boron (B)-Total	mg/L	-	-	-	-	-	-	-	0.047	0.045	-	-	-	-	-	-	-	0.153	0.229	-	-	0.36
Cadmium (Cd)-Total	mg/L	-	-	-	-	-	-	-	<0.000034	0.000153	-	-	-	-	-	-	-	0.000067	0.000099	-	-	0.000045
Calcium (Ca)-Total	mg/L	-	-	-	-	-	-	-	73.5	46.2	-	-	-	-	-	-	-	66.5	60.9	-	-	50.3
Chromium (Cr)-Total	mg/L	-	-	-	-	-	-	-	0.0473	0.00257	-	-	-	-	-	-	-	0.00190	0.00061	-	-	0.0038
Cobalt (Co)-Total	mg/L	-	-	-	-	-	-	-	0.00070	0.00208	-	-	-	-	-	-	-	0.00321	0.00201	-	-	0.00183
Copper (Cu)-Total	mg/L	-	-	-	-	-	-	-	0.00924	0.00970	-	-	-	-	-	-	-	0.00291	0.00142	-	-	<0.0010
Iron (Fe)-Total	mg/L	-	-	-	-	-	-	-	0.412	2.87	-	-	-	-	-	-	-	3.14	0.861	-	-	0.19
Lead (Pb)-Total	mg/L	-	-	-	-	-	-	-	0.00027	0.00186	-	-	-	-	-	-	-	0.00139	0.000425	-	-	<0.00050
Lithium (Li)-Total	mg/L	-	-	-	-	-	-	-	<0.01	0.0056	-	-	-	-	-	-	-	0.0129	0.0191	-	-	0.0361
Magnesium (Mg)-Total	mg/L	-	-	-	-	-	-	-	0.34	2.31	-	-	-	-	-	-	-	12.0	11.1	-	-	9.97
Manganese (Mn)-Total	mg/L	-	-	-	-	-	-	-	0.0182	0.121	-	-	-	-	-	-	-	0.259	0.572	-	-	0.0938

Table C3: Groundwater Quality Data and Guidelines
7 South Mine Goundwater Evaluation - Quinsam Mine

Sample ID	Units	QU-01-07	QU-07-07				QU-08-05		QU-08-05		QU-08-07					QU-08-08		QU08-08A				
Type		borehole	borehole				borehole		well		borehole					borehole		well				
Date Sampled		24/11/2009	19/11/2009	21/07/2010	03/11/2010	27/01/2011	30/03/2009	19/11/2009	25/05/2010	24/01/2011	30/03/2009	18/11/2009	14/07/2010	02/11/2010	25/01/2011	31/03/2009	18/11/2009	28/04/2010	27/05/2010	15/07/2010	03/11/2010	27/01/2011
Mercury (Hg)-Total	mg/L	-	-	-	-	-	-	-	-	0.000018	-	-	-	-	-	-	-	-	-	-	-	<0.000010
Molybdenum (Mo)-Total	mg/L	-	-	-	-	-	-	-	0.0213	0.00456	-	-	-	-	-	-	-	0.00210	0.00205	-	-	0.0012
Nickel (Ni)-Total	mg/L	-	-	-	-	-	-	-	0.0038	0.00607	-	-	-	-	-	-	-	0.00563	0.00323	-	-	0.0031
Phosphorus (P)-Total	mg/L	-	-	-	-	-	-	-	<0.3	0.34	-	-	-	-	-	-	-	<0.3	<0.3	-	-	<0.030
Potassium (K)-Total	mg/L	-	-	-	-	-	-	-	8.0	3.2	-	-	-	-	-	-	-	2.5	<2	-	-	<2.0
Selenium (Se)-Total	mg/L	-	-	-	-	-	-	-	0.00412	0.00055	-	-	-	-	-	-	-	0.00053	<0.0005	-	-	<0.0010
Silicon (Si)-Total	mg/L	-	-	-	-	-	-	-	5.99	5.69	-	-	-	-	-	-	-	15.0	7.00	-	-	4.54
Silver (Ag)-Total	mg/L	-	-	-	-	-	-	-	<0.00002	0.000058	-	-	-	-	-	-	-	0.000023	0.000015	-	-	<0.000020
Sodium (Na)-Total	mg/L	-	-	-	-	-	-	-	107	28.8	-	-	-	-	-	-	-	39.1	28.5	-	-	8.9
Strontium (Sr)-Total	mg/L	-	-	-	-	-	-	-	0.250	0.147	-	-	-	-	-	-	-	0.337	0.425	-	-	0.543
Thallium (Tl)-Total	mg/L	-	-	-	-	-	-	-	<0.0002	0.00013	-	-	-	-	-	-	-	<0.0001	<0.0001	-	-	<0.00020
Tin (Sn)-Total	mg/L	-	-	-	-	-	-	-	0.00040	0.00058	-	-	-	-	-	-	-	0.00493	0.00031	-	-	<0.00050
Titanium (Ti)-Total	mg/L	-	-	-	-	-	-	-	0.020	0.060	-	-	-	-	-	-	-	0.222	0.076	-	-	0.016
Uranium (U)-Total	mg/L	-	-	-	-	-	-	-	0.00124	0.00911	-	-	-	-	-	-	-	0.00361	0.00237	-	-	0.00034
Vanadium (V)-Total	mg/L	-	-	-	-	-	-	-	0.0223	0.0063	-	-	-	-	-	-	-	0.0068	0.0021	-	-	0.0017
Zinc (Zn)-Total	mg/L	-	-	-	-	-	-	-	0.0058	0.0177	-	-	-	-	-	-	-	0.0266	0.0323	-	-	<0.0050
Dissolved Metals																						
Aluminum (Al)-Dissolved	mg/L	<0.01	<0.01	<0.0050	<0.0050	<0.0050	<0.0050	<0.01	0.322	0.0492	<0.0050	<0.01	<0.0050	<0.0050	<0.0050	<0.0050	0.015	-	0.0048	0.0091	<0.0050	0.0073
Antimony (Sb)-Dissolved	mg/L	0.00082	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.0005	0.00114	0.00069	<0.00050	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.0005	-	0.00010	<0.00050	<0.00050	<0.00050
Arsenic (As)-Dissolved	mg/L	0.128	0.0205	0.0187	0.0195	0.0210	0.00396	0.0092	0.0342	0.0285	0.369	0.366	0.361	0.387	0.311	0.400	0.0045	-	0.126	0.145	0.222	0.241
Barium (Ba)-Dissolved	mg/L	0.189	0.078	0.100	0.078	0.095	0.241	0.259	0.0195	0.0187	0.210	0.245	0.195	0.157	0.139	0.133	0.152	-	0.0687	0.079	0.110	0.108
Beryllium (Be)-Dissolved	mg/L	<0.005	<0.005	<0.0010	<0.0010	<0.0010	<0.0010	<0.005	<0.001	<0.00050	<0.0010	<0.005	<0.0010	<0.0010	<0.0010	<0.0010	<0.005	-	<0.0005	<0.0010	<0.0010	<0.0010
Bismuth (Bi)-Dissolved	mg/L	<0.2	<0.2	-	<0.20	<0.20	<0.20	<0.2	<0.001	<0.00050	<0.20	<0.2	<0.20	<0.20	<0.20	<0.20	0.2	-	<0.0005	<0.20	<0.20	<0.20
Boron (B)-Dissolved	mg/L	0.29	<0.1	<0.10	<0.10	<0.10	<0.10	0.14	0.041	0.043	0.64	0.60	0.57	0.58	0.50	0.41	0.18	-	0.227	0.28	0.35	0.36
Cadmium (Cd)-Dissolved	mg/L	<0.00005	<0.00005	<0.000017	<0.000017	<0.000017	<0.000017	<0.00005	0.000034	<0.000010	<0.000017	<0.00005	<0.000017	<0.000017	<0.000017	<0.000017	<0.00005	-	0.000021	0.000030	0.000026	0.000029
Calcium (Ca)-Dissolved	mg/L	46.2	54.5	82.9	62.4	78.6	22.8	40.4	74.6	45.2	43.0	51.3	39.4	63.0	41.1	49.6	21.5	-	63.7	53.1	54.6	52.8
Chromium (Cr)-Dissolved	mg/L	<0.0005	<0.0005	<0.0010	<0.0010	<0.0010	<0.0010	<0.0005	0.0455	0.00018	<0.0010	<0.0005	<0.0010	<0.0010	<0.0010	<0.0020	<0.0005	-	<0.0005	<0.0010	<0.0010	<0.0010
Cobalt (Co)-Dissolved	mg/L	<0.0005	<0.0005	<0.00030	<0.00030	<0.00030	<0.00030	<0.0005	0.00034	0.00022	0.0007	0.00078	0.00089	0.00058	0.00063	0.00115	0.00103	-	0.00159	0.00067	0.00043	0.00073
Copper (Cu)-Dissolved	mg/L	<0.001	<0.001	<0.0010	<0.0010	<0.0010	<0.0010	<0.001	0.00729	<0.00050	<0.0010	<0.001	<0.0010	<0.0010	<0.0010	<0.0010	0.001	-	0.00033	<0.0010	<0.0010	<0.0010
Iron (Fe)-Dissolved	mg/L	0.083	0.144	0.250	0.236	0.200	<0.030	<0.03	<0.03	<0.030	0.108	0.109	0.139	0.245	0.111	0.084	0.140	-	0.109	<0.030	0.109	<0.030
Lead (Pb)-Dissolved	mg/L	<0.001	<0.001	<0.00050	<0.00050	<0.00050	<0.00050	<0.001	<0.0001	<0.000050	<0.00050	<0.001	<0.00050	<0.00050	<0.00050	<0.00050	0.001	-	0.00005	<0.00050	<0.00050	<0.00050
Lithium (Li)-Dissolved	mg/L	<0.05	<0.05	<0.0050	0.0062	<0.0050	0.0258	<0.05	<0.01	0.0055	0.0551	0.064	0.0526	0.0509	0.0444	0.0408	0.05	-	0.0179	0.0259	0.0303	0.0328
Magnesium (Mg)-Dissolved	mg/L	7.91	14.4	23.0	17.4	22.0	3.07	4.38	0.28	2.19	10.4	12.1	10.0	14.6	9.55	10.2	4.74	-	11.7	10.8	10.3	10.2
Manganese (Mn)-Dissolved	mg/L	0.042	0.086	0.134	0.110	0.112	0.00483	<0.01	0.00088	0.0326	0.0237	0.027	0.0306	0.0533	0.0419	0.0446	0.038	-	0.537	0.234	0.155	0.086
Mercury (Hg)-Dissolved	mg/L	<0.0002	<0.0002	<0.000010	<0.000010	<0.000010	<0.000020	<0.0002	-	<0.000010	<0.000020	<0.0002	<0.000010	<0.000010	<0.000010	<0.000020	<0.0002	-	-	<0.000010	<0.000010	<0.000010
Molybdenum (Mo)-Dissolved	mg/L	0.0015	<0.001	<0.0010	<0.0010	<0.0010	<0.0010	<0.001	0.0214	0.00440	<0.0010	<0.001	<0.0010	<0.0010	<0.0010	0.0012	0.0011	-	0.00203	0.0011	<0.0010	0.0011
Nickel (Ni)-Dissolved	mg/L	<0.005	<0.005	<0.0010	0.0011	<0.0010	0.0025	<0.005	0.0032	0.00281	<0.0010	<0.005	<0.0010	0.0016	0.0012	0.0029	<0.005	-	0.00257	0.0012	<0.0010	0.0028
Phosphorus (P)-Dissolved	mg/L	<0.3	<0.3	-	<0.30	<0.030	<0.30	<0.3	<0.3	<0.30	<0.30	<0.3	<0.30	<0.30	<0.03	<0.30	<0.3	-	<0.3	<0.30	<0.30	<0.030
Potassium (K)-Dissolved	mg/L	<2	<2	<2.0	<2.0	<2.0	<2.0	<2	8.0	3.1	2.6	2.8	2.6	2.8	2.3	2.0	<2	-	<2	<2.0	<2.0	<2.0
Selenium (Se)-Dissolved	mg/L	<0.001	<0.001	<0.0010	<0.0010	<0.0010	<0.0010	<0.001	0.00431	0.00034	<0.0010	<0.001	<0.0010	<0.0010	<0.0010	<0.0010	<0.001	-	<0.0005	<0.0010	<0.0010	<0.0010
Silicon (Si)-Dissolved	mg/L	4.23	5.58	-	6.02	5.81	6.63	6.00	5.51	3.32	3.46	3.73	3.86	3.78	3.49	3.66	5.98	-	5.82	5.26	4.69	4.33
Silver (Ag)-Dissolved	mg/L	<0.00005	<0.00005	<0.000020	<0.000020	<0.000020	<0.000020	<0.00005	<0.00002	<0.000010	<0.000020	<0.00005	<0.000020	<0.000020	<0.000020	<0.000020	<0.00005					

Table C3: Groundwater Quality Data and Guidelines
7 South Mine Goundwater Evaluation - Quinsam Mine

Sample ID	Units	QU08-08B			QU08-10	QU08-13A			QU08-13B		QU-09-01					Effluent Permit PE-07008 ^a	BC CSR-AW ^{b, f}	BC WQG-AL ^{c, d, e, f}	BC WQG-AL ^{c, d, e, f}
Type		well			well	well			well		borehole							30 day	Max
Date Sampled		26/04/2010	27/05/2010	24/01/2011	26/05/2010	25/04/2010	27/05/2010	10/12/2010	25/04/2010	28/05/2010	08/04/2009	18/11/2009	15/07/2010	03/11/2010	27/01/2011				
Field Physical Tests		QU08-08B	QU08-08B	QU-08-08B	QU08-10	QU08-13A	QU08-13A	QU-08-13A	QU08-13B	QU08-13B	QU-09-01	MW 09-01	QU-09-01	QU-09-01					
Field Alkalinity, Total (as CaCO3)	mg/L	-	-	171	-	-	-	180	-	-	-	-	-	-	-				
Field Conductivity	uS/cm	251	635	307	594	277	288	221	255	264	271	311	186	249	210				
Field Eh	mV	70.5	-55.2	8	108.0	-74.9	-103.9	62.0	-62.4	-128.2	-96.0	-21.4	-17.8	-106.4	-137.2				
Field pH	pH	8.25	8.29	7.96	7.04	7.66	7.58	7.64	7.84	7.95	7.72	7.51	7.59	7.37	7.36	6.0 - 8.5			
Field Temperature	C	8.79	8.54	5.76	8.17	8.32	9.12	8.11	8.55	8.73	8.52	8.20	9.41	9.62	8.37				
Field Dissolved Oxygen (% Saturation)	%	23.7	1.8	6.3	6.3	1.5	1.8	1.0	0.9	1.7	-	-	-	-	-				
Field Iron Species Tests																			
Field Dissolved Iron, Ferrous	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-				
Field Dissolved Iron, Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-				
Field Dissolved Iron, Ferric (calculated)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-				
Physical Tests																			
Colour, True	CU	<5	5.9	-	13.8	<5	<5	-	<5	<5	-	-	-	-	-				
Conductivity	uS/cm	243	648	305	574	273	283	309	248	262	-	-	-	-	-				
Hardness (as CaCO3)	mg/L	36.6	31.8	14.2	250	19.2	119	125	70.1	78.0	157	184	135	173	155				
pH	pH	8.22	7.41	8.44	7.34	8.19	7.74	8.25	8.24	7.53	-	-	-	-	-	6.0 - 8.5		6.5-9	NP
Total Suspended Solids	mg/L	1620	6470	5460	224	5.5	4.5	4.9	18.0	104	-	-	-	-	-	25		5	25
Total Dissolved Solids	mg/L	220	626	248	387	164	164	179	156	193	-	-	-	-	-				
TDS, Conductivity to TDS factor	-	0.905	0.966	0.813	0.674	0.601	0.580	0.579	0.629	0.737	0.647	0.647	0.647	0.647	0.647				
TDS, Calculated from conductivity	mg/L	-	-	-	400	166	167	128	160	194	175	201	120	161	136				
Turbidity	NTU	936	>4000	>4000	191	22.0	7.97	6.90	21.3	230	-	-	-	-	-			2	8
Anions and Nutrients																			
Acidity (as CaCO3) (pH 8.3)	mg/L	-	-	<1.0	-	-	-	-	-	-	-	4.7	-	-	-				
Alkalinity, Total (as CaCO3)	mg/L	77.4	161	147	192	143	146	151	131	155	158	180	134	160	142			NP	10 ^g
Ammonia as N	mg/L	0.045	<0.010	0.02	0.012	0.154	0.120	0.151	0.129	0.088	-	-	-	-	-	1.0	11.3 ^h	1.85 ^h	12.7 ^h
Bromide (Br)	mg/L	<0.05	<0.50	<0.050	<0.05	<0.05	<0.05	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050				
Chloride (Cl)	mg/L	1.14	<50	0.52	5.28	0.63	0.62	4.10	0.56	0.70	0.67	<0.50	0.45	0.55	0.51		1500	150	600
Fluoride (F)	mg/L	0.167	0.430	0.659	0.217	0.483	0.584	0.569	0.340	0.363	0.542	0.494	0.543	0.552	0.621		2 ⁱ	NP	0.2 ⁱ
Nitrate (as N)	mg/L	0.0156	<0.050	<0.0050	0.0113	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	-	0.0814	0.0538	<0.0050		400	3	32.8
Nitrite (as N)	mg/L	0.0012	<0.010	<0.0010	<0.001	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.0018	-	0.0219	0.0060	<0.0010		0.2 ^j	0.02 ^j	0.06 ^j
Total Kjeldahl Nitrogen	mg/L	-	-	-	-	-	-	0.173	-	-	-	-	-	-	-				
Total Nitrogen	mg/L	-	-	<0.50	-	-	-	-	-	-	-	-	-	-	-				
Ortho Phosphate as P	mg/L	0.0055	0.0456	-	0.0159	0.0210	0.0272	0.0083	0.0215	0.0304	-	-	-	-	-				
Total Dissolved Phosphate As P	mg/L	-	-	0.0933	-	-	-	0.0105	-	-	-	-	-	-	-	0.03			
Total Phosphate as P	mg/L	0.119	0.85	0.34	0.227	0.0362	0.0361	0.0337	0.0479	0.132	-	-	-	-	-				
Sulfate (SO4)	mg/L	47.0	162	22.1	112	9.55	10.8	10.3	8.39	9.76	13.0	36.0	9.84	25.8	37.2		1000	50	100
Sulphide as S	mg/L	<0.020	<0.020	0.0053	<0.020	<0.020	0.036	0.151	<0.020	<0.020	-	-	-	-	-		0.02		0.002 ^g
Organic / Inorganic Carbon																			
Dissolved Organic Carbon	mg/L	-	-	5.56	-	-	-	3.22	-	-	-	-	-	-	-				
Total Organic Carbon	mg/L	2.68	17.0	13.1	8.22	0.66	0.81	3.34	0.53	1.16	-	-	-	-	-				
Total Metals																			
Aluminum (Al)-Total	mg/L	34.5	106	84.6	2.97	0.916	0.0839	0.0463	2.22	6.19	0.272	-	-	-	-				
Antimony (Sb)-Total	mg/L	0.00079	<0.0010	<0.00020	0.00044	0.00044	<0.0001	<0.00010	0.00015	0.00068	0.00162	-	-	-	-				
Arsenic (As)-Total	mg/L	0.00985	0.0663	0.2050	0.00809	0.412	0.433	0.524	0.387	0.448	0.333	-	-	-	-				
Barium (Ba)-Total	mg/L	0.0978	0.463	0.493	0.116	0.0890	0.112	0.138	0.0412	0.0747	0.146	-	-	-	-				
Beryllium (Be)-Total	mg/L	0.0054	0.0155	0.0135	<0.0005	<0.0005	<0.0005	<0.00050	<0.0005	<0.0005	<0.0010	-	-	-	-				
Bismuth (Bi)-Total	mg/L	<0.0025	<0.005	0.0031	<0.0005	<0.0005	<0.0005	<0.00050	<0.0005	<0.0005	<0.20	-	-	-	-				
Boron (B)-Total	mg/L	0.109	0.25	0.29	0.164	0.311	0.340	0.377	0.354	0.257	0.48	-	-	-	-				
Cadmium (Cd)-Total	mg/L	0.000091	0.00052	0.00056	0.000276	0.000022	<0.000017	<0.000017	0.000021	0.000042	0.000026	-	-	-	-				
Calcium (Ca)-Total	mg/L	48.0	123	146	75.3	26.6	33.5	37.4	22.0	26.9	45.1	-	-	-	-				
Chromium (Cr)-Total	mg/L	0.0045	0.0167	0.0148	0.00250	0.00135	<0.0005	0.00228	0.00244	0.0114	0.0137	-	-	-	-				
Cobalt (Co)-Total	mg/L	0.00407	0.0239	0.0141	0.0117	0.00082	0.00036	0.00012	0.00146	0.00581	0.00616	-	-	-	-				
Copper (Cu)-Total	mg/L	0.0124	0.0490	0.0352	0.00855	0.00186	0.00037	<0.00050	0.00396	0.0181	0.0267	-	-	-	-				
Iron (Fe)-Total	mg/L	8.97	34.7	28.7	6.33	0.886	0.266	0.374	1.75	9.91	4.55	-	-	-	-				
Lead (Pb)-Total	mg/L	0.0268	0.0905	0.0910	0.00218	0.000145	0.000087	<0.000050	0.000396	0.000835	<0.00050	-	-	-	-				
Lithium (Li)-Total	mg/L	<0.025	<0.05	0.044	<0.005	0.0336	0.0368	0.0360	0.0190	0.0219	0.0481	-	-	-	-				
Magnesium (Mg)-Total	mg/L	9.89	28.8	22.5	13.6	5.81	7.65	7.76	4.04	7.03	10.5	-	-	-	-				
Manganese (Mn)-Total	mg/L	0.184	1.50	1.45	0.846	0.113	0.129	0.0593	0.137	0.245	0.0772	-	-	-	-				

Table C3: Groundwater Quality Data and Guidelines
7 South Mine Goundwater Evaluation - Quinsam Mine

Sample ID	Units	QU08-08B			QU08-10	QU08-13A			QU08-13B		QU-09-01					Effluent Permit PE-07008 ^a	BC CSR-AW ^{b, f}	BC WQG-AL ^{c, d, e, f}	BC WQG-AL ^{c, d, e, f}
Type		well			well	well			well		borehole							30 day	Max
Date Sampled		26/04/2010	27/05/2010	24/01/2011	26/05/2010	25/04/2010	27/05/2010	10/12/2010	25/04/2010	28/05/2010	08/04/2009	18/11/2009	15/07/2010	03/11/2010	27/01/2011				
Mercury (Hg)-Total	mg/L	-	-	<0.00010	-	-	-	-	-	-	<0.000020	-	-	-	-				
Molybdenum (Mo)-Total	mg/L	0.00077	0.00221	0.00083	0.00346	0.00209	0.00130	0.00121	0.00371	0.00299	0.0049	-	-	-	-				
Nickel (Ni)-Total	mg/L	0.0058	0.0267	0.0189	0.0119	0.00162	0.00071	0.00110	0.00252	0.00854	0.0153	-	-	-	-				
Phosphorus (P)-Total	mg/L	<0.3	0.66	0.81	<0.3	<0.3	<0.3	<0.30	<0.3	<0.3	<0.30	-	-	-	-				
Potassium (K)-Total	mg/L	3.6	9.2	8.9	3.6	<2	2.2	<2.0	<2	2.3	2.5	-	-	-	-				
Selenium (Se)-Total	mg/L	<0.0005	0.00057	0.00020	<0.0005	<0.0005	<0.0005	<0.00040	<0.0005	<0.0005	<0.0010	-	-	-	-				
Silicon (Si)-Total	mg/L	75.6	203	144	11.9	4.65	3.83	3.78	7.85	21.5	4.34	-	-	-	-				
Silver (Ag)-Total	mg/L	<0.00005	<0.0001	0.000049	0.000039	<0.00001	<0.00001	<0.000010	<0.00001	0.000042	0.000104	-	-	-	-				
Sodium (Na)-Total	mg/L	38.7	135	072	40.1	20.3	20.9	22.6	31.2	32.6	8.5	-	-	-	-				
Strontium (Sr)-Total	mg/L	0.348	1.02	1.33	0.318	0.340	0.401	0.418	0.158	0.169	0.746	-	-	-	-				
Thallium (Tl)-Total	mg/L	<0.0005	0.0011	0.0012	<0.0001	<0.0001	<0.0001	<0.00010	<0.0001	<0.0001	<0.00020	-	-	-	-				
Tin (Sn)-Total	mg/L	<0.0005	<0.001	<0.00020	0.00025	<0.0001	<0.0001	0.00014	0.00015	<0.0001	0.00150	-	-	-	-				
Titanium (Ti)-Total	mg/L	0.070	0.099	0.095	0.095	0.049	<0.01	<0.010	0.084	0.607	0.016	-	-	-	-				
Uranium (U)-Total	mg/L	0.0105	0.0337	0.0257	0.00615	0.000330	0.000341	0.000033	0.000489	0.000235	<0.00020	-	-	-	-				
Vanadium (V)-Total	mg/L	0.0190	0.065	0.052	0.0068	0.0026	<0.001	<0.0010	0.0049	0.0243	0.0063	-	-	-	-				
Zinc (Zn)-Total	mg/L	0.0462	0.153	0.115	0.0120	0.0025	0.0024	<0.0030	0.0046	0.0176	0.0123	-	-	-	-				
Dissolved Metals																			
Aluminum (Al)-Dissolved	mg/L	<0.005	0.291	0.540	0.0051	0.0085	0.0038	<0.0030	0.0112	0.0097	<0.0050	<0.010	<0.0050	<0.0050	<0.0050	0.5		0.05 ^b	0.1 ^b
Antimony (Sb)-Dissolved	mg/L	0.00176	0.0018	0.0002	0.00036	0.00025	<0.0001	<0.00010	<0.0001	0.00016	0.00159	<0.00050	0.00077	<0.00050	<0.00050		0.2	NP	0.02 ^g
Arsenic (As)-Dissolved	mg/L	0.00596	0.0134	0.1430	0.00126	0.426	0.468	0.544	0.419	0.475	0.314	0.324	0.197	0.243	0.316		0.05	NP	0.005
Barium (Ba)-Dissolved	mg/L	0.00675	0.0185	0.0078	0.0612	0.0814	0.103	0.133	0.0317	0.0311	0.138	0.183	0.356	0.305	0.217		10	1 ^g	5 ^g
Beryllium (Be)-Dissolved	mg/L	<0.0025	<0.005	<0.0010	<0.0005	<0.0005	<0.0005	<0.00050	<0.0005	<0.0005	<0.0010	<0.0050	<0.0010	<0.0010	<0.0010		0.053	0.0053 ^g	NP
Bismuth (Bi)-Dissolved	mg/L	<0.0025	<0.005	<0.0010	<0.0005	<0.0005	<0.0005	<0.00050	<0.0005	<0.0005	<0.20	<0.20	<0.20	<0.20	<0.20				
Boron (B)-Dissolved	mg/L	0.082	0.17	0.20	0.160	0.299	0.310	0.361	0.328	0.242	0.51	0.57	0.62	0.70	0.68		50	NP	1.2
Cadmium (Cd)-Dissolved	mg/L	0.000085	<0.00017	<0.000020	0.000093	<0.000017	<0.000017	<0.000017	<0.000017	<0.000017	<0.000017	<0.000050	<0.000017	<0.000017	0.000019		0.0003	NP	0.000017 ⁱ
Calcium (Ca)-Dissolved	mg/L	12.1	10.8	04.1	78.1	29.4	35.0	37.4	22.2	24.8	45.6	53.3	37.2	48.7	43.0			NP	4
Chromium (Cr)-Dissolved	mg/L	<0.0025	<0.005	0.0002	<0.0005	<0.0005	<0.0005	<0.00050	<0.0005	<0.0005	<0.0010	<0.00050	<0.0010	<0.0010	<0.0010		0.01	NP	0.001 ^g
Cobalt (Co)-Dissolved	mg/L	<0.0005	<0.001	<0.00020	0.00300	0.00033	0.00031	<0.00010	0.00038	0.00022	0.00453	0.00118	0.00301	0.00275	0.00519		0.04	0.004	0.11
Copper (Cu)-Dissolved	mg/L	0.00100	0.0015	<0.0010	0.00134	0.00045	<0.0001	<0.00050	<0.0001	<0.0001	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.02	0.02 ⁱ	0.002 ⁱ	0.006 ⁱ
Iron (Fe)-Dissolved	mg/L	<0.03	0.180	0.674	<0.03	0.03	0.117	0.294	<0.03	0.039	0.158	0.086	0.097	0.126	0.403	0.5		NP	0.35
Lead (Pb)-Dissolved	mg/L	<0.00025	0.00153	0.00033	0.000068	<0.00005	<0.00005	<0.000050	<0.00005	<0.00005	<0.00050	<0.0010	<0.00050	<0.00050	<0.00050	0.05	0.04 ⁱ	0.004 ⁱ	0.030 ⁱ
Lithium (Li)-Dissolved	mg/L	<0.025	<0.05	0.012	<0.005	0.0314	0.0336	0.0351	0.0164	0.0168	0.0504	0.062	0.0623	0.0577	0.0503			0.096	0.87
Magnesium (Mg)-Dissolved	mg/L	1.55	1.17	0.95	13.2	5.80	7.79	7.64	3.56	3.89	10.4	12.3	10.2	12.4	11.5				
Manganese (Mn)-Dissolved	mg/L	0.00648	0.125	0.040	0.622	0.0931	0.129	0.0531	0.0886	0.0796	0.0386	0.029	0.0220	0.0414	0.0519			0.8 ⁱ	1.0 ⁱ
Mercury (Hg)-Dissolved	mg/L	-	-	<0.000010	-	-	-	-	-	-	<0.000020	<0.00020	<0.000010	<0.000010	<0.000010		0.001	0.00002	NP
Molybdenum (Mo)-Dissolved	mg/L	0.00087	0.00285	0.00109	0.00313	0.00203	0.00127	0.00106	0.00340	0.00327	0.0039	<0.0010	<0.0010	<0.0010	<0.0010		10	1	2
Nickel (Ni)-Dissolved	mg/L	0.0025	<0.005	<0.0010	0.00679	0.00071	0.00056	<0.00050	0.00076	<0.0005	0.0066	<0.0050	0.0073	0.0038	0.0027		0.25 ⁱ	NP	0.025 ^{g, i}
Phosphorus (P)-Dissolved	mg/L	<0.3	<0.3	<0.30	<0.3	<0.3	<0.3	<0.30	<0.3	<0.3	<0.30	<0.30	<0.30	<0.30	<0.30	0.03			
Potassium (K)-Dissolved	mg/L	<2	<2	<2.0	3.2	<2	2.3	<2.0	<2	<2	2.5	2.8	3.4	3.2	2.9			NP	373 ^g
Selenium (Se)-Dissolved	mg/L	<0.0005	<0.0005	<0.00020	<0.0005	<0.0005	<0.0005	<0.00040	<0.0005	<0.0005	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010		0.01	0.002	NP
Silicon (Si)-Dissolved	mg/L	5.35	6.05	10.80	5.16	3.34	3.79	3.72	4.06	4.21	3.94	4.02	3.89	3.47	3.43				
Silver (Ag)-Dissolved	mg/L	<0.00005	<0.0001	<0.000020	<0.00001	<0.00001	<0.00001	<0.000010	<0.00001	<0.00001	<0.000020	<0.000050	<0.000020	<0.000020	<0.000020		0.0005 ⁱ	0.00005 ⁱ	0.0001 ⁱ
Sodium (Na)-Dissolved	mg/L	40.1	142	068	40.2	20.9	20.7	21.6	31.4	31.4	8.4	10.6	9.3	9.8	10.5				
Strontium (Sr)-Dissolved	mg/L	0.114	0.110	0.060	0.298	0.330	0.378	0.392	0.141	0.144	0.742	0.860	0.841	1.03	0.934				
Thallium (Tl)-Dissolved	mg/L	<0.0005	<0.001	<0.00020	<0.0001	<0.0001	<0.0001	<0.00010	<0.0001	<0.0001	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020		0.003	0.0008 ^g	0.0003 ^g
Tin (Sn)-Dissolved	mg/L	<0.0005	<0.001	<0.00020	<0.0001	<0.0001	<0.0001	<0.00010	<0.0001	<0.0001	<0.00050	<0.030	<0.00050	<0.00050	<0.00050				
Titanium (Ti)-Dissolved	mg/L	<0.01	<0.01	0.049	<0.01	<0.01	<0.01	<0.010	<0.01	<0.01	<0.010	<0.050	<0.010	<0.010	<0.010		1	NP	2 ^g
Uranium (U)-Dissolved	mg/L	0.00231	0.00880	0.00304	0.00524	0.000288	0.000312	0.000028	0.000324	0.000117	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020		3	NP	0.3 ^g
Vanadium (V)-Dissolved	mg/L	<0.005	<0.01	0.0051	<0.001	<0.001	<0.001	<0.0010	<0.001	<0.001	<0.0010	<0.030	<0.0010	<0.0010	<0.0010			NP	0.006 ^g
Zinc (Zn)-Dissolved	mg/L	<0.005	<0.01	<0.0060	0.0043	<0.001	<0.001	0.0046	<0.001	<0.001	<0.0050	0.0841	<0.0050	<0.0050	0.0055	0.2	0.075 ⁱ	0.0075 ⁱ	0.033 ⁱ

Results preceded by "<" are below the reported detection limit

Results in *italics* exceed a BC WQG-AL guideline; results in

^a BC Permit PE-07008: British Columbia Ministry of Environment

^b CSR-AW: British Columbia Environmental Management Act

^c BC WQG-AL: British Columbia Ministry of Environment Act

^d BC WQG-AL is intended for surface waters, they are included

^e BC WQG-AL total metal guidelines are compared to dissolved

^f Receiving water quality is modelled on Middle Quinsam Lake

^g Working guideline.

^h Temperature and/or pH dependant guideline.

ⁱ Hardness dependant guideline.

^j Chloride dependant guideline.

Appendix D: Quinsam River Data

Appendix D1: Hydrology Records

Appendix D2: Background Water Quality Data



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***Appendix D1:
Hydrology Records***

Table D1-1 - Water Survey of Canada monthly flow data at Quinam River Diversion for the 1997-2009 period of record.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1997	3.2	3.3	3.6	2.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1998	0.1	0.0	0.0	0.1	3.4	1.8	0.2	0.0	0.0	0.0	3.0	5.5
1999	4.9	1.8	0.1	3.7	2.7	0.1	0.1	0.1	0.1	0.0	0.0	0.1
2000	3.0	3.3	1.8	2.4	2.3	2.0	0.0	0.0	0.0	0.0	0.0	0.0
2001	3.3	0.0	0.2	0.8	2.5	1.8	0.0	0.0	0.0	0.2	2.4	0.0
2002	0.0	0.3	1.3	2.4	2.8	2.0	0.1	0.0	0.0	0.0	1.3	3.3
2003	4.1	2.0	0.9	1.3	1.1	1.2	0.4	0.2	0.0	0.0	0.0	0.1
2004	0.4	2.4	2.7	3.3	2.7	1.3	0.3	0.0	0.0	0.0	3.6	2.3
2005	0.1	0.0	0.0	0.8	0.3	1.5	0.7	0.0	0.0	0.0	2.2	2.3
2006	0.5	1.9	1.5	3.5	3.6	2.3	0.1	0.1	0.0	0.0	0.9	3.2
2007	1.6	2.8	3.0	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2008	2.8	0.1	0.1	0.5	4.2	3.0	0.0	0.0	0.0	0.0	0.0	1.6
2009	1.5	0.1	1.6	2.5	3.0	0.5	0.0	0.0	0.0	0.1	1.0	0.0
Mean	2.0	1.4	1.3	1.9	2.2	1.3	0.2	0.0	0.0	0.0	1.1	1.4
Min	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Max	4.9	3.3	3.6	3.7	4.2	3.0	0.7	0.2	0.1	0.2	3.6	5.5

Table D2 - Water Survey of Canada monthly flow data at Quinam River at Argonaut Bridge for the 1997-2009 period of record.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1997	0.6	0.5	1.1	0.4	5.2	3.0	2.1	0.7	0.9	8.8	8.2	4.1
1998	8.8	6.8	3.4	1.6	0.6	0.5	0.5	0.5	1.4	1.2	1.0	1.1
1999	0.9	3.1	4.7	0.4	2.9	7.0	3.8	1.6	1.5	1.5	4.7	5.0
2000	1.2	0.4	0.4	0.4	0.4	0.4	0.9	0.5	1.0	0.7	0.7	0.5
2001	1.1	0.8	1.8	1.8	0.8	0.5	0.4	0.6	1.8	1.4	4.5	4.0
2002	6.8	1.4	0.5	1.4	0.5	0.4	0.5	0.5	1.4	0.9	0.9	2.0
2003	2.8	0.4	4.8	5.9	2.0	1.2	0.4	0.9	1.7	4.3	1.9	4.2
2004	5.0	0.7	0.8	0.4	0.4	0.5	0.4	0.4	1.3	1.8	3.4	2.8
2005	5.6	2.5	1.5	3.5	2.9	0.4	0.4	1.3	1.8	1.8	2.1	2.8
2006	6.5	1.4	0.9	0.8	0.9	0.5	1.2	0.9	1.3	1.0	4.0	3.2
2007	6.1	1.2	4.1	2.7	4.8	3.4	1.5	1.5	1.9	2.7	6.6	4.1
2008	1.4	1.8	1.9	1.5	0.6	0.5	1.1	1.0	1.0	1.0	1.5	0.5
2009	0.6	1.1	0.7	1.7	0.6	0.8	0.9	0.9	0.9	0.9	10.3	2.8
Mean	3.6	1.7	2.0	1.7	1.7	1.5	1.1	0.9	1.4	2.1	3.8	2.9
Min	0.6	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.9	0.7	0.7	0.5
Max	8.8	6.8	4.8	5.9	5.2	7.0	3.8	1.6	1.9	8.8	10.3	5.0

Table D3 - Water Survey of Canada monthly flow data at Quinam River below Lower Quinsam Lake for the 1997-2009 period of record.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1997	8.9	5.6	8.2	4.6	8.9	4.3	3.6	0.8	2.9	25.1	18.4	12.1
1998	28.0	22.5	8.2	4.3	3.4	1.7	0.9	0.5	1.2	2.5	12.5	10.0
1999	12.4	17.0	14.4	6.8	7.7	13.0	6.2	1.9	1.6	2.6	14.7	12.7
2000	3.6	5.7	4.0	2.7	2.5	2.5	1.1	0.6	1.0	2.1	3.2	5.2
2001	6.6	3.1	3.7	4.2	2.9	1.8	0.5	0.6	2.0	2.9	15.9	13.2
2002	19.1	4.6	3.7	4.6	2.6	1.1	0.8	0.4	1.6	1.1	8.1	14.9
2003	16.1	3.3	17.2	17.6	4.8	2.5	0.6	0.7	1.8	12.6	3.5	14.5
2004	13.1	5.7	5.3	3.5	2.3	1.0	0.6	0.4	1.8	3.1	16.3	9.5
2005	14.9	5.8	3.4	8.1	6.2	2.6	1.5	1.3	2.0	5.4	10.8	14.8
2006	24.7	10.6	10.0	5.4	4.0	2.0	1.4	0.8	1.5	1.6	17.8	17.1
2007	18.2	6.4	12.1	6.7	8.2	5.2	2.2	1.9	2.3	10.1	19.1	11.4
2008	10.8	4.6	6.3	4.4	4.7	2.4	1.1	1.0	1.0	2.0	6.4	3.5
2009	3.6	3.2	5.3	5.4	3.6	1.2	1.4	0.8	1.0	2.1	26.9	8.7
Mean	13.8	7.5	7.8	6.0	4.8	3.2	1.7	0.9	1.7	5.6	13.4	11.3
Min	3.6	3.1	3.4	2.7	2.3	1.0	0.5	0.4	1.0	1.1	3.2	3.5
Max	28.0	22.5	17.2	17.6	8.9	13.0	6.2	1.9	2.9	25.1	26.9	17.1

Table D4 - Water Survey of Canada monthly flow data at Quinam River near Campbell River for the 1997-2009 period of record.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1997	13.5	9.0	12.3	7.5	11.1	6.5	5.2	2.6	5.1	26.8	26.0	16.4
1998	31.0	27.0	10.8	6.1	5.3	3.8	2.3	1.7	2.3	4.4	16.1	14.6
1999	17.6	24.5	18.0	8.6	8.5	13.0	7.5	3.3	2.9	4.3	17.5	16.3
2000	6.7	9.6	7.4	4.4	3.9	4.1	2.6	1.7	2.1	3.7	4.6	8.1
2001	9.0	5.7	5.4	6.0	4.4	3.2	1.6	1.9	3.0	5.0	17.8	18.7
2002	21.1	8.2	6.8	6.8	4.1	2.4	2.0	1.6	2.9	3.1	9.8	16.8
2003	18.5	5.1	17.9	17.9	6.0	3.2	1.5	1.6	2.9	13.6	5.5	17.8
2004	16.6	10.9	9.3	5.8	4.0	2.3	1.6	1.4	3.5	6.4	20.7	14.1
2005	17.3	9.0	6.2	11.9	7.2	3.8	2.8	2.4	3.3	8.1	12.8	14.9
2006	27.8	14.4	14.6	8.7	7.4	3.3	3.2	2.8	2.6	2.9	17.8	21.0
2007	19.0	10.2	14.3	8.8	9.3	6.4	3.3	3.0	3.2	11.6	19.2	14.7
2008	15.0	8.1	8.4	5.8	5.9	3.6	2.4	2.3	2.2	3.8	10.7	6.8
2009	7.7	5.8	8.0	6.7	4.7	2.2	2.5	2.0	2.2	4.1	31.9	10.6
Mean	17.0	11.4	10.7	8.1	6.3	4.4	3.0	2.2	2.9	7.5	16.2	14.7
Min	6.7	5.1	5.4	4.4	3.9	2.2	1.5	1.4	2.1	2.9	4.6	6.8
Max	31.0	27.0	18.0	17.9	11.1	13.0	7.5	3.3	5.1	26.8	31.9	21.0

Table D5 - Summary of stage and discharge measurements collected near the mine site record.

Station	WB Stage (m)	WB Discharge (m3/s)	LLO Stage (m)	LLO Discharge (m3/s)	WA _s Stage (m)	WA Discharge (m3/s)*
April 7, 1997	0.58	1.25	0.34	0.38	0.46	0.362
April 14, 1997	0.57	1.4	0.32	0.3	0.46	0.356
April 21, 1997	0.56	1.3	0.29	0.23	0.46	0.371
April 29, 1997	0.54	1.15	0.28	0.21	0.46	0.365
May 5, 1997	0.89	6.3	0.30	0.26	0.86	6.19
May 12, 1997	0.90	6.8	0.30	0.26	0.90	6.5
May 20, 1997	0.90	6.8	0.18	0.054	0.80	4.84
May 27, 1997	0.80	6.8	0.17	0.044	0.75	3.58
June 2, 1997	0.88	6	0.18	0.054	0.78	4.3
June 9, 1997	0.78	4.2	0.17	0.044	0.70	2.73
June 16, 1997	0.77	3.9	0.13	0.02	0.69	2.55
June 23, 1997	0.76	3.7	0.16	0.036	0.68	2.63
July 14, 1997	0.76	3.7	0.20	0.07	0.68	2.53
July 21, 1997	0.76	3.7	-	-	-	2.05
July 28, 1997	0.56	1.3	0.12	0.015	0.56	1.11
August 5, 1997	0.50	0.9	0.11	0.012	0.50	0.7
August 11, 1997	0.49	0.86	0.10	0	0.50	0.7
August 18, 1997	0.48	0.83	0.08	0	0.50	0.7
August 25, 1997	0.48	0.83	0.09	0	0.50	0.714
September 2, 1997	0.49	0.86	0.14	0.024	0.50	0.707
September 8, 1997	0.49	0.86	0.12	0.015	0.50	0.71
September 15, 1997	0.46	0.7	0.12	0.015	0.50	0.753
September 29, 1997	0.64	2	0.37	0.48	0.55	1.09
October 30, 1997	1.15	14.5	0.43	0.76	1.10	13.5
November 3, 1997	1.40	28	0.47	0.99	1.40	22.3
November 5, 1997	1.50	38	-	-	-	18.3
November 7, 1997	1.50	38	-	-	-	12.8
November 10, 1997	1.12	14	0.44	0.8	0.87	5.82
November 12, 1997	0.99	9.1	-	-	-	3.94
November 17, 1997	0.77	3.9	0.32	0.3	0.62	1.83
November 24, 1997	0.87	5.8	0.38	0.51	0.85	5.25
November 27, 1997	1.08	12	-	-	-	6.41
December 1, 1997	1.40	28	0.50	1.2	1.10	11.1
December 8, 1997	0.88	6	0.35	0.41	0.68	2.74
December 15, 1997	0.95	7.6	0.40	0.62	0.84	5.45
December 19, 1997	0.87	5.6	-	-	-	0.628
December 22, 1997	0.85	5.4	0.48	1.08	0.45	0.51
January 5, 1998	1.01	9.9	0.38	0.51	0.80	4.84
January 12, 1998	0.78	4.2	0.27	0.19	0.61	1.89
January 19, 1998	1.25	19.5	0.65	2.6	0.90	6.56
February 11, 1998	1.15	14.5	-	-	-	6.41
February 16, 1998	1.32	24	0.49	1.15	0.95	7.47
February 27, 1998	0.90	6.8	-	-	-	3.46
March 2, 1998	0.77	3.9	0.36	0.44	-	2.52
March 5, 1998	0.72	3.1	0.34	0.38	0.60	1.92
March 9, 1998	0.65	2.8	0.29	0.23	0.60	1.53
March 11, 1998	0.65	2.8	-	-	-	1.45
March 16, 1998	0.90	6.8	0.35	0.41	0.83	5.18
March 23, 1998	0.78	4.2	0.27	0.19	0.77	4.06
March 30, 1998	0.83	4.8	0.36	0.44	0.73	3.34
April 6, 1998	0.7	2.8	0.29	0.23	0.63	1.87
April 10, 1998	0.61	1.75	0.26	0.16	0.59	1.53

Table D5 - Summary of stage and discharge measurements collected near the mine site record.

Station	WB Stage (m)	WB Discharge (m3/s)	LLO Stage (m)	LLO Discharge (m3/s)	WA _s Stage (m)	WA Discharge (m3/s)*
April 20, 1998	0.6	1.7	0.24	0.13	0.58	1.3
May 5, 1998	0.49	0.82	0.16	0.034	0.48	0.559
May 12, 1998	0.48	0.76	0.11	0.012	0.48	0.56
May 19, 1998	0.5	0.9	0.18	0.048	0.48	0.556
May 25, 1998	0.47	0.72	0.16	0.034	0.48	0.546
June 1, 1998	0.47	0.72	0.16	0.034	0.475	0.545
June 8, 1998	0.45	0.62	0.12	0.014	0.48	0.545
June 16, 1998	0.45	0.62	0.13	0.018	0.48	0.545
June 22, 1998	0.47	0.72	0.14	0.025	0.47	0.545
June 29, 1998	0.48	0.76	0.16	0.034	0.47	0.552
July 4, 1998	0.48	0.76	0.16	0.034	0.47	0.549
July 13, 1998	0.47	0.72	0.14	0.025	0.47	0.535
July 20, 1998	0.44	0.55	0.21	0.08	-	0.521
July 28, 1998	0.44	0.55	0.08	0	0.45	0.509
August 4, 1998	0.44	0.55	NO FLOW	-	0.47	0.508
August 14, 1998	0.44	0.55	NO FLOW	-	0.47	0.509
August 31, 1998	0.44	0.55	NO FLOW	-	-	0.483
September 4, 1998	0.44	0.55	NO FLOW	-	0.47	0.475
September 10, 1998	0.44	0.55	NO FLOW	-	0.47	2.12
September 17, 1998	0.44	0.55	NO FLOW	-	0.47	1.81
September 28, 1998	0.6	1.7	NO FLOW	-	0.6	1.46
October 1, 1998	0.6	1.7	0.1	0	0.61	1.82
October 13, 1998	0.6	1.7	0.16	0.034	0.5	0.944
October 19, 1998	0.6	1.7	0.27	0.18	0.58	1.15
October 26, 1998	0.55	1.4	0.19	0.058	0.55	0.993
November 2, 1998	0.55	1.4	0.2	0.07	0.55	1.02
November 16, 1998	0.76	3.6	0.55	1.65	0.52	0.796
November 23, 1998	0.77	3.9	0.55	1.65	0.5	0.504
November 27, 1998	1.05	10.25	0.7	1.32	0.48	2.76
December 7, 1998	0.67	2.95	0.35	0.42	0.47	0.484
December 14, 1998	1	9	0.55	1.65	0.95	7.47
December 21, 1998	0.61	1.75	0.35	0.42	0.45	0.492
December 31, 1998	0.6	1.7	0.3	0.24	0.46	0.508
January 18, 1999	0.65	2.1	0.49	1.05	0.48	0.678
January 25, 1999	0.58	1.45	0.35	0.42	0.46	0.498
February 1, 1999	0.6	1.7	0.38	0.54	0.46	0.503
February 8, 1999	0.7	2.7	0.42	0.69	0.65	0.514
February 10, 1999	0.6	1.7	0.38	0.54	0.65	0.501
February 23, 1999	1	9	0.54	1.4	0.84	5.02
March 4, 1999	1	9	-	-	-	5.14
March 8, 1999	0.93	6.1	0.32	0.27	-	4.77
March 15, 1999	0.95	6.44	0.4	0.6	0.81	4.69
March 30, 1999	0.95	6.44	0.4	0.6	-	4.72
April 5, 1999	0.6	1.65	0.3	0.25	0.45	0.435
April 12, 1999	0.61	1.7	-	-	-	0.437
April 14, 1999	0.6	1.65	0.35	0.4	-	0.429
April 19, 1999	0.6	1.65	0.35	0.4	-	0.426
April 23, 1999	0.58	1.25	-	-	-	0.423
April 26, 1999	0.55	1.2	0.3	0.25	-	0.421
May 5, 1999	0.5	0.9	0.3	0.25	0.45	0.421
May 14, 1999	0.48	0.83	0.26	0.16	-	0.425
May 17, 1999	0.48	0.83	0.26	0.16	-	0.426

Table D5 - Summary of stage and discharge measurements collected near the mine site record.

Station	WB Stage (m)	WB Discharge (m3/s)	LLO Stage (m)	LLO Discharge (m3/s)	WA _s Stage (m)	WA Discharge (m3/s)*
May 25, 1999	1.02	9.2	0.2	0.07	-	10.4
May 26, 1999	1.04	10.05	-	-	-	10.2
April 1, 2000	0.49	0.86	0.27	0.19	0.45	0.388
April 10, 2000	0.46	0.7	0.22	0.092	0.45	0.376
April 17, 2000	0.46	0.7	0.18	0.05	0.45	0.383
March 26, 2001	0.62	1.9	0.3	0.25	0.85	2.96
April 10, 2001	0.55	1.2	0.27	0.19	0.54	0.887
April 17, 2001	0.47	0.74	0.24	0.13	0.48	0.618
April 24, 2001	0.6	1.7	0.25	0.145	0.64	1.95
May 1, 2001	0.78	4.2	0.23	0.11	0.75	3.1
May 8, 2001	0.52	1	0.23	0.11	0.5	0.711
May 14, 2001	0.46	0.7	0.2	0.07	0.49	0.808
May 22, 2001	0.42	0.5	0.19	0.064	0.45	0.391
May 28, 2001	0.42	0.5	0.14	0.025	0.45	0.394
June 5, 2001	0.42	0.5	0.19	0.064	0.45	0.396
June 11, 2001	0.42	0.5	0.24	0.13	0.45	0.402
June 21, 2001	0.42	0.5	0.19	0.064	0.45	0.629
June 26, 2001	0.44	0.56	0.17	0.044	0.45	0.397
July 5, 2001	0.41	0.46	0.15	0.03	0.45	0.361
July 17, 2001	0.35	0.28	0.09	0	0.44	0.325
July 23, 2001	0.35	0.28	0.09	0	0.44	0.318
July 31, 2001	0.38	0.35	0.09	0	0.51	0.686
August 7, 2001	0.4	0.43	0.08	0	0.47	0.469
August 14, 2001	0.36	0.31	0.07	0	0.45	0.383
August 21, 2001	0.43	0.52	0.06	0	0.45	0.386
August 28, 2001	0.42	0.52	0.1	0	0.62	1.6
September 5, 2001	0.65	2.8	0.1	0	0.7	2.31
September 11, 2001	0.61	1.8	0.07	0	0.63	1.69
September 17, 2001	0.62	2	0.06	0	0.63	1.65
September 24, 2001	0.6	1.7	0.08	0	0.62	1.62
October 2, 2001	0.6	1.7	0.1	0	0.63	1.56
October 9, 2001	0.6	1.7	0.1	0	0.62	1.52
October 15, 2001	0.6	1.7	0.17	0.044	0.61	1.5
October 23, 2001	0.61	1.8	0.21	0.082	0.63	1.64
October 30, 2001	0.5	0.82	0.3	0.26	0.45	0.412
November 5, 2001	0.52	1	0.29	0.23	0.54	0.911
November 14, 2001	0.59	1.5	0.4	0.62	0.46	0.505
November 19, 2001	0.98	8.5	0.4	0.62	0.85	5.92
November 27, 2001	0.8	4.3	0.38	0.52	0.82	4.27
December 3, 2001	0.78	4.2	0.37	0.48	0.72	2.43
December 11, 2001	0.8	4.3	0.4	0.62	0.73	2.8
December 19, 2001	1.3	22	0.5	1.2	1	8.95
December 27, 2001	0.72	3.1	0.3	0.26	0.68	2.9
January 3, 2002	1.2	17	0.6	2.1	1	8.02
January 8, 2002	1.9	82	0.7	3.3	1.55	35.4
January 15, 2002	0.7	2.8	0.39	0.56	0.87	5.22
January 22, 2002	0.55	1.2	0.3	0.26	0.67	2.1
January 29, 2002	0.7	2.8	0.3	0.26	0.64	1.8
February 5, 2002	0.65	2.8	0.3	0.26	0.61	1.47
February 12, 2002	0.54	1.15	0.3	0.26	0.64	1.81
February 19, 2002	0.5	0.9	0.3	0.26	0.45	0.409
February 26, 2002	0.52	1	0.38	0.52	0.6	1.29

Table D5 - Summary of stage and discharge measurements collected near the mine site record.

Station	WB Stage (m)	WB Discharge (m3/s)	LLO Stage (m)	LLO Discharge (m3/s)	WA _s Stage (m)	WA Discharge (m3/s)*
March 5, 2002	0.49	0.82	0.3	0.26	0.49	0.546
March 12, 2002	0.48	0.78	0.45	0.88	0.54	0.991
March 20, 2002	0.48	0.78	0.35	0.41	0.45	0.34
March 27, 2002	0.4	0.43	0.3	0.26	0.45	0.347
April 2, 2002	0.40	0.43	0.35	0.410	0.45	0.374
April 11, 2002	0.50	0.9	0.29	0.230	0.56	1.1
April 16, 2002	0.45	0.64	0.30	0.260	0.79	3.5
April 23, 2002	0.40	0.43	0.27	0.190	0.60	1.19
April 30, 2002	0.46	0.7	0.26	0.160	0.54	0.846
May 6, 2002	0.45	0.64	0.15	0.030	0.55	0.882
May 14, 2002	0.35	0.28	0.15	0.030	0.45	0.37
May 23, 2002	**	**	0.17	0.044	0.45	0.386
May 28, 2002	0.35	0.28	0.17	0.044	0.45	0.388
June 4, 2002	0.35	0.28	0.17	0.044	0.45	0.376
June 13, 2002	0.32	0.21	0.17	0.044	0.45	0.4
June 24, 2002	0.32	0.21	0.08	0.000	0.45	0.399
July 2, 2002	0.32	0.21	0.08	0.000	0.45	0.397
July 11, 2002	0.32	0.21	0.08	0.000	0.49	0.503
July 19, 2002	0.34	0.25	0.07	0.000	0.49	0.457
July 22, 2002	0.25	0.092	0.07	0.000	0.48	0.455
July 30, 2002	0.23	0.07	0.04	0.000	0.47	0.462
August 6, 2002	0.23	0.07	0.04	0.000	0.45	0.405
August 15, 2002	0.24	0.082	0.04	0.000	0.45	0.391
August 20, 2002	0.24	0.082	0	0.000	0.45	0.381
August 27, 2002	0.22	0.06	0	0.000	0.45	0.375
September 3, 2002	0.55	1.2	0	0.000	0.75	3.19
September 10, 2002	0.42	0.5	0	0.000	0.57	1.04
September 17, 2002	0.34	0.25	0	0.000	0.56	0.962
September 24, 2002	0.32	0.21	0	0.000	0.56	0.924
October 1, 2002	0.32	0.21	0.04	0.000	0.56	0.914
October 8, 2002	0.30	0.17	0.06	0.000	0.56	0.898
October 15, 2002	0.28	0.14	0.05	0.000	0.55	0.866
October 22, 2002	0.30	0.17	0.07	0.000	0.55	0.852
November 7, 2002	0.33	0.23	0.13	0.020	0.50	0.89
November 12, 2002	0.40	0.43	0.28	0.210	0.60	1.46
November 18, 2002	0.60	1.7	0.30	0.260	0.48	0.479
November 25, 2002	0.42	0.5	0.34	0.380	0.46	0.425
December 3, 2002	0.30	0.17	0.25	0.145	0.46	0.411
December 10, 2002	0.25	0.092	0.25	0.145	0.46	0.417
December 17, 2002	1.26	20	0.65	2.600	1.00	5.76
December 23, 2002	0.40	0.43	0.40	0.620	0.45	0.399
April 3, 2003	0.40	0.43	0.40	0.620	0.85	3.85
April 9, 2003	1.10	13	0.60	2.100	1.40	31.9
April 16, 2003	0.70	2.8	0.35	0.410	0.80	4.01
April 23, 2003	0.60	1.7	0.35	0.410	0.68	2.49
May 1, 2003	0.60	1.7	0.30	0.260	0.64	2.3
May 5, 2003	0.70	2.8	0.30	0.260	0.68	2.45
May 15, 2003	0.60	1.7	0.27	0.190	0.62	1.8
May 22, 2003	0.45	0.64	0.25	0.145	0.53	1.01
May 27, 2003	0.75	4.4	0.26	0.160	0.75	2.22
June 5, 2003	0.40	0.43	0.21	0.082	0.60	1.86
June 11, 2003	0.63	2.4	0.15	0.030	0.63	1.67

Table D5 - Summary of stage and discharge measurements collected near the mine site record.

Station	WB Stage (m)	WB Discharge (m3/s)	LLO Stage (m)	LLO Discharge (m3/s)	WA _s Stage (m)	WA Discharge (m3/s)*
June 17, 2003	0.47	0.74	0.16	0.036	0.49	0.515
June 23, 2003	0.39	0.4	0.16	0.036	0.42	0.366
July 3, 2003	0.37	0.32	0.14	0.024	0.42	0.362
July 9, 2003	0.46	0.7	0.13	0.020	0.42	0.362
July 14, 2003	0.35	0.28	0.09	0.000	0.40	0.361
July 29, 2003	0.31	0.19	0.02	0.000	0.42	0.361
August 6, 2003	0.33	0.23	0.01	0.000	0.42	0.362
August 11, 2003	0.32	0.21	0.01	0.000	0.43	0.363
August 18, 2003	0.32	0.21	0.01	0.000	0.42	0.365
August 26, 2003	0.37	0.32	0.01	0.000	0.46	0.897
September 3, 2003	0.65	2.8	0.01	0.000	0.70	1.63
September 9, 2003	0.62	2	0.01	0.000	0.60	1.57
September 16, 2003	0.55	1.2	0.01	0.000	0.61	1.73
September 23, 2003	0.54	1.15	0.01	0.000	0.61	1.66
October 1, 2003	0.52	1	0.01	0.000	0.60	1.54
October 7, 2003	0.72	3.1	0.01	0.000	0.60	1.52
October 14, 2003	0.57	1.4	0.15	0.030	0.60	1.76
October 21, 2003	1.10	13	0.55	1.600	1.30	13
October 29, 2003	0.77	3.9	0.35	0.410	0.77	3.33
November 3, 2003	0.62	2	0.27	0.190	0.64	1.97
November 12, 2003	0.57	1.4	0.25	0.145	0.63	1.86
November 18, 2003	0.65	2.8	0.34	0.380	0.64	2.11
November 26, 2003	0.57	1.4	0.30	0.260	0.62	1.64
December 3, 2003	0.62	2	0.36	0.440	0.62	1.84
December 9, 2003	0.97	8.2	0.45	0.880	0.89	4.68
December 17, 2003	0.97	8.2	0.58	1.900	0.90	6.33
December 22, 2003	0.87	5.6	0.43	0.760	0.78	3.63
December 29, 2003	0.85	5.4	0.39	0.560	0.79	3.8
January 5, 2004	0.65	2.8	0.30	0.260	0.66	2.14
January 12, 2004	0.97	8.2	0.45	0.880	0.95	6.96
January 20, 2004	0.97	8.2	0.42	0.700	0.95	6.02
January 28, 2004	0.50	0.9	0.45	0.880	0.54	1.1
February 3, 2004	0.40	0.43	0.32	0.300	0.45	0.502
February 9, 2004	0.42	0.5	0.39	0.560	0.45	0.462
February 17, 2004	0.42	0.5	0.36	0.440	0.45	1.08
February 24, 2004	0.50	0.9	0.35	0.410	0.54	1.01
March 1, 2004	0.51	0.95	0.32	0.300	0.53	0.887
March 9, 2004	0.54	1.15	0.34	0.380	0.55	1.06
March 16, 2004	0.46	0.7	0.30	0.260	0.44	0.423
March 22, 2004	0.46	0.7	0.33	0.330	0.45	0.431
March 30, 2004	0.56	1.3	0.36	0.440	0.5	0.905
April 6, 2004	0.40	0.43	0.28	0.210	0.44	0.418
April 12, 2004	0.46	0.7	0.27	0.190	0.44	0.414
April 19, 2004	0.38	0.35	0.27	0.190	0.44	0.42
April 27, 2004	0.36	0.31	0.27	0.190	0.44	0.413
May 4, 2004	0.35	0.28	0.24	0.130	0.45	0.478
May 11, 2004	0.35	0.28	0.23	0.110	0.45	0.428
May 17, 2004	0.33	0.23	0.18	0.054	0.45	0.466
May 22, 2004	0.32	0.21	0.15	0.030	0.44	0.427
June 2, 2004	0.32	0.21	0.18	0.054	0.44	0.42
June 8, 2004	0.38	0.35	0.17	0.044	0.49	0.439
June 17, 2004	0.35	0.28	0.15	0.030	0.45	0.43

Table D5 - Summary of stage and discharge measurements collected near the mine site record.

Station	WB Stage (m)	WB Discharge (m3/s)	LLO Stage (m)	LLO Discharge (m3/s)	WA _s Stage (m)	WA Discharge (m3/s)*
June 22, 2004	0.34	0.25	0.12	0.015	0.45	0.428
June 29, 2004	0.34	0.25	0.05	0.000	0.45	0.426
July 5, 2004	0.34	0.25	0.05	0.000	0.45	0.43
July 13, 2004	0.34	0.25	0.10	0.000	0.44	0.382
July 20, 2004	0.32	0.21	0.08	0.000	0.43	0.351
July 26, 2004	0.31	0.19	0.05	0.000	0.45	0.405
August 3, 2004	0.31	0.19	0.03	0.000	0.45	0.415
August 10, 2004	0.32	0.21	0.01	0.000	0.45	0.415
August 17, 2004	0.31	0.19	0.01	0.000	0.45	0.423
August 23, 2004	0.32	0.21	0.01	0.000	0.45	0.434
September 2, 2004	0.36	0.31	0.06	0.000	0.52	1.07
September 7, 2004	0.50	0.9	0.05	0.000	0.59	1.4
September 13, 2004	0.50	0.9	0.11	0.012	0.59	1.39
September 20, 2004	0.50	0.9	0.23	0.110	0.58	1.29
September 27, 2004	0.57	1.4	0.55	1.600	0.19	1.35
October 5, 2004	0.56	1.3	0.14	0.024	0.61	1.7
October 13, 2004	**	**	0.18	0.054	0.61	1.67
October 18, 2004	0.55	1.2	0.18	0.054	0.61	1.62
October 25, 2004	0.60	1.7	0.29	0.230	0.63	1.95
November 1, 2004	0.65	2.8	0.15	0.030	0.65	2.02
November 9, 2004	0.92	7.2	0.53	1.400	0.78	3.95
November 15, 2004	1.38	27	0.66	2.700	1.60	26.2
November 22, 2004	0.65	2.8	0.42	0.700	0.43	0.432
December 1, 2004	0.55	1.2	0.35	0.410	0.43	0.415
December 7, 2004	0.56	1.3	0.37	0.480	0.42	0.42
December 14, 2004	0.90	6.8	0.49	1.150	0.62	2.36
December 21, 2004	0.95	7.6	0.42	0.700	0.90	5
December 28, 2004	0.75	4.4	0.34	0.380	0.67	2.45
January 4, 2005	0.65	2.8	0.32	0.300	0.60	1.59
January 11, 2005	0.58	1.45	0.28	0.210	0.56	1.24
January 18, 2005	0.61	1.8	0.31	0.280	0.61	2.44
January 25, 2005	1.10	13	0.30	0.260	1.37	13.7
February 1, 2005	1.00	9.4	0.34	0.380	0.83	5.07
February 8, 2005	0.98	8.5	0.37	0.480	0.76	3.36
February 15, 2005	0.72	3.1	0.30	0.260	0.60	1.67
February 22, 2005	0.67	2.4	0.26	0.160	0.56	1.22
March 1, 2005	0.64	2	0.25	0.145	0.55	1.2
March 7, 2005	0.65	2.8	0.25	0.145	0.55	1.22
March 15, 2005	0.72	3.1	0.29	0.230	0.62	1.75
March 22, 2005	0.68	2.5	0.28	0.210	0.56	1.35
March 29, 2005	0.72	3.1	0.29	0.230	0.6	1.71
April 6, 2005	0.96	8	0.38	0.520	0.79	4.32
April 12, 2005	0.92	7.2	0.37	0.480	0.75	2.81
April 18, 2005	0.90	6.8	0.38	0.520	0.73	3.34
April 26, 2005	0.92	7.2	0.28	0.210	0.78	3.62
May 2, 2005	0.72	3.1	0.22	0.096	0.44	0.469
May 10, 2005	0.78	4.2	0.16	0.036	0.57	1.34
May 17, 2005	0.65	2.8	0.19	0.066	0.55	1.24
May 24, 2005	1.15	14.5	0.50	1.200	1.10	11
May 31, 2005	0.65	2.8	0.28	0.210	0.69	1.69
June 6, 2005	0.56	1.3	0.27	0.190	0.42	0.413
June 14, 2005	0.55	1.2	0.26	0.160	0.42	0.417

Table D5 - Summary of stage and discharge measurements collected near the mine site record.

Station	WB Stage (m)	WB Discharge (m3/s)	LLO Stage (m)	LLO Discharge (m3/s)	WA _s Stage (m)	WA Discharge (m3/s)*
June 21, 2005	0.55	1.2	0.29	0.230	0.43	0.416
June 29, 2005	0.48	0.78	0.27	0.190	0.42	0.391
July 4, 2005	0.52	1	0.24	0.130	0.42	0.385
July 12, 2005	0.52	1	0.19	0.066	0.42	0.385
July 19, 2005	0.52	1	0.24	0.130	0.41	0.387
July 26, 2005	0.51	0.95	0.19	0.066	0.41	0.406
August 2, 2005	0.59	1.6	0.16	0.036	0.53	0.996
August 9, 2005	0.55	1.2	0.15	0.030	0.50	0.89
August 16, 2005	0.53	1.15	0.12	0.015	0.50	0.933
August 24, 2005	0.55	1.2	0.14	0.024	0.50	0.878
August 31, 2005	0.75	3.7	0.15	0.030	0.65	2.25
September 7, 2005	0.67	2.4	0.16	0.036	0.60	1.67
September 13, 2005	0.68	2.5	0.15	0.030	0.60	1.94
September 20, 2005	0.68	2.5	0.14	0.024	0.60	1.93
September 27, 2005	0.63	2.4	0.13	0.020	0.56	1.37
October 3, 2005	0.62	2	0.19	0.066	0.57	1.37
October 11, 2005	0.62	2	0.19	0.066	0.57	1.38
October 18, 2005	0.90	6.8	0.47	0.990	0.65	2.25
October 25, 2005	-	**	-	**	-	1.92
November 1, 2005	0.88	6	0.45	0.990	0.65	2.38
November 8, 2005	0.75	3.7	0.38	0.520	0.46	0.6
November 15, 2005	1.00	9.4	0.47	0.980	0.75	3.53
November 23, 2005	0.60	1.7	0.35	0.410	0.42	0.438
November 30, 2005	0.58	1.45	0.28	0.210	0.42	0.42
December 5, 2005	0.56	1.3	0.27	0.190	0.40	0.417
December 13, 2005	0.52	1	0.27	0.190	0.42	0.414
December 20, 2005	0.68	2.5	0.28	0.210	0.42	0.422
December 29, 2005	1.30	22	0.32	0.300	0.90	5.27
January 3, 2006	1.40	28	0.49	1.150	1.00	8.55
January 9, 2006	1.20	17	0.45	0.990	1.08	9.85
January 18, 2006	0.95	7.6	0.35	0.410	0.95	6.96
January 24, 2006	0.85	5.4	0.24	0.130	0.73	2.94
January 31, 2006	0.85	5.4	0.32	0.300	0.72	2.09
February 7, 2006	0.90	6.8	0.35	0.410	0.44	0.465
February 14, 2006	0.60	1.7	0.25	0.145	0.42	0.41
February 21, 2006	0.70	2.8	0.28	0.210	0.58	1.51
February 28, 2006	0.70	2.8	0.28	0.210	0.59	1.52
March 6, 2006	0.75	3.7	0.45	0.990	0.50	0.892
March 14, 2006	0.63	2.4	0.35	0.410	0.43	0.429
March 22, 2006	0.60	1.7	0.28	0.210	0.42	0.429
March 29, 2006	0.62	2	0.45	0.990	0.47	0.552
April 3, 2006	0.67	2.4	0.40	0.600	0.47	0.653
April 12, 2006	0.70	2.8	0.30	0.260	0.65	1.91
April 18, 2006	0.65	2.8	0.38	0.520	0.46	0.433
April 25, 2006	0.52	1	0.35	0.410	0.46	0.435
May 2, 2006	0.55	1.2	0.27	0.190	0.47	0.452
May 10, 2006	0.45	0.64	0.25	0.145	0.45	0.42
May 16, 2006	0.55	1.2	0.20	0.070	0.45	0.523
May 24, 2006	0.70	2.8	0.16	0.036	0.60	1.39
May 31, 2006	0.57	1.4	0.25	0.145	0.46	0.422
June 8, 2006	0.56	1.3	0.18	0.054	0.46	0.423
June 12, 2006	0.55	1.2	0.16	0.036	0.46	0.423

Table D5 - Summary of stage and discharge measurements collected near the mine site record.

Station	WB Stage (m)	WB Discharge (m3/s)	LLO Stage (m)	LLO Discharge (m3/s)	WA _s Stage (m)	WA Discharge (m3/s)*
June 20, 2006	0.57	1.4	0.19	0.066	0.45	0.403
June 27, 2006	0.55	1.2	0.16	0.036	0.45	0.4
July 6, 2006	0.70	2.8	0.10	0.000	0.62	1.55
July 11, 2006	0.68	2.5	0.13	0.020	0.59	1.33
July 17, 2006	0.68	2.5	0.13	0.020	0.59	1.29
July 26, 2006	0.60	1.7	0.12	0.015	0.53	0.821
August 2, 2006	0.58	1.45	0.08	0.000	0.52	0.727
August 9, 2006	0.58	1.45	0.06	0.000	0.52	0.718
August 15, 2006	0.58	1.45	0.04	0.000	0.52	0.701
August 22, 2006	0.58	1.45	0.02	0.000	0.50	0.691
August 29, 2006	0.70	2.8	0.00	0.000	0.63	1.58
September 7, 2006	0.58	1.45	0.00	0.000	0.59	1.23
September 12, 2006	0.68	2.5	0.00	0.000	0.59	1.38
September 19, 2006	0.70	2.8	0.00	0.000	0.60	1.36
September 26, 2006	0.69	2.7	0.00	0.000	0.59	1.3
October 3, 2006	0.55	1.2	0.00	0.000	0.59	1.28
October 10, 2006	0.56	1.3	0.00	0.000	0.57	1.14
October 17, 2006	0.55	1.2	0.00	0.000	0.57	1.06
October 24, 2006	0.52	1	0.08	0.000	0.53	0.788
November 1, 2006	0.56	1.3	0.24	0.130	0.55	0.88
November 7, 2006	0.72	3.1	0.38	0.520	0.61	1.48
November 14, 2006	0.75	3.7	0.45	0.860	0.60	1.47
November 21, 2006	1.55	41	0.65	2.600	1.20	14.2
December 5, 2006	0.60	1.7	0.35	0.410	0.45	0.441
December 12, 2006	1.30	22	**	**	0.95	10.3
December 19, 2006	0.65	2.8	0.45	0.860	0.63	1.73
December 27, 2006	0.85	5.4	0.47	0.990	0.58	1.14
January 2, 2007	0.85	5.4	0.46	0.920	0.82	12
January 9, 2007	1.30	22	0.50	1.200	0.93	11.7
January 15, 2007	1.05	11.2	0.41	0.660	0.78	4.13
January 23, 2007	0.90	6.8	0.46	0.920	0.79	2.98
January 31, 2007	0.66	2.2	0.40	0.620	0.43	0.457
February 6, 2007	0.58	1.45	0.39	0.560	0.40	0.451
February 13, 2007	0.67	2.4	0.45	0.860	0.47	0.972
February 19, 2007	0.90	6.8	0.45	0.860	0.73	3.88
February 27, 2007	0.65	2.8	0.40	0.600	0.40	0.47
March 6, 2007	0.58	1.45	0.37	0.480	0.40	0.462
March 13, 2007	1.20	17	0.50	1.200	0.98	10.6
March 20, 2007	0.98	8.5	0.44	0.800	0.74	5.33
March 27, 2007	1.00	9.4	0.44	0.800	0.82	4.11
April 2, 2007	0.46	0.72	0.35	0.410	0.40	0.461
April 10, 2007	0.50	0.9	0.34	0.380	0.60	2.15
April 17, 2007	0.88	6	0.40	0.600	0.66	3.86
April 24, 2007	0.90	6.8	0.39	0.560	0.70	3.75
May 1, 2007	0.92	7.2	0.34	0.380	0.75	4.04
May 8, 2007	0.94	7.4	0.32	0.300	0.81	5.39
May 15, 2007	0.92	7.2	0.29	0.230	0.79	4.66
May 23, 2007	0.85	5.4	0.25	0.145	0.75	4.18
May 29, 2007	0.95	7.6	0.24	0.130	0.80	4.72
June 5, 2007	1.20	17	0.22	0.096	0.87	6.39
June 12, 2007	0.90	6.8	0.22	0.096	0.74	3.5
June 19, 2007	0.79	4.3	0.20	0.070	0.66	2.59

Table D5 - Summary of stage and discharge measurements collected near the mine site record.

Station	WB Stage (m)	WB Discharge (m3/s)	LLO Stage (m)	LLO Discharge (m3/s)	WA _s Stage (m)	WA Discharge (m3/s)*
June 26, 2007	0.75	3.7	0.19	0.066	0.59	1.64
July 3, 2007	0.72	3.1	0.22	0.096	0.59	1.69
July 9, 2007	0.70	2.8	0.18	0.054	0.57	1.48
July 16, 2007	0.70	2.8	0.16	0.036	0.56	1.43
July 24, 2007	0.69	2.7	0.23	0.110	0.57	1.45
August 1, 2007	0.68	2.5	0.18	0.054	0.56	1.4
August 8, 2007	0.68	2.5	0.18	0.054	0.56	1.4
August 14, 2007	0.68	2.5	0.19	0.066	0.56	1.37
August 21, 2007	0.66	2.2	0.22	0.096	0.56	1.39
August 28, 2007	0.68	2.5	0.23	0.110	0.55	1.75
September 5, 2007	0.73	3.1	0.23	0.110	0.60	1.81
September 11, 2007	0.70	2.8	0.19	0.066	0.59	1.74
September 18, 2007	0.73	3.1	0.18	0.054	0.61	1.99
September 25, 2007	0.72	3.1	0.18	0.054	0.61	1.93
October 2, 2007	0.75	3.7	0.30	0.260	0.63	2.05
October 10, 2007	0.98	8.5	0.48	1.150	0.67	3.2
October 16, 2007	0.68	2.5	0.35	0.410	0.65	2.47
October 23, 2007	0.79	4.3	0.44	0.800	0.70	3.04
November 1, 2007	0.92	7.2	0.38	0.520	0.71	3.33
November 6, 2007	0.72	3.1	0.35	0.410	0.68	2.88
November 13, 2007	2.20	115	1.10	12.500	1.30	27
November 20, 2007	1.15	14.5	0.40	0.600	0.79	5.41
November 27, 2007	0.68	2.5	0.34	0.380	0.57	2.5
December 4, 2007	0.85	5.4	0.38	0.520	0.82	9.45
December 11, 2007	0.80	4.3	0.38	0.520	0.67	3.79
December 18, 2007	0.70	2.8	0.40	0.600	0.55	2.75
December 27, 2007	0.65	2.1	0.36	0.410	0.53	2.39
January 2, 2008	0.62	2	0.31	0.280	0.52	2.31
January 8, 2008	0.90	6.8	0.56	1.700	0.59	3.18
January 15, 2008	0.55	1.2	0.40	0.600	0.30	0.685
January 22, 2008	0.53	1.15	0.34	0.380	0.28	0.368
January 29, 2008	0.48	0.78	0.32	0.300	0.28	0.365
February 5, 2008	0.55	1.2	0.30	0.260	0.45	1.76
February 12, 2008	0.55	1.2	0.33	0.330	0.45	1.98
February 19, 2008	0.55	1.2	0.35	0.410	0.48	1.81
February 26, 2008	0.55	1.2	0.35	0.410	0.48	1.79
March 4, 2008	0.68	2.5	0.44	0.800	0.49	1.96
March 13, 2008	0.78	4.2	**	**	0.50	2.01
March 18, 2008	0.76	3.9	0.43	0.920	0.49	1.88
March 25, 2008	0.74	3.4	0.32	0.300	0.48	1.88
April 1, 2008	0.73	3.1	0.33	0.330	0.58	1.85
April 8, 2008	0.74	3.4	0.34	0.380	0.59	1.87
April 15, 2008	0.69	2.7	0.34	0.380	0.59	1.86
April 22, 2008	0.70	2.8	0.29	0.230	0.59	1.84
April 29, 2008	0.55	1.2	0.27	0.190	0.39	0.351
May 6, 2008	0.42	0.5	0.32	0.300	0.38	0.347
May 12, 2008	0.40	0.43	0.19	0.066	0.38	0.367
May 19, 2008	0.59	1.6	0.21	0.084	0.55	1.62
May 26, 2008	0.40	0.43	0.17	0.044	0.39	0.371
June 2, 2008	0.34	0.25	0.19	0.066	0.40	0.357
June 9, 2008	0.40	0.43	0.22	0.096	0.39	0.365
June 17, 2008	0.38	0.35	0.20	0.072	0.39	0.351

Table D5 - Summary of stage and discharge measurements collected near the mine site record.

Station	WB Stage (m)	WB Discharge (m3/s)	LLO Stage (m)	LLO Discharge (m3/s)	WA _s Stage (m)	WA Discharge (m3/s)*
June 25, 2008	0.35	0.28	0.18	0.054	0.40	0.311
July 2, 2008	0.48	0.78	0.18	0.054	0.55	1.14
July 7, 2008	0.46	0.7	0.18	0.054	0.51	1.14
July 15, 2008	0.48	0.78	0.10	0.000	0.53	1.05
July 22, 2008	0.47	0.74	0.08	0.000	0.53	1.04
July 29, 2008	0.45	0.64	0.08	0.000	0.53	1.02
August 6, 2008	0.45	0.64	0.08	0.000	0.52	1.01
August 12, 2008	0.45	0.64	0.10	0.000	0.52	1.01
August 19, 2008	0.45	0.64	0.10	0.000	0.52	0.977
August 26, 2008	0.46	0.7	0.10	0.000	0.52	0.99
September 2, 2008	0.47	0.74	0.12	0.015	0.53	1.07
September 8, 2008	0.48	0.78	0.10	0.000	0.53	1.04
September 16, 2008	0.47	0.74	0.10	0.000	0.53	1.03
September 22, 2008	0.47	0.74	0.09	0.000	0.52	1.02
September 29, 2008	0.46	0.7	0.09	0.000	0.50	0.945
October 7, 2008	0.48	1.14	0.17	0.025	0.52	1.02
October 14, 2008	0.47	1.03	0.18	0.034	0.52	1.01
October 20, 2008	0.51	1.45	0.23	0.120	0.54	1.05
October 27, 2008	*	*	0.23	0.120	0.53	1.05
November 3, 2008	0.54	1.77	0.29	0.309	0.55	1.25
November 10, 2008	0.60	2.39	0.31	0.393	0.57	1.38
November 17, 2008	0.69	3.29	0.39	0.801	0.59	1.39
November 24, 2008	0.69	3.29	0.39	0.834	0.59	1.61
December 1, 2008	0.73	3.68	0.30	0.349	0.69	2.91
December 8, 2008	0.49	1.24	0.30	0.349	0.30	0.371
December 15, 2008	0.51	1.45	0.30	0.349	0.40	0.372
December 22, 2008	0.57	2.08	0.28	0.271	0.40	0.351
December 29, 2008	0.45	0.82	0.25	0.172	0.40	0.357
January 4, 2009	0.43	0.6	0.24	0.145	0.41	0.363
January 12, 2009	0.59	2.28	0.35	0.592	0.47	0.673
January 19, 2009	0.49	1.24	0.30	0.349	0.41	0.386
January 26, 2009	0.45	0.82	0.29	0.289	0.42	0.38
February 3, 2009	0.60	2.39	0.27	0.235	0.60	1.43
February 9, 2009	0.57	2.08	0.27	0.235	0.57	1.24
February 16, 2009	0.53	1.66	0.26	0.202	0.53	1
February 23, 2009	0.50	1.35	0.25	0.172	0.52	0.953
March 2, 2009	0.60	2.39	0.38	0.769	0.56	0.978
March 9, 2009	0.56	1.93	0.35	0.565	0.42	0.407
March 16, 2009	0.50	1.35	0.30	0.349	0.42	0.377
March 23, 2009	0.69	3.29	0.38	0.769	0.51	0.979
March 30, 2009	0.55	1.87	0.35	0.592	0.43	0.415
April 6, 2009	0.75	3.87	0.36	0.649	0.73	0.411
April 13, 2009	0.73	3.68	0.34	0.538	0.69	2.96
April 20, 2009	0.67	3.04	0.30	0.349	0.70	3.29
April 27, 2009	0.48	1.14	0.26	0.202	0.42	0.359
May 4, 2009	0.40	0.27	0.23	0.120	0.65	0.376
May 11, 2009	0.49	1.24	0.37	0.708	0.42	0.385
May 19, 2009	0.43	0.60	0.24	0.145	0.42	0.371
May 27, 2009	0.48	1.14	0.26	0.202	0.42	0.381
June 2, 2009	0.40	0.27	0.19	0.046	0.42	0.38
June 8, 2009	0.43	0.56	0.16	0.016	0.42	0.373
June 15, 2009	0.46	0.92	0.13	0.014	0.53	1

Table D5 - Summary of stage and discharge measurements collected near the mine site record.

Station	WB Stage (m)	WB Discharge (m3/s)	LLO Stage (m)	LLO Discharge (m3/s)	WA _s Stage (m)	WA Discharge (m3/s)*
June 22, 2009	0.49	1.24	0.13	0.014	0.54	1.17
June 29, 2009	0.49	1.19	0.13	0.014	0.55	1.15
July 6, 2009	0.49	1.24	0.15	0.014	0.53	1.05
July 6, 2009	0.49	1.24	0.15	0.014	0.53	1.05
July 13, 2009	0.48	1.14	0.18	0.034	0.53	1.02
July 13, 2009	0.48	1.14	0.18	0.034	0.53	1.02
July 20, 2009	0.43	0.60	0.13	0.014	0.49	0.805
July 27, 2009	0.42	0.49	0.10	0.033	0.49	0.799
August 4, 2009	0.40	0.27	0.08	0.067	0.49	0.791
August 10, 2009	0.42	0.49	0.07	0.076	0.50	0.788
August 16, 2009	0.42	0.49	0.07	0.085	0.49	0.759
August 24, 2009	0.44	0.71	0.07	0.076	0.50	1.04
September 1, 2009	0.48	1.08	0.07	0.076	0.53	1.04
September 8, 2009	0.46	0.92	0.08	0.059	0.51	0.962
September 14, 2009	0.46	0.87	0.10	0.035	0.51	0.925
September 21, 2009	0.45	0.82	0.10	0.033	0.51	0.93
September 30, 2009	0.46	0.92	0.10	0.033	0.50	0.93
October 1, 2009	0.46	0.92	0.10	0.033	0.50	0.926
October 8, 2009	0.45	0.82	0.09	0.045	0.50	0.911
October 13, 2009	0.46	0.92	1.00	9.705	0.51	0.925
October 19, 2009	0.50	1.35	0.20	0.060	0.50	1.02
October 26, 2009	0.45	0.82	0.25	0.172	0.43	0.649
November 2, 2009	0.65	2.84	0.35	0.565	0.55	1.33

* denotes daily discharge recorded at the WSC Quinsam River at Argonaut Bridge hydrometric station.

***Appendix D2:
Background Water Quality Data***

Table D6 - Summary of water quality data collected at the WB site.																							
Parameter	Units	06/03/1988	13/03/1988	20/03/1988	28/03/1988	05/04/1988	11/04/1988	18/04/1988	24/04/1988	02/05/1988	09/05/1988	17/05/1988	24/05/1988	01/06/1988	06/06/1988	13/06/1988	24/06/1988	04/07/1988	11/07/1988	17/07/1988	02/08/1988	08/08/1988	15/08/1988
Cond-L	uS/cm	32.7	32	34	29	33	21		37	32	37	37	43	44	41	42	41	42.4	51	33	45.9	39.6	44.7
Hardness (as CaCO3)	mg/L																						
pH-L	pH Units	7.9	8	8.4	8	7.5	8.2	8.2	8.2	8.2	7.4	7.7	7.7	7.1	7.2	7.2	7.2	7.3	7.2	7.19	8.1	7.38	7.49
TSS	mg/L	6	2.7	5.3	1	1	4.7	1	1	1.3	1	2	3.3	5.3	1.3	1	1	2	1	1	2	3.3	1
Acidity 8.3	mg/L																						
Acidity 4.5	mg/L																						
Alk-T	mg/L																						
N-NH3	mg/L	0.012		0.019		0.057		0.032		0.021	0.011	0.009	0.017	0.027		0.025	0.006	0.031	0.014	0.005	0.009		
NO2+NO3	mg/L	0.068		0.047		0.044		0.029	0.01	0.005	0.005	0.005	0.005	0.006			0.005	0.005	0.001	0.005	0.005	0.005	
N-TKN	mg/L						0.11		0.14	0.13	0.11	0.15	0.34					0.12	0.016	0.17	0.097	0.07	
P-PO4-D	mg/L																						
P-PO4-T	mg/L																						
SO4-D	mg/L	1				1								1	1	1.2				2.3			
Al-T	mg/L	0.015				0.046														0.023			
Sb-T	mg/L																						
As-T	mg/L																						
Ba-T	mg/L																						
Be-T	mg/L																						
B-T	mg/L																						
Cd-T	mg/L																						
Ca-T	mg/L																						
Cr-T	mg/L																						
Co-T	mg/L																						
Cu-T	mg/L	0.001				0.001														0.001			
Fe-T	mg/L																						
Pb-T	mg/L	0.001				0.001														0.016			
Li-T	mg/L																						
Mg-T	mg/L																						
Mn-T	mg/L	0.016				0.005														0.009			
Hg-T	mg/L																						
Mo-T	mg/L																						
Ni-T	mg/L																						
P-T	mg/L	0.006		0.003					0.028	0.001	0.001	0.005	0.013	0.012	0.003	0.008		0.004	0.006	0.004			
K-T	mg/L																						
Se-T	mg/L																						
Ag-T	mg/L																						
Na-T	mg/L																						
Tl-T	mg/L																						
Sn-T	mg/L																						
Ti-T	mg/L																						
U-T	mg/L																						
V-T	mg/L																						
Zn-T	mg/L	0.005				0.008														0.005			
Zr-T	mg/L																						
Al-D	mg/L	0.017				0.023																	
Sb-D	mg/L																						
As-D	mg/L																						
Ba-D	mg/L																						
Be-D	mg/L																						
B-D	mg/L																						
Cd-D	mg/L																						
Ca-D	mg/L	15.2				13.3																	
Cr-D	mg/L																						
Co-D	mg/L																						
Cu-D	mg/L	0.001				0.001																	
Fe-D	mg/L	0.03				0.03														0.03			
Pb-D	mg/L	0.001				0.001																	
Li-D	mg/L																						
Mg-D	mg/L																						
Mn-D	mg/L	0.005				0.005																	
Hg-D	mg/L																						
Mo-D	mg/L																						
Ni-D	mg/L																						
P-D	mg/L	0.005		0.002					0.003	0.001	0.001	0.003	0.011	0.011	0.003	0.004		0.002	0.003	0.003	0.002		
K-D	mg/L																						
Se-D	mg/L																						
U-D	mg/L																						
V-D	mg/L																						
Zn-D	mg/L	0.005				0.005																	

Table D6 - Summary of water quality data collected at the WB site.

Parameter	Units	22/08/1988	30/08/1988	06/09/1988	12/09/1988	26/09/1988	03/10/1988	13/10/1988	23/10/1988	02/11/1988	07/11/1988	21/11/1988	05/12/1988	12/12/1988	20/12/1988	29/12/1988	16/01/1989	23/01/1989	30/01/1989	06/02/1989	13/02/1989	27/02/1989	06/03/1989
Cond-L	uS/cm	47.3	42.4	44.5	39.2	44	75.6	44.4		61.6	33.6	38.5	43.2	39.7	50.1	52.5	45.2	47.1	52.4	40	55.5	42.7	42
Hardness (as CaCO3)	mg/L																						
pH-L	pH Units	6.7	7.04	5.88	7.13	7	7.36	7.22	7.17	7.19	7.21	7.08	7.3	7.19	7.3	7.13	7.19	7.01	7.15	7.1	7.49	6.61	6.63
TSS	mg/L	2.7	1.3	1	1	2	1	1	1	1	4	1	2.7	1	1	1	1	2	3.3	1.3	1	1	1
Acidity 8.3	mg/L																						
Acidity 4.5	mg/L																						
Alk-T	mg/L																						
N-NH3	mg/L	0.016			0.019		0.005	0.007			0.024	0.007	0.005	0.005	0.006	0.001	0.005	0.005				0.006	0.011
NO2+NO3	mg/L	0.005			0.005		0.096	0.005			0.05	0.077	0.036	0.046	0.035	0.047							
N-TKN	mg/L	0.1			0.14			0.091			0.11		0.17	0.41			0.09						
P-PO4-D	mg/L																						
P-PO4-T	mg/L																						
SO4-D	mg/L	1			1		1	1					1		5.3					3.3			
Al-T	mg/L	0.02						0.011															
Sb-T	mg/L																						
As-T	mg/L																						
Ba-T	mg/L																						
Be-T	mg/L																						
B-T	mg/L																						
Cd-T	mg/L																						
Ca-T	mg/L																						
Cr-T	mg/L																						
Co-T	mg/L																						
Cu-T	mg/L	0.001						0.002															
Fe-T	mg/L																						
Pb-T	mg/L	0.001						0.001															
Li-T	mg/L																						
Mg-T	mg/L																						
Mn-T	mg/L	0.005						0.005															
Hg-T	mg/L																						
Mo-T	mg/L																						
Ni-T	mg/L																						
P-T	mg/L	0.002			0.012		0.01	0.004			0.007		0.006	0.01	0.016	0.001	0.002	0.003	0.008				
K-T	mg/L																						
Se-T	mg/L																						
Ag-T	mg/L																						
Na-T	mg/L																						
Tl-T	mg/L																						
Sn-T	mg/L																						
Ti-T	mg/L																						
U-T	mg/L																						
V-T	mg/L																						
Zn-T	mg/L	0.005						0.005															
Zr-T	mg/L																						
Al-D	mg/L	0.012						0.005															
Sb-D	mg/L																						
As-D	mg/L																						
Ba-D	mg/L																						
Be-D	mg/L																						
B-D	mg/L																						
Cd-D	mg/L																						
Ca-D	mg/L	5.83																					
Cr-D	mg/L																						
Co-D	mg/L																						
Cu-D	mg/L	0.001						0.001															
Fe-D	mg/L	0.005						0.03					0.090		0.027								
Pb-D	mg/L	0.001						0.001															
Li-D	mg/L																						
Mg-D	mg/L	0.700																					
Mn-D	mg/L	0.005						0.005															
Hg-D	mg/L																						
Mo-D	mg/L																						
Ni-D	mg/L																						
P-D	mg/L	0.002			0.008		0.008	0.004			0.004	0.015	0.006	0.007	0.01	0.001	0.002	0.003	0.002		0.004		0.001
K-D	mg/L																						
Se-D	mg/L																						
U-D	mg/L																						
V-D	mg/L																						
Zn-D	mg/L	0.005						0.005															

Table D6 - Summary of water quality data
collected at the WB site.

Parameter	Units	13/03/1989	20/03/1989	28/03/1989	05/04/1989	11/04/1989	18/04/1989	04/07/1989	30/10/1989	05/12/1989	16/01/1990	04/02/1990	07/02/1990	28/02/1990	19/03/1990	26/03/1990	02/04/1990	15/04/1990	30/05/1990	12/06/1990	18/06/1990	25/06/1990	05/11/1990
Cond-L	uS/cm	38.9	42.8	37.7	47.2	57.3	51.5	7.3	50.3	47.4	44.1	45.9	56.8	58.5	47.6	56.7	63	81	53.7	47.6	59.5	61.8	
Hardness (as CaCO3)	mg/L																						
pH-L	pH Units	6.91	7.27	6.96	7.7	7.41	7.39	7.3	7.26	6.98	7.02	6.66	7.35	6.63	6.09	7.37	7.48	7.12	7.27	6.91	7.28	7.46	6.64
TSS	mg/L	2.7	1	1.3	1	1	1	3.3	1	2.7	1	3	1	3.3	1	1	6	1	<1	<1	<1	<1	1
Acidity 8.3	mg/L																						
Acidity 4.5	mg/L																						
Alk-T	mg/L																						
N-NH3	mg/L	0.005		0.005				0.011	0.005	0.005							0.005	0.005	0.005	0.009		0.009	0.013
NO2+NO3	mg/L																						
N-TKN	mg/L																0.15		0.08	0.15		0.27	
P-PO4-D	mg/L																						
P-PO4-T	mg/L																						
SO4-D	mg/L																						2.3
Al-T	mg/L																0.037						
Sb-T	mg/L																						
As-T	mg/L																						
Ba-T	mg/L																						
Be-T	mg/L																						
B-T	mg/L																						
Cd-T	mg/L																						
Ca-T	mg/L																7.57		6.5				
Cr-T	mg/L																						
Co-T	mg/L																						
Cu-T	mg/L																0.002		<0.001				
Fe-T	mg/L																0.03						
Pb-T	mg/L																						
Li-T	mg/L																						
Mg-T	mg/L																						
Mn-T	mg/L																1.13		0.91				
Hg-T	mg/L																0.041		<0.005				
Mo-T	mg/L																						
Ni-T	mg/L																						
P-T	mg/L	0.006		0.001	0.010		0.005	0.005	0.005	0.005							0.011	0.001	0.008	0.002		0.007	0.004
K-T	mg/L																						
Se-T	mg/L																						
Ag-T	mg/L																						
Na-T	mg/L																						
Tl-T	mg/L																						
Sn-T	mg/L																						
Ti-T	mg/L																						
U-T	mg/L																						
V-T	mg/L																						
Zn-T	mg/L																						
Zr-T	mg/L																0.005		0.009				
Al-D	mg/L																						
Sb-D	mg/L																						
As-D	mg/L																						
Ba-D	mg/L																						
Be-D	mg/L																						
B-D	mg/L																						
Cd-D	mg/L																						
Ca-D	mg/L																						
Cr-D	mg/L																						
Co-D	mg/L																						
Cu-D	mg/L																						
Fe-D	mg/L																						0.03
Pb-D	mg/L																						
Li-D	mg/L																						
Mg-D	mg/L																						
Mn-D	mg/L																						
Hg-D	mg/L																						
Mo-D	mg/L																						
Ni-D	mg/L																						
P-D	mg/L	0.001		0.001	0.001		0.001	0.002	0.002	0.005							0.008	0.001	0.001	0.001		0.003	0.001
K-D	mg/L																						
Se-D	mg/L																						
U-D	mg/L																						
V-D	mg/L																						
Zn-D	mg/L																						

Table D6 - Summary of water quality data collected at the WB site.

Parameter	Units	04/02/1991	02/04/1991	15/04/1991	30/05/1991	12/06/1991	18/06/1991	25/06/1991	05/11/1991	06/04/1992	06/04/1992	21/04/1992	21/04/1992	15/05/1992	15/05/1992	11/06/1992	11/06/1992	06/08/1992	06/08/1992	03/09/1992	03/09/1992	09/10/1992	09/10/1992
Cond-L	uS/cm	45.9	63	81	53.7	47.6	59.5	61.8		111.0	111.0	95.5	95.5			73.2	73.2	58.1	58.1	60.5	60.5	57.0	57.0
Hardness (as CaCO3)	mg/L		23.7									27.0	27.0										
pH-L	pH Units	6.66	7.48	7.12	7.27	6.91	7.28	7.46	6.64	7.46	7.46	7.03	7.03			6.94	6.94	6.94	6.94	7.37	7.37	7.61	7.61
TSS	mg/L	3	6	1	<1	<1	<1	<1	1	<1	<1	<1	<1	<1	<1	1	1	1	1	<1	<1	2	2
Acidity 8.3	mg/L																						
Acidity 4.5	mg/L																						
Alk-T	mg/L																						
N-NH3	mg/L		0.005	0.005	0.005	0.009		0.009	0.013			<0.005	<0.005			<0.005	<0.005						
NO2+NO3	mg/L																						
N-TKN	mg/L		0.15		0.08	0.15		0.27								0.24	0.24						
P-PO4-D	mg/L											0.004		<0.001		0.003						0.007	
P-PO4-T	mg/L											0.009				0.003						0.008	
SO4-D	mg/L								2.3			23.2	23.2										
Al-T	mg/L		0.037									0.04	0.04										
Sb-T	mg/L																						
As-T	mg/L																						
Ba-T	mg/L																						
Be-T	mg/L																						
B-T	mg/L																						
Cd-T	mg/L																						
Ca-T	mg/L		7.57		6.5																		
Cr-T	mg/L																						
Co-T	mg/L																						
Cu-T	mg/L		0.002		<0.001							0.001	0.001										
Fe-T	mg/L																						
Pb-T	mg/L																						
Li-T	mg/L																						
Mg-T	mg/L		1.13		0.91																		
Mn-T	mg/L		0.041		<0.005							<0.005	<0.005										
Hg-T	mg/L																						
Mo-T	mg/L																						
Ni-T	mg/L																						
P-T	mg/L		0.011	0.001	0.008	0.002		0.007	0.004				0.009				0.003						0.008
K-T	mg/L																						
Se-T	mg/L																						
Ag-T	mg/L																						
Na-T	mg/L																						
Tl-T	mg/L																						
Sn-T	mg/L																						
Ti-T	mg/L																						
U-T	mg/L																						
V-T	mg/L																						
Zn-T	mg/L		0.005		0.009							<0.005	<0.005										
Zr-T	mg/L																						
Al-D	mg/L																						
Sb-D	mg/L																						
As-D	mg/L																						
Ba-D	mg/L																						
Be-D	mg/L																						
B-D	mg/L																						
Cd-D	mg/L																						
Ca-D	mg/L											8.97	8.97										
Cr-D	mg/L																						
Co-D	mg/L																						
Cu-D	mg/L																						
Fe-D	mg/L		0.03						0.03			0.004	0.004										
Pb-D	mg/L																						
Li-D	mg/L																						
Mg-D	mg/L											1.12	1.12										
Mn-D	mg/L																						
Hg-D	mg/L																						
Mo-D	mg/L																						
Ni-D	mg/L																						
P-D	mg/L		0.008	0.001	0.001	0.001		0.003	0.001				0.004		<0.001		0.003						0.007
K-D	mg/L																						
Se-D	mg/L																						
U-D	mg/L																						
V-D	mg/L																						
Zn-D	mg/L																						

Table D6 - Summary of water quality data collected at the WB site.

Parameter	Units	06/11/1992	06/11/1992	19/11/1992	19/11/1992	02/12/1992	02/12/1992	21/12/1992	21/12/1992	01/01/1993	01/01/1993	08/02/1993	08/02/1993	23/02/1993	23/02/1993	09/03/1993	09/03/1993	29/03/1993	29/03/1993	07/04/1993	27/04/1993	04/05/1993
Cond-L	uS/cm	48.5	48.5	51.6	51.6	74.4	74.4	72.0	72.0	80.0	80.0	83.9	83.9	88.9	88.9	107.0	107.0	131.0	131.0			
Hardness (as CaCO3)	mg/L	18.4	18.4					20.0	20.0			24.2	24.2									
pH-L	pH Units	7.36	7.36	7.17	7.17	7.35	7.35	7.49	7.49	7.16	7.16	7.35	7.35	7.74	7.74	7.50	7.50	7.56	7.56	7.55	7.81	7.3
TSS	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	3	3	4	4	2	2	<1	<1	3	3	1	1	1
Acidity 8.3	mg/L																					
Acidity 4.5	mg/L																					
Alk-T	mg/L																					
N-NH3	mg/L	0.005	0.005									0.009	0.009									
NO2+NO3	mg/L																					
N-TKN	mg/L	0.25	0.25					0.33	0.33													
P-PO4-D	mg/L	<0.001				0.002		<0.001				0.003	0.003	0.003	0.003	<0.001	<0.001	0.002	0.002			
P-PO4-T	mg/L	0.002										0.003	0.003									
SO4-D	mg/L					16.1	16.1													43.9		
Al-T	mg/L	0.03	0.03									0.05	0.05									
Sb-T	mg/L																					
As-T	mg/L																					
Ba-T	mg/L																					
Be-T	mg/L																					
B-T	mg/L																					
Cd-T	mg/L																					
Ca-T	mg/L	5.91	5.91									7.66	7.66									
Cr-T	mg/L																					
Co-T	mg/L																					
Cu-T	mg/L	<0.001	<0.001																			
Fe-T	mg/L	0.056																				
Pb-T	mg/L																					
Li-T	mg/L																					
Mg-T	mg/L	0.90	0.90									1.24	1.24									
Mn-T	mg/L	0.01	0.01									0.01	0.01									
Hg-T	mg/L																					
Mo-T	mg/L																					
Ni-T	mg/L																					
P-T	mg/L		0.002																			
K-T	mg/L																					
Se-T	mg/L																					
Ag-T	mg/L																					
Na-T	mg/L																					
Tl-T	mg/L																					
Sn-T	mg/L																					
Ti-T	mg/L																					
U-T	mg/L																					
V-T	mg/L																					
Zn-T	mg/L	<0.005	<0.005																			
Zr-T	mg/L																					
Al-D	mg/L					0.033	0.033															
Sb-D	mg/L																					
As-D	mg/L																					
Ba-D	mg/L																					
Be-D	mg/L																					
B-D	mg/L																					
Cd-D	mg/L																					
Ca-D	mg/L																					
Cr-D	mg/L																					
Co-D	mg/L																					
Cu-D	mg/L																					
Fe-D	mg/L		0.056																			
Pb-D	mg/L																					
Li-D	mg/L																					
Mg-D	mg/L																					
Mn-D	mg/L																					
Hg-D	mg/L																					
Mo-D	mg/L																					
Ni-D	mg/L																					
P-D	mg/L		<0.001				0.002		<0.001													
K-D	mg/L																					
Se-D	mg/L																					
U-D	mg/L																					
V-D	mg/L																					
Zn-D	mg/L																					

Table D6 - Summary of water quality data collected at the WB site.																						
Parameter	Units	28/05/1993	10/06/1993	21/06/1993	05/07/1993	03/08/1993	27/09/1993	26/10/1993	27/11/1993	06/12/1993	08/12/1993	13/12/1993	21/12/1993	02/01/1994	13/01/1994	31/01/1994	01/02/1994	07/02/1994	01/03/1994	07/03/1994	16/03/1994	24/03/1994
Cond-L	uS/cm																					
Hardness (as CaCO3)	mg/L																					
pH-L	pH Units	6.85	7.78	7.53	7.60	7.40	6.66	7.28	7.49	6.84	6.58	6.58	7.03	7.12	6.98	7.16	7.04	7.03	7.05	6.99	7.15	7.08
TSS	mg/L	1	1	3	3	1	1	1	1	1	3	5	1	1	1	1	1	2	1	13	1	1
Acidity 8.3	mg/L																					
Acidity 4.5	mg/L																					
Alk-T	mg/L																					
N-NH3	mg/L																					
NO2+NO3	mg/L																					
N-TKN	mg/L																					
P-PO4-D	mg/L																					
P-PO4-T	mg/L																					
SO4-D	mg/L						13.2	16	14.4	12.5	16.4	22.6	14.4	36.8	29.0	37.7	33.8	37.5	11.0	11.5	43.7	43.8
Al-T	mg/L																					
Sb-T	mg/L																					
As-T	mg/L																					
Ba-T	mg/L																					
Be-T	mg/L																					
B-T	mg/L																					
Cd-T	mg/L																					
Ca-T	mg/L																					
Cr-T	mg/L																					
Co-T	mg/L																					
Cu-T	mg/L																					
Fe-T	mg/L																					
Pb-T	mg/L																					
Li-T	mg/L																					
Mg-T	mg/L																					
Mn-T	mg/L																					
Hg-T	mg/L																					
Mo-T	mg/L																					
Ni-T	mg/L																					
P-T	mg/L																					
K-T	mg/L																					
Se-T	mg/L																					
Ag-T	mg/L																					
Na-T	mg/L																					
Tl-T	mg/L																					
Sn-T	mg/L																					
Ti-T	mg/L																					
U-T	mg/L																					
V-T	mg/L																					
Zn-T	mg/L																					
Zr-T	mg/L																					
Al-D	mg/L																					
Sb-D	mg/L																					
As-D	mg/L																					
Ba-D	mg/L																					
Be-D	mg/L																					
B-D	mg/L																					
Cd-D	mg/L																					
Ca-D	mg/L																					
Cr-D	mg/L																					
Co-D	mg/L																					
Cu-D	mg/L																					
Fe-D	mg/L																					
Pb-D	mg/L																					
Li-D	mg/L																					
Mg-D	mg/L																					
Mn-D	mg/L																					
Hg-D	mg/L																					
Mo-D	mg/L																					
Ni-D	mg/L																					
P-D	mg/L																					
K-D	mg/L																					
Se-D	mg/L																					
U-D	mg/L																					
V-D	mg/L																					
Zn-D	mg/L																					

Table D6 - Summary of water quality data collected at the WB site.																						
Parameter	Units	15/04/1994	15/05/1994	15/10/1994	15/11/1994	15/12/1994	15/01/1995	15/02/1995	15/03/1995	10/04/1995	17/04/1995	08/05/1995	22/05/1995	12/06/1995	10/07/1995	14/08/1995	21/08/1995	11/09/1995	09/10/1995	13/11/1995	11/12/1995	18/12/1995
Cond-L	uS/cm	172.000	137.000	68.500	82.000	76.300	121.000	179.000	216.000													
Hardness (as CaCO3)	mg/L																					
pH-L	pH Units	7.140	7.290	7.370	6.890	6.930	7.060	7.180	6.910													
TSS	mg/L	<1	<1	<1	2.000	2.000	<1	1.000	<1													
Acidity 8.3	mg/L																					
Acidity 4.5	mg/L																					
Alk-T	mg/L																					
N-NH3	mg/L																					
NO2+NO3	mg/L																					
N-TKN	mg/L																					
P-PO4-D	mg/L																					
P-PO4-T	mg/L																					
SO4-D	mg/L									75	66.1	49.5	44.1	34.3	23.1	18.9	21.7	15.9	13.3	13.9	29.7	15.4
Al-T	mg/L																					
Sb-T	mg/L																					
As-T	mg/L																					
Ba-T	mg/L																					
Be-T	mg/L																					
B-T	mg/L																					
Cd-T	mg/L																					
Ca-T	mg/L																					
Cr-T	mg/L																					
Co-T	mg/L																					
Cu-T	mg/L																					
Fe-T	mg/L																					
Pb-T	mg/L																					
Li-T	mg/L																					
Mg-T	mg/L																					
Mn-T	mg/L																					
Hg-T	mg/L																					
Mo-T	mg/L																					
Ni-T	mg/L																					
P-T	mg/L																					
K-T	mg/L																					
Se-T	mg/L																					
Ag-T	mg/L																					
Na-T	mg/L																					
Tl-T	mg/L																					
Sn-T	mg/L																					
Ti-T	mg/L																					
U-T	mg/L																					
V-T	mg/L																					
Zn-T	mg/L																					
Zr-T	mg/L																					
Al-D	mg/L																					
Sb-D	mg/L																					
As-D	mg/L																					
Ba-D	mg/L																					
Be-D	mg/L																					
B-D	mg/L																					
Cd-D	mg/L																					
Ca-D	mg/L																					
Cr-D	mg/L																					
Co-D	mg/L																					
Cu-D	mg/L																					
Fe-D	mg/L																					
Pb-D	mg/L																					
Li-D	mg/L																					
Mg-D	mg/L																					
Mn-D	mg/L																					
Hg-D	mg/L																					
Mo-D	mg/L																					
Ni-D	mg/L																					
P-D	mg/L																					
K-D	mg/L																					
Se-D	mg/L																					
U-D	mg/L																					
V-D	mg/L																					
Zn-D	mg/L																					

Table D6 - Summary of water quality data collected at the WB site.																						
Parameter	Units	25/12/1995	01/01/1996	08/01/1996	12/01/1996	15/01/1996	18/01/1996	22/01/1996	27/01/1996	02/02/1996	05/02/1996	12/02/1996	18/02/1996	19/02/1996	22/02/1996	26/02/1996	01/03/1996	04/03/1996	11/03/1996	12/03/1996	18/03/1996	25/03/1996
Cond-L	uS/cm		108		71		88.8		95.3	105		148	145		98.4		67.8			95	80.1	
Hardness (as CaCO3)	mg/L						27.6						39.8		27.6							
pH-L	pH Units		7.2		7.29		7.23		7.21	7.04		7.28	7.03		7.01		7.09			7.05	7.13	
TSS	mg/L		2		1		2		<1	3		4	<1		<1		2			1	<1	
Acidity 8.3	mg/L																					
Acidity 4.5	mg/L																					
Alk-T	mg/L																					
N-NH3	mg/L												<.005									
NO2+NO3	mg/L																					
N-TKN	mg/L																					
P-PO4-D	mg/L																					
P-PO4-T	mg/L																					
SO4-D	mg/L	25.4		18.7	18.7	21.3	21.3	22.5	22.5	25.8	25.8	41.7	41.7	41.7	26.1	26.1	13.1	13.1	23.8	23.8	19.6	42.7
Al-T	mg/L		<.20							<.20			<.20									
Sb-T	mg/L																					
As-T	mg/L																					
Ba-T	mg/L																					
Be-T	mg/L																					
B-T	mg/L																					
Cd-T	mg/L																					
Ca-T	mg/L		9.87				8.76			10.3			12.8									
Cr-T	mg/L																					
Co-T	mg/L																					
Cu-T	mg/L		<.010							<.010			<.010									
Fe-T	mg/L																					
Pb-T	mg/L		<.050							<.050			<.050									
Li-T	mg/L																					
Mg-T	mg/L																					
Mn-T	mg/L		<.005							0.009			0.006									
Hg-T	mg/L																					
Mo-T	mg/L																					
Ni-T	mg/L																					
P-T	mg/L												0.007									
K-T	mg/L																					
Se-T	mg/L																					
Ag-T	mg/L																					
Na-T	mg/L																					
Tl-T	mg/L																					
Sn-T	mg/L																					
Ti-T	mg/L																					
U-T	mg/L																					
V-T	mg/L																					
Zn-T	mg/L		<.005							<.005			<.005									
Zr-T	mg/L																					
Al-D	mg/L												<.20									
Sb-D	mg/L																					
As-D	mg/L																					
Ba-D	mg/L																					
Be-D	mg/L																					
B-D	mg/L																					
Cd-D	mg/L																					
Ca-D	mg/L												12.4		8.68							
Cr-D	mg/L																					
Co-D	mg/L																					
Cu-D	mg/L												<.010									
Fe-D	mg/L												<.030									
Pb-D	mg/L												<.005									
Li-D	mg/L																					
Mg-D	mg/L												2.16		1.44							
Mn-D	mg/L												<.005									
Hg-D	mg/L																					
Mo-D	mg/L																					
Ni-D	mg/L																					
P-D	mg/L												0.004									
K-D	mg/L																					
Se-D	mg/L																					
U-D	mg/L																					
V-D	mg/L																					
Zn-D	mg/L												<.005									

Table D6 - Summary of water quality data collected at the WB site.																						
Parameter	Units	27/03/1996	01/04/1996	15/04/1996	22/04/1996	06/05/1996	13/05/1996	20/05/1996	27/05/1996	03/06/1996	10/06/1996	17/06/1996	24/06/1996	01/07/1996	08/07/1996	15/07/1996	22/07/1996	05/08/1996	12/08/1996	19/08/1996	26/08/1996	02/09/1996
Cond-L	uS/cm	143																				
Hardness (as CaCO3)	mg/L																					
pH-L	pH Units	7.12																				
TSS	mg/L	5																				
Acidity 8.3	mg/L																					
Acidity 4.5	mg/L																					
Alk-T	mg/L																					
N-NH3	mg/L																					
NO2+NO3	mg/L																					
N-TKN	mg/L																					
P-PO4-D	mg/L																					
P-PO4-T	mg/L																					
SO4-D	mg/L	42.7	50.4	34.3	35.9	25.8	23.9	26.9	34.9	34.2	28.2	25.2	20.9	21.2	19.4	17	15.5	14.6	12.8	15.3	12.4	12.5
Al-T	mg/L																					
Sb-T	mg/L																					
As-T	mg/L																					
Ba-T	mg/L																					
Be-T	mg/L																					
B-T	mg/L																					
Cd-T	mg/L																					
Ca-T	mg/L																					
Cr-T	mg/L																					
Co-T	mg/L																					
Cu-T	mg/L																					
Fe-T	mg/L																					
Pb-T	mg/L																					
Li-T	mg/L																					
Mg-T	mg/L																					
Mn-T	mg/L																					
Hg-T	mg/L																					
Mo-T	mg/L																					
Ni-T	mg/L																					
P-T	mg/L																					
K-T	mg/L																					
Se-T	mg/L																					
Ag-T	mg/L																					
Na-T	mg/L																					
Tl-T	mg/L																					
Sn-T	mg/L																					
Ti-T	mg/L																					
U-T	mg/L																					
V-T	mg/L																					
Zn-T	mg/L																					
Zr-T	mg/L																					
Al-D	mg/L																					
Sb-D	mg/L																					
As-D	mg/L																					
Ba-D	mg/L																					
Be-D	mg/L																					
B-D	mg/L																					
Cd-D	mg/L																					
Ca-D	mg/L																					
Cr-D	mg/L																					
Co-D	mg/L																					
Cu-D	mg/L																					
Fe-D	mg/L																					
Pb-D	mg/L																					
Li-D	mg/L																					
Mg-D	mg/L																					
Mn-D	mg/L																					
Hg-D	mg/L																					
Mo-D	mg/L																					
Ni-D	mg/L																					
P-D	mg/L																					
K-D	mg/L																					
Se-D	mg/L																					
U-D	mg/L																					
V-D	mg/L																					
Zn-D	mg/L																					

Table D6 - Summary of water quality data collected at the WB site.																						
Parameter	Units	09/09/1996	16/09/1996	23/09/1996	07/10/1996	28/10/1996	04/11/1996	11/11/1996	18/11/1996	25/11/1996	02/12/1996	09/12/1996	16/12/1996	23/12/1996	06/01/1997	13/01/1997	20/01/1997	27/01/1997	03/02/1997	10/02/1997	17/02/1997	24/02/1997
Cond-L	uS/cm																					
Hardness (as CaCO3)	mg/L																					
pH-L	pH Units																					
TSS	mg/L																					
Acidity 8.3	mg/L																					
Acidity 4.5	mg/L																					
Alk-T	mg/L																					
N-NH3	mg/L																					
NO2+NO3	mg/L																					
N-TKN	mg/L																					
P-PO4-D	mg/L																					
P-PO4-T	mg/L																					
SO4-D	mg/L	12	10.4	12.2	9.9	29.3	29.1	25	41	48	48	40	39	38	32	45	38	40	44	22	67	66
Al-T	mg/L																					
Sb-T	mg/L																					
As-T	mg/L																					
Ba-T	mg/L																					
Be-T	mg/L																					
B-T	mg/L																					
Cd-T	mg/L																					
Ca-T	mg/L																					
Cr-T	mg/L																					
Co-T	mg/L																					
Cu-T	mg/L																					
Fe-T	mg/L																					
Pb-T	mg/L																					
Li-T	mg/L																					
Mg-T	mg/L																					
Mn-T	mg/L																					
Hg-T	mg/L																					
Mo-T	mg/L																					
Ni-T	mg/L																					
P-T	mg/L																					
K-T	mg/L																					
Se-T	mg/L																					
Ag-T	mg/L																					
Na-T	mg/L																					
Tl-T	mg/L																					
Sn-T	mg/L																					
Ti-T	mg/L																					
U-T	mg/L																					
V-T	mg/L																					
Zn-T	mg/L																					
Zr-T	mg/L																					
Al-D	mg/L																					
Sb-D	mg/L																					
As-D	mg/L																					
Ba-D	mg/L																					
Be-D	mg/L																					
B-D	mg/L																					
Cd-D	mg/L																					
Ca-D	mg/L																					
Cr-D	mg/L																					
Co-D	mg/L																					
Cu-D	mg/L																					
Fe-D	mg/L																					
Pb-D	mg/L																					
Li-D	mg/L																					
Mg-D	mg/L																					
Mn-D	mg/L																					
Hg-D	mg/L																					
Mo-D	mg/L																					
Ni-D	mg/L																					
P-D	mg/L																					
K-D	mg/L																					
Se-D	mg/L																					
U-D	mg/L																					
V-D	mg/L																					
Zn-D	mg/L																					

Table D6 - Summary of water quality data collected at the WB site.																						
Parameter	Units	03/03/1997	10/03/1997	17/03/1997	24/03/1997	01/04/1997	07/04/1997	10/04/1997	14/04/1997	17/04/1997	21/04/1997	27/04/1997	28/04/1997	05/05/1997	12/05/1997	19/05/1997	02/06/1997	09/06/1997	16/06/1997	23/06/1997	30/06/1997	07/07/1997
Cond-L	uS/cm											199										
Hardness (as CaCO3)	mg/L											50										
pH-L	pH Units											7.28										
TSS	mg/L					<1		<1		2		1										
Acidity 8.3	mg/L																					
Acidity 4.5	mg/L																					
Alk-T	mg/L																					
N-NH3	mg/L																					
NO2+NO3	mg/L																					
N-TKN	mg/L											0.12										
P-PO4-D	mg/L																					
P-PO4-T	mg/L																					
SO4-D	mg/L	45	46	49	73	70	70	68	68	65	65	64	64	60	19	7	7	6	5	5	6	5
Al-T	mg/L											<2										
Sb-T	mg/L																					
As-T	mg/L																					
Ba-T	mg/L																					
Be-T	mg/L																					
B-T	mg/L																					
Cd-T	mg/L																					
Ca-T	mg/L											15.6										
Cr-T	mg/L																					
Co-T	mg/L																					
Cu-T	mg/L																					
Fe-T	mg/L																					
Pb-T	mg/L																					
Li-T	mg/L																					
Mg-T	mg/L																					
Mn-T	mg/L											2.68										
Hg-T	mg/L											<.005										
Mo-T	mg/L																					
Ni-T	mg/L																					
P-T	mg/L																					
K-T	mg/L																					
Se-T	mg/L																					
Ag-T	mg/L																					
Na-T	mg/L																					
Tl-T	mg/L																					
Sn-T	mg/L																					
Ti-T	mg/L																					
U-T	mg/L																					
V-T	mg/L																					
Zn-T	mg/L																					
Zr-T	mg/L																					
Al-D	mg/L																					
Sb-D	mg/L																					
As-D	mg/L																					
Ba-D	mg/L																					
Be-D	mg/L																					
B-D	mg/L																					
Cd-D	mg/L																					
Ca-D	mg/L																					
Cr-D	mg/L																					
Co-D	mg/L																					
Cu-D	mg/L																					
Fe-D	mg/L																					
Pb-D	mg/L																					
Li-D	mg/L																					
Mg-D	mg/L																					
Mn-D	mg/L																					
Hg-D	mg/L																					
Mo-D	mg/L																					
Ni-D	mg/L																					
P-D	mg/L																					
K-D	mg/L																					
Se-D	mg/L																					
U-D	mg/L																					
V-D	mg/L																					
Zn-D	mg/L																					

Table D6 - Summary of water quality data collected at the WB site.																						
Parameter	Units	15/12/1997	22/12/1997	05/01/1998	19/01/1998	26/01/1998	02/02/1998	09/02/1998	16/02/1998	23/02/1998	02/03/1998	09/03/1998	16/03/1998	23/03/1998	06/04/1998	13/04/1998	20/04/1998	27/04/1998	05/05/1998	12/05/1998	18/05/1998	19/05/1998
Cond-L	uS/cm														199			92				
Hardness (as CaCO3)	mg/L																	30.90				
pH-L	pH Units																	7.44	7.23	7.40	7.39	7.39
TSS	mg/L														2.00	2.00	4.00	2.00	<1	<1	<1	<1
Acidity 8.3	mg/L																					
Acidity 4.5	mg/L																					
Alk-T	mg/L																					
N-NH3	mg/L																	<.005				
NO2+NO3	mg/L																					
N-TKN	mg/L																	0.110				
P-PO4-D	mg/L																					
P-PO4-T	mg/L																					
SO4-D	mg/L	41	25	19	30	31	20	40	27	22	27	33	28	21	18	20	24	20		24	28	28
Al-T	mg/L																	<.2				
Sb-T	mg/L																					
As-T	mg/L																					
Ba-T	mg/L																					
Be-T	mg/L																					
B-T	mg/L																					
Cd-T	mg/L																					
Ca-T	mg/L																	10.10				
Cr-T	mg/L																					
Co-T	mg/L																					
Cu-T	mg/L																	0.02				
Fe-T	mg/L																	0.03				
Pb-T	mg/L																	<.05				
Li-T	mg/L																					
Mg-T	mg/L																	1.40				
Mn-T	mg/L																	0.005				
Hg-T	mg/L																					
Mo-T	mg/L																					
Ni-T	mg/L																					
P-T	mg/L																	0.007				
K-T	mg/L																					
Se-T	mg/L																					
Ag-T	mg/L																					
Na-T	mg/L																					
Tl-T	mg/L																					
Sn-T	mg/L																					
Ti-T	mg/L																					
U-T	mg/L																					
V-T	mg/L																					
Zn-T	mg/L																	<.005				
Zr-T	mg/L																					
Al-D	mg/L																					
Sb-D	mg/L																					
As-D	mg/L																					
Ba-D	mg/L																					
Be-D	mg/L																					
B-D	mg/L																					
Cd-D	mg/L																					
Ca-D	mg/L																					
Cr-D	mg/L																					
Co-D	mg/L																					
Cu-D	mg/L																					
Fe-D	mg/L																					
Pb-D	mg/L																					
Li-D	mg/L																					
Mg-D	mg/L																					
Mn-D	mg/L																					
Hg-D	mg/L																					
Mo-D	mg/L																					
Ni-D	mg/L																					
P-D	mg/L																	0.003				
K-D	mg/L																					
Se-D	mg/L																					
U-D	mg/L																					
V-D	mg/L																					
Zn-D	mg/L																					

Table D6 - Summary of water quality data collected at the WB site.																						
Parameter	Units	25/05/1998	26/05/1998	01/06/1998	08/06/1998	15/06/1998	22/06/1998	06/07/1998	13/07/1998	20/07/1998	27/07/1998	03/08/1998	04/08/1998	31/08/1998	02/09/1998	07/09/1998	08/09/1998	21/09/1998	28/09/1998	05/10/1998	06/10/1998	12/10/1998
Cond-L	uS/cm	94	94				94			83	83	57	57	80	80	82	82	68	76	77	76	96
Hardness (as CaCO3)	mg/L	30.10								29.80									48.00			
pH-L	pH Units	7.39	7.39				7.45			7.40	7.40	7.51	7.51	6.92	6.92	7.48	7.48	7.38	7.54	7.74	7.54	7.45
TSS	mg/L	<1	<1	3.00	<1	<1	<1	<1	<1	<1	<1	1	1	3	3	1	1	3	2	<1	2	3
Acidity 8.3	mg/L																					
Acidity 4.5	mg/L																					
Alk-T	mg/L																					
N-NH3	mg/L	<.005	<.005				<.005			<.005	<.005	<0.005	<0.005									
NO2+NO3	mg/L																					
N-TKN	mg/L	0.150	0.150				0.130			0.120	0.120	0.150	0.150									
P-PO4-D	mg/L																					
P-PO4-T	mg/L																					
SO4-D	mg/L	21	21	20	17	22	17	16	15	19		17	17	17	17	17	17	11	11	12		20
Al-T	mg/L	<.2	<.2				<.2			<.2	<.2	<.2	<.2									
Sb-T	mg/L																					
As-T	mg/L																					
Ba-T	mg/L																					
Be-T	mg/L																					
B-T	mg/L																					
Cd-T	mg/L																					
Ca-T	mg/L	9.84	9.84				10.90			9.78	9.78	9.69	9.69									
Cr-T	mg/L																					
Co-T	mg/L																					
Cu-T	mg/L	<.001	<.001				<.01			<.01	<.01	<.01	<.01									
Fe-T	mg/L	0.03	0.03				0.04			0.04	0.04	0.05	0.05									
Pb-T	mg/L	<.0001	<.0001				<.005			<.05	<.005	<.05	<.005									
Li-T	mg/L																					
Mg-T	mg/L	1.30	1.30				1.50			1.30	1.30	1.30	1.30									
Mn-T	mg/L	0.006	0.006				0.009			<.005	<.005	0.009	0.009									
Hg-T	mg/L																					
Mo-T	mg/L																					
Ni-T	mg/L																					
P-T	mg/L	0.003	0.003				0.003			0.003	0.003	0.003	0.003									
K-T	mg/L																					
Se-T	mg/L																					
Ag-T	mg/L																					
Na-T	mg/L																					
Tl-T	mg/L																					
Sn-T	mg/L																					
Ti-T	mg/L																					
U-T	mg/L																					
V-T	mg/L																					
Zn-T	mg/L	<.005	<.005				<.005			<.005	<.005	<.005	<.005									
Zr-T	mg/L																					
Al-D	mg/L																					
Sb-D	mg/L																					
As-D	mg/L																					
Ba-D	mg/L																					
Be-D	mg/L																					
B-D	mg/L																					
Cd-D	mg/L																					
Ca-D	mg/L																					
Cr-D	mg/L																					
Co-D	mg/L																					
Cu-D	mg/L																					
Fe-D	mg/L																					
Pb-D	mg/L																					
Li-D	mg/L																					
Mg-D	mg/L																					
Mn-D	mg/L																					
Hg-D	mg/L																					
Mo-D	mg/L																					
Ni-D	mg/L																					
P-D	mg/L	<.001	<.001				<.001			0.002	0.002	<0.001	<0.001									
K-D	mg/L																					
Se-D	mg/L																					
U-D	mg/L																					
V-D	mg/L																					
Zn-D	mg/L																					

Table D6 - Summary of water quality data collected at the WB site.																						
Parameter	Units	13/10/1998	19/10/1998	26/10/1998	02/11/1998	09/11/1998	16/11/1998	24/11/1998	07/12/1998	14/12/1998	21/12/1998	28/12/1998	29/12/1998	04/01/1999	11/01/1999	18/01/1999	25/01/1999	01/02/1999	08/02/1999	15/02/1999	01/03/1999	08/03/1999
Cond-L	uS/cm	77	92	109	108	199	199					156	156	135	147	135	179	194	172	145	127	128
Hardness (as CaCO3)	mg/L				23.00									46.20				55.40			35.50	
pH-L	pH Units	7.74	7.34	7.52	7.43	7.58	7.58					7.17	7.17	7.40	7.04	6.96	7.54	7.05	6.97	7.03	6.99	7.04
TSS	mg/L	<1	<1	<1	2	<1	<1	<1	2	48	<01.0	<01.0	<01.0	<1.0	1	<1.0	2	<3.0	3	<3.0	<3.0	<3.0
Acidity 8.3	mg/L																					
Acidity 4.5	mg/L																					
Alk-T	mg/L																	23.00				
N-NH3	mg/L													0.010				<0.005			<0.005	
NO2+NO3	mg/L																					
N-TKN	mg/L													0.140				0.120			0.080	
P-PO4-D	mg/L																					
P-PO4-T	mg/L																					
SO4-D	mg/L	12	21	26	27	58	72	72	42		49	52	52	51	47	43	54	66	61	44	29	34
Al-T	mg/L											<0.02	<0.02	0.002		0.001		0.003			0.004	
Sb-T	mg/L																					
As-T	mg/L																					
Ba-T	mg/L																					
Be-T	mg/L																					
B-T	mg/L																					
Cd-T	mg/L																					
Ca-T	mg/L											16.00	16.00									
Cr-T	mg/L																					
Co-T	mg/L																					
Cu-T	mg/L											<0.01	<0.01									
Fe-T	mg/L											<0.03	<0.03									
Pb-T	mg/L											<0.05	<0.05									
Li-T	mg/L																					
Mg-T	mg/L																					
Mn-T	mg/L											2.40	2.40									
Hg-T	mg/L											0.008	0.008									
Mo-T	mg/L																					
Ni-T	mg/L																					
P-T	mg/L													0.001		<0.001		0.002			0.003	
K-T	mg/L																					
Se-T	mg/L																					
Ag-T	mg/L																					
Na-T	mg/L																					
Tl-T	mg/L																					
Sn-T	mg/L																					
Ti-T	mg/L																					
U-T	mg/L																					
V-T	mg/L																					
Zn-T	mg/L											<0.005	<0.005									
Zr-T	mg/L																					
Al-D	mg/L																					
Sb-D	mg/L																					
As-D	mg/L																					
Ba-D	mg/L																					
Be-D	mg/L																					
B-D	mg/L																					
Cd-D	mg/L																					
Ca-D	mg/L																					
Cr-D	mg/L																					
Co-D	mg/L																					
Cu-D	mg/L																					
Fe-D	mg/L																					
Pb-D	mg/L																					
Li-D	mg/L																					
Mg-D	mg/L																					
Mn-D	mg/L																					
Hg-D	mg/L																					
Mo-D	mg/L																					
Ni-D	mg/L																					
P-D	mg/L													0.001		<0.001		0.001			0.001	
K-D	mg/L																					
Se-D	mg/L																					
U-D	mg/L																					
V-D	mg/L																					
Zn-D	mg/L																					

Table D6 - Summary of water quality data collected at the WB site.																						
Parameter	Units	15/03/1999	22/03/1999	29/03/1999	05/04/1999	19/04/1999	26/04/1999	03/05/1999	17/05/1999	28/06/1999	19/07/1999	16/08/1999	20/09/1999	25/10/1999	08/11/1999	15/11/1999	06/12/1999	13/12/1999	20/12/1999	27/12/1999	03/01/2000	10/01/2000
Cond-L	uS/cm	127	142	142	159			188	174	46	41	46	56	100	157	66	86	88	80	114	134	112
Hardness (as CaCO3)	mg/L				47.8			51.2		21.2	20.9	20.8	21.2	31.5	45.1	21.6		29.8				34.3
pH-L	pH Units	7.08	6.76	6.76	6.84	7.6	7.14	7.47	6.98	7.12	7.22	7.13	7.5	7.72	7.75	7.41	7.59	7.54	7.65	7.87	7.72	7.36
TSS	mg/L	<3.0	<3.0	<3.0	<3	5	<3	<3.0	<3.0	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	11	<3	<3
Acidity 8.3	mg/L																					
Acidity 4.5	mg/L																					
Alk-T	mg/L																					
N-NH3	mg/L				<0.005		0.005	<0.005	0.022	<0.005	<0.05	<0.005	0.007	<0.005	<0.005	<0.005		<0.005				<0.005
NO2+NO3	mg/L																					
N-TKN	mg/L				0.07		0.09	0.26	0.08	0.07	0.06	0.25	0.12	0.27	0.1	0.11		0.08				0.08
P-PO4-D	mg/L																					
P-PO4-T	mg/L																					
SO4-D	mg/L	35	40	40	52	60	53	59	62	4	3	4	7	21	38	11		10	17	27	35	27
Al-T	mg/L				<0.2		<.2	<0.2		<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2		<0.2				<0.2
Sb-T	mg/L																					
As-T	mg/L																					
Ba-T	mg/L																					
Be-T	mg/L																					
B-T	mg/L																					
Cd-T	mg/L																					
Ca-T	mg/L				15.6		13.2	16.1		7.21	7.23	6.89	7.26	10.4	15.4	7.36		9.54				11.1
Cr-T	mg/L																					
Co-T	mg/L																					
Cu-T	mg/L				<0.01		<0.01	<0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01				<0.01
Fe-T	mg/L				0.03		0.04	0.04		0.04	0.05	0.04	0.04	0.04	0.06	0.04		0.02				0.04
Pb-T	mg/L				<0.005		<0.005	<0.005		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005		<0.005				<0.005
Li-T	mg/L																					
Mg-T	mg/L				2		1.9	2.3		0.8	0.8	0.8	0.9	1.3	2	1		1.3				1.5
Mn-T	mg/L				0.007		0.008	0.005		0.008	0.011	0.006	0.006	0.011	0.012	0.006		<0.005				0.005
Hg-T	mg/L																					
Mo-T	mg/L																					
Ni-T	mg/L																					
P-T	mg/L				<0.002		0.003	0.004	0.003	0.002	0.004	0.002	0.002	0.002	0.002	<0.002		<0.002				0.002
K-T	mg/L																					
Se-T	mg/L																					
Ag-T	mg/L																					
Na-T	mg/L																					
Tl-T	mg/L																					
Sn-T	mg/L																					
Ti-T	mg/L																					
U-T	mg/L																					
V-T	mg/L																					
Zn-T	mg/L				<0.005		<0.005	<0.005		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005		<0.005				<0.005
Zr-T	mg/L																					
Al-D	mg/L																					
Sb-D	mg/L																					
As-D	mg/L																					
Ba-D	mg/L																					
Be-D	mg/L																					
B-D	mg/L																					
Cd-D	mg/L																					
Ca-D	mg/L																					
Cr-D	mg/L																					
Co-D	mg/L																					
Cu-D	mg/L																					
Fe-D	mg/L																					
Pb-D	mg/L																					
Li-D	mg/L																					
Mg-D	mg/L																					
Mn-D	mg/L																					
Hg-D	mg/L																					
Mo-D	mg/L																					
Ni-D	mg/L																					
P-D	mg/L				<0.002		0.002	<0.002	<0.002	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002		<0.002				0.002
K-D	mg/L																					
Se-D	mg/L																					
U-D	mg/L																					
V-D	mg/L																					
Zn-D	mg/L																					

Table D6 - Summary of water quality data collected at the WB site.

[illegible]

Table D6 - Summary of water quality data collected at the WB site.																						
Parameter	Units	19/06/2000	03/07/2000	07/08/2000	04/09/2000	02/10/2000	09/10/2000	16/10/2000	23/10/2000	06/11/2000	13/11/2000	20/11/2000	27/11/2000	04/12/2000	11/12/2000	18/12/2000	01/01/2001	08/01/2001	15/01/2001	29/01/2001	05/02/2001	12/02/2001
Cond-L	uS/cm	164	160	99	96	87	90	102	115	115	127	132	180	130	148	139	131	126	119	178	199	235
Hardness (as CaCO3)	mg/L		43.4	32.5	32	28.1				35.2				45				42.5				59.5
pH-L	pH Units	7.9	7.78	6.99	7.69	7.82	7.68	8.08	7.84	7.67	7.77	7.82	7.86	7.68	7.85	7.76	7.82	7.71	7.73	7.69	7.88	7.69
TSS	mg/L	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Acidity 8.3	mg/L																					
Acidity 4.5	mg/L																					
Alk-T	mg/L																					
N-NH3	mg/L		<0.005	<0.005	0.006	<0.005	0.009			0.008				0.007				0.009				<0.005
NO2+NO3	mg/L																					
N-TKN	mg/L		0.1	0.12	0.08	0.07				0.09				0.17				0.16				0.12
P-PO4-D	mg/L																					
P-PO4-T	mg/L																					
SO4-D	mg/L	44	41	23	17	13	15	20	26	25	28	32	50	34	38	36	33	33	30	54	65	64
Al-T	mg/L		<0.2	<0.2	<0.2	<0.2				<0.2				<0.2								
Sb-T	mg/L																					
As-T	mg/L																					
Ba-T	mg/L																					
Be-T	mg/L																					
B-T	mg/L																					
Cd-T	mg/L																					
Ca-T	mg/L		13.3	10.9	10.4	9.54				11.8				14.1								
Cr-T	mg/L																					
Co-T	mg/L																					
Cu-T	mg/L		<0.01	<0.01	<0.1	<0.01				<0.01				<0.01				<0.01				
Fe-T	mg/L		0.04	0.04	0.04	0.03				<0.03				0.05								
Pb-T	mg/L		<0.005	<0.005	<0.005	<0.005				<0.005				<0.005				<0.005				
Li-T	mg/L																					
Mg-T	mg/L		1.9	1.4	1.4	1.2				1.6				1.9								
Mn-T	mg/L		0.006	0.007	0.006	0.007				<0.005				0.007								
Hg-T	mg/L																					
Mo-T	mg/L																					
Ni-T	mg/L																					
P-T	mg/L		0.003	0.003	0.002	<0.002	<0.002			0.002				<0.002								
K-T	mg/L																					
Se-T	mg/L																					
Ag-T	mg/L																					
Na-T	mg/L																					
Tl-T	mg/L																					
Sn-T	mg/L																					
Ti-T	mg/L																					
U-T	mg/L																					
V-T	mg/L																					
Zn-T	mg/L		<0.005	<0.005	<0.005	<0.005				<0.005				<0.005								
Zr-T	mg/L																					
Al-D	mg/L																					
Sb-D	mg/L																					
As-D	mg/L																					
Ba-D	mg/L																					
Be-D	mg/L																					
B-D	mg/L																					
Cd-D	mg/L																					
Ca-D	mg/L																					
Cr-D	mg/L																					
Co-D	mg/L																					
Cu-D	mg/L																					
Fe-D	mg/L																					
Pb-D	mg/L																					
Li-D	mg/L																					
Mg-D	mg/L																					
Mn-D	mg/L																					
Hg-D	mg/L																					
Mo-D	mg/L																					
Ni-D	mg/L																					
P-D	mg/L		<0.002	<0.002	<0.002	<0.002	<0.002			<0.002				<0.002								
K-D	mg/L																					
Se-D	mg/L																					
U-D	mg/L																					
V-D	mg/L																					
Zn-D	mg/L																					

Table D6 - Summary of water quality data collected at the WB site.																						
Parameter	Units	19/02/2001	26/02/2001	05/03/2001	12/03/2001	19/03/2001	26/03/2001	02/04/2001	09/04/2001	16/04/2001	23/04/2001	07/05/2001	14/05/2001	21/05/2001	28/05/2001	04/06/2001	11/06/2001	18/06/2001	25/06/2001	02/07/2001	09/07/2001	16/07/2001
Cond-L	uS/cm	211	209	241	231	226	166	132	119	129	129	91	97	101	100	100	123	103	113	95	97	97
Hardness (as CaCO3)	mg/L			63.3					37.4				35.7			34				31.3		35
pH-L	pH Units	7.69	7.8	7.8	7.85	7.86	7.83	7.74	7.86	7.78	7.73	7.77	7.61	7.72	7.83	7.71	7.84	7.94	7.79	7.88	7.8	7.76
TSS	mg/L	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Acidity 8.3	mg/L																					
Acidity 4.5	mg/L																					
Alk-T	mg/L																					
N-NH3	mg/L			<0.005					<0.005				<0.005			0.005				0.018		0.01
NO2+NO3	mg/L																					
N-TKN	mg/L			0.11					0.08				0.1			0.09				0.2		0.11
P-PO4-D	mg/L								0.002				0.002			0.002				<0.002		0.003
P-PO4-T	mg/L								0.003				0.003			0.003						0.003
SO4-D	mg/L	64	65	72	67	67	44	32	27	29	29	15	17	18	18	17	25	18	21	19	19	21
Al-T	mg/L																					
Sb-T	mg/L																					
As-T	mg/L																					
Ba-T	mg/L																					
Be-T	mg/L																					
B-T	mg/L																					
Cd-T	mg/L																					
Ca-T	mg/L																					
Cr-T	mg/L																					
Co-T	mg/L																					
Cu-T	mg/L																					
Fe-T	mg/L																					
Pb-T	mg/L																					
Li-T	mg/L																					
Mg-T	mg/L																					
Mn-T	mg/L																					
Hg-T	mg/L																					
Mo-T	mg/L																					
Ni-T	mg/L																					
P-T	mg/L																					
K-T	mg/L																					
Se-T	mg/L																					
Ag-T	mg/L																					
Na-T	mg/L																					
Tl-T	mg/L																					
Sn-T	mg/L																					
Ti-T	mg/L																					
U-T	mg/L																					
V-T	mg/L																					
Zn-T	mg/L																					
Zr-T	mg/L																					
Al-D	mg/L																					
Sb-D	mg/L																					
As-D	mg/L																					
Ba-D	mg/L																					
Be-D	mg/L																					
B-D	mg/L																					
Cd-D	mg/L																					
Ca-D	mg/L																					
Cr-D	mg/L																					
Co-D	mg/L																					
Cu-D	mg/L																					
Fe-D	mg/L																					
Pb-D	mg/L																					
Li-D	mg/L																					
Mg-D	mg/L																					
Mn-D	mg/L																					
Hg-D	mg/L																					
Mo-D	mg/L																					
Ni-D	mg/L																					
P-D	mg/L																					
K-D	mg/L																					
Se-D	mg/L																					
U-D	mg/L																					
V-D	mg/L																					
Zn-D	mg/L																					

Table D6 - Summary of water quality data collected at the WB site.																						
Parameter	Units	23/07/2001	06/08/2001	13/08/2001	20/08/2001	27/08/2001	03/09/2001	10/09/2001	17/09/2001	24/09/2001	01/10/2001	08/10/2001	15/10/2001	22/10/2001	05/11/2001	12/11/2001	19/11/2001	26/11/2001	03/12/2001	10/12/2001	17/12/2001	24/12/2001
Cond-L	uS/cm	97	93	90	95	90	84	79	74	69	72	71	82	106	136	162	122	85	105	99	122	104
Hardness (as CaCO3)	mg/L			42.6						27.9		25.4				49.5			32.2			
pH-L	pH Units	7.84	7.89	7.81	7.89	7.76	7.77	7.88	7.83	7.49	7.68	7.86	7.72	7.78	7.71	7.84	7.67	7.7	7.8	7.66	7.52	7.55
TSS	mg/L	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Acidity 8.3	mg/L																					
Acidity 4.5	mg/L																					
Alk-T	mg/L																					
N-NH3	mg/L			0.01						<0.005		0.008				<0.005			0.053			
NO2+NO3	mg/L																					
N-TKN	mg/L			0.09						0.51		0.08				0.16			0.08			
P-PO4-D	mg/L			<0.006						<0.002		0.002				<0.002			<0.002			
P-PO4-T	mg/L			<0.006						<0.002		0.002				<0.002			0.002			
SO4-D	mg/L	17	18	16	15	16	13	12	10	9	10	11	14	21	32	43	31	16	21	23	32	27
Al-T	mg/L																					
Sb-T	mg/L																					
As-T	mg/L																					
Ba-T	mg/L																					
Be-T	mg/L																					
B-T	mg/L																					
Cd-T	mg/L																					
Ca-T	mg/L																					
Cr-T	mg/L																					
Co-T	mg/L																					
Cu-T	mg/L																					
Fe-T	mg/L																					
Pb-T	mg/L																					
Li-T	mg/L																					
Mg-T	mg/L																					
Mn-T	mg/L																					
Hg-T	mg/L																					
Mo-T	mg/L																					
Ni-T	mg/L																					
P-T	mg/L																					
K-T	mg/L																					
Se-T	mg/L																					
Ag-T	mg/L																					
Na-T	mg/L																					
Tl-T	mg/L																					
Sn-T	mg/L																					
Ti-T	mg/L																					
U-T	mg/L																					
V-T	mg/L																					
Zn-T	mg/L																					
Zr-T	mg/L																					
Al-D	mg/L																					
Sb-D	mg/L																					
As-D	mg/L																					
Ba-D	mg/L																					
Be-D	mg/L																					
B-D	mg/L																					
Cd-D	mg/L																					
Ca-D	mg/L																					
Cr-D	mg/L																					
Co-D	mg/L																					
Cu-D	mg/L																					
Fe-D	mg/L																					
Pb-D	mg/L																					
Li-D	mg/L																					
Mg-D	mg/L																					
Mn-D	mg/L																					
Hg-D	mg/L																					
Mo-D	mg/L																					
Ni-D	mg/L																					
P-D	mg/L																					
K-D	mg/L																					
Se-D	mg/L																					
U-D	mg/L																					
V-D	mg/L																					
Zn-D	mg/L																					

Table D6 - Summary of water quality data collected at the WB site.																						
Parameter	Units	07/01/2002	14/01/2002	21/01/2002	29/01/2002	04/02/2002	11/02/2002	18/02/2002	25/02/2002	04/03/2002	11/03/2002	18/03/2002	25/03/2002	01/04/2002	08/04/2002	15/04/2002	22/04/2002	06/05/2002	13/05/2002	20/05/2002	27/05/2002	03/06/2002
Cond-L	uS/cm	167	134	73	103	137	131	133	137	134	182	169	204	232	190	122	118	118	135	136	143	134
Hardness (as CaCO3)	mg/L			25.2			40				50.9				56.4			35.3				43.5
pH-L	pH Units	7.65	7.76	7.68	7.65	7.79	7.93	7.3	7.43	7.62	7.58	7.55	7.74	7.83	7.71	7.71	7.63	7.59	7.71	7.71	7.77	7.86
TSS	mg/L	<3	6	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Acidity 8.3	mg/L			2			4				2				1			2				3
Acidity 4.5	mg/L																					
Alk-T	mg/L																					
N-NH3	mg/L			<0.005			0.005				<0.005				<0.005			<0.005				<0.005
NO2+NO3	mg/L																					
N-TKN	mg/L			0.08			0.07				0.08				0.05			0.12				0.06
P-PO4-D	mg/L			<0.002			0.003				<0.002				0.003			<0.002				<0.002
P-PO4-T	mg/L			<0.002			0.003				<0.002				0.002			<0.002				<0.002
SO4-D	mg/L	49	34	14	23	33	35	35	37	39	54	53	59	76	59	30	27	32	34	36	36	35
Al-T	mg/L		<0.2				<0.2				<0.2				0.023			<0.2				<0.2
Sb-T	mg/L		<0.2				<0.2				<0.2				<0.05			<0.2				<0.2
As-T	mg/L		<0.2				<0.2				<0.2				<0.05			<0.2				<0.2
Ba-T	mg/L		<0.01				<0.01				<0.01				0.003			<0.01				<0.01
Be-T	mg/L		<0.005				<0.005				<0.005				<0.001			<0.005				<0.005
B-T	mg/L		<0.1				<0.1				<0.1				0.1			<0.1				<0.1
Cd-T	mg/L		<0.01				<0.01				<0.01				<0.001			<0.01				<0.01
Ca-T	mg/L		12.10				12.40				16.70				18.3			13.1				13.5
Cr-T	mg/L		<0.01				<0.01				<0.001				<0.005			<0.01				<0.01
Co-T	mg/L		<0.01				<0.01				<0.01				<0.005			<0.01				<0.01
Cu-T	mg/L		<0.01				<0.01				<0.01				<0.001			<0.01				<0.01
Fe-T	mg/L		0.04				0.03				0.05				0.04			<0.03				<0.03
Pb-T	mg/L		<0.005				<0.005				<0.005				<0.001			<0.0005				<0.0005
Li-T	mg/L		<0.01				<0.01				<0.01				<0.01			<0.01				<0.01
Mg-T	mg/L		1.7				1.7				2.3				2.6			1.7				1.9
Mn-T	mg/L		0.006				<0.005				0.014				0.006			0.006				<0.005
Hg-T	mg/L																					
Mo-T	mg/L		<0.03				<0.03				<0.03				<0.01			<0.03				<0.03
Ni-T	mg/L		<0.05				<0.05				<0.05				<0.005			<0.05				<0.05
P-T	mg/L		<0.3				<0.3				<0.3				<0.3			<0.3				<0.3
K-T	mg/L		<2				<2				<2				<1			<2				<2
Se-T	mg/L		<0.2				<0.2				<0.2				<0.02			<0.2				<0.2
Ag-T	mg/L		<0.01				<0.01				<0.01				<0.01			<0.01				<0.01
Na-T	mg/L		7				10				14				16			9				10
Tl-T	mg/L		<0.2				<0.2				<0.2				<0.03			<0.2				<0.2
Sn-T	mg/L		<0.03				<0.03				<0.03				<0.02			<0.03				<0.03
Ti-T	mg/L		<0.01				<0.01				<0.01				<0.01			<0.01				<0.01
U-T	mg/L																					
V-T	mg/L		<0.03				<0.03				<0.03				<0.03			<0.03				<0.03
Zn-T	mg/L		<0.005				<0.005				<0.005				<0.005			<0.005				<0.005
Zr-T	mg/L																					
Al-D	mg/L		<0.2				<0.2				<0.2				0.024			0.019				0.013
Sb-D	mg/L		<0.2				<0.2				<0.2				<0.05			<0.05				<0.05
As-D	mg/L		<0.2				<0.2				<0.2				<0.05			<0.05				<0.05
Ba-D	mg/L		<0.01				<0.01				<0.01				0.002			0.002				0.002
Be-D	mg/L		<0.005				<0.005				<0.005				<0.001			<0.001				<0.001
B-D	mg/L		<0.1				<0.1				<0.1				0.1			<0.05				<0.05
Cd-D	mg/L		<0.01				<0.01				<0.01				<0.001			<0.001				<0.001
Ca-D	mg/L		14.20				13.60				17.90				18.40			13.50				14.3
Cr-D	mg/L		<0.01				<0.01				<0.01				<0.005			<0.005				<0.005
Co-D	mg/L		<0.01				<0.01				<0.01				<0.005			<0.005				<0.005
Cu-D	mg/L		<0.01				<0.01				<0.01				0.001			0.002				<0.001
Fe-D	mg/L		<0.03				<0.03				0.04				0.03			0.02				0.01
Pb-D	mg/L		<0.001				<0.001				<0.001				<0.001			0.028				<0.005
Li-D	mg/L		<0.01				<0.01				<0.01				<0.01			<0.01				<0.01
Mg-D	mg/L		2.0				1.9				2.5				2.6			1.8				1.9
Mn-D	mg/L		0.007				0.006				0.014				0.003			0.003				0.003
Hg-D	mg/L																					
Mo-D	mg/L		<0.03				<0.03				<0.03				<0.01			<0.01				<0.01
Ni-D	mg/L		<0.05				<0.05				<0.05				<0.005			<0.005				<0.005
P-D	mg/L		<0.3				<0.3				<0.3				<0.3			<0.3				<0.3
K-D	mg/L		<2				<2				<2				<1			<1				<1
Se-D	mg/L		<0.2				<0.2				<0.2				<0.02			<0.02				<0.02
U-D	mg/L																					
V-D	mg/L		<0.03				<0.03				<0.03				<0.03			<0.03				<0.03
Zn-D	mg/L		<0.005				<0.005				<0.005				<0.005			<0.005				<0.005

Table D6 - Summary of water quality data collected at the WB site.																						
Parameter	Units	10/06/2002	17/06/2002	24/06/2002	01/07/2002	08/07/2002	15/07/2002	22/07/2002	05/08/2002	12/08/2002	19/08/2002	26/08/2002	02/09/2002	09/09/2002	16/09/2002	23/09/2002	07/10/2002	14/10/2002	21/10/2002	28/10/2002	04/11/2002	11/11/2002
Cond-L	uS/cm	135	132	133	126	109	104	98	94	92	90	89	85	81	78	80	69	72	79	85	102	159
Hardness (as CaCO3)	mg/L				44.5				35				33.4					28.8			35.1	
pH-L	pH Units	7.85	7.72	7.8	7.81	7.83	7.85	7.82	7.84	7.96	7.75	7.89	7.68	7.76	7.74	7.71	7.84	7.39	7.7	7.72	7.62	7.75
TSS	mg/L	<3	<3	<3	<3	<3	<3	<3	<3	<3	3	<3	<3	<3	<3	<3	<3	<3	3	<3	<3	<3
Acidity 8.3	mg/L				2				4				1					3			1	
Acidity 4.5	mg/L																					
Alk-T	mg/L																					
N-NH3	mg/L				<0.005				<0.005				<0.005					0.011			0.017	
NO2+NO3	mg/L																					
N-TKN	mg/L				0.1				0.12				0.13					0.1			0.12	
P-PO4-D	mg/L				<0.002				<0.002				0.002					0.002			<0.002	
P-PO4-T	mg/L				0.003				0.002				0.004					0.003			0.003	
SO4-D	mg/L	34	31	33	27	24	22	20	18	17	15	15	14	12	13	12	13	13	13	13	21	44
Al-T	mg/L				<0.2				<0.2				<0.2					<0.2			0.007	
Sb-T	mg/L				<0.2				<0.2				<0.2					<0.2			<0.0005	
As-T	mg/L				<0.2				<0.2				<0.2					<0.2			<0.0005	
Ba-T	mg/L				<0.01				<0.01				<0.01					<0.01			<0.02	
Be-T	mg/L				<0.005				<0.005				<0.005					<0.005			<0.001	
B-T	mg/L				<0.1				<0.1				<0.1					<0.1			<0.1	
Cd-T	mg/L				<0.01				<0.01				<0.01					<0.01			<0.00005	
Ca-T	mg/L				14.4				11.7				10.8					10.7			11.2	
Cr-T	mg/L				<0.01				<0.01				<0.01					<0.01			<0.001	
Co-T	mg/L				<0.01				<0.01				<0.01					<0.01			<0.0003	
Cu-T	mg/L				<0.01				<0.01				<0.01					<0.01			<0.001	
Fe-T	mg/L				<0.03				<0.03				0.030					0.05			0.060	
Pb-T	mg/L				<0.0005				<0.0005				<0.0005					<0.0005			<0.0005	
Li-T	mg/L				<0.01				<0.01				<0.01					<0.01			<0.005	
Mg-T	mg/L				1.8				1.4				1.4					1.3			1.5	
Mn-T	mg/L				0.008				0.005				0.006					0.005			0.018	
Hg-T	mg/L																					
Mo-T	mg/L				<0.03				<0.03				<0.03					<0.03			<0.001	
Ni-T	mg/L				<0.05				<0.05				<0.05					<0.05			<0.001	
P-T	mg/L				<0.3				<0.3				<0.3					<0.3			<2	
K-T	mg/L				<2				<2				<2									
Se-T	mg/L				<0.2				<0.2				<0.2					<0.2			<0.001	
Ag-T	mg/L				<0.01				<0.01				<0.01					<0.01			<0.00002	
Na-T	mg/L				9				6				5					4			6	
Tl-T	mg/L				<0.2				<0.2				<0.2					<0.03			<0.0005	
Sn-T	mg/L				<0.03				<0.03				<0.03					<0.01			<0.01	
Ti-T	mg/L				<0.01				<0.01				<0.01								<0.0002	
U-T	mg/L																					
V-T	mg/L				<0.03				<0.03				<0.03					<0.03			<0.03	
Zn-T	mg/L				<0.005				<0.005				<0.005					<0.005			<0.005	
Zr-T	mg/L																					
Al-D	mg/L				0.016				0.012				0.014					0.010			<0.005	
Sb-D	mg/L				<0.05				<0.05				<0.05					<0.05			<0.0005	
As-D	mg/L				<0.05				<0.05				<0.05					<0.05			<0.0005	
Ba-D	mg/L				0.002				0.001				0.001					0.001			<0.02	
Be-D	mg/L				<0.001				<0.001				<0.001					<0.001			<0.001	
B-D	mg/L				<0.05				<0.05				<0.05					<0.001			<0.00005	
Cd-D	mg/L				<0.001				<0.001				<0.001					<0.005			<0.001	
Ca-D	mg/L				14.8				11.8				11.0					10.60			11.5	
Cr-D	mg/L				<0.005				<0.005				<0.005					<0.005			<0.0003	
Co-D	mg/L				<0.005				<0.005				<0.005					<0.005			<0.001	
Cu-D	mg/L				<0.001				<0.001				<0.001					<0.001			<0.001	
Fe-D	mg/L				0.010				<0.01				0.020					0.03			0.040	
Pb-D	mg/L				<0.001				<0.001				<0.001					<0.001			<0.0005	
Li-D	mg/L				<0.01				<0.01				<0.01					<0.01			<0.005	
Mg-D	mg/L				1.82				1.38				1.44					1.31			1.50	
Mn-D	mg/L				0.004				<0.001				0.002					0.001			0.0054	
Hg-D	mg/L																					
Mo-D	mg/L				<0.01				<0.01				<0.01					<0.01			<0.001	
Ni-D	mg/L				<0.005				<0.005				<0.005					<0.005			<0.001	
P-D	mg/L				<0.3				<0.3				<0.3					<0.3			<0.3	
K-D	mg/L				<1				<1				<1									
Se-D	mg/L				<0.02				<0.02				<0.02					<0.02			<0.001	
U-D	mg/L																					
V-D	mg/L				<0.03				<0.03				<0.03					<0.03			<0.03	
Zn-D	mg/L				<0.005				<0.005				<0.005					<0.005			<0.005	

Table D6 - Summary of water quality data collected at the WB site.

Parameter	Units	18/11/2002	25/11/2002	02/12/2002	09/12/2002	16/12/2002	23/12/2002	06/01/2003	03/02/2003	10/03/2003	14/04/2003	05/05/2003	02/06/2003	07/07/2003	18/08/2003	01/09/2003	01/10/2003	03/11/2003	03/12/2003	05/01/2004	12/01/2004	20/01/2004
Cond-L	uS/cm	121	109	123	177	101	101													111	101	85.2
Hardness (as CaCO3)	mg/L			45.5																35.4		
pH-L	pH Units	7.53	7.83	7.29	7.61	7.51	7.54													7.68	7.65	7.68
TSS	mg/L	<3	<3	<3	<3	<3	<3													<3	<3	<3
Acidity 8.3	mg/L			1																1.1		
Acidity 4.5	mg/L																					
Alk-T	mg/L																					
N-NH3	mg/L			0.013																0.005		
NO2+NO3	mg/L																					
N-TKN	mg/L			0.1																<0.005		
P-PO4-D	mg/L			0.003																0.0039		
P-PO4-T	mg/L			0.005																0.0052		
SO4-D	mg/L	31	27	30	49	24	26													24.3	21.5	15.5
Al-T	mg/L			0.016				0.033	0.041	0.018	0.046	0.046	0.021	0.018	0.017	0.014	0.012	0.1220	0.042	0.023		
Sb-T	mg/L			<0.0005				<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00050		
As-T	mg/L			<0.0005				<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00050		
Ba-T	mg/L			<0.02				<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.020		
Be-T	mg/L			<0.001				<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0010		
B-T	mg/L			<0.1				<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.10		
Cd-T	mg/L			<0.00005				<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005		
Ca-T	mg/L			12.9				8.5	15.0	18.9	11.4	12.2	9.6	11.6	14.2	11.0	8.9	10.20	12.4	10.6		
Cr-T	mg/L			<0.001				<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0010		
Co-T	mg/L			<0.0003				<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.00030		
Cu-T	mg/L			<0.001				<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0014	<0.001	0.002		
Fe-T	mg/L			0.060				<0.03	0.350	0.050	<0.03	<0.03	0.040	0.040	0.030	<0.03	0.040	0.243	0.080	<0.030		
Pb-T	mg/L			<0.0005				<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.001	<0.0005	<0.0005	<0.00050		
Li-T	mg/L			<0.005				<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.0050		
Mg-T	mg/L			1.1				1.1	1.8	2.1	1.6	1.5	1.2	1.4	1.8	1.1	1.3	1.56	1.3			
Mn-T	mg/L			0.011				0.0039	0.0084	0.0076	0.0040	0.0049	0.0073	0.0099	0.0072	0.0042	0.0049	0.04500	0.013	0.0042		
Hg-T	mg/L																					
Mo-T	mg/L			<0.001				<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0010		
Ni-T	mg/L			<0.001				<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0010		
P-T	mg/L			<2				<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2.0	<2.0		
K-T	mg/L																					
Se-T	mg/L			<0.001				<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0010	<0.0010		
Ag-T	mg/L			<0.00002				<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	0.000153	<0.00002	<0.00002		
Na-T	mg/L			9				4	14	21	8	10	5	7	11	8	3	6	7.5	9		
Tl-T	mg/L			<0.0005				<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.00020		
Sn-T	mg/L			<0.01				<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00050		
Ti-T	mg/L			<0.0002				<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.010		
U-T	mg/L							<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.00020		
V-T	mg/L			<0.03				<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.030		
Zn-T	mg/L			<0.005				<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.0050		
Zr-T	mg/L																					
Al-D	mg/L			0.031				0.024	0.031	0.016	0.027	0.069	0.025	0.016	0.021	0.012	0.012	0.0217	0.022	0.023		
Sb-D	mg/L			<0.0005				<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00050		
As-D	mg/L			<0.0005				<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00050		
Ba-D	mg/L			<0.02				<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.020		
Be-D	mg/L			<0.001				<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0010		
B-D	mg/L			<0.00005				<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.10		
Cd-D	mg/L			<0.001				<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	0.00006	<0.00005		
Ca-D	mg/L			14.8				9.1	15.1	19.5	11.3	14.3	10.3	11.4	15.3	12.6	10.0	13.20	14.8	11.8		
Cr-D	mg/L							<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0010		
Co-D	mg/L			0.0003				<0.0003	<0.0003	<0.0003	<0.0003	0.0004	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.00030		
Cu-D	mg/L			<0.001				<0.001	<0.001	<0.001	<0.001	0.001	0.002	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	0.002		
Fe-D	mg/L			0.230				<0.03	<0.03	<0.03	<0.03	0.350	<0.03	0.030	<0.03	<0.03	0.030	0.049	0.031	<0.030		
Pb-D	mg/L			<0.0005				<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.001	<0.0005	<0.0005	<0.00050		
Li-D	mg/L			<0.005				<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.0050		
Mg-D	mg/L			2.10				1.20	2.10	2.80	1.70	1.80	1.30	1.50	1.90	1.90	1.30	1.75	1.92	1.47		
Mn-D	mg/L			0.0164				0.0053	0.0057	0.0063	0.0032	0.0188	0.0054	0.0067	0.0028	0.0030	0.0023	0.01510	0.0101	0.0060		
Hg-D	mg/L																					
Mo-D	mg/L			<0.001				<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0010		
Ni-D	mg/L			<0.001				<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0010		
P-D	mg/L			<0.3																		
K-D	mg/L							<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2.0	<2.0		
Se-D	mg/L			<0.001				<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0010		
U-D	mg/L							<0.0002	<0.0002	<0.0002												

Table D6 - Summary of water quality data collected at the WB site.																						
Parameter	Units	28/01/2004	03/02/2004	09/02/2004	17/02/2004	24/02/2004	01/03/2004	09/03/2004	16/03/2004	23/03/2004	30/03/2004	06/04/2004	13/04/2004	19/04/2004	27/04/2004	04/05/2004	11/05/2004	17/05/2004	26/05/2004	02/06/2004	08/06/2004	17/06/2004
Cond-L	uS/cm	92	97.9	123	158	186	165	206	194	198	209	197	211	217	228	223	219	206	199	191	192	186
Hardness (as CaCO3)	mg/L			35.6			53.6							60.8				55		50		
pH-L	pH Units	7.7	7.66	8.2	7.71	7.81	7.7	7.79	7.8	7.87	7.85	7.87	7.83	7.68	7.79	7.92	7.87	7.76	7.82	7.86	7.81	7.78
TSS	mg/L	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	4.3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Acidity 8.3	mg/L			<1			1.4							2.5				1.7		3.2		
Acidity 4.5	mg/L																					
Alk-T	mg/L																					
N-NH3	mg/L			0.0127			<0.005							<0.005				0.0053		<0.005		
NO2+NO3	mg/L																					
N-TKN	mg/L			0.198			0.136							0.073				0.104		0.093		
P-PO4-D	mg/L			<0.002			<0.002							<0.002				<0.002		<0.002		
P-PO4-T	mg/L			0.0022			0.0033							0.0048				0.0036		0.0022		
SO4-D	mg/L	19	20.8	28.5	42.6	51	47.4	59.3	54.8	56.6	58.1	55.3	59.8	61.3	61.6	63	57.6	56.1	52.3	50.4	49.2	48
Al-T	mg/L			0.027			0.025							0.017				0.013		0.017		
Sb-T	mg/L			<0.00050			<0.00050							<0.00050				<0.00050		<0.00050		
As-T	mg/L			<0.00050			<0.00050							<0.00050				<0.00050		<0.00050		
Ba-T	mg/L			<0.020			<0.020							<0.020				<0.020		<0.020		
Be-T	mg/L			<0.0010			<0.0010							<0.0010				<0.0010		<0.0010		
B-T	mg/L			<0.10			<0.10							0.2				0.1		<0.10		
Cd-T	mg/L			<0.00005			<0.00005							<0.00005				<0.00005		<0.00005		
Ca-T	mg/L			11.3			15.2							17.7				17.7		16.0		
Cr-T	mg/L			<0.0010			<0.0010							<0.0010				<0.0010		<0.0010		
Co-T	mg/L			<0.00030			<0.00030							<0.00030				<0.00030		<0.00030		
Cu-T	mg/L			<0.0010			<0.0010							<0.0010				0.001		<0.0010		
Fe-T	mg/L			0.04			0.046							0.031				0.032		<0.030		
Pb-T	mg/L			<0.0010			<0.00050							<0.00050				<0.00050		<0.0010		
Li-T	mg/L			<0.0050			<0.0050							<0.0050				<0.0050		<0.0050		
Mg-T	mg/L			1.5			2.08							2.6				2.3		2.18		
Mn-T	mg/L			0.004			0.008							0.008				0.0087		0.008		
Hg-T	mg/L																					
Mo-T	mg/L			<0.0010			<0.0010							<0.0010				<0.0010		<0.0010		
Ni-T	mg/L			<0.0010			<0.0010							<0.0010				<0.0010		<0.0010		
P-T	mg/L			<2.0			<2.0							<2.0				<2.0		<2.0		
K-T	mg/L																					
Se-T	mg/L			<0.0010			<0.0010							<0.0010				<0.0010		<0.0010		
Ag-T	mg/L			<0.00002			<0.00002							<0.00002				<0.00002		<0.00002		
Na-T	mg/L			10			15.4							23				19		17.1		
Tl-T	mg/L			<0.00020			<0.00020							<0.00020				<0.00020		<0.00020		
Sn-T	mg/L			<0.00050			<0.00050							<0.00050				<0.00050		<0.00050		
Ti-T	mg/L			<0.010			<0.010							<0.010				<0.010		<0.010		
U-T	mg/L			<0.00020			<0.00020							<0.00020				<0.00020		<0.00020		
V-T	mg/L			<0.030			<0.030							<0.030				<0.030		<0.030		
Zn-T	mg/L			<0.0050			<0.0050							<0.0050				<0.0050		<0.0050		
Zr-T	mg/L																					
Al-D	mg/L			0.050			0.021							0.016				0.013		0.016		
Sb-D	mg/L			<0.00050			<0.00050							<0.00050				<0.00050		<0.00050		
As-D	mg/L			0.008			<0.00050							<0.00050				<0.00050		<0.00050		
Ba-D	mg/L			<0.020			<0.020							<0.020				<0.020		<0.020		
Be-D	mg/L			<0.0010			<0.0010							<0.0010				<0.0010		<0.0010		
B-D	mg/L			<0.10			<0.10							0.1				<0.10		<0.10		
Cd-D	mg/L			0.000			<0.00005							<0.00005				<0.00005		<0.00005		
Ca-D	mg/L			11.7			17.5							19.7				18.1		16.3		
Cr-D	mg/L			<0.0010			<0.0010							<0.0010				<0.0010		<0.0010		
Co-D	mg/L			0.001			<0.00030							<0.00030				<0.00030		<0.00030		
Cu-D	mg/L			0.003			<0.0010							0.002				<0.0010		<0.0010		
Fe-D	mg/L			2.07			0.037							<0.030				<0.030		<0.030		
Pb-D	mg/L			<0.0010			<0.00050							<0.00050				<0.00050		<0.0010		
Li-D	mg/L			<0.0050			<0.0050							<0.0050				<0.0050		<0.0050		
Mg-D	mg/L			1.57			2.42							2.82				2.37		2.26		
Mn-D	mg/L			0.0186			0.0103							0.007				0.0075		0.0057		
Hg-D	mg/L																					
Mo-D	mg/L			<0.0010			<0.0010							<0.0010				<0.0010		<0.0010		
Ni-D	mg/L			0.002			<0.0010							<0.0010				<0.0010		<0.0010		
P-D	mg/L																					
K-D	mg/L			<2.0			<2.0							<2.0				<2.0		<2.0		
Se-D	mg/L			<0.0010			<0.0010							<0.0010				<0.0010		<0.0010		
U-D	mg/L			<0.00020			<0.00020							<0.00020				<0.00020		<0.00020		
V-D	mg/L			<0.030			<0.030							<0.030				<0.030		<0.030		

Table D6 - Summary of water quality data collected at the WB site.

Parameter	Units	17/06/2004	22/06/2004	29/06/2004	05/07/2004	13/07/2004	20/07/2004	27/07/2004	03/08/2004	10/08/2004	17/08/2004	24/08/2004	02/09/2004	02/09/2004	07/09/2004	14/09/2004	21/09/2004	27/09/2004	05/10/2004	13/10/2004	18/10/2004	26/10/2004
Cond-L	uS/cm	186	180	173	172	164	159	156	143	139	140	132	132	130	133	127	132	134	130	129	158	144
Hardness (as CaCO3)	mg/L						48.8			41.3			40.9	42.1					48.5			
pH-L	pH Units	7.8	7.91	7.77	7.84	7.94	7.7	7.91	7.71	7.68	7.75	7.8	7.87	7.83	7.86	7.71	6.66	7.75	7.62	7.73	8.04	7.83
TSS	mg/L	3	<3	<3	<3	<3	<3	<3	<3	<3	3.3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Acidity 8.3	mg/L						2.7			1.8			<1	<1					1.3			
Acidity 4.5	mg/L																					
Alk-T	mg/L																					
N-NH3	mg/L						0.0053			0.013			<0.02	<0.02					<0.02			
NO2+NO3	mg/L																					
N-TKN	mg/L						0.142			0.083			0.109	0.103					0.077			
P-PO4-D	mg/L						<0.002			<0.002			<0.002	<0.002					<0.002			
P-PO4-T	mg/L						0.0024			<0.002			0.0021	0.0025					<0.002			
SO4-D	mg/L	48.1	44.5	44.9	43.3	39.5	38	35.9	33.7	32.2	30	28.3	28.1	28	27.9	27.8	30.5	32.2	31.2	28.3	30.2	35.6
Al-T	mg/L						0.018			0.021			0.0518	0.0128					0.0121			
Sb-T	mg/L						<0.00050			<0.00050			<0.00050	<0.00050					<0.00050			
As-T	mg/L						<0.00050			<0.00050			<0.00050	<0.00050					<0.00050			
Ba-T	mg/L						<0.020			<0.020			<0.020	<0.020					<0.020			
Be-T	mg/L						<0.0010			<0.0010			<0.0010	<0.0010					<0.0010			
B-T	mg/L						<0.10			<0.10			<0.10	<0.10					<0.10			
Cd-T	mg/L						<0.00005			<0.00005			<0.00005	<0.00005					<0.00005			
Ca-T	mg/L						14.0			14.2			13.1	13.3					14.3			
Cr-T	mg/L						<0.0010			<0.0010			<0.0010	<0.0010					<0.0010			
Co-T	mg/L						<0.00030			<0.00030			<0.00030	<0.00030					<0.00030			
Cu-T	mg/L						<0.0010			<0.0010			<0.0010	<0.0010					<0.0010			
Fe-T	mg/L						<0.030			<0.030			<0.030	<0.030					<0.030			
Pb-T	mg/L						<0.00050			<0.00050			<0.00050	<0.00050					<0.00050			
Li-T	mg/L						<0.0050			<0.0050			<0.0050	<0.0050					<0.0050			
Mg-T	mg/L						2.0			1.8			1.8	1.76					1.9			
Mn-T	mg/L						0.010			0.008			0.0091	0.010					0.0055			
Hg-T	mg/L																		<0.00005			
Mo-T	mg/L						<0.0010			<0.0010			<0.0010	<0.0010					<0.0010			
Ni-T	mg/L						<0.0010			<0.0010			<0.0010	<0.0010					<0.0010			
P-T	mg/L						<2.0			<2.0			<2.0	<2.0					<2.0			
K-T	mg/L																					
Se-T	mg/L						<0.0010			<0.0010			<0.0010	<0.0010					<0.0010			
Ag-T	mg/L						<0.00002			<0.00002			<0.00002	<0.00002					<0.00002			
Na-T	mg/L						13			12			10	10.4					10.000			
Tl-T	mg/L						<0.00020			<0.00020			<0.00020	<0.00020					<0.00020			
Sn-T	mg/L						<0.00050			<0.00050			<0.00050	<0.00050					<0.00050			
Ti-T	mg/L						0.010			<0.010			<0.010	<0.010					<0.010			
U-T	mg/L						<0.00020			<0.00020			<0.00020	<0.00020					<0.00020			
V-T	mg/L						<0.030			<0.030			<0.030	<0.030					<0.030			
Zn-T	mg/L						<0.0050			<0.0050			<0.0050	<0.0050					<0.0050			
Zr-T	mg/L																					
Al-D	mg/L						0.018			0.020			0.011	0.013					0.0166			
Sb-D	mg/L						<0.00050			<0.00050			<0.00050	<0.00050					<0.00050			
As-D	mg/L						<0.00050			<0.00050			<0.00050	<0.00050					<0.00050			
Ba-D	mg/L						<0.020			<0.020			<0.020	<0.020					<0.020			
Be-D	mg/L						<0.0010			<0.0010			<0.0010	<0.0010					<0.0010			
B-D	mg/L						<0.10			<0.10			<0.10	<0.10					<0.10			
Cd-D	mg/L						<0.00005			<0.00005			<0.00005	<0.00005					<0.00005			
Ca-D	mg/L						15.8			14.5			13.5	13.8					15.9			
Cr-D	mg/L						<0.0010			<0.0010			<0.0010	<0.0010					<0.0010			
Co-D	mg/L						<0.00030			<0.00030			<0.00030	<0.00030					<0.00030			
Cu-D	mg/L						<0.0010			<0.0010			<0.0010	<0.0010					<0.0010			
Fe-D	mg/L						<0.030			<0.030			<0.030	<0.030					<0.030			
Pb-D	mg/L						<0.00050			<0.00050			<0.00050	<0.00050					<0.00050			
Li-D	mg/L						<0.0050			<0.0050			<0.0050	<0.0050					<0.0050			
Mg-D	mg/L						2.28			1.91			1.76	1.85					2.13			
Mn-D	mg/L						0.004			0.0012			0.0034	0.0029					0.00227			
Hg-D	mg/L																		<0.00005			
Mo-D	mg/L						<0.0010			<0.0010			<0.0010	<0.0010					<0.0010			
Ni-D	mg/L						<0.0010			<0.0010			<0.0010	<0.0010					<0.0010			
P-D	mg/L																					
K-D	mg/L						<2.0			<2.0			<2.0	<2.0					<2.0			
Se-D	mg/L						<0.0010			<0.0010			<0.0010	<0.0010					<0.0010			
U-D	mg/L						<0.00020			<0.00020			<0.00020	<0.00020					<0.00020			
V-D	mg/L						<0.030			<0.030			<0.030	<0.030					<0.030			
Zn-D	mg/L						<0.0050			<0.0050			<0.0050	<0.0050					<0.0050			

Table D6 - Summary of water quality data collected at the WB site.

Parameter	Units	02/11/2004	09/11/2004	15/11/2004	22/11/2004	01/12/2004	01/12/2004	07/12/2004	14/12/2004	21/12/2004	28/12/2004	04/01/2005	11/01/2005	18/01/2005	25/01/2005	01/02/2005	08/02/2005	16/02/2005	16/02/2005	22/02/2005	01/03/2005	07/03/2005
Cond-L	uS/cm	182	114	153	103	144	143	163	158	155	124	142	140	146	72.9	91.2	123	117	116	136	168	185
Hardness (as CaCO3)	mg/L		44.4			48.7	47.3							46.3		30.8					48.7	
pH-L	pH Units	7.61	7.44	7.1	7.05	7.6	7.05	7.18	6.79	7.49	7.58	7.21	7.35	7.46	7.08	7.63	7.16	7.37	7.41	6.95	7.57	7.71
TSS	mg/L	3.3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Acidity 8.3	mg/L		2.9			6.3	7.5							3.1		4.3					3.3	
Acidity 4.5	mg/L																					
Alk-T	mg/L																					
N-NH3	mg/L		0.009			0.0153	0.0147							<0.005		<0.005					<0.005	
NO2+NO3	mg/L		0.0290													0.0321					0.0323	
N-TKN	mg/L		<0.05			0.153	0.161							<0.05		0.073					0.098	
P-PO4-D	mg/L		<0.002		0.0022	0.0020	0.0024							<0.002		<0.002					<0.002	
P-PO4-T	mg/L		0.0049			0.0050	0.0042							<0.002		0.0023					<0.002	
SO4-D	mg/L	50.5	28.2	42.3	30.7	40.5	41.5	46.1	43.4	40.2	28.9	31.9	34.4	36.6	14.1	18.1	27.3	27.5	27.1	33.3	43.6	51.3
Al-T	mg/L		0.0264			0.0422	0.0485							0.023		0.032					0.026	
Sb-T	mg/L		<0.00050			<0.00050	<0.00050							<0.00050		<0.00050					<0.00050	
As-T	mg/L		<0.00050			<0.00050	<0.00050							<0.00050		<0.00050					<0.00050	
Ba-T	mg/L		<0.020			<0.020	<0.020							<0.020		<0.020					<0.020	
Be-T	mg/L		<0.0010			<0.0010	<0.0010							<0.0010		<0.0010					<0.0010	
B-T	mg/L		<0.10			<0.10	<0.10							<0.10		<0.10					<0.10	
Cd-T	mg/L		<0.00005			<0.00005	<0.00005							<0.00005		<0.00005					<0.00005	
Ca-T	mg/L		12.3			14.2	12.9							15.20		10.200					15.400	
Cr-T	mg/L		<0.0010			<0.0010	<0.0010							<0.0010		<0.0010					<0.0010	
Co-T	mg/L		<0.00030			<0.00030	<0.00030							<0.00030		<0.00030					<0.00030	
Cu-T	mg/L		<0.0010			<0.0010	<0.0010							<0.0010		<0.0010					<0.0010	
Fe-T	mg/L		0.07			0.075	0.064							0.05		<0.030					0.053	
Pb-T	mg/L		<0.00050			<0.00050	<0.00050							<0.00050		<0.00050					<0.00050	
Li-T	mg/L		<0.0050			<0.0050	<0.0050							<0.0050		<0.0050					<0.0050	
Mg-T	mg/L		1.7			1.91	1.74							1.82		1.290					2.240	
Mn-T	mg/L		0.013			0.00898	0.00888							0.0069		0.003					0.006	
Hg-T	mg/L		<0.00005			<0.00005	<0.00005															
Mo-T	mg/L		<0.0010			<0.0010	<0.0010							<0.0010		<0.0010					<0.0010	
Ni-T	mg/L		<0.0010			<0.0010	<0.0010							<0.0010		<0.0010					<0.0010	
P-T	mg/L		<2.0			<2.0	<2.0							<2.0		<2.0					<2.0	
K-T	mg/L																					
Se-T	mg/L		<0.0010			<0.0010	<0.0010							<0.0010		<0.0010					<0.0010	
Ag-T	mg/L		<0.00002			<0.00002	<0.00002							<0.00002		<0.00002					<0.00002	
Na-T	mg/L		8			9.2	8.2							14.200		7.500					13.000	
Tl-T	mg/L		<0.00020			<0.00020	<0.00020							<0.00020		<0.00020					<0.00020	
Sn-T	mg/L		<0.00050			<0.00050	<0.00050							<0.00050		<0.00050					<0.00050	
Ti-T	mg/L		<0.010			<0.010	<0.010							<0.010		<0.010					<0.010	
U-T	mg/L		<0.00020			<0.00020	<0.00020							<0.00020		<0.00020					<0.00020	
V-T	mg/L		<0.030			<0.030	<0.030							<0.030		<0.030					<0.030	
Zn-T	mg/L		<0.0050			<0.0050	<0.0050							<0.0050		<0.0050					<0.0050	
Zr-T	mg/L																					
Al-D	mg/L		0.0253			0.0451	0.0384							0.028		0.028					0.030	
Sb-D	mg/L		<0.00050			<0.00050	<0.00050							<0.00050		<0.00050					<0.00050	
As-D	mg/L		<0.00050			<0.00050	<0.00050							<0.00050		<0.00050					<0.00050	
Ba-D	mg/L		<0.020			<0.020	<0.020							<0.020		<0.020					<0.020	
Be-D	mg/L		<0.0010			<0.0010	<0.0010							<0.0010		<0.0010					<0.0010	
B-D	mg/L		<0.10			<0.10	<0.10							<0.10		<0.10					<0.10	
Cd-D	mg/L		<0.00005			<0.00005	<0.00005							<0.00005		<0.00005					0.000	
Ca-D	mg/L		14.5			16.0	15.5							15.50		10.200					15.800	
Cr-D	mg/L		<0.0010			<0.0010	<0.0010							<0.0010		<0.0010					<0.0010	
Co-D	mg/L		<0.00030			<0.00030	<0.00030							<0.00030		<0.00030					<0.00030	
Cu-D	mg/L		<0.0010			<0.0010	<0.0010							<0.0010		<0.0010					<0.0010	
Fe-D	mg/L		0.06			0.070	0.056							0.05		0.031					0.041	
Pb-D	mg/L		<0.00050			<0.00050	<0.00050							<0.00050		<0.00050					<0.00050	
Li-D	mg/L		<0.0050			<0.0050	<0.0050							<0.0050		<0.0050					<0.0050	
Mg-D	mg/L		2.00			2.15	2.09							1.85		1.280					2.280	
Mn-D	mg/L		0.0100			0.00795	0.00735							0.0066		0.002					0.005	
Hg-D	mg/L		<0.00005			<0.00005	<0.00005															
Mo-D	mg/L		<0.0010			<0.0010	<0.0010							<0.0010		<0.0010					<0.0010	
Ni-D	mg/L		<0.0010			<0.0010	<0.0010							<0.0010		<0.0010					<0.0010	
P-D	mg/L																					
K-D	mg/L		<2.0			<2.0	<2.0							<2.0		<2.0					<2.0	
Se-D	mg/L		<0.0010			<0.0010	<0.0010							<0.0010		<0.0010					<0.0010	
U-D	mg/L		<0.00020			<0.00020	<0.00020							<0.00020		<0.00020					<0.00020	
V-D	mg/L		<0.030			<0.030	<0.030							<0.030		<0.030					<0.030	
Zn-D	mg/L		<0.0050			<0.0050	<0.0050							<0.0050		<0.0050					<0.0050	

Table D6 - Summary of water quality data collected at the WB site.																						
Parameter	Units	15/03/2005	22/03/2005	29/03/2005	06/04/2005	12/04/2005	19/04/2005	02/05/2005	10/05/2005	10/05/2005	17/05/2005	21/05/2005	31/05/2005	06/06/2005	14/06/2005	21/06/2005	29/06/2005	04/07/2005	12/07/2005	19/07/2005	26/07/2005	02/08/2005
Cond-L	uS/cm	161	150	170	126	100	98.3	83	109	109	103	94.5	94.5	90.5	112	122	130	132	144	145	155	148
Hardness (as CaCO3)	mg/L				38.4			31.3						32				41.3				
pH-L	pH Units	7.72	7.48	7.12	7.45	7.01	7.72	7.97	7.39	7.32	7.68	7.78	7.78	7.51	7.93	7.66	7.79	7.95	7.67	7.71	8.03	7.83
TSS	mg/L	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Acidity 8.3	mg/L				3.2			7.3						3.8				2.9				
Acidity 4.5	mg/L																					
Alk-T	mg/L																					
N-NH3	mg/L				<0.005			0.0093						0.0067				<0.005				
NO2+NO3	mg/L				0.0231			0.0069						<0.005				<0.005				
N-TKN	mg/L				0.063			0.073						0.067				0.096				
P-PO4-D	mg/L				<0.002			<0.002						<0.002				<0.002				
P-PO4-T	mg/L				<0.002			<0.002						<0.002				<0.002				
SO4-D	mg/L	40.2	38.3	47.8	29.7	20.8	21	14.8	21.9	21.2	19.8	17.2	17.2	17.6	26.3	27.9	29.6	28.3	<1	33.1	36.2	37.9
Al-T	mg/L				0.030			0.023						0.020				0.0351				
Sb-T	mg/L				<0.00050			<0.00050						<0.00050				<0.00050				
As-T	mg/L				<0.00050			<0.00050						<0.00050				0.00077				
Ba-T	mg/L				<0.020			<0.020						<0.020				<0.020				
Be-T	mg/L				<0.0010			<0.0010						<0.0010				<0.0010				
B-T	mg/L				<0.10			<0.10						<0.10				<0.10				
Cd-T	mg/L				<0.00005			<0.00005						<0.00005				<0.00005				
Ca-T	mg/L				12.000			10.000						10.300				13.8				
Cr-T	mg/L				<0.0010			<0.0010						<0.0010				<0.0010				
Co-T	mg/L				<0.00030			<0.00030						<0.00030				<0.00030				
Cu-T	mg/L				<0.0010			<0.0010						<0.0010				0.0020				
Fe-T	mg/L				0.048			0.048						0.049				0.153				
Pb-T	mg/L				<0.00050			<0.00050						<0.00050				<0.00050				
Li-T	mg/L				<0.0050			<0.0050						<0.0050				<0.0050				
Mg-T	mg/L				1.690			1.360						1.290				1.84				
Mn-T	mg/L				0.006			0.007						0.012				0.0182				
Hg-T	mg/L							<0.00005						<0.00002				<0.00002				
Mo-T	mg/L				<0.0010			<0.0010						<0.0010				<0.0010				
Ni-T	mg/L				<0.0010			<0.0010						<0.0010				<0.0010				
P-T	mg/L				<2.0			<2.0						<2.0				<2.0				
K-T	mg/L																					
Se-T	mg/L				<0.0010			<0.0010						<0.0010				<0.0010				
Ag-T	mg/L				<0.00002			<0.00002						<0.00002				<0.00002				
Na-T	mg/L				10.100			4.900						4.900				10.3				
Tl-T	mg/L				<0.00020			<0.00020						<0.00020				<0.00020				
Sn-T	mg/L				<0.00050			<0.00050						<0.00050				<0.00050				
Ti-T	mg/L				<0.010			<0.010						<0.010				<0.010				
U-T	mg/L				<0.00020			<0.00020						<0.00020				<0.00020				
V-T	mg/L				<0.030			<0.030						<0.030				<0.030				
Zn-T	mg/L				<0.0050			<0.0050						<0.0050				<0.0050				
Zr-T	mg/L																					
Al-D	mg/L				0.018			0.019						0.018				0.0158				
Sb-D	mg/L				<0.00050			<0.00050						<0.00050				<0.00050				
As-D	mg/L				<0.00050			<0.00050						<0.00050				<0.00050				
Ba-D	mg/L				<0.020			<0.020						<0.020				<0.020				
Be-D	mg/L				<0.0010			<0.0010						<0.0010				<0.0010				
B-D	mg/L				<0.10			<0.10						<0.10				<0.10				
Cd-D	mg/L				<0.00005			<0.00005						<0.00005				<0.00005				
Ca-D	mg/L				12.500			10.300						10.600				13.6				
Cr-D	mg/L				<0.0010			<0.0010						<0.0010				<0.0010				
Co-D	mg/L				<0.00030			<0.00030						<0.00030				<0.00030				
Cu-D	mg/L				<0.0010			<0.0010						<0.0010				<0.0010				
Fe-D	mg/L				<0.030			0.033						0.035				0.032				
Pb-D	mg/L				<0.00050			<0.00050						<0.00050				<0.00050				
Li-D	mg/L				<0.0050			<0.0050						<0.0050				<0.0050				
Mg-D	mg/L				1.770			1.390						1.320				1.81				
Mn-D	mg/L				0.003			0.006						0.011				0.0110				
Hg-D	mg/L							<0.00005						<0.00002				<0.00002				
Mo-D	mg/L				<0.0010			<0.0010						<0.0010				<0.0010				
Ni-D	mg/L				<0.0010			<0.0010						<0.0010				<0.0010				
P-D	mg/L																					
K-D	mg/L				<2.0			<2.0						<2.0				<2.0				
Se-D	mg/L				<0.0010			<0.0010						<0.0010				<0.0010				
U-D	mg/L				<0.00020			<0.00020						<0.00020				<0.00020				
V-D	mg/L				<0.030			<0.030						<0.030				<0.030				
Zn-D	mg/L				<0.0050			<0.0050						<0.0050				<0.0050				

Table D6 - Summary of water quality data collected at the WB site.

Parameter	Units	09/08/2005	15/08/2005	24/08/2005	24/08/2005	30/08/2005	07/09/2005	13/09/2005	21/09/2005	27/09/2005	03/10/2005	11/10/2005	18/10/2005	25/10/2005	01/11/2005	08/11/2005	15/11/2005	23/11/2005	23/11/2005	30/11/2005	05/12/2005	13/12/2005
Cond-L	uS/cm	130	120	112	110	100	90.1	94.9	89.9	82	85.5	90.2	144	118	123	130	100	114	113	150	158	158
Hardness (as CaCO3)	mg/L		46.7				31.8				40.3				47.6						50.7	
pH-L	pH Units	7.63	7.82	7.44	7.3	7.56	7.69	7.67	6.98	7.65	7.67	7.82	6.47	8.02	7.98	7.63	6.98	7.38	7.36	6.88	7.73	7.29
TSS	mg/L	<3	<3	<3	3.2	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Acidity 8.3	mg/L		2.8				4.1				4.2				2.2						11.3	
Acidity 4.5	mg/L																					
Alk-T	mg/L																					
N-NH3	mg/L		<0.005				<0.005				0.006				0.0173						0.0167	
NO2+NO3	mg/L		<0.005				0.0053				<0.005				0.0390						0.0448	
N-TKN	mg/L		0.124				0.25				0.098				0.187						0.106	
P-PO4-D	mg/L		<0.002				<0.002				<0.002				0.0021					<0.002		
P-PO4-T	mg/L		<0.002				<0.002				0.0035				0.0027					0.0024		
SO4-D	mg/L	29	25.6	22.3	22.1	10	15.7	18.9	17	13.5	14	15.7	40.6	25.5	29.6	30.9	21.4	27.3	27.3	32.3	41.7	39
Al-T	mg/L		0.0157				0.0163				0.0102				0.0236						0.0231	
Sb-T	mg/L		<0.00050				<0.00050				<0.00050				<0.00050						<0.00050	
As-T	mg/L		<0.00050				<0.00050				<0.00050				<0.00050						<0.00050	
Ba-T	mg/L		<0.020				<0.020				<0.020				<0.020						<0.020	
Be-T	mg/L		<0.0010				<0.0010				<0.0010				<0.0010						<0.0010	
B-T	mg/L		<0.10				<0.10				<0.10				<0.10						<0.10	
Cd-T	mg/L		<0.000017				<0.000017				<0.000017				<0.000017						<0.000017	
Ca-T	mg/L		13.7				9.70				10.8				13.5						16.2	
Cr-T	mg/L		<0.0010				<0.0010				<0.0010				<0.0010						<0.0010	
Co-T	mg/L		<0.00030				<0.00030				<0.00030				<0.00030						<0.00030	
Cu-T	mg/L		<0.0010				<0.0010				<0.0010				<0.0010						<0.0010	
Fe-T	mg/L		0.044				0.064				0.046				0.086						0.112	
Pb-T	mg/L		<0.00050				<0.00050				<0.00050				<0.00050						<0.00050	
Li-T	mg/L		<0.0050				<0.0050				<0.0050				<0.0050						<0.0050	
Mg-T	mg/L		1.83				1.30				1.36				1.81						2.34	
Mn-T	mg/L		0.00687				0.00628				0.00811				0.0135						0.0106	
Hg-T	mg/L		<0.000020				<0.000020				<0.000020				<0.000020						<0.000020	
Mo-T	mg/L		<0.0010				<0.0010				<0.0010				<0.0010						<0.0010	
Ni-T	mg/L		<0.0010				<0.0010				<0.0010				<0.0010						<0.0010	
P-T	mg/L		<2.0				<2.0				<2.0				<2.0						<2.0	
K-T	mg/L																					
Se-T	mg/L		<0.0010				<0.0010				<0.0010				<0.0010						<0.0010	
Ag-T	mg/L		<0.000020				<0.000020				<0.000020				<0.000020						<0.000020	
Na-T	mg/L		8.2				4.5				4.3				7.1						15.1	
Tl-T	mg/L		<0.00020				<0.00020				<0.00020				<0.00020						<0.00020	
Sn-T	mg/L		<0.00050				<0.00050				<0.00050				<0.00050						<0.00050	
Ti-T	mg/L		<0.010				<0.010				<0.010				<0.010						<0.010	
U-T	mg/L		<0.00020				<0.00020				<0.00020				<0.00020						<0.00020	
V-T	mg/L		<0.030				<0.030				<0.030				<0.030						<0.030	
Zn-T	mg/L		<0.0050				<0.0050				<0.0050				<0.0050						<0.0050	
Zr-T	mg/L																					
Al-D	mg/L		0.0208				0.0103				0.0111				0.0205						0.0173	
Sb-D	mg/L		<0.00050				<0.00050				<0.00050				<0.00050						<0.00050	
As-D	mg/L		<0.00050				<0.00050				<0.00050				<0.00050						<0.00050	
Ba-D	mg/L		<0.020				<0.020				<0.020				<0.020						<0.020	
Be-D	mg/L		<0.0010				<0.0010				<0.0010				<0.0010						<0.0010	
B-D	mg/L		<0.10				<0.10				<0.10				<0.10						<0.10	
Cd-D	mg/L		<0.000017				<0.000017				<0.000017				<0.000017						<0.000017	
Ca-D	mg/L		15.3				10.4				13.2				15.6						16.4	
Cr-D	mg/L		<0.0010				<0.0010				<0.0010				<0.0010						<0.0010	
Co-D	mg/L		<0.00030				<0.00030				<0.00030				<0.00030						<0.00030	
Cu-D	mg/L		<0.0010				<0.0010				<0.0010				<0.0010						<0.0010	
Fe-D	mg/L		0.033				0.034				<0.030				0.066						0.056	
Pb-D	mg/L		<0.00050				<0.00050				<0.00050				<0.00050						<0.00050	
Li-D	mg/L		<0.0050				<0.0050				<0.0050				<0.0050						<0.0050	
Mg-D	mg/L		2.08				1.42				1.78				2.11						2.37	
Mn-D	mg/L		0.00387				0.00186				0.00638				0.0104						0.00889	
Hg-D	mg/L		<0.000020				<0.000020				<0.000020				<0.000020						<0.000020	
Mo-D	mg/L		<0.0010				<0.0010				<0.0010				<0.0010						<0.0010	
Ni-D	mg/L		<0.0010				<0.0010				<0.0010				<0.0010						<0.0010	
P-D	mg/L																					
K-D	mg/L		<2.0				<2.0				<2.0				<2.0						<2.0	
Se-D	mg/L		<0.0010				<0.0010				<0.0010				<0.0010						<0.0010	
U-D	mg/L		<0.00020				<0.00020				<0.00020				<0.00020						<0.00020	
V-D	mg/L		<0.030				<0.030				<0.030				<0.030						<0.030	
Zn-D	mg/L		<0.0050				<0.0050				<0.0050				<0.0050						<0.0050	

Table D6 - Summary of water quality data collected at the WB site.

Parameter	Units	20/12/2005	29/12/2005	03/01/2006	06/01/2006	09/01/2006	18/01/2006	24/01/2006	31/01/2006	07/02/2006	14/02/2006	21/02/2006	21/02/2006	28/02/2006	06/03/2006	14/03/2006	22/03/2006	29/03/2006	03/04/2006	12/04/2006	18/04/2006	25/04/2006
Cond-L	uS/cm	175	116	108		121	122	133	129	104	125	173	170	184	173	180	232	188	220	234	229	214
Hardness (as CaCO3)	mg/L			35.9							46				51.5				63.8			
pH-L	pH Units	7.63	7.08	7.9		6.83	7.48	7.15	7.39	8.29	8.05	7.56	7.52	7.59	7.82	7.26	7.65	7.26	7.66	7.46	7.13	7.79
TSS	mg/L	<3	<3	<3		<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Acidity 8.3	mg/L			4.1							4.3				4.1				2			
Acidity 4.5	mg/L																					
Alk-T	mg/L																					
N-NH3	mg/L			0.01							<0.005				0.0053				<0.005			
NO2+NO3	mg/L			0.0482							0.0378				0.0439				0.0448			
N-TKN	mg/L			0.091							0.052				0.053				<0.05			
P-PO4-D	mg/L			0.0035							0.0023				<0.002				<0.002			
P-PO4-T	mg/L			0.0038							0.0034				<0.002				0.0032			
SO4-D	mg/L	37.9	25.6	25		28.4	29	31.1	30.9	24.5	32	44.8	44.2	55.8	48.2	46.5	67.6	7	64.9	66.2	61.8	55.6
Al-T	mg/L				0.0398						0.0391				0.0462				0.0279			
Sb-T	mg/L				<0.00050						<0.00050				<0.00050				<0.00050			
As-T	mg/L				<0.00050						<0.00050				<0.00050				<0.00050			
Ba-T	mg/L				<0.020						<0.020				<0.020				<0.060			
Be-T	mg/L				<0.0010						<0.0010				<0.0010				<0.0010			
B-T	mg/L				<0.10						<0.10				<0.10				<0.30			
Cd-T	mg/L				<0.000017						<0.000017				<0.000017				<0.000017			
Ca-T	mg/L				11.6						12.3				17.0				20.0			
Cr-T	mg/L				<0.0010						<0.0010				<0.0010				<0.0010			
Co-T	mg/L				<0.00030						<0.00030				<0.00030				<0.00030			
Cu-T	mg/L				<0.0010						<0.0010				<0.0010				<0.0010			
Fe-T	mg/L				0.045						0.060				0.058				0.114			
Pb-T	mg/L				<0.00050						<0.00050				<0.00050				<0.00050			
Li-T	mg/L				<0.0050						<0.0050				<0.0050				<0.0050			
Mg-T	mg/L				1.52						1.79				2.29				2.76			
Mn-T	mg/L				0.00452						0.0101				0.0151				0.0156			
Hg-T	mg/L				<0.000020						<0.000020				<0.000020				<0.000020			
Mo-T	mg/L				<0.0010						<0.0010				<0.0010				<0.0010			
Ni-T	mg/L				<0.0010						<0.0010				<0.0010				<0.0010			
P-T	mg/L				<2.0						<2.0				<2.0				<2.0			
K-T	mg/L																					
Se-T	mg/L				<0.0010						<0.0010				<0.0010				<0.0010			
Ag-T	mg/L				<0.000020						<0.000020				<0.000020				<0.000020			
Na-T	mg/L				8.5						10.6				16.0				21.8			
Tl-T	mg/L				<0.00020						<0.00020				<0.00020				<0.00020			
Sn-T	mg/L				<0.00050						0.00085				<0.00050				<0.00050			
Ti-T	mg/L				<0.010						<0.010				<0.010				<0.030			
U-T	mg/L				<0.00020						<0.00020				<0.00020				<0.00020			
V-T	mg/L				<0.030						<0.030				<0.030				<0.090			
Zn-T	mg/L				<0.0050						<0.0050				<0.0050				<0.0050			
Zr-T	mg/L																					
Al-D	mg/L				0.0313						0.0344				0.0290				0.0228			
Sb-D	mg/L				<0.00050						<0.00050				<0.00050				<0.00050			
As-D	mg/L				<0.00050						<0.00050				<0.00050				<0.00050			
Ba-D	mg/L				<0.020						<0.020				<0.020				<0.060			
Be-D	mg/L				<0.0010						<0.0010				<0.0010				<0.0010			
B-D	mg/L				<0.10						<0.10				<0.10				<0.30			
Cd-D	mg/L				<0.000017						0.000024				<0.000017				0.000043			
Ca-D	mg/L				12.7						15.3				17.2				20.9			
Cr-D	mg/L				<0.0010						<0.0010				0.0022				<0.0010			
Co-D	mg/L				<0.00030						0.00064				<0.00030				<0.00030			
Cu-D	mg/L				<0.0010						<0.0010				<0.0010				<0.0010			
Fe-D	mg/L				0.035						0.045				0.136				<0.090			
Pb-D	mg/L				<0.00050						<0.00050				<0.00050				<0.00050			
Li-D	mg/L				<0.0050						<0.0050				<0.0050				<0.0050			
Mg-D	mg/L				1.66						2.25				2.31				2.80			
Mn-D	mg/L				0.00505						0.0161				0.0155				0.0137			
Hg-D	mg/L				<0.000020						<0.000020				<0.000020				<0.000020			
Mo-D	mg/L				<0.0010						<0.0010				<0.0010				<0.0010			
Ni-D	mg/L				<0.0010						0.0013				<0.0010				<0.0010			
P-D	mg/L																					
K-D	mg/L				<2.0						<2.0				<2.0				<2.0			
Se-D	mg/L				<0.0010						<0.0010				<0.0010				<0.0010			
U-D	mg/L				<0.00020						<0.00020				<0.00020				<0.00020			
V-D	mg/L				<0.030						<0.030				<0.030				<0.090			
Zn-D	mg/L				<0.0050						<0.0050				<0.0050				<0.0050			

Table D6 - Summary of water quality data collected at the WB site.

Parameter	Units	02/05/2006	08/05/2006	16/05/2006	16/05/2006	24/05/2006	31/05/2006	08/06/2006	12/06/2006	20/06/2006	27/06/2006	06/07/2006	11/07/2006	18/07/2006	25/07/2006	02/08/2006	10/08/2006	15/08/2006	22/08/2006	22/08/2006	29/08/2006	07/09/2006
Cond-L	uS/cm	204	199	186	189	2170	141	141	143	143	139	117	109	101	96.2	92.2	91.8	92.4	90.2	90.5	88.5	86.8
Hardness (as CaCO3)	mg/L	57.6							48.1			49.5				39.7						37.6
pH-L	pH Units	7.79	7.72	7.74	7.76	8.11	7.79	8.1	7.73	7.8	7.77	7.8	7.63	7.78	7.82	7.76	7.67	7.68	7.73	7.7	7.81	7.68
TSS	mg/L	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Acidity 8.3	mg/L	1.1							2.1			<1				1.4						1.6
Acidity 4.5	mg/L																					
Alk-T	mg/L																					
N-NH3	mg/L	0.0067							0.0073			0.0093				0.007						0.008
NO2+NO3	mg/L	0.0105							<0.005			<0.005				<0.005						<0.005
N-TKN	mg/L	0.078							0.079			<0.05				0.107						0.103
P-PO4-D	mg/L	<0.002							<0.002			0.0130				<0.002						<0.002
P-PO4-T	mg/L	0.0023							0.0024			0.0256				0.0028						0.004
SO4-D	mg/L	56.9	49.9	49.9	50.7	36.1	32.2	21.8	34	28.5	32.9	24.9	21.2	18.7	16.7	16.7	15.8	16.3	16.4	16.5	14.6	14.4
Al-T	mg/L	0.0378							0.0186			0.0168				0.0157						0.0171
Sb-T	mg/L	<0.00050							<0.00050			<0.00050				<0.00050						<0.00050
As-T	mg/L	<0.00050							<0.00050			<0.00050				<0.00050						<0.00050
Ba-T	mg/L	<0.020							<0.020			<0.020				<0.020						<0.020
Be-T	mg/L	<0.0010							<0.0010			<0.0010				<0.0010						<0.0010
B-T	mg/L	<0.10							<0.10			<0.10				<0.10						<0.10
Cd-T	mg/L	<0.000017							0.000021			<0.000017				<0.000017						<0.000017
Ca-T	mg/L	19.5							14.5			12.9				11.2						11.1
Cr-T	mg/L	<0.0010							<0.0010			<0.0010				<0.0010						<0.0010
Co-T	mg/L	<0.00030							<0.00030			<0.00030				<0.00030						<0.00030
Cu-T	mg/L	<0.0010							<0.0010			<0.0010				<0.0010						<0.0010
Fe-T	mg/L	<0.030							0.034			0.044				0.051						0.053
Pb-T	mg/L	<0.00050							<0.00050			<0.00050				<0.00050						<0.0010
Li-T	mg/L	<0.0050							<0.0050			<0.0050				<0.0050						<0.0050
Mg-T	mg/L	2.69							1.88			1.59				1.39						1.33
Mn-T	mg/L	0.0104							0.0165			0.00893				0.00797						0.00644
Hg-T	mg/L	<0.000020							<0.000020			<0.000020				<0.000020						<0.000020
Mo-T	mg/L	<0.0010							<0.0010			<0.0010				<0.0010						<0.0010
Ni-T	mg/L	<0.0010							<0.0010			<0.0010				<0.0010						<0.0010
P-T	mg/L	<2.0							<2.0			<2.0				<2.0						<2.0
K-T	mg/L																					
Se-T	mg/L	<0.0010							<0.0010			<0.0010				<0.0010						<0.0010
Ag-T	mg/L	<0.000020							<0.000020			<0.000020				<0.000020						<0.000020
Na-T	mg/L	24.8							12.7			9.0				5.9						5.3
Tl-T	mg/L	<0.00020							<0.00020			<0.00020				<0.00020						<0.00020
Sn-T	mg/L	<0.00050							<0.00050			<0.00050				<0.00050						<0.00050
Ti-T	mg/L	<0.010							<0.010			<0.010				<0.010						<0.010
U-T	mg/L	<0.00020							<0.00020			<0.00020				<0.00020						<0.00020
V-T	mg/L	<0.030							<0.030			<0.030				<0.030						<0.030
Zn-T	mg/L	<0.0050							<0.0050			<0.0050				<0.0050						<0.0050
Zr-T	mg/L																					
Al-D	mg/L	0.0143							0.0169			0.0205				0.0164						0.0124
Sb-D	mg/L	<0.00050							<0.00050			<0.00050				<0.00050						<0.00050
As-D	mg/L	<0.00050							<0.00050			<0.00050				<0.00050						<0.00050
Ba-D	mg/L	<0.020							<0.020			<0.020				<0.020						<0.020
Be-D	mg/L	<0.0010							<0.0010			<0.0010				<0.0010						<0.0010
B-D	mg/L	<0.10							<0.10			<0.10				<0.10						<0.10
Cd-D	mg/L	<0.000017							<0.000017			0.000051				0.000043						0.000021
Ca-D	mg/L	18.8							15.8			16.3				13.1						12.5
Cr-D	mg/L	<0.0010							<0.0010			<0.0010				<0.0010						<0.0010
Co-D	mg/L	<0.00030							<0.00030			<0.00030				<0.00030						<0.00030
Cu-D	mg/L	<0.0010							<0.0010			<0.0010				<0.0010						<0.0010
Fe-D	mg/L	<0.030							<0.030			<0.030				0.035						0.034
Pb-D	mg/L	<0.00050							<0.00050			<0.00050				<0.00050						<0.0010
Li-D	mg/L	<0.0050							<0.0050			<0.0050				<0.0050						<0.0050
Mg-D	mg/L	2.57							2.08			2.12				1.70						1.56
Mn-D	mg/L	0.00675							0.0122			0.00287				0.00295						0.00167
Hg-D	mg/L	<0.000020							<0.000020			<0.000020				<0.000020						<0.000020
Mo-D	mg/L	<0.0010							<0.0010			<0.0010				<0.0010						<0.0010
Ni-D	mg/L	<0.0010							<0.0010			<0.0010				<0.0010						<0.0010
P-D	mg/L																					
K-D	mg/L	<2.0							<2.0			<2.0				<2.0						<2.0
Se-D	mg/L	<0.0010							<0.0010			<0.0010				<0.0010						<0.0010
U-D	mg/L	<0.00020							<0.00020			<0.00020				<0.00020						<0.00020
V-D	mg/L	<0.030							<0.030			<0.030				<0.030						<0.030
Zn-D	mg/L	<0.0050							<0.0050			<0.0050				<0.0050						<0.0050

Table D6 - Summary of water quality data collected at the WB site.																						
Parameter	Units	12/09/2006	12/09/2006	19/09/2006	19/09/2006	26/09/2006	26/09/2006	03/10/2006	03/10/2006	03/10/2006	10/10/2006	11/10/2006	17/10/2006	17/10/2006	17/10/2006	17/10/2006	24/10/2006	24/10/2006	01/11/2006	01/11/2006	01/11/2006	07/11/2006
Cond-L	uS/cm	87.3	87.3	95.6	95.6	87.7	87.7	88.2	88.2		90.7	90.7	92.7	1110	1110	92.7	89	89.0	113		113	160
Hardness (as CaCO3)	mg/L							42.9		42.9									39.7	39.7	35.9	
pH-L	pH Units	7.74	7.74	7.51	7.51	7.56	7.56	7.71	7.71		7.49	7.49	7.73	8.23	8.23	7.73	7.65	7.65	7.76		7.76	7.77
TSS	mg/L	<3	<3.0	<3	<3.0	<3	<3.0	<3	<3.0		<3	<3.0	7.3	<3	<3.0	7.3	<3	<3.0	<3		<3.0	<3
Acidity 8.3	mg/L							1.4											1.7			
Acidity 4.5	mg/L																					
Alk-T	mg/L								26.0												27.5	
N-NH3	mg/L							0.0053	0.0053										0.0120		0.0120	
NO2+NO3	mg/L							<0.005	<0.0050										0.0051		0.0051	
N-TKN	mg/L							0.1350	0.135										0.2230		0.223	
P-PO4-D	mg/L							<0.002	<0.0020										<0.002		<0.0020	
P-PO4-T	mg/L							0.0024	0.0024										0.0027		0.0027	
SO4-D	mg/L	14.8	14.8	18	18.0	16.2	16.2	15.5	15.5		15.9	15.9	15.2	15.3	15.3	15.2	15.8	15.8	24.6		24.6	40.1
Al-T	mg/L									0.0118										0.0057		
Sb-T	mg/L									<0.00050										<0.00050		
As-T	mg/L									<0.00050										<0.00050		
Ba-T	mg/L									<0.020										<0.020		
Be-T	mg/L									<0.0010										<0.0010		
B-T	mg/L									<0.10										<0.10		
Cd-T	mg/L									<0.000017										<0.000017		
Ca-T	mg/L									10.8										12.3		
Cr-T	mg/L									<0.0010										<0.0010		
Co-T	mg/L									<0.00030										<0.00030		
Cu-T	mg/L									<0.0010										<0.0010		
Fe-T	mg/L									0.052										0.049		
Pb-T	mg/L									<0.00050										<0.00050		
Li-T	mg/L									<0.0050										<0.0050		
Mg-T	mg/L									1.37										1.55		
Mn-T	mg/L									0.00595										0.0130		
Hg-T	mg/L									<0.000020										<0.000020		
Mo-T	mg/L									<0.0010										<0.0010		
Ni-T	mg/L									<0.0010										<0.0010		
P-T	mg/L																					
K-T	mg/L									<2.0										<2.0		
Se-T	mg/L									<0.0010										<0.0010		
Ag-T	mg/L									<0.000020										<0.000020		
Na-T	mg/L									5.3										6.9		
Tl-T	mg/L									<0.00020										<0.00020		
Sn-T	mg/L									<0.00050										<0.00050		
Ti-T	mg/L									<0.010										<0.010		
U-T	mg/L									<0.00020										<0.00020		
V-T	mg/L									<0.030										<0.030		
Zn-T	mg/L									<0.0050										<0.0050		
Zr-T	mg/L																					
Al-D	mg/L									0.0083										0.0056		
Sb-D	mg/L									<0.00050										<0.00050		
As-D	mg/L									<0.00050										<0.00050		
Ba-D	mg/L									<0.020										<0.020		
Be-D	mg/L									<0.0010										<0.0010		
B-D	mg/L									<0.10										<0.10		
Cd-D	mg/L									0.000024										0.000026		
Ca-D	mg/L								11.3	14.1										13.2	11.9	
Cr-D	mg/L									<0.0010										<0.0010		
Co-D	mg/L									<0.00030										<0.00030		
Cu-D	mg/L									<0.0010										0.0027		
Fe-D	mg/L									0.037										0.042		
Pb-D	mg/L									<0.00050										<0.00050		
Li-D	mg/L									<0.0050										<0.0050		
Mg-D	mg/L								1.40	1.85										1.64	1.49	
Mn-D	mg/L									0.00227										0.00969		
Hg-D	mg/L									<0.000020										<0.000020		
Mo-D	mg/L									<0.0010										<0.0010		
Ni-D	mg/L									<0.0010										<0.0010		
P-D	mg/L																					
K-D	mg/L									<2.0										<2.0		
Se-D	mg/L									<0.0010										<0.0010		
U-D	mg/L									<0.00020										<0.00020		
V-D	mg/L									<0.030										<0.030		
Zn-D	mg/L									<0.0050										<0.0050		

Table D6 - Summary of water quality data collected at the WB site.																						
Parameter	Units	07/11/2006	14/11/2006	14/11/2006	21/11/2006	21/11/2006	28/11/2006	28/11/2006	05/12/2006	05/12/2006	06/12/2006	12/12/2006	12/12/2006	19/12/2006	19/12/2006	27/12/2006	27/12/2006	02/01/2007	02/01/2007	09/01/2007	15/01/2007	23/01/2007
Cond-L	uS/cm	160	145	145	93.9	93.9	92.7	92.7	112		112	157	157	90	90.0	147	147		165	101	109	145
Hardness (as CaCO3)	mg/L								37.3	37.3	33.4							46.1	45.2			
pH-L	pH Units	7.77	7.7	7.70	7.47	7.47	7.52	7.52	7.61		7.61	7.15	7.15	7.34	7.34	7.66	7.66		7.73	7.55	7.46	7.55
TSS	mg/L	<3.0	<3	<3.0	<3	<3.0	<3	<3.0	<3		<3.0	3.6	3.6	<3	<3.0	<3	<3.0		<3.0	<3.0	<3.0	<3.0
Acidity 8.3	mg/L								<1													
Acidity 4.5	mg/L																					
Alk-T	mg/L										23.5								30.9			
N-NH3	mg/L								0.0107		0.0107								0.0079			
NO2+NO3	mg/L								0.0195		0.0195								0.0324			
N-TKN	mg/L								0.0910		0.091								0.114			
P-PO4-D	mg/L								0.0020		0.0020								0.0043			
P-PO4-T	mg/L								0.0040		0.0040								0.0046			
SO4-D	mg/L	40.1	35	35.0	21.4	21.4	19.3	19.3	25.3		25.3	43.8	43.8	17.8	17.8	39.6	39.6		45.1	20.7	23.3	32.2
Al-T	mg/L								0.0294									0.0577				
Sb-T	mg/L								<0.00050									<0.00050				
As-T	mg/L								<0.00050									<0.00050				
Ba-T	mg/L								<0.020									<0.020				
Be-T	mg/L								<0.0010									<0.0010				
B-T	mg/L								<0.10									<0.10				
Cd-T	mg/L								<0.000017									<0.000017				
Ca-T	mg/L								11.2									15.0				
Cr-T	mg/L								<0.0010									<0.0010				
Co-T	mg/L								<0.00030									<0.00030				
Cu-T	mg/L								<0.0010									<0.0010				
Fe-T	mg/L								0.043									0.040				
Pb-T	mg/L								<0.00050									<0.00050				
Li-T	mg/L								<0.0050									<0.0050				
Mg-T	mg/L								1.51									2.04				
Mn-T	mg/L								0.00613									0.00656				
Hg-T	mg/L								<0.000020									<0.000020				
Mo-T	mg/L								<0.0010									<0.0010				
Ni-T	mg/L								<0.0010									<0.0010				
P-T	mg/L																					
K-T	mg/L								<2.0									<2.0				
Se-T	mg/L								<0.0010									<0.0010				
Ag-T	mg/L								<0.000020									<0.000020				
Na-T	mg/L								9.9									17.0				
Tl-T	mg/L								<0.00020									<0.00020				
Sn-T	mg/L								<0.00050									<0.00050				
Ti-T	mg/L								<0.010									<0.010				
U-T	mg/L								<0.00020									<0.00020				
V-T	mg/L								<0.030									<0.030				
Zn-T	mg/L								<0.0050									<0.0050				
Zr-T	mg/L																					
Al-D	mg/L								0.0238									0.0322				
Sb-D	mg/L								<0.00050									<0.00050				
As-D	mg/L								<0.00050									<0.00050				
Ba-D	mg/L								<0.020									<0.020				
Be-D	mg/L								<0.0010									<0.0010				
B-D	mg/L								<0.10									<0.10				
Cd-D	mg/L								<0.000017									<0.000017				
Ca-D	mg/L								12.2		10.9							15.1	14.8			
Cr-D	mg/L								<0.0010									<0.0010				
Co-D	mg/L								<0.00030									<0.00030				
Cu-D	mg/L								<0.0010									<0.0010				
Fe-D	mg/L								<0.030									<0.030				
Pb-D	mg/L								<0.00050									<0.00050				
Li-D	mg/L								<0.0050									<0.0050				
Mg-D	mg/L								1.65		1.48							2.06	2.00			
Mn-D	mg/L								0.00599									0.00695				
Hg-D	mg/L								<0.000020									<0.000020				
Mo-D	mg/L								<0.0010									<0.0010				
Ni-D	mg/L								<0.0010									<0.0010				
P-D	mg/L																					
K-D	mg/L								<2.0									<2.0				
Se-D	mg/L								<0.0010									<0.0010				
U-D	mg/L								<0.00020									<0.00020				
V-D	mg/L								<0.030									<0.030				
Zn-D	mg/L								<0.0050									<0.0050				

Table D6 - Summary of water quality data collected at the WB site.																						
Parameter	Units	23/01/2007	31/01/2007	06/02/2007	06/02/2007	13/02/2007	20/02/2007	27/02/2007	06/03/2007	06/03/2007	13/03/2007	20/03/2007	27/03/2007	03/04/2007	10/04/2007	17/04/2007	24/04/2007	01/05/2007	01/05/2007	08/05/2007	15/05/2007	23/05/2007
Cond-L	uS/cm	146	117		144	141	117	166		177	118	96.1	107	141	140	165	110	80.1	79.9	71.4	61.6	
Hardness (as CaCO3)	mg/L			43.3	42.1				53.0	48.4				46.9								30.7
pH-L	pH Units	7.57	7.32		7.63	7.58	7.80	7.29		7.89	7.81	7.50	7.70	7.77	7.79	7.70	7.72	7.50	7.50	7.32	7.58	
TSS	mg/L	<3.0	<3.0		<3.0	<3.0	<3.0	<3.0		3.2	<3.0	<3.0	<3.0	4.4	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	
Acidity 8.3	mg/L																					
Acidity 4.5	mg/L																					
Alk-T	mg/L				29.0					32.0				27.3								
N-NH3	mg/L				<0.0050					0.0057				<0.0050								
NO2+NO3	mg/L				0.0408					0.0339				0.0239								
N-TKN	mg/L				0.107					0.077				<0.050								
P-PO4-D	mg/L				<0.0020					0.0021				0.0021								
P-PO4-T	mg/L				0.0119					0.0044				0.0050								
SO4-D	mg/L	32.9	23.5		37.9	37.6	29.6	42.4		50.4	26.8	21.1	25.9	36.5	30.8	40.8	25.8	15.6	15.7	11.7	9.0	
Al-T	mg/L			0.0343					0.0400					0.0227								0.0209
Sb-T	mg/L			<0.00050					<0.00050					<0.00050								<0.00050
As-T	mg/L			<0.00050					<0.00050					<0.00050								<0.00050
Ba-T	mg/L			<0.020					<0.020					<0.020								<0.020
Be-T	mg/L			<0.0010					<0.0010					<0.0010								<0.0010
B-T	mg/L			<0.10					<0.10					<0.10								<0.10
Cd-T	mg/L			<0.000017					<0.000017					<0.000017								<0.000017
Ca-T	mg/L			13.8					16.3					14.8								8.65
Cr-T	mg/L			<0.0010					<0.0010					<0.0010								<0.0010
Co-T	mg/L			<0.00030					<0.00030					<0.00030								<0.00030
Cu-T	mg/L			<0.0010					<0.0010					<0.0010								<0.0010
Fe-T	mg/L			0.038					0.053					0.033								<0.030
Pb-T	mg/L			<0.00050					<0.00050					<0.00050								<0.00050
Li-T	mg/L			<0.0050					<0.0050					<0.0050								<0.0050
Mg-T	mg/L			1.86					2.16					1.75								0.99
Mn-T	mg/L			0.00696					0.00821					0.0140								0.00579
Hg-T	mg/L			<0.000020					<0.000020					<0.000020								<0.000020
Mo-T	mg/L			<0.0010					<0.0010					<0.0010								<0.0010
Ni-T	mg/L			<0.0010					<0.0010					<0.0010								<0.0010
P-T	mg/L																					
K-T	mg/L			<2.0					<2.0					<2.0								<2.0
Se-T	mg/L			<0.0010					<0.0010					<0.0010								<0.0010
Ag-T	mg/L			<0.000020					<0.000020					<0.000020								<0.000020
Na-T	mg/L			13.0					16.9					10.2								2.9
Tl-T	mg/L			<0.00020					<0.00020					<0.00020								<0.00020
Sn-T	mg/L			<0.00050					<0.00050					<0.00050								<0.00050
Ti-T	mg/L			<0.010					<0.010					<0.010								<0.010
U-T	mg/L			<0.00020					<0.00020					<0.00020								<0.00020
V-T	mg/L			<0.030					<0.030					<0.030								<0.030
Zn-T	mg/L			<0.0050					<0.0050					<0.0050								<0.0050
Zr-T	mg/L																					
Al-D	mg/L			0.0227					0.0217					0.0204								0.0188
Sb-D	mg/L			<0.00050					<0.00050					<0.00050								<0.00050
As-D	mg/L			<0.00050					<0.00050					<0.00050								<0.00050
Ba-D	mg/L			<0.020					<0.020					<0.020								<0.020
Be-D	mg/L			<0.0010					<0.0010					<0.0010								<0.0010
B-D	mg/L			<0.10					<0.10					<0.10								<0.10
Cd-D	mg/L			<0.000017					<0.000017					<0.000017								<0.000017
Ca-D	mg/L			14.2	13.8				17.5	15.9				15.7								10.3
Cr-D	mg/L			<0.0010					<0.0010					<0.0010								<0.0010
Co-D	mg/L			<0.00030					<0.00030					<0.00030								<0.00030
Cu-D	mg/L			<0.0010					<0.0010					<0.0010								<0.0010
Fe-D	mg/L			0.032					0.032					<0.030								<0.030
Pb-D	mg/L			<0.00050					<0.00050					<0.00050								<0.00050
Li-D	mg/L			<0.0050					<0.0050					<0.0050								<0.0050
Mg-D	mg/L			1.90	1.85				2.27	2.11				1.86								1.21
Mn-D	mg/L			0.00631					0.00729					0.0133								0.00505
Hg-D	mg/L			<0.000020					<0.000020					0.000028								<0.000020
Mo-D	mg/L			<0.0010					<0.0010					<0.0010								<0.0010
Ni-D	mg/L			<0.0010					<0.0010					<0.0010								<0.0010
P-D	mg/L																					
K-D	mg/L			<2.0					<2.0					<2.0								<2.0
Se-D	mg/L			<0.0010					<0.0010					<0.0010								<0.0010
U-D	mg/L			<0.00020					<0.00020					<0.00020								<0.00020
V-D	mg/L			<0.030					<0.030					<0.030								<0.030
Zn-D	mg/L			<0.0050					<0.0050					<0.0050								<0.0050

Table D6 - Summary of water quality data collected at the WB site.																						
Parameter	Units	23/05/2007	29/05/2007	05/06/2007	05/06/2007	12/06/2007	19/06/2007	26/06/2007	04/07/2007	04/07/2007	10/07/2007	17/07/2007	24/07/2007	01/08/2007	01/08/2007	08/08/2007	14/08/2007	14/08/2007	21/08/2007	28/08/2007	05/09/2007	05/09/2007
Cond-L	uS/cm	61.3	58.1		52.7	60.6	64.6	64.5		79.0	78.8	69.8	78.1		69.3	63.2	72.3	69.3	67.9	73.7		83.7
Hardness (as CaCO3)	mg/L	25.0		28.3	25.0				40.2	29.1				32.4	28.8						30.6	28.8
pH-L	pH Units	7.41	7.63		7.61	7.64	7.68	7.57		7.49	7.05	7.57	7.41		7.65	7.15	7.75	7.73	7.72	6.83		7.99
TSS	mg/L	<3.0	<3.0		<3.0	<3.0	<3.0	<3.0		3.7	<3.0	<3.0	<3.0		<3.0	<3.0	<3.0	<3.0	<3.0	<3.0		<3.0
Acidity 8.3	mg/L																					
Acidity 4.5	mg/L																					
Alk-T	mg/L	16.9			20.6					22.5					22.5							23.5
N-NH3	mg/L	<0.020			0.0070					0.0101					0.0069							<0.020
NO2+NO3	mg/L	<0.0050			<0.0050					<0.0050					<0.0050							<0.0050
N-TKN	mg/L	0.077			0.057					0.146					0.163							0.118
P-PO4-D	mg/L	<0.0020			0.0025					<0.0020					<0.0020							<0.0020
P-PO4-T	mg/L	0.0027			0.0035					0.0028					0.0077							0.0029
SO4-D	mg/L	7.93	7.5		6.04	7.14	8.60	9.6		13.8	13.6	9.96	13.3		9.94	8.7	10.5	10.6	9.9	12.3		14.9
Al-T	mg/L			0.0179					0.0169					0.0216							0.0116	
Sb-T	mg/L			<0.00050					<0.00050					<0.00050							<0.00050	
As-T	mg/L			<0.00080					<0.00050					<0.00050							<0.00050	
Ba-T	mg/L			<0.020					<0.020					<0.020							<0.020	
Be-T	mg/L			<0.0010					<0.0010					<0.0010							<0.0010	
B-T	mg/L			<0.10					<0.10					<0.10							<0.10	
Cd-T	mg/L			<0.000017					<0.000017					<0.000017							<0.000017	
Ca-T	mg/L			7.93					10.3					9.92							9.43	
Cr-T	mg/L			<0.0010					<0.0010					<0.0010							<0.0010	
Co-T	mg/L			<0.00030					<0.00030					<0.00030							<0.00030	
Cu-T	mg/L			<0.0010					<0.0010					<0.0010							<0.0010	
Fe-T	mg/L			0.031					0.047					0.063							0.049	
Pb-T	mg/L			<0.00050					<0.00050					<0.00050							<0.00050	
Li-T	mg/L			<0.0050					<0.0050					<0.0050							<0.0050	
Mg-T	mg/L			0.94					1.20					1.15							1.12	
Mn-T	mg/L			0.00816					0.0119					0.0110							0.00743	
Hg-T	mg/L			<0.000020					<0.000020					<0.000020							<0.000020	
Mo-T	mg/L			<0.0010					<0.0010					<0.0010							<0.0010	
Ni-T	mg/L			<0.0010					<0.0010					<0.0010							<0.0010	
P-T	mg/L																					
K-T	mg/L			<2.0					<2.0					<2.0							<2.0	
Se-T	mg/L			<0.0010					<0.0010					<0.0010							<0.0010	
Ag-T	mg/L			<0.000020					<0.000020					<0.000020							<0.000020	
Na-T	mg/L			2.3					4.1					3.1							4.6	
Tl-T	mg/L			<0.00020					<0.00020					<0.00020							<0.00020	
Sn-T	mg/L			<0.00050					<0.00050					<0.00050							<0.00050	
Ti-T	mg/L			<0.010					<0.010					<0.010							<0.010	
U-T	mg/L			<0.00020					<0.00020					<0.00020							<0.00020	
V-T	mg/L			<0.030					<0.030					<0.030							<0.030	
Zn-T	mg/L			<0.0050					<0.0050					<0.0050							<0.0050	
Zr-T	mg/L																					
Al-D	mg/L			0.0164					0.0148					0.0143							0.0430	
Sb-D	mg/L			<0.00050					<0.00050					<0.00050							<0.00050	
As-D	mg/L			<0.00050					<0.00050					<0.00050							<0.00050	
Ba-D	mg/L			<0.020					<0.020					<0.020							<0.020	
Be-D	mg/L			<0.0010					<0.0010					<0.0010							<0.0010	
B-D	mg/L			<0.10					<0.10					<0.10							<0.10	
Cd-D	mg/L			<0.000017					<0.000017					<0.000017							<0.000017	
Ca-D	mg/L	8.44		9.47	8.45				13.5	9.71				10.9	9.63						10.3	9.58
Cr-D	mg/L			<0.0010					<0.0010					<0.0010							<0.0010	
Co-D	mg/L			<0.00030					<0.00030					<0.00030							<0.00030	
Cu-D	mg/L			<0.0010					<0.0010					<0.0010							0.0017	
Fe-D	mg/L			<0.030					<0.030					0.033							0.112	
Pb-D	mg/L			<0.00050					<0.00050					<0.00050							<0.00050	
Li-D	mg/L			<0.0050					<0.0050					<0.0050							<0.0050	
Mg-D	mg/L	0.97		1.14	0.94				1.61	1.17				1.28	1.15						1.21	1.18
Mn-D	mg/L			0.00754					0.0107					0.00888							0.00645	
Hg-D	mg/L			<0.000020					<0.000020					<0.000020							<0.000020	
Mo-D	mg/L			<0.0010					<0.0010					<0.0010							<0.0010	
Ni-D	mg/L			<0.0010					<0.0010					<0.0010							<0.0010	
P-D	mg/L																					
K-D	mg/L			<2.0					<2.0					<2.0							<2.0	
Se-D	mg/L			<0.0010					<0.0010					<0.0010							<0.0010	
U-D	mg/L			<0.00020					<0.00020					<0.00020							<0.00020	
V-D	mg/L			<0.030					<0.030					<0.030							<0.030	
Zn-D	mg/L			<0.0050					<0.0050					<0.0050							<0.0050	

Table D6 - Summary of water quality data collected at the WB site.																						
Parameter	Units	11/09/2007	18/09/2007	25/09/2007	02/10/2007	02/10/2007	10/10/2007	16/10/2007	23/10/2007	01/11/2007	01/11/2007	06/11/2007	14/11/2007	20/11/2007	20/11/2007	27/11/2007	04/12/2007	04/12/2007	11/12/2007	18/12/2007	27/12/2007	02/01/2008
Cond-L	uS/cm	86.8	87.0	94.0		115	181	113	127		122	122	90.8	85.2	84.7	109	123		82.5	138	147	140
Hardness (as CaCO3)	mg/L				42.1	36.9				43.0	38.1						33.3	36.4				34.8
pH-L	pH Units	7.81	7.79	7.70		7.63	7.72	7.57	6.89		7.61	7.75	7.50	7.63	7.62	7.60	7.63		7.48	7.54	7.69	7.73
TSS	mg/L	<3.0	<3.0	<3.0		<3.0	<3.0	<3.0	<3.0		<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0		<3.0	<3.0	<3.0	<3.0
Acidity 8.3	mg/L																					
Acidity 4.5	mg/L																					
Alk-T	mg/L					26.3					25.1						29.7					29.9
N-NH3	mg/L					0.0068					<0.020						<0.020					<0.020
NO2+NO3	mg/L					<0.0050					0.0178						0.0175					0.0287
N-TKN	mg/L					0.121					0.092						0.068					0.080
P-PO4-D	mg/L					<0.0020					<0.0020						<0.0020					<0.0020
P-PO4-T	mg/L					0.0022					0.0039						0.0020					0.0027
SO4-D	mg/L	14.4	15.4	17.3		25.9	47.4	24.6	26		27.9	27.2	19.4	14.5	14.6	22.2	26.1		15.7	30.3	33.9	30.5
Al-T	mg/L				0.0101					0.0217								0.0293				
Sb-T	mg/L				<0.00050					<0.00050								<0.00050				
As-T	mg/L				<0.00050					<0.00050								<0.00050				
Ba-T	mg/L				<0.020					<0.020								<0.020				
Be-T	mg/L				<0.0010					<0.0010								<0.0010				
B-T	mg/L				<0.10					<0.10								<0.10				
Cd-T	mg/L				<0.000017					<0.000017								<0.000017				
Ca-T	mg/L				12.7					13.2								11.3				
Cr-T	mg/L				<0.0010					<0.0010								<0.0010				
Co-T	mg/L				<0.00030					<0.00030								<0.00030				
Cu-T	mg/L				<0.0010					<0.0010								<0.0010				
Fe-T	mg/L				0.042					0.060								0.059				
Pb-T	mg/L				<0.00050					<0.00050								<0.00050				
Li-T	mg/L				<0.0050					<0.0050								<0.0050				
Mg-T	mg/L				1.44					1.75								1.37				
Mn-T	mg/L				0.00913					0.00985								0.00670				
Hg-T	mg/L				<0.000020					<0.000020								<0.000020				
Mo-T	mg/L				<0.0010					<0.0010								<0.0010				
Ni-T	mg/L				<0.0010					<0.0010								<0.0010				
P-T	mg/L																					
K-T	mg/L				<2.0					<2.0								<2.0				
Se-T	mg/L				<0.0010					<0.0010								<0.0010				
Ag-T	mg/L				<0.000020					<0.000020								<0.000020				
Na-T	mg/L				8.4					10.2								11.6				
Tl-T	mg/L				<0.00020					<0.00020								<0.00020				
Sn-T	mg/L				<0.00050					<0.00050								<0.00050				
Ti-T	mg/L				<0.010					<0.010								<0.010				
U-T	mg/L				<0.00020					<0.00020								<0.00020				
V-T	mg/L				<0.0010					<0.0010								<0.0010				
Zn-T	mg/L				<0.0050					<0.0050								<0.0050				
Zr-T	mg/L																					
Al-D	mg/L				0.0093					0.0204								0.0191				
Sb-D	mg/L				<0.00050					<0.00050								<0.00050				
As-D	mg/L				<0.00050					<0.00050								<0.00050				
Ba-D	mg/L				<0.020					<0.020								<0.020				
Be-D	mg/L				<0.0010					<0.0010								<0.0010				
B-D	mg/L				<0.10					<0.10								<0.10				
Cd-D	mg/L				<0.000017					<0.000017								0.000019				
Ca-D	mg/L				14.1	12.4				14.1	12.5						11.1	12.1				11.5
Cr-D	mg/L				<0.0010					<0.0010								<0.0010				
Co-D	mg/L				<0.00030					<0.00030								<0.00030				
Cu-D	mg/L				<0.0010					<0.0010								<0.0010				
Fe-D	mg/L				<0.030					0.049								<0.030				
Pb-D	mg/L				<0.00050					<0.00050								<0.00050				
Li-D	mg/L				<0.0050					<0.0050								<0.0050				
Mg-D	mg/L				1.66	1.47				1.87	1.67						1.36	1.48				1.46
Mn-D	mg/L				0.00671					0.00759								0.00445				
Hg-D	mg/L				<0.000020					<0.000020								<0.000020				
Mo-D	mg/L				<0.0010					<0.0010								<0.0010				
Ni-D	mg/L				<0.0010					<0.0010								<0.0010				
P-D	mg/L																					
K-D	mg/L				<2.0					<2.0								<2.0				
Se-D	mg/L				<0.0010					<0.0010								<0.0010				
U-D	mg/L				<0.00020					<0.00020								<0.00020				
V-D	mg/L				<0.0010					<0.0010								<0.0010				
Zn-D	mg/L				<0.0050					<0.0050								<0.0050				

Table D6 - Summary of water quality data collected at the WB site.

Parameter	Units	02/01/2008	08/01/2008	15/01/2008	22/01/2008	29/01/2008	05/02/2008	05/02/2008	12/02/2008	19/02/2008	26/02/2008	26/02/2008	04/03/2008	04/03/2008	13/03/2008	18/03/2008	25/03/2008	01/04/2008	01/04/2008	09/04/2008	15/04/2008	22/04/2008
Cond-L	uS/cm		117	143	134	135		95.0	166	148	153	153		134	186	160	173	150		165	130	113
Hardness (as CaCO3)	mg/L	41.0					31.6	28.1					38.4	35.2				37.0	38.6			
pH-L	pH Units		7.52	7.67	7.58	7.55		7.56	7.85	7.65	7.68	7.70		7.36	7.67	7.65	7.70	7.71		7.71	7.51	7.36
TSS	mg/L		<3.0	<3.0	<3.0	<3.0		<3.0	10.0	10.1	<3.0	<3.0		<3.0	<3.0	<3.0	<3.0	<3.0		<3.0	<3.0	<3.0
Acidity 8.3	mg/L																					
Acidity 4.5	mg/L																					
Alk-T	mg/L							25.6						30.4				30.0				
N-NH3	mg/L							<0.020						<0.020				<0.0050				
NO2+NO3	mg/L							0.0272						0.0341				0.0239				
N-TKN	mg/L							0.096						0.068				0.050				
P-PO4-D	mg/L							0.0022														
P-PO4-T	mg/L							0.0031						0.0022				0.0027				
SO4-D	mg/L		28.1	35.9	31.8	32.0		17.1	38.3	31.3	35.5	35.1		31.6	46.6	40.2	41.2	35.6		40.9	29.6	24.3
Al-T	mg/L	0.0221					0.0214						0.0233						0.0203			
Sb-T	mg/L	<0.00050					<0.00050						<0.00050						<0.00050			
As-T	mg/L	<0.00050					<0.00050						<0.00050						<0.00050			
Ba-T	mg/L	<0.020					<0.020						<0.020						<0.020			
Be-T	mg/L	<0.0010					<0.0010						<0.0010						<0.0010			
B-T	mg/L	<0.10					<0.10						<0.10						<0.10			
Cd-T	mg/L	<0.000017					<0.000017						<0.000017						<0.000017			
Ca-T	mg/L	12.1					9.28						12.1						12.4			
Cr-T	mg/L	<0.0010					<0.0010						<0.0010						<0.0010			
Co-T	mg/L	<0.00030					<0.00030						<0.00030						<0.00030			
Cu-T	mg/L	<0.0010					<0.0010						<0.0010						<0.0010			
Fe-T	mg/L	0.037					0.033						0.039						0.030			
Pb-T	mg/L	<0.00050					<0.00050						<0.00050						<0.00050			
Li-T	mg/L	<0.0050					<0.0050						<0.0050						<0.0050			
Mg-T	mg/L	1.58					1.15						1.53						1.66			
Mn-T	mg/L	0.00478					0.00538						0.00476						0.00398			
Hg-T	mg/L	<0.000020					<0.000020						0.000032						<0.000020			
Mo-T	mg/L	<0.0010					<0.0010						<0.0010						<0.0010			
Ni-T	mg/L	<0.0010					<0.0010						<0.0010						<0.0010			
P-T	mg/L																					
K-T	mg/L	<2.0					<2.0						<2.0						<2.0			
Se-T	mg/L	<0.0010					<0.0010						<0.0010						<0.0010			
Ag-T	mg/L	<0.000020					<0.000020						<0.000020						<0.000020			
Na-T	mg/L	14.2					7.3						13.2						15.5			
Tl-T	mg/L	<0.00020					<0.00020						<0.00020						<0.00020			
Sn-T	mg/L	<0.00050					<0.00050						<0.00050						<0.00050			
Ti-T	mg/L	<0.010					<0.010						<0.010						<0.010			
U-T	mg/L	<0.00020					<0.00020						<0.00020						<0.00020			
V-T	mg/L	<0.0010					<0.0010						<0.0010						<0.0010			
Zn-T	mg/L	<0.0050					<0.0050						<0.0050						<0.0050			
Zr-T	mg/L																					
Al-D	mg/L	0.0185					0.0186						0.0199						0.0192			
Sb-D	mg/L	<0.00050					<0.00050						<0.00050						<0.00050			
As-D	mg/L	<0.00050					<0.00050						<0.00050						<0.00050			
Ba-D	mg/L	<0.020					<0.020						<0.020						<0.020			
Be-D	mg/L	<0.0010					<0.0010						<0.0010						<0.0010			
B-D	mg/L	<0.10					<0.10						<0.10						<0.10			
Cd-D	mg/L	<0.000017					0.000021						0.000027						<0.000017			
Ca-D	mg/L	13.5					10.5	9.42					12.7	11.6				12.1				
Cr-D	mg/L	<0.0010					<0.0010						<0.0010						<0.0010			
Co-D	mg/L	<0.00030					<0.00030						<0.00030						<0.00030			
Cu-D	mg/L	<0.0010					<0.0010						<0.0010						<0.0010			
Fe-D	mg/L	<0.030					<0.030						0.031						<0.030			
Pb-D	mg/L	<0.00050					<0.00050						<0.00050						<0.00050			
Li-D	mg/L	<0.0050					<0.0050						<0.0050						<0.0050			
Mg-D	mg/L	1.75					1.30	1.11					1.63	1.51				1.62				
Mn-D	mg/L	0.00459					0.00540						0.00446						0.00317			
Hg-D	mg/L	<0.000020					<0.000020						<0.000020						<0.000020			
Mo-D	mg/L	<0.0010					<0.0010						<0.0010						<0.0010			
Ni-D	mg/L	<0.0010					<0.0010						<0.0010						<0.0010			
P-D	mg/L																					
K-D	mg/L	<2.0					<2.0						<2.0						<2.0			
Se-D	mg/L	<0.0010					<0.0010						<0.0010						<0.0010			
U-D	mg/L	<0.00020					<0.00020						<0.00020						<0.00020			
V-D	mg/L	<0.0010					<0.0010						<0.0010						<0.0010			
Zn-D	mg/L	<0.0050					<0.0050						<0.0050						<0.0050			

Table D6 - Summary of water quality data collected at the WB site.																						
Parameter	Units	29/04/2008	06/05/2008	06/05/2008	12/05/2008	20/05/2008	26/05/2008	26/05/2008	02/06/2008	02/06/2008	09/06/2008	17/06/2008	25/06/2008	02/07/2008	07/07/2008	15/07/2008	15/07/2008	22/07/2008	29/07/2008	07/08/2008	07/08/2008	12/08/2008
Cond-L	uS/cm	112	124		116	114	104	103		113	118	127	119	107	94.2	86.1		84.6	80.5		82.0	78.4
Hardness (as CaCO3)	mg/L		37.0	41.4					35.4							30.7	39.6			30.7	28.8	
pH-L	pH Units	7.65	7.63		7.64	7.55	7.69	7.69		8.12	7.67	7.46	7.59	7.71	7.80	7.85		7.83	7.66		7.62	7.77
TSS	mg/L	<3.0	23.3		9.2	<3.0	<3.0	3.8		<3.0	3.7	<3.0	<3.0	<3.0	<3.0	<3.0		<3.0	<3.0		<3.0	7.3
Acidity 8.3	mg/L																					
Acidity 4.5	mg/L																					
Alk-T	mg/L		26.6							26.4						25.2					25.7	
N-NH3	mg/L		<0.0050							<0.0050						0.051					<0.020	
NO2+NO3	mg/L		0.0073							<0.0050						<0.0050					<0.0050	
N-TKN	mg/L		0.130							0.077						0.150					0.074	
P-PO4-D	mg/L		<0.0020							<0.0020						<0.0020					<0.0020	
P-PO4-T	mg/L		0.0175							0.0034						0.0038					0.0026	
SO4-D	mg/L	24.6	30.2		25.5	24.0	21.4	21.5		22.2	25.4	28.3	25.2	21.3	16.9	14.4		13.3	12.5		12.2	11.4
Al-T	mg/L			0.0259					0.0260								0.0201			0.0147		
Sb-T	mg/L			<0.00050					<0.00050								<0.00050			<0.00050		
As-T	mg/L			<0.00050					<0.00050								<0.00050			<0.00050		
Ba-T	mg/L			<0.020					<0.020								<0.020			<0.020		
Be-T	mg/L			<0.0010					<0.0010								<0.0010			<0.0010		
B-T	mg/L			<0.10					<0.10								<0.10			<0.10		
Cd-T	mg/L			<0.000017					<0.000017								<0.000017			<0.000017		
Ca-T	mg/L			13.0					11.4								10.2			9.75		
Cr-T	mg/L			<0.0010					<0.0010								<0.0010			<0.0010		
Co-T	mg/L			<0.00030					<0.00030								<0.00030			<0.00030		
Cu-T	mg/L			<0.0010					<0.0010								<0.0010			<0.0010		
Fe-T	mg/L			0.048					0.049								0.077			0.035		
Pb-T	mg/L			<0.00050					<0.00050								<0.00050			<0.00050		
Li-T	mg/L			<0.0050					<0.0050								<0.0050			<0.0050		
Mg-T	mg/L			1.52					1.42								1.27			1.17		
Mn-T	mg/L			0.00842					0.0126								0.00972			0.00529		
Hg-T	mg/L			<0.000020					<0.000020								<0.000020			<0.000020		
Mo-T	mg/L			<0.0010					<0.0010								<0.0010			<0.0010		
Ni-T	mg/L			<0.0010					<0.0010								<0.0010			<0.0010		
P-T	mg/L																					
K-T	mg/L			<2.0					<2.0								<2.0			<2.0		
Se-T	mg/L			<0.0010					<0.0010								<0.0010			<0.0010		
Ag-T	mg/L			<0.000020					<0.000020								<0.000020			<0.000020		
Na-T	mg/L			9.1					7.8								5.2			5.2		
Tl-T	mg/L			<0.00020					<0.00020								<0.00020			<0.00020		
Sn-T	mg/L			<0.00050					<0.00050								<0.00050			<0.00050		
Ti-T	mg/L			<0.010					<0.010								<0.010			<0.010		
U-T	mg/L			<0.00020					<0.00020								<0.00020			<0.00020		
V-T	mg/L			<0.0010					<0.0010								<0.0010			<0.0010		
Zn-T	mg/L			<0.0050					<0.0050								<0.0050			<0.0050		
Zr-T	mg/L																					
Al-D	mg/L			0.0146					0.0227								0.0219			0.0134		
Sb-D	mg/L			<0.00050					<0.00050								<0.00050			<0.00050		
As-D	mg/L			<0.00050					<0.00050								<0.00050			<0.00050		
Ba-D	mg/L			<0.020					<0.020								<0.020			<0.020		
Be-D	mg/L			<0.0010					<0.0010								<0.0010			<0.0010		
B-D	mg/L			<0.10					<0.10								<0.10			<0.10		
Cd-D	mg/L			<0.000017					0.000022								0.000022			0.000021		
Ca-D	mg/L		12.4	13.9					11.8							10.2	13.1			10.2	9.66	
Cr-D	mg/L			<0.0010					<0.0010								<0.0010			<0.0010		
Co-D	mg/L			<0.00030					<0.00030								<0.00030			0.00030		
Cu-D	mg/L			<0.0010					<0.0010								<0.0010			0.0013		
Fe-D	mg/L			<0.030					<0.030								0.039			<0.030		
Pb-D	mg/L			<0.00050					<0.00050								<0.00050			<0.00050		
Li-D	mg/L			<0.0050					<0.0050								<0.0050			<0.0050		
Mg-D	mg/L		1.48	1.63					1.44							1.28	1.68			1.25	1.14	
Mn-D	mg/L			0.00461					0.0119								0.00709			0.00139		
Hg-D	mg/L			<0.000020					<0.000020								<0.000020			<0.000020		
Mo-D	mg/L			<0.0010					<0.0010								<0.0010			<0.0010		
Ni-D	mg/L			<0.0010					<0.0010								<0.0010			<0.0010		
P-D	mg/L																					
K-D	mg/L			<2.0					<2.0								<2.0			<2.0		
Se-D	mg/L			<0.0010					<0.0010								<0.0010			<0.0010		
U-D	mg/L			<0.00020					<0.00020								<0.00020			<0.00020		
V-D	mg/L			<0.0010					<0.0010								<0.0010			<0.0010		
Zn-D	mg/L			<0.0050					<0.0050								<0.0050			<0.0050		

Table D6 - Summary of water quality data collected at the WB site.																						
Parameter	Units	19/08/2008	19/08/2008	27/08/2008	02/09/2008	09/09/2008	09/09/2008	16/09/2008	22/09/2008	29/09/2008	07/10/2008	14/10/2008	14/10/2008	21/10/2008	28/10/2008	03/11/2008	03/11/2008	11/11/2008	17/11/2008	25/11/2008	02/12/2008	02/12/2008
Cond-L	uS/cm	98.1	97.9	80.2	91.5		89.8	96.9	106	115	121		128	129	128		150	138	117	118	106	
Hardness (as CaCO3)	mg/L					33.6	31.5					42.3	39.4			48.2	46.6				33.8	36.5
pH-L	pH Units	7.69	7.44	7.58	7.76		7.67	7.81	7.67	7.72	7.81		7.88	7.79	7.15		7.77	7.48	7.17	7.58	7.82	
TSS	mg/L	<3.0	<3.0	<3.0	<3.0		<3.0	<3.0	<3.0	<3.0	<3.0		<3.0	<3.0	<3.0		<3.0	<3.0	<3.0	<3.0	<3.0	
Acidity 8.3	mg/L																					
Acidity 4.5	mg/L																					
Alk-T	mg/L						24.1						28.7				30.2				23.6	
N-NH3	mg/L						<0.0050						<0.020				0.0084				0.0053	
NO2+NO3	mg/L						<0.0050						0.0074				0.0077				0.0267	
N-TKN	mg/L						0.063						0.096				0.087				0.100	
P-PO4-D	mg/L						<0.0020						0.0025				<0.0020				0.0024	
P-PO4-T	mg/L						0.0025						0.0038				0.0039				0.0035	
SO4-D	mg/L	18.7	19.1	14.2	15.9		16.0	18.5	21.1	22.9	26.2		28.6	32.3	29.0		32.6	29.0	26.5	25.9	23.5	
Al-T	mg/L					0.0133						0.0092				0.0087					0.0200	
Sb-T	mg/L					<0.00050						<0.00050				<0.00050					<0.00050	
As-T	mg/L					<0.00050						<0.00050				<0.00050					<0.00050	
Ba-T	mg/L					<0.020						<0.020				<0.020					<0.020	
Be-T	mg/L					<0.0010						<0.0010				<0.0010					<0.0010	
B-T	mg/L					<0.10						<0.10				<0.10					<0.10	
Cd-T	mg/L					<0.000017						<0.000017				<0.000017					<0.000017	
Ca-T	mg/L					11.0						13.4				15.9					11.0	
Cr-T	mg/L					<0.0010						<0.0010				<0.0010					<0.0010	
Co-T	mg/L					<0.00030						<0.00030				<0.00030					<0.00030	
Cu-T	mg/L					<0.0010						<0.0010				<0.0010					<0.0010	
Fe-T	mg/L					0.040						0.036				0.042					0.052	
Pb-T	mg/L					<0.00050						<0.00050				<0.00050					<0.00050	
Li-T	mg/L					<0.0050						<0.0050				<0.0050					<0.0050	
Mg-T	mg/L					1.28						1.62				1.87					1.45	
Mn-T	mg/L					0.00641						0.00665				0.00841					0.00589	
Hg-T	mg/L					<0.000020						<0.000020				<0.000020					<0.000020	
Mo-T	mg/L					<0.0010						<0.0010				<0.0010					<0.0010	
Ni-T	mg/L					<0.0010						<0.0010				<0.0010					<0.0010	
P-T	mg/L																					
K-T	mg/L					<2.0						<2.0				<2.0					<2.0	
Se-T	mg/L					<0.0010						<0.0010				<0.0010					<0.0010	
Ag-T	mg/L					<0.000020						<0.000020				<0.000020					<0.000020	
Na-T	mg/L					5.5						10.2				11.2					7.5	
Tl-T	mg/L					<0.00020						<0.00020				<0.00020					<0.00020	
Sn-T	mg/L					<0.00050						<0.00050				<0.00050					<0.00050	
Ti-T	mg/L					<0.010						<0.010				<0.010					<0.010	
U-T	mg/L					<0.00020						<0.00020				<0.00020					<0.00020	
V-T	mg/L					<0.0010						<0.0010				<0.0010					<0.0010	
Zn-T	mg/L					<0.0050						<0.0050				<0.0050					<0.0050	
Zr-T	mg/L																					
Al-D	mg/L					0.0133						0.0105				0.0089					0.0155	
Sb-D	mg/L					<0.00050						<0.00050				<0.00050					<0.00050	
As-D	mg/L					<0.00050						<0.00050				<0.00050					<0.00050	
Ba-D	mg/L					<0.020						<0.020				<0.020					<0.020	
Be-D	mg/L					<0.0010						<0.0010				<0.0010					<0.0010	
B-D	mg/L					<0.10						<0.10				<0.10					<0.10	
Cd-D	mg/L					<0.000017						<0.000017				<0.000017					<0.000017	
Ca-D	mg/L					11.3	10.5					14.1	13.2			16.2	15.6			11.2	12.0	
Cr-D	mg/L					<0.0010						<0.0010				<0.0010					<0.0010	
Co-D	mg/L					<0.00030						<0.00030				<0.00030					<0.00030	
Cu-D	mg/L					<0.0010						<0.0010				<0.0010					<0.0010	
Fe-D	mg/L					<0.030						0.032				<0.030					0.050	
Pb-D	mg/L					<0.00050						<0.00050				<0.00050					<0.00050	
Li-D	mg/L					<0.0050						<0.0050				<0.0050					<0.0050	
Mg-D	mg/L					1.31	1.26					1.71	1.58			1.91	1.87			1.44	1.57	
Mn-D	mg/L					0.00223						0.00353				0.00350					0.00503	
Hg-D	mg/L					<0.000020						<0.000020				<0.000020					<0.000020	
Mo-D	mg/L					<0.0010						<0.0010				<0.0010					<0.0010	
Ni-D	mg/L					<0.0010						<0.0010				<0.0010					<0.0010	
P-D	mg/L																					
K-D	mg/L					<2.0						<2.0				<2.0					<2.0	
Se-D	mg/L					<0.0010						<0.0010				<0.0010					<0.0010	
U-D	mg/L					<0.00020						<0.00020				<0.00020					<0.00020	
V-D	mg/L					<0.0010						<0.0010				<0.0010					<0.0010	
Zn-D	mg/L					<0.0050						<0.0050				<0.0050					<0.0050	

Table D6 - Summary of water quality data collected at the WB site.																						
Parameter	Units	08/12/2008	15/12/2008	22/12/2008	30/12/2008	04/01/2009	04/01/2009	12/01/2009	19/01/2009	26/01/2009	03/02/2009	03/02/2009	09/02/2009	16/02/2009	23/02/2009	03/03/2009	09/03/2009	16/03/2009	23/03/2009	30/03/2009	06/04/2009	13/04/2009
Cond-L	uS/cm	105	101	96.0	105	105		138	144	116	92.4		113	102	105	141	133	170	153	172	172	247
Hardness (as CaCO3)	mg/L					36.8	36.4				33.2	33.6				52.4					48.3	
pH-L	pH Units	7.52	7.49	7.48	7.39	7.62		7.66	7.61	6.70	7.97		7.38	7.58	7.53	7.50	7.66	7.61	7.62	7.53	7.74	7.79
TSS	mg/L	<3.0	<3.0	<3.0	<3.0	<3.0		<3.0	<3.0	<3.0	<3.0		<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Acidity 8.3	mg/L																					
Acidity 4.5	mg/L																					
Alk-T	mg/L					23.0					22.5					25.2					28.1	
N-NH3	mg/L					0.0231					0.0053					<0.0050					<0.0050	
NO2+NO3	mg/L					0.0461					0.0512					0.0821					0.0367	
N-TKN	mg/L					0.177					0.077					0.118					0.103	
P-PO4-D	mg/L					0.0032					0.0034					0.0025					<0.0020	
P-PO4-T	mg/L					0.0036					0.0038					0.0038					0.0021	
SO4-D	mg/L	23.7	24.4	22.1	23.5	25.3		36.4	26.9	29.3	19.9		27.8	24.8	23.6	41.2	36.2	44.8	40.9	43.2	47.7	74.2
Al-T	mg/L						0.0209					0.0195				0.0505					0.0219	
Sb-T	mg/L						<0.00050					<0.00050				<0.00050					<0.00050	
As-T	mg/L						<0.00050					<0.00050				<0.00050					<0.00050	
Ba-T	mg/L						<0.020					<0.020				<0.020					<0.020	
Be-T	mg/L						<0.0010					<0.0010				<0.0010					<0.0010	
B-T	mg/L						<0.10					<0.10				<0.10					<0.10	
Cd-T	mg/L						<0.000017					<0.000017				<0.000017					<0.000017	
Ca-T	mg/L						11.7					10.7				16.2					15.4	
Cr-T	mg/L						<0.0010					<0.0010				<0.0010					<0.0010	
Co-T	mg/L						<0.00030					<0.00030				<0.00030					<0.00030	
Cu-T	mg/L						<0.0010					<0.0010				<0.0010					<0.0010	
Fe-T	mg/L						0.066					0.044				0.098					0.054	
Pb-T	mg/L						<0.00050					<0.00050				<0.00050					<0.00050	
Li-T	mg/L						<0.0050					<0.0050				<0.0050					<0.0050	
Mg-T	mg/L						1.64					1.45				2.24					2.05	
Mn-T	mg/L						0.00937					0.00566				0.0167					0.00622	
Hg-T	mg/L						<0.000020					<0.000020				<0.000020					<0.000020	
Mo-T	mg/L						<0.0010					<0.0010				<0.0010					<0.0010	
Ni-T	mg/L						<0.0010					<0.0010				<0.0010					<0.0010	
P-T	mg/L																					
K-T	mg/L						<2.0					<2.0				<2.0					<2.0	
Se-T	mg/L						<0.0010					<0.0010				<0.0010					<0.0010	
Ag-T	mg/L						<0.000020					<0.000020				<0.000020					<0.000020	
Na-T	mg/L						7.1					5.4				9.1					14.5	
Tl-T	mg/L						<0.00020					<0.00020				<0.00020					<0.00020	
Sn-T	mg/L						<0.00050					<0.00050				<0.00050					<0.00050	
Ti-T	mg/L						<0.010					<0.010				<0.010					<0.010	
U-T	mg/L						<0.00020					<0.00020				<0.00020					<0.00020	
V-T	mg/L						<0.0010					<0.0010				<0.0010					<0.0010	
Zn-T	mg/L						<0.0050					<0.0050				<0.0050					<0.0050	
Zr-T	mg/L																					
Al-D	mg/L						0.0169					0.0164				0.0276					0.0152	
Sb-D	mg/L						<0.00050					<0.00050				<0.00050					<0.00050	
As-D	mg/L						<0.00050					<0.00050				<0.00050					<0.00050	
Ba-D	mg/L						<0.020					<0.020				<0.020					<0.020	
Be-D	mg/L						<0.0010					<0.0010				<0.0010					<0.0010	
B-D	mg/L						<0.10					<0.10				<0.10					<0.10	
Cd-D	mg/L						<0.000017					0.000092				0.000766					<0.000017	
Ca-D	mg/L					12.0	11.9				10.9	11.0				17.2					15.9	
Cr-D	mg/L						<0.0010					<0.0010				<0.0010					<0.0010	
Co-D	mg/L						<0.00030					<0.00030				<0.00030					<0.00030	
Cu-D	mg/L						0.0010					<0.0010				0.0018					<0.0010	
Fe-D	mg/L						0.043					0.037				0.060					0.037	
Pb-D	mg/L						<0.00050					<0.00050				<0.00050					<0.00050	
Li-D	mg/L						<0.0050					<0.0050				<0.0050					<0.0050	
Mg-D	mg/L					1.67	1.64				1.48	1.49				2.27					2.10	
Mn-D	mg/L						0.00855					0.00535				0.0127					0.00443	
Hg-D	mg/L						<0.000020					<0.000020				<0.000020					<0.000020	
Mo-D	mg/L						<0.0010					<0.0010				<0.0010					<0.0010	
Ni-D	mg/L						<0.0010					<0.0010				<0.0010					<0.0010	
P-D	mg/L																					
K-D	mg/L						<2.0					<2.0				<2.0					<2.0	
Se-D	mg/L						<0.0010					<0.0010				<0.0010					<0.0010	
U-D	mg/L						<0.00020					<0.00020				<0.00020					<0.00020	
V-D	mg/L						<0.0010					<0.0010				<0.0010					<0.0010	
Zn-D	mg/L						<0.0050					<0.0050				<0.0050					<0.0050	

Table D6 - Summary of water quality data collected at the WB site.

Parameter	Units	20/04/2009	27/04/2009	04/05/2009	11/05/2009	19/05/2009	26/05/2009	01/06/2009	08/06/2009	13/06/2009	15/06/2009	22/06/2009	29/06/2009	07/07/2009	20/07/2009	27/07/2009	05/08/2009	10/08/2009	17/08/2009	24/08/2009	31/08/2009	08/09/2009
Cond-L	uS/cm	215	151	159	156	161	181	198	198	121	194	177	155	135	112	103	105	108	111	107	105	112
Hardness (as CaCO3)	mg/L			45.9				51.8						39.0			34.5				34.4	
pH-L	pH Units	7.93	7.74	7.89	7.69	7.87	8.02	7.87	7.85	7.58	7.94	7.90	7.79	7.94	8.06	7.60	7.94	7.89	7.89	7.95	7.43	7.57
TSS	mg/L	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Acidity 8.3	mg/L																					
Acidity 4.5	mg/L																					
Alk-T	mg/L			29.3				37.8						32.2			28.3				28.4	
N-NH3	mg/L			<0.0050				<0.0050						<0.0050			0.0116				<0.0050	
NO2+NO3	mg/L			<0.0050				<0.0050						<0.0050			<0.0050				<0.0050	
N-TKN	mg/L			0.104				0.096						0.150			0.132				0.128	
P-PO4-D	mg/L			<0.0020				<0.0020						<0.0020			<0.0020				<0.0020	
P-PO4-T	mg/L			0.0026				<0.0020						<0.0020			<0.0020				<0.0020	
SO4-D	mg/L	55.9	35.6	30.3	38.6	41.0	42.6	51.2	49.8	23.0	44.1	40.2	34.9	27.1	20.7	18.8	18.3	18.9	20.7	19.3	18.5	19.6
Al-T	mg/L			0.0144				0.0164						<0.020			0.0159				0.0123	
Sb-T	mg/L			<0.00050				<0.00050						<0.00050			<0.00050				<0.00050	
As-T	mg/L			<0.00050				<0.00050						<0.00050			<0.00050				<0.00050	
Ba-T	mg/L			<0.020				<0.020						<0.020			<0.020				<0.020	
Be-T	mg/L			<0.0010				<0.0010						<0.0010			<0.0010				<0.0010	
B-T	mg/L			<0.10				<0.10						<0.10			<0.10				<0.10	
Cd-T	mg/L			<0.000017				<0.000017						<0.000017			<0.000017				<0.000017	
Ca-T	mg/L			15.3				16.1						13.1			11.5				11.6	
Cr-T	mg/L			<0.0010				<0.0010						<0.0010			<0.0010				<0.0010	
Co-T	mg/L			<0.00030				<0.00030						<0.00030			<0.00030				<0.00030	
Cu-T	mg/L			<0.0010				<0.0010						<0.0010			<0.0010				<0.0010	
Fe-T	mg/L			0.041				0.036						0.044			0.044				0.035	
Pb-T	mg/L			<0.00050				<0.00050						<0.00050			<0.00050				<0.00050	
Li-T	mg/L			<0.0050				<0.0050						<0.0050			<0.0050				<0.0050	
Mg-T	mg/L			1.88				2.13						1.59			1.40				1.42	
Mn-T	mg/L			0.00588				0.00817						0.00928			0.0131				0.00713	
Hg-T	mg/L			<0.000020				<0.000020						<0.000020			<0.000020				<0.000020	
Mo-T	mg/L			<0.0010				<0.0010						<0.0010			<0.0010				<0.0010	
Ni-T	mg/L			<0.0010				<0.0010						<0.0010			<0.0010				<0.0010	
P-T	mg/L																					
K-T	mg/L			<2.0				<2.0						<2.0			<2.0				<2.0	
Se-T	mg/L			<0.0010				<0.0010						<0.0010			<0.0010				<0.0010	
Ag-T	mg/L			<0.000020				<0.000020						<0.000020			<0.000020				<0.000020	
Na-T	mg/L			13.7				20.8						11.2			7.5				8.0	
Tl-T	mg/L			<0.00020				<0.00020						<0.00020			<0.00020				<0.00020	
Sn-T	mg/L			<0.00050				<0.00050						<0.00050			<0.00050				<0.00050	
Ti-T	mg/L			<0.010				<0.010						<0.010			<0.010				<0.010	
U-T	mg/L			<0.00020				<0.00020						<0.00020			<0.00020				<0.00020	
V-T	mg/L			<0.0010				<0.0010						<0.0010			<0.0010				<0.0010	
Zn-T	mg/L			<0.0050				<0.0050						<0.0050			<0.0050				<0.0050	
Zr-T	mg/L																					
Al-D	mg/L			0.0122				0.0131						0.0154			0.0143				0.0148	
Sb-D	mg/L			<0.00050				<0.00050						<0.00050			<0.00050				<0.00050	
As-D	mg/L			<0.00050				<0.00050						<0.00050			<0.00050				<0.00050	
Ba-D	mg/L			<0.020				<0.020						<0.020			<0.020				<0.020	
Be-D	mg/L			<0.0010				<0.0010						<0.0010			<0.0010				<0.0010	
B-D	mg/L			<0.10				<0.10						<0.10			<0.10				<0.10	
Cd-D	mg/L			<0.000017				<0.000017						<0.000017			<0.000017				<0.000017	
Ca-D	mg/L			15.3				17.0						13.0			11.5				11.5	
Cr-D	mg/L			<0.0010				<0.0010						<0.0010			<0.0010				<0.0010	
Co-D	mg/L			<0.00030				<0.00030						<0.00030			<0.00030				<0.00030	
Cu-D	mg/L			<0.0010				<0.0010						<0.0010			<0.0010				<0.0010	
Fe-D	mg/L			<0.030				<0.030						<0.030			<0.030				<0.030	
Pb-D	mg/L			<0.00050				<0.00050						<0.00050			<0.00050				<0.00050	
Li-D	mg/L			<0.0050				<0.0050						<0.0050			<0.0050				<0.0050	
Mg-D	mg/L			1.88				2.25						1.58			1.40				1.40	
Mn-D	mg/L			0.00380				0.00541						0.00349			0.00453				0.00190	
Hg-D	mg/L			<0.000020				<0.000020						<0.000020			<0.000020				<0.000020	
Mo-D	mg/L			<0.0010				<0.0010						<0.0010			<0.0010				<0.0010	
Ni-D	mg/L			<0.0010				<0.0010						<0.0010			<0.0010				<0.0010	
P-D	mg/L																					
K-D	mg/L			<2.0				<2.0														

Table D6 - Summary of water quality data collected at the WB site.																						
Parameter	Units	14/09/2009	21/09/2009	01/10/2009	05/10/2009	13/10/2009	19/10/2009	26/10/2009	02/11/2009	09/11/2009	16/11/2009	23/11/2009	30/11/2009	07/12/2009	14/12/2009	21/12/2009	28/12/2009	05/01/2010	11/01/2010	18/01/2010	25/01/2010	01/02/2010
Cond-L	uS/cm	112	116	121	121	116	132	147	177	147	111	78.2	88.7	114	130	113	146	145	156	103	138	119
Hardness (as CaCO3)	mg/L			37.0					46.0				26.9					39.8				32.6
pH-L	pH Units	7.92	7.51	7.99	7.85	7.41	7.39	7.89	7.70	7.65	7.62	7.57	7.79	7.37	7.38	7.60	7.59	7.69	7.62	7.48	7.75	7.94
TSS	mg/L	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Acidity 8.3	mg/L																					
Acidity 4.5	mg/L																					
Alk-T	mg/L			29.2					31.4				27.5					32.2				29.3
N-NH3	mg/L			<0.0050					0.0080				<0.020					<0.0050				<0.0050
NO2+NO3	mg/L			<0.0050					0.0150				0.0169					0.0245				0.0235
N-TKN	mg/L			0.080					0.283				0.085					0.084				0.067
P-PO4-D	mg/L			<0.0020					<0.0020				<0.0020					<0.0020				<0.0020
P-PO4-T	mg/L			0.0023					0.0034				0.0042					0.0030				0.0037
SO4-D	mg/L	20.3	22.6	24.5	24.5	24.3	28.0	34.8	44.1	36.7	29.0	15.8	15.6	22.0	27.1	23.7	26.7	34.0	30.9	23.0	32.7	26.0
Al-T	mg/L			0.0076					0.0096				0.0517					0.0393				0.0452
Sb-T	mg/L			<0.00050					<0.00050				<0.00050					<0.00050				<0.00050
As-T	mg/L			<0.00050					<0.00050				<0.00050					<0.00050				<0.00050
Ba-T	mg/L			<0.020					<0.020				<0.020					<0.020				<0.020
Be-T	mg/L			<0.0010					<0.0010				<0.0010					<0.0010				<0.0010
B-T	mg/L			<0.10					<0.10				<0.10					<0.10				<0.10
Cd-T	mg/L			<0.000017					<0.000017				<0.000017					<0.000017				<0.000017
Ca-T	mg/L			12.5					14.9				9.01					13.0				10.1
Cr-T	mg/L			<0.0010					<0.0010				<0.0010					<0.0010				<0.0010
Co-T	mg/L			<0.00030					<0.00030				<0.00030					<0.00030				<0.00030
Cu-T	mg/L			<0.0010					<0.0010				<0.0010					<0.0010				<0.0010
Fe-T	mg/L			0.051					<0.050				0.047					0.043				0.040
Pb-T	mg/L			<0.00050					<0.00050				<0.00050					<0.00050				<0.00050
Li-T	mg/L			<0.0050					<0.0050				<0.0050					<0.0050				<0.0050
Mg-T	mg/L			1.55					1.78				1.10					1.67				1.37
Mn-T	mg/L			0.00660					0.0108				0.00366					0.00610				0.00413
Hg-T	mg/L			<0.000020					<0.000020				<0.000020					<0.000020				<0.000020
Mo-T	mg/L			<0.0010					<0.0010				<0.0010					<0.0010				<0.0010
Ni-T	mg/L			<0.0010					<0.0010				<0.0010					<0.0010				<0.0010
P-T	mg/L																					
K-T	mg/L			<2.0					<2.0				<2.0					<2.0				<2.0
Se-T	mg/L			<0.0010					<0.0010				<0.0010					<0.0010				<0.0010
Ag-T	mg/L			<0.000020					<0.000020				<0.000020					<0.000020				<0.000020
Na-T	mg/L			9.4					11.5				7.9					15.1				13.4
Tl-T	mg/L			<0.00020					<0.00020				<0.00020					<0.00020				<0.00020
Sn-T	mg/L			<0.00050					<0.00050				<0.00050					<0.00050				<0.00050
Ti-T	mg/L			<0.010					<0.010				<0.010					<0.010				<0.010
U-T	mg/L			<0.00020					<0.00020				<0.00020					<0.00020				<0.00020
V-T	mg/L			<0.0010					<0.0010				<0.0010					<0.0010				<0.0010
Zn-T	mg/L			<0.0050					<0.0050				<0.0050					<0.0050				<0.0050
Zr-T	mg/L																					
Al-D	mg/L			0.0078					0.0055				0.0210					0.0204				0.0281
Sb-D	mg/L			<0.00050					<0.00050				<0.00050					<0.00050				<0.00050
As-D	mg/L			<0.00050					<0.00050				<0.00050					<0.00050				<0.00050
Ba-D	mg/L			<0.020					<0.020				<0.020					<0.020				<0.020
Be-D	mg/L			<0.0010					<0.0010				<0.0010					<0.0010				<0.0010
B-D	mg/L			<0.10					<0.10				<0.10					<0.10				<0.10
Cd-D	mg/L			<0.000017					<0.000017				<0.000017					<0.000017				<0.000017
Ca-D	mg/L			12.3					15.5				8.99					13.2				10.7
Cr-D	mg/L			<0.0010					<0.0010				<0.0010					<0.0010				<0.0010
Co-D	mg/L			<0.00030					<0.00030				<0.00030					<0.00030				<0.00030
Cu-D	mg/L			<0.0010					<0.0010				<0.0010					<0.0010				<0.0010
Fe-D	mg/L			<0.030					<0.030				<0.030					<0.030				<0.030
Pb-D	mg/L			<0.00050					<0.00050				<0.00050					<0.00050				<0.00050
Li-D	mg/L			<0.0050					<0.0050				<0.0050					<0.0050				<0.0050
Mg-D	mg/L			1.54					1.80				1.09					1.67				1.39
Mn-D	mg/L			0.00167					0.00444				0.00179					0.00424				0.00262
Hg-D	mg/L			<0.000020					<0.000020				<0.000020					<0.000020				<0.000020
Mo-D	mg/L			<0.0010					<0.0010				<0.0010					<0.0010				<0.0010
Ni-D	mg/L			<0.0010					<0.0010				<0.0010					<0.0010				<0.0010
P-D	mg/L																					
K-D	mg/L			<2.0					<2.0				<2.0					<2.0				<2.0
Se-D	mg/L			<0.0010					<0.0010				<0.0010					<0.0010				<0.0010
U-D	mg/L			<0.00020					<0.00020				<0.00020					<0.00020				<0.00020
V-D	mg/L			<0.0010					<0.0010				<0.0010					<0.0010				<0.0010
Zn-D	mg/L			<0.0050					<0.0050				<0.0050					<0.0050				<0.0050

Table D6 - Summary of water quality data collected at the WB site.																						
Parameter	Units	08/02/2010	15/02/2010	22/02/2010	02/03/2010	08/03/2010	15/03/2010	22/03/2010	29/03/2010	06/04/2010	13/04/2010	19/04/2010	26/04/2010	03/05/2010	10/05/2010	17/05/2010	25/05/2010	31/05/2010	08/06/2010	14/06/2010	21/06/2010	28/06/2010
Cond-L	uS/cm	144	130	114	148	127	172	140	140	109	123	120	124	144	158	175	171	169	167	140	138	147
Hardness (as CaCO3)	mg/L				41.6					32.8				43.8				45.3				
pH-L	pH Units	8.05	7.24	7.72	8.18	7.39	7.30	7.36	7.75	8.17	7.68	7.77	7.66	7.97	7.88	7.47	7.84	7.95	7.64	7.48	7.82	7.80
TSS	mg/L	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	3.8	<3.0	9.8	<3.0	3.1	<3.0	3.1	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Acidity 8.3	mg/L																					
Acidity 4.5	mg/L																					
Alk-T	mg/L				31.4					26.6				31.6				36.3				
N-NH3	mg/L				<0.0050					<0.0050				<0.0050				0.0085				
NO2+NO3	mg/L				0.0213					0.0169				<0.0050				<0.0050				
N-TKN	mg/L				0.103					0.068				<0.050				<0.050				
P-PO4-D	mg/L				<0.0020					<0.0020				<0.0020				<0.0020				
P-PO4-T	mg/L				0.0039					0.0029				0.0030				0.0027				
SO4-D	mg/L	33.1	28.1	24.5	32.0	27.6	48.5	31.3	33.2	24.1	26.1	26.2	30.0	35.4	32.8	40.2	41.8	40.8	34.2	33.0	31.9	35.2
Al-T	mg/L				0.0391					0.0306				0.0550				0.0192				
Sb-T	mg/L				<0.00050					<0.00050				<0.00050				<0.00050				
As-T	mg/L				<0.00050					<0.00050				<0.00050				<0.00050				
Ba-T	mg/L				<0.020					<0.020				<0.020				<0.020				
Be-T	mg/L				<0.0010					<0.0010				<0.0010				<0.0010				
B-T	mg/L				<0.10					<0.10				<0.10				<0.10				
Cd-T	mg/L				<0.000017					<0.000017				<0.000017				<0.000017				
Ca-T	mg/L				13.4					10.5				13.0				14.2				
Cr-T	mg/L				<0.0010					<0.0010				<0.0010				<0.0010				
Co-T	mg/L				<0.00030					<0.00030				<0.00030				<0.00030				
Cu-T	mg/L				<0.0010					<0.0010				<0.0010				<0.0010				
Fe-T	mg/L				0.050					0.039				0.087				<0.030				
Pb-T	mg/L				<0.00050					<0.00050				<0.00050				<0.00050				
Li-T	mg/L				<0.0050					<0.0050				<0.0050				<0.0050				
Mg-T	mg/L				1.70					1.41				1.76				1.80				
Mn-T	mg/L				0.00633					0.00408				0.0143				0.00896				
Hg-T	mg/L				<0.000010					<0.000010				<0.000010				<0.000010				
Mo-T	mg/L				<0.0010					<0.0010				<0.0010				<0.0010				
Ni-T	mg/L				<0.0010					<0.0010				<0.0010				<0.0010				
P-T	mg/L																					
K-T	mg/L				<2.0					<2.0				<2.0				<2.0				
Se-T	mg/L				<0.0010					<0.0010				<0.0010				<0.0010				
Ag-T	mg/L				<0.000020					<0.000020				<0.000020				<0.000020				
Na-T	mg/L				13.5					10.1				14.6				17.3				
Tl-T	mg/L				<0.00020					<0.00020				<0.00020				<0.00020				
Sn-T	mg/L				<0.00050					<0.00050				<0.00050				<0.00050				
Ti-T	mg/L				<0.010					<0.010				<0.010				<0.010				
U-T	mg/L				<0.00020					<0.00020				<0.00020				<0.00020				
V-T	mg/L				<0.0010					<0.0010				<0.0010				<0.0010				
Zn-T	mg/L				<0.0050					<0.0050				<0.0050				<0.0050				
Zr-T	mg/L																					
Al-D	mg/L				0.0302					0.0202				0.0169				0.0147				
Sb-D	mg/L				<0.00050					<0.00050				<0.00050				<0.00050				
As-D	mg/L				<0.00050					<0.00050				<0.00050				<0.00050				
Ba-D	mg/L				<0.020					<0.020				<0.020				<0.020				
Be-D	mg/L				<0.0010					<0.0010				<0.0010				<0.0010				
B-D	mg/L				<0.10					<0.10				<0.10				<0.10				
Cd-D	mg/L				<0.000017					<0.000017				<0.000017				<0.000017				
Ca-D	mg/L				13.8					10.8				14.6				15.0				
Cr-D	mg/L				<0.0010					<0.0010				<0.0010				<0.0010				
Co-D	mg/L				<0.00030					<0.00030				<0.00030				<0.00030				
Cu-D	mg/L				<0.0010					<0.0010				<0.0010				<0.0010				
Fe-D	mg/L				0.048					<0.030				<0.030				<0.030				
Pb-D	mg/L				<0.00050					<0.00050				<0.00050				<0.00050				
Li-D	mg/L				<0.0050					<0.0050				<0.0050				<0.0050				
Mg-D	mg/L				1.74					1.45				1.80				1.89				
Mn-D	mg/L				0.00382					0.00215				0.00787				0.00614				
Hg-D	mg/L				<0.000010					<0.000010				<0.000010				<0.000010				
Mo-D	mg/L				<0.0010					<0.0010				<0.0010				<0.0010				
Ni-D	mg/L				<0.0010					<0.0010				<0.0010				<0.0010				
P-D	mg/L																					
K-D	mg/L				<2.0					<2.0				<2.0				<2.0				
Se-D	mg/L				<0.0010					<0.0010				<0.0010				<0.0010				
U-D	mg/L				<0.00020					<0.00020				<0.00020				<0.00020				
V-D	mg/L				<0.0010					<0.0010				<0.0010				<0.0010				
Zn-D	mg/L				<0.0050					<0.0050				<0.0050				<0.0050				

Table D6 - Summary of water quality data collected at the WB site.																						
Parameter	Units	05/07/2010	12/07/2010	19/07/2010	26/07/2010	03/08/2010	09/08/2010	16/08/2010	23/08/2010	31/08/2010	07/09/2010	07/09/2010	14/09/2010	20/09/2010	27/09/2010	05/10/2010	12/10/2010	18/10/2010	25/10/2010	01/11/2010	15/11/2010	22/11/2010
Cond-L	uS/cm	144	120	110	101	97.3	96	96	98	96	95	97	95.1	92.7	94.5	529	103	105	111	114	83	95
Hardness (as CaCO3)	mg/L	41.8				31.4	31.5		22.6	29.4						30.9						
pH-L	pH Units	7.62	7.86	7.83	7.85	7.90	7.30	7.34	7.81	7.69	7.69	7.69	7.59	7.79	7.72	7.79	7.66	7.76	7.60	7.53	7.72	7.33
TSS	mg/L	<3.0	<3.0	<3.0	<3.0	<3.0	<1		1	<1		<1	<3.0	<3.0	<3.0	<1	<4	<1	<1	<1	<1	<4
Acidity 8.3	mg/L															0.6	<0.5					0.5
Acidity 4.5	mg/L															<0.5	<0.5					<0.5
Alk-T	mg/L	35.0				27.8										110	32					26
N-NH3	mg/L	0.0058				0.0064						0.062				0.045						
NO2+NO3	mg/L	<0.0050				<0.0050				<0.002		<0.0002				<0.02						<0.02
N-TKN	mg/L	<0.050				0.067						0.16				0.16						
P-PO4-D	mg/L	<0.0020				<0.0020	1.7		1.1	0.8												
P-PO4-T	mg/L	0.0024				0.0026	0.008		0.008	0.004												
SO4-D	mg/L	33.2	24.5	21.2	18.2	16.7		14					16.1	16.3	16.8	20	19	20	23	25	13	17
Al-T	mg/L	0.0187				0.0205	0.0163	0.0162	0.0164			0.0125				0.014		0.0121	0.0103	0.0173	0.0236	
Sb-T	mg/L	<0.00050				<0.00050	<0.00002	<0.00002	<0.00002			<0.00002				<0.0005		<0.00002	<0.00002	<0.00002	<0.00002	
As-T	mg/L	<0.00050				<0.00050	0.00018	0.00020	0.00023			0.00020				0.0002		0.00016	0.00015	0.00018	0.00016	
Ba-T	mg/L	<0.020				<0.020	0.00141	0.00129	0.00149			0.00155				0.002		0.00192	0.00194	0.00249	0.00185	
Be-T	mg/L	<0.0010				<0.0010	<0.00001	<0.00001	<0.00001			<0.00001				<0.0001		<0.00001	<0.00001	<0.00001	<0.00001	
B-T	mg/L	<0.10				<0.10	<0.05	<0.05	<0.05			<0.05				<0.05		<0.05	<0.05	<0.05	<0.05	
Cd-T	mg/L	<0.000017				<0.000017	<0.000005	<0.000005	<0.000005			<0.000005				0.00003		0.000030	<0.000005	0.000042	0.000011	
Ca-T	mg/L	13.9				10.6										10.3						
Cr-T	mg/L	<0.0010				<0.0010	<0.0001	<0.0001	<0.0001			<0.0001				<0.001		<0.0001	<0.0001	<0.0001	<0.0001	
Co-T	mg/L	<0.00030				<0.00030	<0.00001	0.000010	0.000010			0.000009				<0.0005		0.000010	0.000014	0.000020	0.000019	
Cu-T	mg/L	<0.0010				<0.0010	0.00049	0.00056	0.00055			0.00053				0.0006		0.00062	0.00044	0.00042	0.00056	
Fe-T	mg/L	0.034				0.049										0.055						
Pb-T	mg/L	<0.00050				<0.00050	<0.000005	0.000006	0.000006			0.000007				<0.0002		0.000014	0.000008	0.000018	0.000007	
Li-T	mg/L	<0.0050				<0.0050	<0.0005	<0.0005	<0.0005			<0.0005				<0.005		<0.0005	<0.0005	<0.0005	<0.0005	
Mg-T	mg/L	1.73				1.28	1.24	1.28	1.43			1.25				1.23		1.34	1.27	1.42	1.23	
Mn-T	mg/L	0.0107				0.00993	0.00988	0.00793	0.0154			0.0128				0.011		0.0191	0.0170	0.0149	0.00819	
Hg-T	mg/L	<0.000010				<0.000010	<0.000010	<0.00001	<0.00001							0.00004		<0.00001	<0.00001		<0.00001	
Mo-T	mg/L	<0.0010				<0.0010	0.00019	0.00017	0.00023			0.00013				<0.001		0.00014	0.00017	0.00013	0.00013	
Ni-T	mg/L	<0.0010				<0.0010	0.00025	0.00008	0.00003			0.00003				<0.001		0.00004	0.00008	0.00008	0.00007	
P-T	mg/L											0.005				<0.005		0.029	0.003	0.003	<0.002	
K-T	mg/L	<2.0				<2.0										0.16						
Se-T	mg/L	<0.0010				<0.0010	0.00004	0.00005	0.00006			0.00005				<0.0001		<0.00004	0.00005	<0.00004	0.00004	
Ag-T	mg/L	<0.000020				<0.000020	0.000005	<0.000005	<0.000005			<0.000005				<0.00002		<0.000005	<0.000005	<0.000005	<0.000005	
Na-T	mg/L	13.8				7.1										6.37						
Tl-T	mg/L	<0.00020				<0.00020	0.0404	<0.000002	<0.000002			<0.000002				<0.00005		<0.000002	<0.000002	<0.000002	<0.000002	
Sn-T	mg/L	<0.00050				<0.00050	<0.000002	<0.00001	<0.00001			<0.00001				<0.005		0.00001	<0.00001	<0.00001	0.00003	
Ti-T	mg/L	<0.010				<0.010										<0.005						
U-T	mg/L	<0.00020				<0.00020	0.000004	0.000008	0.000039			0.000003				<0.0001		<0.000002	0.000004	0.000003	0.000003	
V-T	mg/L	<0.0010				<0.0010	<0.0002	0.0003	0.0002			0.0002				<0.005		<0.0002	<0.0002	<0.0002	<0.0002	
Zn-T	mg/L	<0.0050				<0.0050	<0.0001	0.0002	<0.0001			0.0003				<0.005		0.0003	0.0002	0.0004	0.0006	
Zr-T	mg/L																					

Table D6 - Summary of water quality data
collected at the WB site.

Parameter	Units	29/11/2010	07/12/2010	07/12/2010	13/12/2010	20/12/2010	27/12/2010	04/01/2011	10/01/2011
Cond-L	uS/cm	103	98	101	92	106	95	139	136
Hardness (as CaCO3)	mg/L		33.3	31.5				38.5	
pH-L	pH Units	7.31	7.40	7.70	7.38	6.98	7.33	7.20	7.02
TSS	mg/L	<4	<4	<4	<4	<4	<4	<4	<4
Acidity 8.3	mg/L	0.6	<0.5	<0.5	3.3	0.5	0.9	<0.5	0.6
Acidity 4.5	mg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Alk-T	mg/L	24	23	26	22	23	24	27	27
N-NH3	mg/L		0.030	0.061				<0.05	
NO2+NO3	mg/L	<0.02	0.02	0.03	0.03	0.03	0.02	0.02	0.03
N-TKN	mg/L		0.11	0.37				0.10	
P-PO4-D	mg/L								
P-PO4-T	mg/L								
SO4-D	mg/L	21	21	22	19	23	20	33	33
Al-T	mg/L		0.041	0.038				0.042	
Sb-T	mg/L		<0.0005	<0.0005				<0.0005	
As-T	mg/L		0.0003	<0.0001				0.0001	
Ba-T	mg/L		0.003	0.002				0.003	
Be-T	mg/L		<0.0001	<0.0001				<0.0001	
B-T	mg/L		<0.05	<0.05				<0.05	
Cd-T	mg/L		<0.00001	<0.00001				0.00001	
Ca-T	mg/L		10.8	10.3				12.6	
Cr-T	mg/L		<0.001	<0.001				<0.001	
Co-T	mg/L		<0.0005	<0.0005				<0.0005	
Cu-T	mg/L		0.0005	0.0007				0.0006	
Fe-T	mg/L		0.083	0.080				0.061	
Pb-T	mg/L		<0.0002	<0.0002				<0.0002	
Li-T	mg/L		<0.005	<0.005				<0.005	
Mg-T	mg/L		1.51	1.41				1.72	
Mn-T	mg/L		0.008	0.008				0.008	
Hg-T	mg/L		0.00002	<0.00002				<0.00002	
Mo-T	mg/L		<0.001	<0.001				<0.001	
Ni-T	mg/L		<0.001	<0.001				<0.001	
P-T	mg/L		<0.005	<0.005				<0.005	
K-T	mg/L		0.15	0.16				0.22	
Se-T	mg/L		<0.0001	<0.0001				<0.0001	
Ag-T	mg/L		<0.00002	<0.00002				<0.00002	
Na-T	mg/L		6.22	5.84				10.9	
Tl-T	mg/L		<0.00005	<0.00005				<0.00005	
Sn-T	mg/L		<0.005	<0.005				<0.005	
Ti-T	mg/L		<0.005	<0.005				<0.005	
U-T	mg/L		<0.0001	<0.0001				<0.0001	
V-T	mg/L		<0.005	<0.005				<0.005	
Zn-T	mg/L		<0.005	<0.005				<0.005	
Zr-T	mg/L		<0.0005	<0.0005				<0.0005	
Al-D	mg/L		0.023	0.024				0.027	
Sb-D	mg/L		<0.0005	<0.0005				<0.0005	
As-D	mg/L		0.0002	0.0002				0.0002	
Ba-D	mg/L		0.003	0.002				0.003	
Be-D	mg/L		<0.0001	<0.0001				<0.0001	
B-D	mg/L		<0.05	<0.05				<0.05	
Cd-D	mg/L		0.00001	0.00002				0.00004	
Ca-D	mg/L		10.2	10.7				12.4	
Cr-D	mg/L		<0.001	<0.001				<0.001	
Co-D	mg/L		<0.0005	<0.0005				<0.0005	
Cu-D	mg/L		0.0006	0.0006				0.0072	
Fe-D	mg/L		0.048	0.048				0.035	
Pb-D	mg/L		<0.0002	<0.0002				<0.0002	
Li-D	mg/L		<0.005	<0.005				<0.005	
Mg-D	mg/L		1.40	1.44				1.59	
Mn-D	mg/L		0.007	0.007				0.006	
Hg-D	mg/L		<0.00002	<0.00002				<0.00002	
Mo-D	mg/L		<0.001	<0.001				<0.001	
Ni-D	mg/L		<0.001	<0.001				<0.001	
P-D	mg/L		<0.005	<0.005				<0.005	
K-D	mg/L		0.16	0.17				0.22	
Se-D	mg/L		<0.0001	<0.0001				<0.0001	
U-D	mg/L		<0.0001	<0.0001				<0.0001	
V-D	mg/L		<0.005	<0.005				<0.005	
Zn-D	mg/L		<0.005	<0.005				<0.005	

Table D7 - Summary of water quality data collected at the 7SQR site.

[illegible]

***Appendix E:
Predicted Concentrations
in Quinsam River***



HILLSBOUROUGH
Resources Limited

River Scenario 1 Worst Case: Concentrations in Quinsam River (MEDIAN Seepage Flux)

COC	Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	7Q10
Aluminum (Al) Dissolved	mg/L	2.5E-02	2.9E-02	2.4E-02	2.0E-02	1.6E-02	1.8E-02	1.7E-02	1.6E-02	1.6E-02	1.0E-02	1.6E-02	2.6E-02	1.9E-02
Arsenic (As) Total	mg/L	1.9E-04	2.0E-04	2.0E-04	2.1E-04	2.1E-04	2.2E-04	2.6E-04	2.9E-04	2.5E-04	2.1E-04	1.9E-04	1.9E-04	5.1E-04
Boron (B) Total	mg/L	2.5E-02	2.5E-02	2.5E-02	2.5E-02	2.5E-02	2.5E-02	2.5E-02	2.6E-02	2.5E-02	2.5E-02	2.5E-02	2.5E-02	2.7E-02
Cadmium (Cd) Total	mg/L	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05
Cobalt (Co) Total	mg/L	9.6E-05	1.0E-04	9.9E-05	1.0E-04	1.0E-04	1.1E-04	1.2E-04	1.3E-04	1.1E-04	1.0E-04	9.6E-05	9.7E-05	2.0E-04
Copper (Cu) Total	mg/L	5.5E-04	5.6E-04	5.5E-04	5.6E-04	5.6E-04	5.6E-04	5.7E-04	5.8E-04	5.7E-04	5.6E-04	5.5E-04	5.5E-04	6.5E-04
Fluoride (F) Total	mg/L													
Iron (Fe) Total	mg/L	6.7E-02	1.1E-01	8.7E-02	9.1E-02	1.0E-01	1.1E-01	1.7E-01	2.0E-01	1.4E-01	8.5E-02	1.0E-01	9.2E-02	5.0E-01
Manganese (Mn) Total	mg/L	6.4E-03	6.8E-03	1.0E-02	8.5E-03	9.3E-03	1.2E-02	1.3E-02	1.2E-02	9.7E-03	9.7E-03	1.5E-02	9.1E-03	1.9E-02
Nickel (Ni) Total	mg/L	2.3E-04	2.4E-04	2.4E-04	2.4E-04	2.5E-04	2.5E-04	2.7E-04	3.0E-04	2.7E-04	2.4E-04	2.3E-04	2.3E-04	4.3E-04
Selenium (Se) Total	mg/L	4.4E-05	4.5E-05	4.5E-05	4.5E-05	4.5E-05	4.5E-05	4.6E-05	4.7E-05	4.6E-05	4.5E-05	4.4E-05	4.5E-05	5.2E-05
Sulphate (SO4) Dissolved	mg/L	3.0E+01	3.6E+01	4.6E+01	4.3E+01	3.4E+01	3.3E+01	2.4E+01	1.9E+01	1.9E+01	2.2E+01	2.8E+01	3.0E+01	2.2E+01
Zinc (Zn) Total	mg/L	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.1E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.2E-03

River Scenario 1 Worst Case: Concentrations in Quinsam River (10% MAP Seepage Flux)

COC	Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	7Q10
Aluminum (Al) Dissolved	mg/L	2.5E-02	2.9E-02	2.4E-02	2.0E-02	1.6E-02	1.8E-02	1.7E-02	1.6E-02	1.6E-02	1.0E-02	1.6E-02	2.6E-02	1.9E-02
Arsenic (As) Total	mg/L	2.1E-04	2.4E-04	2.4E-04	2.5E-04	2.7E-04	3.0E-04	3.8E-04	4.7E-04	3.5E-04	2.5E-04	2.1E-04	2.2E-04	1.0E-03
Boron (B) Total	mg/L	2.5E-02	2.5E-02	2.5E-02	2.5E-02	2.5E-02	2.6E-02	2.6E-02	2.7E-02	2.6E-02	2.5E-02	2.5E-02	2.5E-02	2.9E-02
Cadmium (Cd) Total	mg/L	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.3E-05
Cobalt (Co) Total	mg/L	1.0E-04	1.1E-04	1.1E-04	1.2E-04	1.2E-04	1.3E-04	1.6E-04	1.9E-04	1.5E-04	1.2E-04	1.0E-04	1.1E-04	3.6E-04
Copper (Cu) Total	mg/L	5.6E-04	5.7E-04	5.7E-04	5.7E-04	5.7E-04	5.8E-04	6.1E-04	6.3E-04	6.0E-04	5.7E-04	5.6E-04	5.6E-04	7.9E-04
Fluoride (F) Total	mg/L													
Iron (Fe) Total	mg/L	9.5E-02	1.7E-01	1.3E-01	1.5E-01	1.7E-01	2.0E-01	3.3E-01	4.4E-01	2.8E-01	1.4E-01	1.3E-01	1.3E-01	1.2E+00
Manganese (Mn) Total	mg/L	7.1E-03	8.0E-03	1.1E-02	9.9E-03	1.1E-02	1.4E-02	1.7E-02	1.8E-02	1.3E-02	1.1E-02	1.6E-02	9.9E-03	3.5E-02
Nickel (Ni) Total	mg/L	2.4E-04	2.6E-04	2.6E-04	2.7E-04	2.8E-04	3.0E-04	3.5E-04	4.1E-04	3.3E-04	2.7E-04	2.4E-04	2.5E-04	7.5E-04
Selenium (Se) Total	mg/L	4.5E-05	4.6E-05	4.6E-05	4.6E-05	4.6E-05	4.7E-05	4.9E-05	5.1E-05	4.8E-05	4.6E-05	4.5E-05	4.5E-05	6.3E-05
Sulphate (SO4) Dissolved	mg/L	3.0E+01	3.7E+01	4.7E+01	4.4E+01	3.5E+01	3.3E+01	2.5E+01	2.1E+01	2.0E+01	2.3E+01	2.8E+01	3.0E+01	2.7E+01
Zinc (Zn) Total	mg/L	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.1E-03	1.1E-03	1.1E-03	1.1E-03	1.1E-03	1.0E-03	1.0E-03	1.0E-03	1.4E-03

River Scenario 2 Predicted Case: Concentrations in Quinsam River (MEDIAN Seepage Flux)

COC	Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	7Q10
Aluminum (Al) Dissolved	mg/L	2.5E-02	2.9E-02	2.4E-02	2.0E-02	1.6E-02	1.8E-02	1.7E-02	1.6E-02	1.6E-02	1.0E-02	1.6E-02	2.6E-02	1.9E-02
Arsenic (As) Total	mg/L	1.9E-04	2.0E-04	2.0E-04	2.1E-04	2.1E-04	2.2E-04	2.6E-04	2.9E-04	2.5E-04	2.1E-04	1.9E-04	1.9E-04	5.1E-04
Boron (B) Total	mg/L	2.5E-02	2.5E-02	2.5E-02	2.5E-02	2.5E-02	2.5E-02	2.5E-02	2.6E-02	2.5E-02	2.5E-02	2.5E-02	2.5E-02	2.7E-02
Cadmium (Cd) Total	mg/L	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05
Cobalt (Co) Total	mg/L	9.6E-05	1.0E-04	9.9E-05	1.0E-04	1.0E-04	1.1E-04	1.2E-04	1.3E-04	1.1E-04	1.0E-04	9.6E-05	9.7E-05	2.0E-04
Copper (Cu) Total	mg/L	5.5E-04	5.5E-04	5.5E-04	5.5E-04	5.5E-04	5.5E-04	5.5E-04	5.5E-04	5.5E-04	5.5E-04	5.5E-04	5.5E-04	5.5E-04
Fluoride (F) Total	mg/L													
Iron (Fe) Total	mg/L	4.8E-02	8.0E-02	5.5E-02	5.0E-02	5.2E-02	4.2E-02	6.3E-02	4.7E-02	4.8E-02	4.6E-02	8.2E-02	7.0E-02	6.7E-02
Manganese (Mn) Total	mg/L	6.2E-03	6.4E-03	9.9E-03	8.0E-03	8.7E-03	1.1E-02	1.2E-02	1.0E-02	8.6E-03	9.2E-03	1.5E-02	8.9E-03	1.4E-02
Nickel (Ni) Total	mg/L	2.3E-04	2.4E-04	2.4E-04	2.4E-04	2.5E-04	2.5E-04	2.7E-04	3.0E-04	2.7E-04	2.4E-04	2.3E-04	2.3E-04	4.3E-04
Selenium (Se) Total	mg/L	4.4E-05	4.5E-05	4.5E-05	4.5E-05	4.5E-05	4.5E-05	4.6E-05	4.7E-05	4.6E-05	4.5E-05	4.4E-05	4.5E-05	5.2E-05
Sulphate (SO4) Dissolved	mg/L	3.0E+01	3.6E+01	4.6E+01	4.3E+01	3.4E+01	3.2E+01	2.4E+01	1.9E+01	1.8E+01	2.2E+01	2.8E+01	3.0E+01	2.0E+01
Zinc (Zn) Total	mg/L	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.1E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.2E-03

River Scenario 2 Predicted Case: Final Concentrations in Quinsam River (10% MAP Seepage Flux)

COC	Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	7Q10
Aluminum (Al) Dissolved	mg/L	2.5E-02	2.9E-02	2.4E-02	2.0E-02	1.6E-02	1.8E-02	1.7E-02	1.6E-02	1.6E-02	1.0E-02	1.6E-02	2.6E-02	1.9E-02
Arsenic (As) Total	mg/L	2.1E-04	2.4E-04	2.4E-04	2.5E-04	2.7E-04	3.0E-04	3.8E-04	4.7E-04	3.5E-04	2.5E-04	2.1E-04	2.2E-04	1.0E-03
Boron (B) Total	mg/L	2.5E-02	2.5E-02	2.5E-02	2.5E-02	2.5E-02	2.6E-02	2.6E-02	2.7E-02	2.6E-02	2.5E-02	2.5E-02	2.5E-02	2.9E-02
Cadmium (Cd) Total	mg/L	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.3E-05
Cobalt (Co) Total	mg/L	1.0E-04	1.1E-04	1.1E-04	1.2E-04	1.2E-04	1.3E-04	1.6E-04	1.9E-04	1.5E-04	1.2E-04	1.0E-04	1.1E-04	3.6E-04
Copper (Cu) Total	mg/L	5.5E-04	5.5E-04	5.5E-04	5.5E-04	5.5E-04	5.5E-04	5.5E-04	5.5E-04	5.5E-04	5.5E-04	5.5E-04	5.5E-04	5.5E-04
Fluoride (F) Total	mg/L													
Iron (Fe) Total	mg/L	4.9E-02	8.1E-02	5.6E-02	5.2E-02	5.4E-02	4.4E-02	6.7E-02	5.3E-02	5.2E-02	4.8E-02	8.3E-02	7.0E-02	8.4E-02
Manganese (Mn) Total	mg/L	6.5E-03	7.0E-03	1.0E-02	8.7E-03	9.5E-03	1.2E-02	1.3E-02	1.3E-02	1.0E-02	9.9E-03	1.5E-02	9.2E-03	2.1E-02
Nickel (Ni) Total	mg/L	2.4E-04	2.6E-04	2.6E-04	2.7E-04	2.8E-04	3.0E-04	3.5E-04	4.1E-04	3.3E-04	2.7E-04	2.4E-04	2.5E-04	7.5E-04
Selenium (Se) Total	mg/L	4.5E-05	4.6E-05	4.6E-05	4.6E-05	4.6E-05	4.7E-05	4.9E-05	5.1E-05	4.8E-05	4.6E-05	4.5E-05	4.5E-05	6.3E-05
Sulphate (SO4) Dissolved	mg/L	3.0E+01	3.6E+01	4.6E+01	4.4E+01	3.5E+01	3.3E+01	2.4E+01	2.0E+01	1.9E+01	2.2E+01	2.8E+01	3.0E+01	2.3E+01
Zinc (Zn) Total	mg/L	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.1E-03	1.1E-03	1.1E-03	1.1E-03	1.1E-03	1.0E-03	1.0E-03	1.0E-03	1.4E-03